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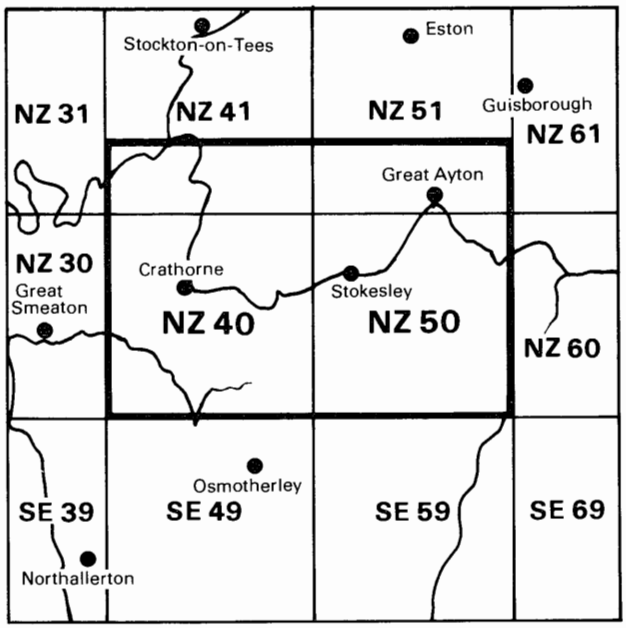

The sand and gravel resources of the country around Stokesley, North Yorkshire

Description of 1:25 000 sheets NZ 40 and 50, and parts of NZ 41 and 51

R. G. Crofts

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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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The asterisks on the cover indicate that parts of sheets adjacent to the ones cited are described in this report.

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 resources of alternative aggregates are available. Following a short feasibility project, initiated in 1966 by the Ministry of Land and Natural Resources, the Mineral Assessment Unit (now the Industrial Minerals Assessment Unit) began systematic surveys in 1968. The work is now being financed by the Department of the Environment and is being undertaken with the co-operation of the Sand and Gravel Association of Great Britain.

This report describes the resources of sand and gravel of the country around Stokesley, North Yorkshire, shown on the accompanying 1:25 000 resource map. The survey was conducted by Mr R. G. Crofts and is based on the six-inch scale geological surveys carried out by Institute Field Staff in 1878, 1965–68 and 1977–79. Mr C. L. Reeves (Land Agent), has been responsible for negotiating access to land for drilling. The ready co-operation of land owners, tenants and the North Yorkshire County Council in this work is gratefully acknowledged.

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R. G. CROFTS

SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and 120 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of sand and gravel resources in the area around Stokesley, North Yorkshire.

All deposits in the area 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 4 resource blocks, containing between 1.3 and 11.7 km^2 of sand and gravel. For each block the geology of the deposits is described and the mineral-bearing area, the mean thicknesses of overburden and mineral and the mean gradings are stated. Detailed borehole data are also given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

Bibliographical reference
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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." At the 'inferred' level "quantitative estimates are based largely on broad knowledge of the geologic character of the deposit . . . there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geological evidence: this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geological evidence of their presence." (Bureau of Mines and Geological Survey, 1948, p. 15).

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

The following arbitrary physical criteria have been adopted:

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

A deposit of sand and gravel which broadly meets

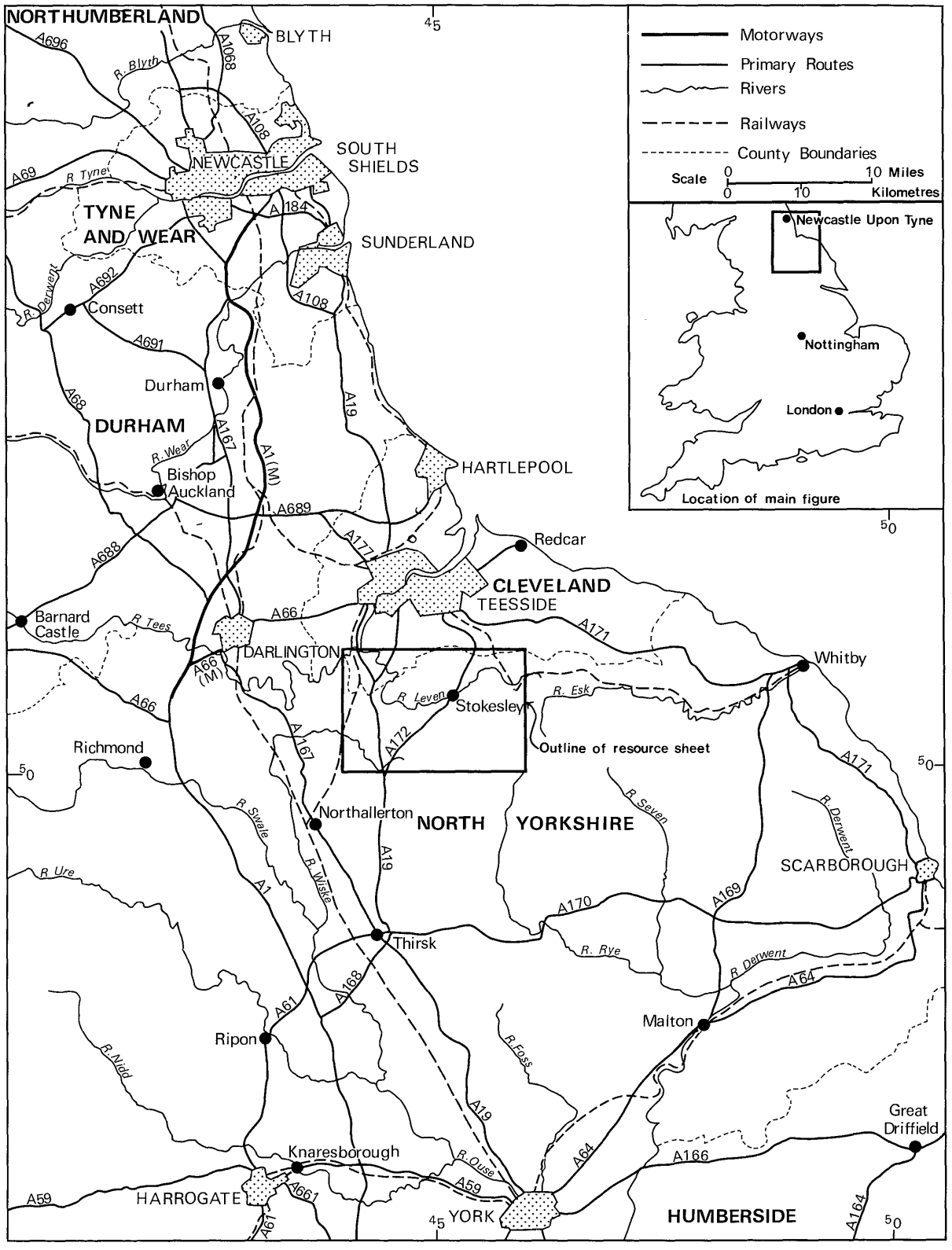

Figure 1 Map showing the location of the resource sheet (NZ 40 and 50, and parts of NZ 41 and 51).

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

For the 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^2 of sand and gravel. No account is taken of any factors, for example, roads, villages and land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

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

DESCRIPTION OF THE STOKESLEY DISTRICT

GENERAL

The district is dominated by the Cleveland Hills cuesta in the south-east, where bleak moorland reaches a height of 435 m above OD on Cringle Moor [537 039]. In contrast the low ground of the fertile Cleveland Plain slopes gently from 152 m above OD near the base of the escarpment at Battersby [596 075], westwards to 61 m above OD at Picton [416 075].

The Leven is the principal river of the district, flowing westwards to Crathorne [442 074] and then northwards to join the River Tees near Yarm. In its lower reaches it is deeply incised into the drift. A second westerly-flowing stream, the River Wiske, drains the south-west corner of the area and later turns south to join the River Swale in the Vale of York (Figure 1).

Stokesley, a small market town, provides a focus for this agricultural district and also serves, along with Hutton Rudby and Great Ayton, as a dormitory settlement for the Teesside conurbation.

Branch lines connect with the main 'east-coast' railway and the A19 trunk road crosses the district, linking it with industrial and commercial centres to the south and north.

GEOLOGY

The first geological survey of the district was made in the last century and the geology of part of the area is described in Old Series memoirs for sheets 96 (Fox-Strangways and others, 1885, 1886) and 104 (Barrow, 1888). Most of the ground has been resurveyed since 1977 and a new memoir describing the geology of the district is in preparation. The geological succession is summarised in Table 1 and briefly described below.

Table 1 Classification and geological sequence

DRIFT			
Recent and Pleistocene			Peat
			Alluvium
			Alluvial Fans
			River Terrace Deposits, undifferentiated
			Lacustine Deposits
			Fluvio-Glacial Delta Sand
			Glacial Sand and Gravel and laminated clay
SOLID			Till (Boulder Clay)
Tertiary (Igneous)			(Cleveland Dyke)
Jurassic	Middle Jurassic		Ravenscar Group
			Dogger Formation
	Lower Jurassic	'Upper Lias'	Shales including the Jet Rock and Alum Shales
		'Middle Lias'	Cleveland Ironstone Formation
			Staithes Formation
		'Lower Lias'	Shales
Triassic	Rhaetic		Penarth Group
			Mercia Mudstone Group (Keuper Marl)
			Sherwood Sandstone Group (Bunter Sandstone)

SOLID

Of the solid strata listed in Table 1 only the higher Jurassic beds and the Cleveland Dyke are well exposed. The remainder are mostly concealed by up to 40 m of drift and their descriptions are based largely on borehole data and evidence from adjacent areas.

Sherwood Sandstone Group Rocks of this Group are partially exposed in the Tees Valley and near Crathorne, where it comprises a characteristic brick-red, and locally yellowish grey or mottled, fine- to medium-grained sandstone. Boreholes in the district prove a thickness of some 200 m.

Mercia Mudstone Group In this district, the Mercia Mudstone Group is exposed only sporadically in the Leven Valley near Hutton Rudby but is known extensively from boreholes penetrating beneath the drift. It consists of approximately 200 m of reddish brown mudstones, siltstones and subordinate sandstones showing sporadic green mottling with thin gypsum bands.

Rhaetic Boreholes and exposures from outside the district prove that Rhaetic strata, some 12 m thick, rest unconformably on the Mercia Mudstones. The Rhaetic beds consist of dark grey paper shales with thin sandstone and limestone bands.

Lower Jurassic The Lias is represented by a cyclic sequence of dark grey fossiliferous mudstones, fine- to medium-grained sandstones, shelly and calcareous in part, and oolitic and nodullar ironstones totalling about 350 m in thickness. The Cleveland Ironstones, the Jet Rock and Alum Shales included in this sequence were all extensively worked in the 19th century.

Middle Jurassic About 100 m of Middle Jurassic strata crop out in the district. The Dogger, which locally forms the basal beds, is a complex and variable formation, commonly conglomeratic and fossiliferous but also represented by ferruginous sandstones, shales and impure limestones. The overlying Ravenscar Group is a cyclic sequence dominated by thick sandstones together with subordinate thin mudstones, seat-earths, coals and shelly limestones.

Cleveland Dyke The dyke, classified as a tholeiitic dolerite, is exposed to the north of Great Ayton where it is 25 m wide and has been quarried extensively for roadstone. It crops out in a series of *en-échelon* segments across the northeast corner of the district and forms a distinctive ridge even where covered by till.

DRIFT

The remnants of a widespread till-sheet which formerly covered the entire district occur as pebbly deposits of Wolstonian age (Older Drift) at levels in excess of 1000 ft (305 m) in the Cleveland Hills.

During the last (Devensian) glaciation the Tees lowlands, of which this district is part, was the receiving ground for ice from the Lake District via Stainmore, from Scotland via the Tyne Gap and the east coast, and locally from the Tees and Wear valleys. The interrelationships and movements of these ice flows were complex and further influenced by offshore Scandinavian ice. When this southerly flow of ice met the now ice-free Cleveland Hills, it bifurcated, with one flow passing down the Vale of York and the other along the East Yorkshire coast.

As a result of this glaciation, nearly all ground below 180 m (600 ft) is covered by glacial drift. Till, the thickest and most extensive deposit, forms a platform upon which a veneer of more recent late glacial and post-glacial deposits occur. The rivers Leven and Tees have dissected the drift during the post-glacial period and in a few localities exposed the underlying solid rocks.

Till (Boulder Clay) In the north-west of the district, till is divided by sands and laminated clays into the 'Upper' and 'Lower' boulder clays. These were long thought to be the results of two glaciations or of two separate phases of a single glaciation but they are now believed to be part of a regional till/sand complex produced during a single glacial episode.

Exposures in the Leven Valley show that till may exceed 30 m in thickness. It is predominantly brown in colour, particularly when weathered, but greyish brown varieties are common in the so-called 'Lower Boulder Clay', as are reddish brown types in the 'Upper'; in places where it overlies Jurassic bedrock the deposit is grey to dark grey. Erratics derived from local Carboniferous and Permo-Triassic outcrops are common, although rocks from the Lake District and Cheviots are also represented. Locally the till contains bands of stoneless clay which are commonly silty and may include partings of fine quartz sand.

Glacial Sand and Gravel The major deposit of Glacial Sand and Gravel known in the district lies around Seamer [497 102] and Stokesley [525 035] where it is largely concealed beneath till and alluvial deposits. Around Seamer, ridges of largely 'clayey' sand and pebbly sand, generally capped by till, probably mark the position of a temporary halt of the ice during the last deglaciation as suggested by Elgee (1908, p. 379). IMAU boreholes proved thicknesses of sand in excess of 23 m in these ridges but the deposits are known to be lenticular.

To the south-east, and probably contemporaneous with these sands, is a belt of pebbly sands and gravels running from south of Stokesley to near Great Ayton [560 110]. The deposit is known principally from boreholes and its extent is uncertain. However, it appears to coincide with the river terrace deposits hereabouts (see below) and may have been deposited from pro-glacial drainage flowing south-westwards through the Langbaurgh Ridge overflow channel [553 123] (Best 1956, p. 304).

Small isolated hills of Glacial Sand and Gravel are found throughout the district, including Bonny Hill [570 055] and Sand Hill [434 085] and steep-sided deposits abut the Cleveland escarpment, as at Shepherd Hill [447 012] and Undercliffe [577 111]; the latter are thought to have been deposited by pro-glacial or glacio-lacustrine drainage (Kendall 1902, p. 513; 1903, p. 12). In addition, isolated bodies of sand and gravel of uncertain extent within the till, have been proved by boreholes throughout the district; they may be associated with thin laminated clays and pass laterally into them.

Fluvio-Glacial Delta Sand Distinctive flat-topped hills are found around Greenhow Hill Moor [540 117] and comprise sequences of quartz sand and laminated clay which are considered to be remnants of a fluvio-glacial delta.

Lacustrine deposits Widely scattered, small, ill-drained depressions in the boulder clay, such as those around Seamer, and more extensive areas, near Sexhow [485 062], are floored by lacustrine deposits. These are generally sequences of interbedded clays and silts with sporadic partings of sand and peat.

River Terrace Deposits River terrace deposits are present adjacent to the alluvium in the Tees and Leven valleys. The terraces occur at numerous elevations above the alluvium and are composed of gravels overlain by silts and clays with thin sand bands.

In the mainly broad open Leven valley between Stokesley and Great Ayton, laminated clays and silts as well as sands and gravels occur. The River Leven which now occupies the valley seems too small to have cut and alluviated it, and this feature may have resulted from pro-glacial drainage flowing through the Langbaurgh overflow.

Alluvial fans Alluvial fans are generally found at the outfalls of small steeply graded valleys, for example on Seamer Carrs [100 487] and in the Leven valley [457 104]. Their lithology is influenced by the surrounding deposits and therefore varies greatly.

Alluvium Alluvium is present in the Leven and Tees valleys and as narrow ribbons in many of their tributaries. Up to 5 m of clays and silts with thin sands and peats and normally underlain by gravels have been provided by boreholes.

Peat Peat is found in small depressions in the till and in isolated patches on the Jurassic uplands. It is also associated with the lacustrine and alluvial deposits.

COMPOSITION OF THE SAND AND GRAVEL

The potentially workable sand and gravel deposits in the district consist of glacial sand and gravel, fluvio-glacial delta sand and fluvial deposits.

Glacial Sand and Gravel and Fluvio-Glacial Delta Sand Around and to the south and east of Stokesley, glacial sand and gravel, which is almost entirely concealed beneath alluvium and Older Alluvium, has a mean grading of 9% fines, 57% sand and 34% gravel. Gravel, usually in excess of 27%, was found in all the boreholes proving the deposit and the fines content is generally low. In places 'clayey' or 'very clayey' sands overlie the cleaner deposits, as for example at borehole 50 NW 16 where the 21% fines content of the upper sands contrasts with the 4% fines in the underlying gravels. The pebbles are dominantly subangular to rounded sandstone, with lesser amounts of limestone, igneous rocks from the Borrowdale Volcanic Group and minor quantities of quartz, dolomite and shale. *Gryphea* and belemnite fossil fragments were found in some samples. Fine, medium and coarse sands are more or less equally represented in the sand fraction. Quartz is dominant in all grades but lithic fragments as represented in the gravel fraction are increasingly common in the coarse sand fraction.

The glacial sand and gravel elsewhere, together with the fluvioglacial sand have a mean grading of 20% fines, 73% sand and 7% gravel. The gravelly bands which may be present are thin and commonly clayey as in boreholes 40 NE 8 and 51 SW 13. Fine and coarse, angular to rounded, sandstone pebbles dominate the gravel fraction but locally high concentrations of mudstone and

Table 2 The sand and gravel resources of the resource sheet

Resource block	Area		Mean thickness			Volume of mineral			Mean grading percentage		
	Block	Mineral	Overburden	Mineral	Waste parting		Limits at the 95% probability level		Fines	Sand $+\frac{1}{16}$	Gravel
	km^2	km^2	m	m	m	$10^6 m^3$	±%	$\pm 10^6 m^3$	$-\frac{1}{16}$ mm	−4 mm	+4 mm
A	10.2	9.7	2.0	4.2	0.2	41	39	16	9	56	35
B	7.4	7.0	3.3	2.5	–	18	88	16	9	50	41
A + B	17.6	16.7	2.7	3.5	0.1	59	36	21	9	54	37
C	13.4	11.7	2.5	8.4	1.0	98	74	73	20	74	6
A to C	31.0	28.4	2.5	5.5	0.5	156	41	64			
Inferred assessment: exposed mineral in block D											
D	83.4	1.3	0.5	3.8	0.6	5	Speculative				

shale are found, as in borehole 50 SW 7. Carboniferous limestone, igneous rocks from the Borrowdale Volcanic Group and the Cleveland Dyke, and quartz are present in small quantities, with lesser amounts of dolomite, chert and ironstone. The sand fraction typically contains a high percentage of fine quartz sand.

Fluvial deposits
Gravel or sandy gravel occurs beneath fluvial clays and silts in the valleys of the Tees and of the Leven downstream from Skutterskelfe [490 073]. Details of thickness and grading are given in the description of block B below.

Angular to subrounded sandstone is the dominant constituent of the gravel, followed by appreciable amounts of Carboniferous limestone and lesser amounts of basic igneous rocks, quartz, quartzite and dolomite. Chert and shale occur in generally minor amounts. In the sand fraction quartz dominates the fine and medium grades but in the coarse grade, angular lithic fragments representative of the gravel fraction are in the majority.

THE MAP

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

Geological data The geological base is derived from the geological maps of the district. Most of the ground has been recently resurveyed on the six-inch scale by field staff of the Institute's North-Eastern England and Cumbria Unit, but the eastern area was last surveyed in 1878 and was only partially revised in 1979. The geological maps are regarded as the best interpretation of the information available at the time of survey. It is inevitable that local irregularities or discrepancies will be revealed as additional information becomes available (as for example at borehole 40 SE 10). These are taken into account in the assessment of the resources.

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

Mineral resource information The mineral-bearing ground is subdivided 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, and areas where it is present in continuous or 'almost continuous' spreads beneath overburden. The 'discontinuous' mineral category has not been recognised in this area.

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

For the most part the depicted distribution of the various categories of deposits is based on the mapped geological boundaries. Where there is a transition from one category to another which cannot be related to the geological map and which cannot be delineated accurately, inferred boundaries, shown by a distinctive symbol, have been inserted. The symbol is intended to signify an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size being limited only by cartographic considerations. For the purpose of measuring areas the centreline of the symbol is used.

RESULTS

The results of the assessment are summarised in Table 2. Fuller grading particulars are shown in Tables 3 to 6 and Figures 2, 4, 5 and 6.

Accuracy of results Three of the four resource blocks have been statistically assessed, and for these the accuracy of the results is indicated by the confidence limits of 39%, 88% and 74% at the 95% probability level (that is, it is probable that 19 times out of 20 the true volumes present lie between these limits). However, the true values are more likely to be nearer the figures estimated than the limits. Moreover, it is probable that in each block roughly the same percentage limits would apply for the estimate of volume of a very much smaller parcel of ground (say 1 km^2) containing similar sand and gravel deposits if the results from the same number of sample points (as provided by, say, ten boreholes) were

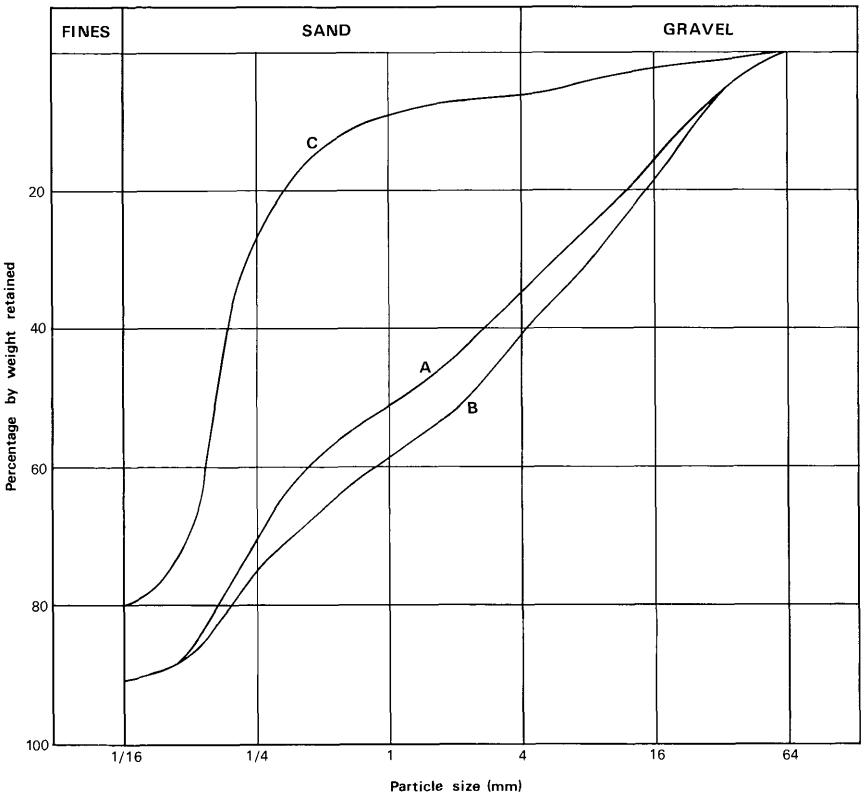

Figure 2 Mean particle-size distribution for the mineral in resource blocks A to C (see also Figures 4 to 6).

Block	Percentage by weight retained					
	$\frac{1}{16}$ mm	$\frac{1}{4}$ mm	1 mm	4 mm	16 mm	64 mm
A	91	71	52	35	16	0
B	91	76	59	41	18	0
C	80	26	9	6	2	0

used in the calculation. Thus, if closer limits are needed for the quotation of reserves of part of a block, it can be expected that data from more than ten sample points will be required, even if the area is quite small. An inferred assessment is offered for block D.

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

NOTES ON THE RESOURCE BLOCKS

Where possible, the resource blocks have been delineated so as to contain deposits of similar material (Figure 3). Blocks A and B contain mainly gravelly mineral while blocks C and D consist of dominantly sand-grade material. Glacial sand and gravel around Stokesley and Great Ayton, mainly beneath river terrace deposits, make up block A. Block B consists of alluvium and terrace deposits of the Tees and the Leven valley downstream from Skutterskelfe, as well as alluvium-filled channels at the foot of the Cleveland Hills between Ingleby Arncliffe and Whorlton. In contrast, blocks C and D contain much glacial sand, commonly of considerable thickness and with widely variable overburden. The major part of the mineral is found in block C, around Seamer. Block D encompasses all other assessed ground and includes widely scattered pockets of glacial sand and gravel, both at surface and concealed.

Block A (Table 3, Figure 4)

The mineral of block A consists of Glacial Sand and Gravel which is largely concealed beneath alluvial overburden.

Proved thicknesses of mineral within the Glacial Sand and Gravel range from 1.2 to 9.0 m with a mean of 4.2 m. With one exception all boreholes encountered gravel or sandy gravel but in a number of them, mainly in the south of the block, these gravels were overlain by 'clayey' usually pebbly sands; the latter constitute the whole of the mineral in borehole 50 NW 15. The 'clayey' pebbly sands are up to 4.5 m thick and their mean thickness, considering all the sample points, is 1.7 m; their mean grading is fines 15%, sand 75% and gravel 10%. The gravels and sandy gravels are up to 6.4 m thick and have a mean thickness of 2.5 m and a mean grading of fines 5%, sand 44% and gravel 51%.

Overall, the mineral of the block has a mean grading of fines 9%, sand 56% and gravel 35%, and an estimated volume of 41 million $m^3 \pm 39\%$.

Overburden, where its presence is indicated on the resource map, ranges in thickness from 0.2 to 4.6 m, with a mean of 2.0 m; it generally consists of silts and clays. A waste parting 1.8 m thick was found in borehole 50 NW 21.

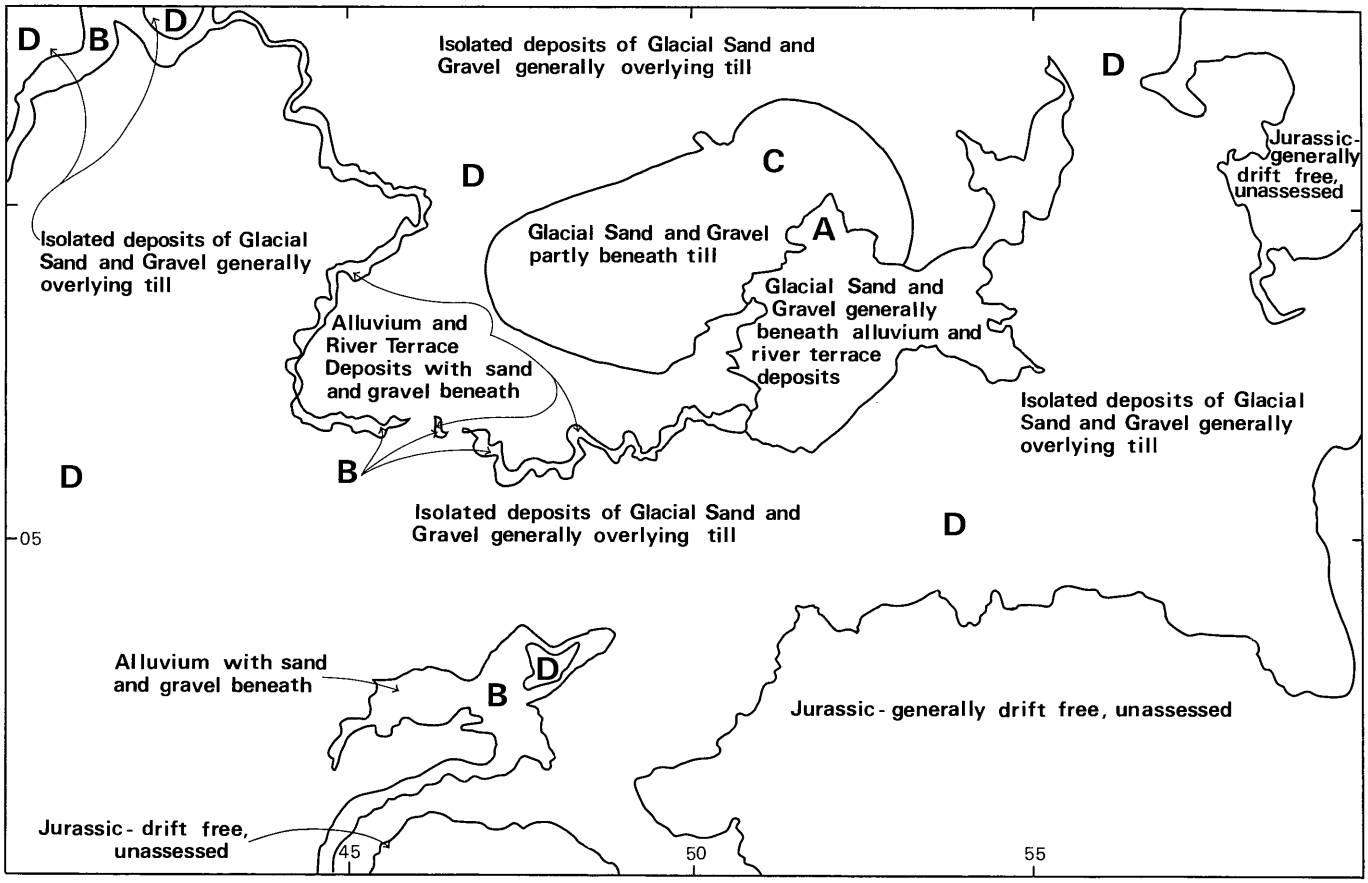

Figure 3 Map showing the relationship between the principal sand and gravel deposits and the resource block boundaries.

Table 3 Block A: data from assessment boreholes

Borehole	Recorded thickness		Mean grading percentage					
	Mineral	Over-burden	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel
	m	m	$-\frac{1}{16}$ mm	$+\frac{1}{16}$ $-\frac{1}{4}$ mm	$+\frac{1}{4}$ -1 mm	$+1$ -4 mm	$+4$ -16 mm	$+16$ mm
50 NW 10	1.2	4.6	2	4	12	27	37	18
50 NW 12	5.3	0.5	8	12	14	19	28	19
50 NW 13	2.6	0.2	16	31	16	9	15	13
50 NW 15	3.5	3.5	15	42	22	13	7	1
50 NW 16	9.0	0.2	9	19	21	15	21	15
50 NW 17	7.3	1.8	9	17	27	20	18	9
50 NW 20	5.6	2.8	8	31	30	14	10	7
50 NW 21	1.9*	2.8	12	23	9	10	25	21
50 NW 23	2.2	2.2	18	36	16	11	10	9
50 NE 7	6.5	0.2	10	17	16	15	18	24
51 SW 16	1.4	3.8	3	2	4	13	46	32
51 SE 6	6.4	1.8	3	6	15	23	28	25

* Excluding 1.8 m waste parting.

Table 4 Block B: data from assessment boreholes

Borehole	Recorded thickness		Mean grading percentage					
	Mineral	Overburden	Fines $-\frac{1}{16}$ mm	Fine Sand $+\frac{1}{16}$ $-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand $+1$ -4 mm	Fine gravel $+4$ -16 mm	Coarse gravel $+16$ mm
	m	m						
40 NW 16	0.9	0.4	12	28	19	6	7	28
40 NE 14	2.4	0.8	15	28	13	12	15	17
40 SE 7	3.2	4.8	4	7	20	32	31	6
40 SE 8	absent	–	–	–	–	–	–	–
41 SW 9	2.2	5.3	8	7	16	11	26	32

Block B (Table 4, Figure 5)
This block is in two parts and encompasses fluvial deposits in the Tees and Leven valleys and between Ingleby Arncliffe and Whorlton. The assessment is based on five IMAU boreholes and several others.

A single borehole (41 SW 9) in the Tees valley proved 2.2 m of gravel with a mean grading of fines 8%, sand 34% and gravel 58%. Four boreholes in the Leven valley downstream from Skutterskelfe found sand and gravel between 0.9 and 2.4 m thick and the mean grading based on two IMAU boreholes is fines 14%, sand 53% and gravel 33%. To the south three boreholes sunk into alluvium near Swainby proved sand and gravel up to 8.3 m thick; a fourth hole here encountered only silts and clays but since the extent of the barren area cannot be delineated the whole of the area of the alluvium is shown as mineral on the resource map and the calculation of resources includes the 'nil' thickness record. The mineral in the single IMAU borehole here grades at 4% fines, 59% sand and 37% gravel.

The estimated mean thickness of mineral in the block is 2.5 m. The estimated mineral volume is 18 million m^3 but the high confidence limits of 88% reflect the variability of the deposit and the uncertainty of the estimate.

Overburden in the Leven valley generally proved to be thin sandy soil or sandy clay, as in borehole 40 NW 16; elsewhere in the block it generally consists of interbedded silts and clays, often laminated, with a maximum thickness of 8.3 m proven in borehole 40 SE 19. The mean thickness of the overburden is 3.3 m.

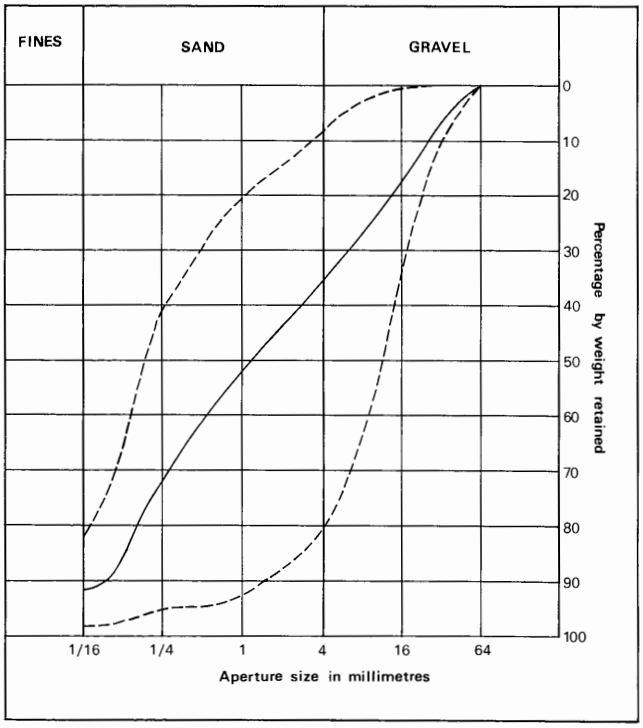

Figure 4 Grading characteristics of the mineral in block A. The continuous line is the cumulative frequency curve of the mean grading of the block as a whole. The broken lines denote the envelope within which the mean grading curves for individual boreholes fall.

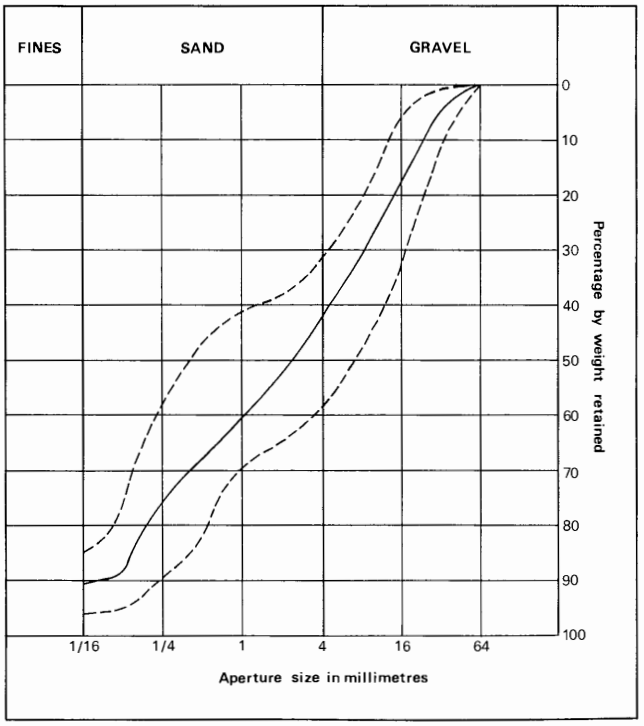

Figure 5 Grading characteristics of the mineral in block B. The continuous line is the cumulative frequency curve of the mean grading of the block as a whole. The broken lines denote the envelope within which the mean grading curves for individual boreholes fall.

Table 5 Block C: data from assessment boreholes

Borehole	Recorded thickness		Mean grading percentage					
	Mineral	Overburden	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}-1$ mm	Coarse sand $+1-4$ mm	Fine gravel $+4-16$ mm	Coarse gravel $+16$ mm
	m	m						
40 NE 3	1.3	3.7	3	2	3	23	30	39
40 NE 5	4.4	4.3	17	81	2	0	0	0
40 NE 7	8.4*	0.2	19	69	9	1	1	1
40 NE 8	1.4	1.4	28	31	12	3	12	14
40 NE 11	0.0	–	–	–	–	–	–	–
41 SE 22	23.8	1.2	22	47	23	5	2	1
50 NW 9	19.0	6.0	15	52	27	3	1	2†
50 NW 11	3.5	1.8	31	51	10	4	3	1
50 NW 14	2.0	1.3	34	62	3	1	0	0
51 SW 13	6.8‡	1.6	19	15	33	17	12	4
51 SW 14	21.3	3.7	21	66	5	2	3	3

* Excluding 9.2 m waste parting.
† Includes 1% cobbles.
‡ Excluding 0.8 m waste parting.

Block C (Table 5, Figure 6)
The drift of this block consists of a complex of glacial sand and gravel and till. Sand and gravel extends beneath till cover and its extent is therefore uncertain; however, an inferred boundary has been drawn on the resource map to indicate the approximate limits of potentially workable material. Borehole 40 NE 11, towards the centre of the block, encountered no sand and gravel and since the barren area cannot be delineated, the 'nil' value has been taken into account in assessing the resources.

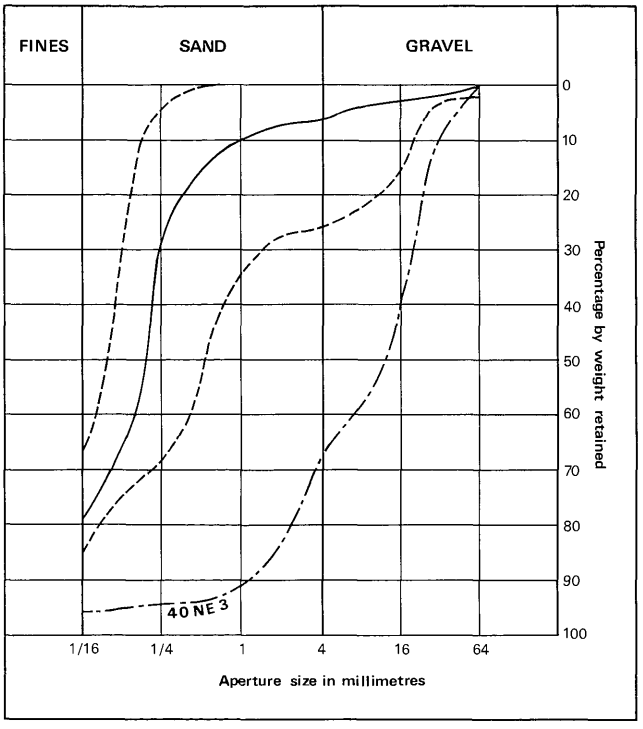

Figure 6 Grading characteristics of the mineral in block C. The continuous line is the cumulative frequency curve of the mean grading of the block as a whole. The broken lines denote the envelope within which the mean grading curves for individual boreholes fall, with the exception of borehole 40 NE 3, whose mean grading is shown by the dotted line.

Although gravel is present in places, the mineral consists almost entirely of 'clayey' and 'very clayey' sands. It is extremely variable in thickness, ranging from zero to more than 23.8 m, and may extend below the level of workability assumed for the purpose of this survey (25 m). The mean proved thickness of the potentially workable material is 8.4 m and the mean grading is 20% fines, 74% sand and 6% gravel. The estimated mineral volume is 98 million $m^3 \pm 74\%$, the high confidence limits reflecting the variability of the deposits.

Overburden is also variable. Where its presence is indicated on the resource map it consists generally of firm sandy or stony clay up to 6.0 m thick; elsewhere it comprises thin sandy soil. Waste partings of 9.2 and 0.8 m respectively were recorded in boreholes 40 NE 7 and 51 SW 13.

Table 6 Block D: data from assessment boreholes proving mineral

Borehole	Recorded thickness			Mean grading percentage					
	Mineral	Over-burden	Waste Parting	Fines $-\frac{1}{16}$	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$	Medium sand $+\frac{1}{4}$ -1	Coarse sand $+1$ -4	Fine gravel $+4$ -16	Coarse gravel $+16$
	m	m	m	mm	mm	mm	mm	mm	mm
40 SE 5	3.0	2.5	0.2	19	48	4	7	13	9
40 SE 10	2.6	0.2	3.4	29	29	17	13	9	3
40 SE 13	18.2	6.8	–	20	48	10	6	6	10
41 SE 17	15.5	9.5	–	17	68	14	1	0	0
50 NE 3	2.3	0.4	–	29	39	22	5	4	1
50 NE 15	16.3	1.3	1.6	16	38	24	9	6	7
50 SW 7	2.2	1.6	–	34	40	19	3	3	1
50 SW 9	9.4	2.5	–	20	26	25	14	12	3
51 SW 11	4.8	0.3	1.2	21	68	7	2	1	1
51 SE 7	21.1	3.2	0.7	20	76	4	trace	0	0

Block D (Table 6)
This block encompasses all the drift-covered ground not included in blocks A, B and C. It has an area of 183.4 km^2 and was explored by 92 IMAU boreholes. Of these only ten encountered potentially workable mineral; the remainder proved waste only or waste on bedrock, though three of them were abandoned before reaching the prescribed depth.

Although some of the 'successful' boreholes proved considerable thicknesses of sand and gravel, e.g. 40 SE 13 and 41 SE 17 with more than 18.2 m and 15.5 m respectively, it has not been possible within the limits of the survey to delineate fully the area occupied by potentially workable mineral: no assessment of total volume is possible, therefore.

Where sand and gravel is exposed its minimum extent can be determined with reasonable certainty. Four such outcrops within this block exceed 0.25 km^2 in area and for these a speculative volume assessment of 5 million m^3 is offered. Other smaller areas of exposed sand and gravel have not been assessed.

APPENDIX A

FIELD AND LABORATORY PROCEDURES

Experience has shown that a minimum of five sample-points, evenly distributed across a sand and gravel deposit, are needed to provide a worthwhile statistical assessment, and 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 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, usually about 10 km² in size, with sufficient sample points in each block to meet the aims of the survey. Where possible, block boundaries are determined by geological boundaries, but otherwise, subdivisions are arbitrary and may be unrelated to the geology.

Prior to the drilling by IMAU a survey is carried out to record any exposures, and inquiries are made to ascertain what borehole information is available. Borehole sites are then selected to provide an even pattern of sample-points at a density of approximately one per square kilometre. 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 position of roads and farms) may reflect particular geological conditions, and hence bias the drilling results.

The principal area of study was the valley of the River Tees and other potentially workable deposits. Large areas away from the River Tees, considered to be barren of mineral on the basis of borehole records and mapping, were not drilled.

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 at a diameter of about 200 mm, beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites of difficult access). Shell and auger rigs have proved to be almost ideal.

Wherever possible, deposits above the water table were drilled dry, but in gravels a small amount of water was added as necessary to facilitate drilling and sampling. Below the water table the use of a bailer resulted in the probable loss of some of the fine fraction, the pumping action drawing unwanted material, especially sand, into the hole from the sides or bottom.

In general, a continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or at every 1 m (3.3 ft) depth. In the event of excessively large samples being taken a representative sub-sample is obtained by cone and quartering in the field. The samples, each weighing up to 100 kg, are despatched in heavy-duty polythene bags to a laboratory for grading. The grading procedure is based on BS 1377:1967. Random checks on the accuracy of the grading are made in the Institute's laboratories.

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

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

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

1 A statistical assessment is made of an area of mineral greater than 2 km², 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. 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

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

4 The above relationship may be transposed such that

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

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

If, therefore, the standard deviation for area is small with respect to that for 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}, . . . l_{m_n}, then the best estimate of mean thickness, $\bar{l}_m$, is given by

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

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

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

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

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are small relative to those in thickness. The relationship $S_A/S_{\bar{l}_m} \leqslant \frac{1}{3}$ is assumed in all cases. It follows from equation [2] that

$$S_{\bar{l}_m} \leqslant S_V \leqslant 1.05\, S_{\bar{l}_m} \quad . \qquad [3]$$

7 The limits on the estimate of mean thickness of mineral, $L_{\bar{l}_m}$, may be expressed in absolute units $\pm(t/\sqrt{n})\times S_{\bar{l}_m}$ or as a percentage $\pm(t/\sqrt{n})\times S_{\bar{l}_m}\times(100/\bar{l}_m)$ per cent, where t is Student's t at the 95 per cent probability level for $(n-1)$ degrees of freedom, evaluated by reference to statistical tables. (In applying Student's t it is assumed that the measurements are distributed normally.)

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

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

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

9 In calculating confidence limits for volume, L_V, the following inequality corresponding to equation [3] is applied: $L_{\bar{l}_m} \leq L_V \leq 1.05\ L_{\bar{l}_m}$

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

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

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

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

per cent.

11 The application of this procedure to a fictitious area is illustrated in Figures 7 and 8.

Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.25 km² and 2 km² 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 km².

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 (see Figure 9). 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 Note 9, 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 (Table 7), which is used in this Report.

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

Each bulk sample is described, subjectively, by a geologist at the borehole site. Being based on visual examination, the description of the grading is inexact, the accuracy depending on the experience of the observer. The

Block calculation 1:25 000 Block } Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

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

Thickness estimate measurements in metres
l_o = overburden thickness l_m = mineral thickness

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

Calculation of confidence limits

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

$\Sigma(wl_m - \overline{wl_m})^2 = 15.82$
$n = 8$
t = 2.365

L_V is calculated as

$1.05(t/\overline{wl_m})\sqrt{[\Sigma(wl_m - \overline{wl_m})^2/n(n-1)]} \times 100$
$= 1.05 \times (2.365/6.5)\sqrt{[15.82/(8 \times 7)]} \times 100$
$= 20.3$
$\triangleq 20$ per cent

Figure 7 Example of resource block assessments calculation and results.

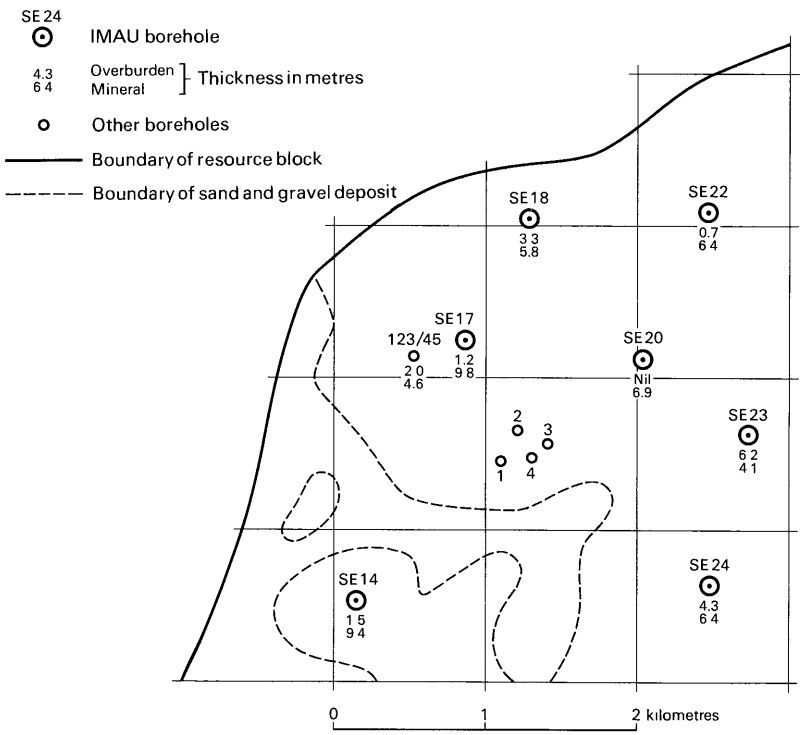

Figure 8 Example of resource block assessment: map of fictitious block.

descriptions recorded are modified, as necessary, when the laboratory results become available.

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'flint and quartz' indicates 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, 1957), are as follows.

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

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

Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. 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.

Table 7 Classification of gravel, sand and fines

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

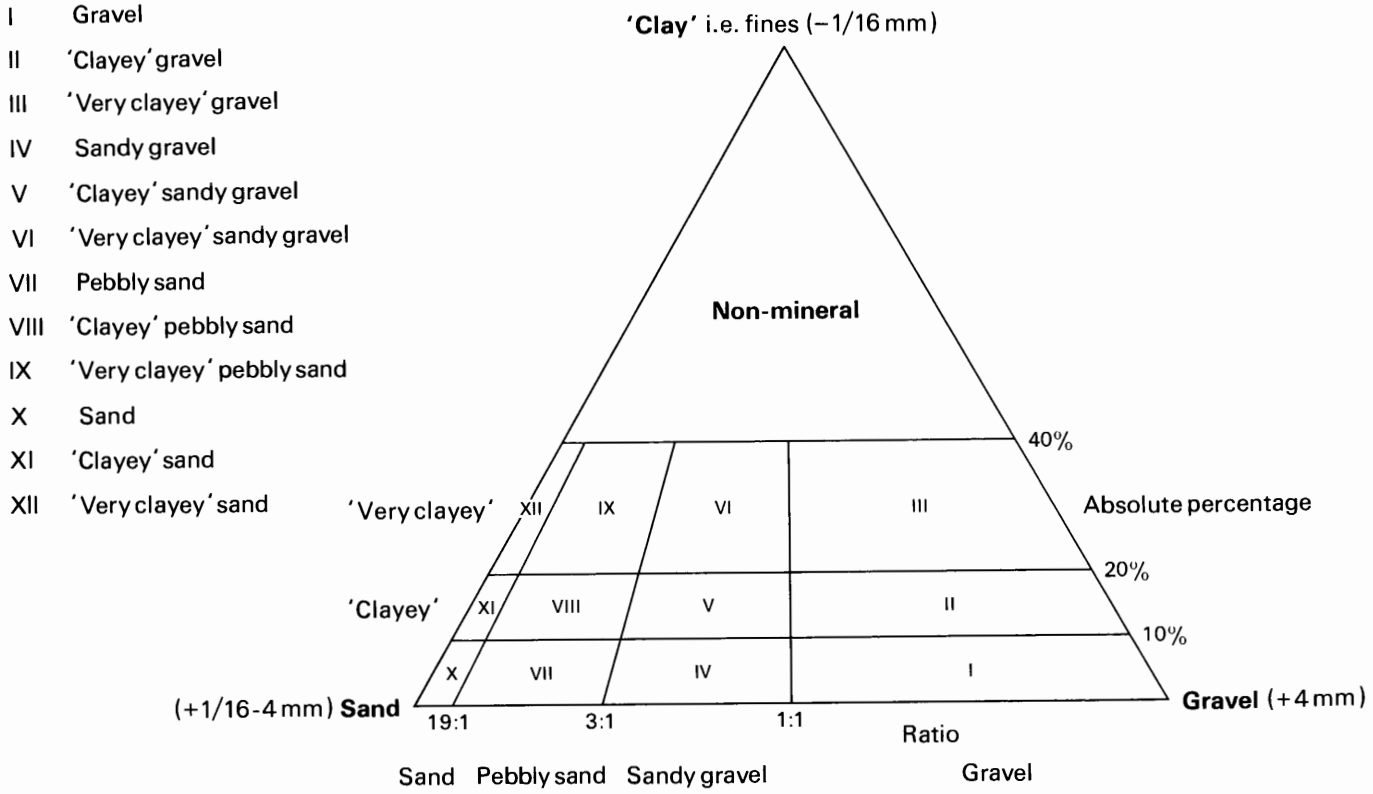

Figure 9 Diagram to show the descriptive categories used in the classification of sand and gravel.

APPENDIX D

EXPLANATION OF THE BOREHOLE RECORDS

Annotated fictitious example

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

Surface level (+ 49.7 m) + 163 ft[4]
Water struck at + 45.9 m[5]
October 1972[6]

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

LOG

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

GRADING[10]

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	5	46	49	2.8–3.8	20	14	62	2	2	–	
				3.8–4.8	2	2	12	18	42	24	
				4.8–5.8	1	3	24	13	35	24	
				5.8–6.8	0	4	21	20	26	29	
				6.8–8.2	4	3	23	10	23	37	
				Mean	5	5	28	13	25	24	
b	5	95	0	9.3–10.3	3	73	23	1	–	–	
				10.3–10.7	9	85	5	1	–	–	
				Mean	5	77	17	1	–	–	
a + b	5	56	39	Mean	5	20	26	10	20	9	

COMPOSITION[11]

Depth below surface (m)	Percentages by weight of gravel fraction				
	Flint	Quartz	Limestone	Chalk	Ironstone
3.8–4.8	41	5	50	1	3
4.8–5.8	39	3	45	5	8
5.8–6.8	45	2	42	5	6
6.8–8.2	19	6	61	3	11
Mean	35	4	51	3	7

The numbered paragraphs below correspond to 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, here CK 66.

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, here NW 5.

Thus the full Registration Number is CK 66 NW 5. Usually this is abbreviated to NW 5 in the text of the report.

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

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

4 Surface level
The surface level at the borehole site is given in metres and feet above Ordnance Datum. Although measurements were made in feet, approximate conversions to metres are given in brackets.

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

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

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

8 Thickness and Depth
The plus sign (+) indicates that the base of the deposit was not reached during drilling.

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

10 Grading data
A continuous series of bulk samples is taken throughout the thickness of the 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 percentage of fines ($-\frac{1}{16}$ mm), fine sand ($+\frac{1}{16}$–$\frac{1}{4}$ mm), medium sand ($+\frac{1}{4}$–1 mm), coarse sand (+1–4 mm), fine gravel (+4–16 mm), and coarse and cobble gravel (+16 mm) are stated.

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

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

11 Composition
Details of the composition of selected samples or groups of samples may be given. Where appropriate the calculated weighted mean composition of groups of samples may be quoted.

In analysing samples from the district covered by this report, the following categories of gravel were recognised:

Sandstone—Carboniferous, generally medium grained; moderately well cemented.

Limestone—Carboniferous, varying from pure pale limestone to dark muddy limestone.

Quartz and quartzite—subordinate components of fine fraction.

Igneous—three main types:

1 Doleritic, Cleveland Dyke and Whin Sill types.

2 Borrowdale Volcanic Group rocks—generally green intermediate tuffs or agglomerates.

3 Volcanic rocks from the Southern Uplands—mainly purple tuffs and lavas.

Dolomite—includes dolomitic limestone, mainly from the Magnesian Limestone but traces from Carboniferous sources.

Chert and silicified limestone—Carboniferous, subordinate amounts.

Shale and mudstone—mainly Carboniferous and Jurassic but including some Mercia Mudstones.

APPENDIX E

LIST OF BOREHOLES USED IN THE ASSESSMENT OF RESOURCES

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLES

Borehole	Grid reference
NZ 40 NW	
11	4151 0973
12	4322 0977
13	4030 0767
14	4235 0821
15	4407 0821
16	4492 0881
17	4338 0630
18	4491 0633
19	4057 0595
20	4187 0572
21	4314 0523
NZ 40 NE	
2	4681 0950
3	4885 0997
4	4604 0820
5	4722 0899
6	4742 0832
7	4865 0871
8	4940 0820
9	4605 0728
10	4781 0717
11	4961 0940
12	4867 0780
13	4922 0720
14	4712 0664
15	4867 0622
16	4514 0519
17	4681 0539
18	4959 0536
NZ 40 SW	
7	4123 0416
8	4217 0358
9	4428 0376
10	4161 0197
11	4313 0143
12	4451 0261
13	4050 0046
14	4199 0039
15	4427 0056
NZ 40 SE	
2	4561 0420
3	4772 0412
4	4958 0425
5	4703 0316
6	4809 0308
7	4624 0253
8	4739 0225
9	4523 0178
10	4882 0199
11	4546 0054
12	4659 0083
13	4772 0100
14	4901 0081
NZ 41 SW	
9	4136 1248
10	4469 1293
11	4138 1110
12	4316 1106
13	4397 1060
NZ 41 SE	
15	4769 1278
16	4856 1282
17	4968 1242
18	4576 1112
19	4873 1138
20	4949 1130
21	4867 1076
22	4962 1046
NZ 50 NW	
9	5121 0948
10	5226 0920
11	5320 0969
12	5416 0926
13	5495 0994
14	5052 0902
15	5154 0876
16	5273 0816
17	5342 0858
18	5499 0868
19	5028 0776
20	5169 0742
21	5235 0710
22	5357 0761
23	5453 0798
24	5049 0692
25	5103 0635
26	5352 0683
27	5459 0699
28	5036 0580
29	5151 0541
30	5341 0553
NZ 50 NE	
3	5622 0950
4	5804 0913
5	5592 0806
6	5710 0874
7	5528 0761
8	5701 0752
9	5913 0892
10	5520 0648
11	5725 0654
12	5851 0632
13	5975 0698
14	5529 0550
15	5701 0553
16	5883 0552
NZ 50 SW	
5	5258 0459
6	5042 0367
7	5139 0369
8	5062 0269
9	5062 0046
NZ 50 SE	
2	5550 0451
3	5773 0459
4	5879 0443
5	5917 0361
NZ 51 SW	
8	5041 1254
9	5224 1285
10	5133 1195
11	5389 1163
12	5076 1102
13	5140 1112
14	5036 1035
15	5357 1065
16	5466 1055
NZ 51 SE	
5	5609 1233
6	5531 1080
7	5771 1118

OTHER BOREHOLES

NZ 40 NW 7	4384 0719
NZ 40 NE 1	4558 0940
NZ 40 SE 15	4510 0049
NZ 40 SE 19	4537 0084
NZ 41 SE 7	4532 1066
NZ 51 SW 1	5318 1272

APPENDIX F

INDUSTRIAL MINERAL ASSESSMENT UNIT
BOREHOLE RECORDS

NZ 40 NW 11 4151 0973 East of Low Forest House **Block D**

Surface level (+35.7 m) +117 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown, silty in parts; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.7+	18.0

NZ 40 NW 12 4322 0977 Kirklevington **Block D**

Surface level (+46.5 m) +151 ft
Water struck at +42.2 m
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Deposits	Clay, red-brown with blue and grey mottling	2.3	2.5
Till	Clay, red-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	4.7	7.2
	Clay, red brown, silty, with thin quartz sand partings	2.0	9.2
	Clay, grey-brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	8.8+	18.0

NZ 40 NW 13 4030 0767 Staindale Hill **Block D**

Surface level (+56.1 m) +184 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	4.2	4.4
	Clay, red-brown, silty, stone-free	1.2	5.6
	Clay, red to red-brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	12.4+	18.0

NZ 40 NW 14 4235 0821 North of Picton Station **Block D**

Surface level (+49.7 m) +163 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.6	0.6
Till	Clay, red-brown to brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks; raft of grey mudstone from 10.5 to 11.8 m	17.4+	18.0

NZ 40 NW 15 4407 0821 North of Crathorne Grange **Block D**

Surface level (+56.4 m) +185 ft
Water struck at +42.4 m
November 1977

Waste 20.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.4	0.4
Till	Clay, chocolate-brown to 11.0 m, increasingly red below; small pebbles of sandstone and Permo-Triassic rocks (dominant in lower part); 0.5 m silty band at 14.5 m	19.6+	20.0

NZ 40 NW 16 4492 0881 West of Hunter Banks **Block B**

Surface level (+ 24.7 m) + 81 ft
Water struck at + 23.7 m
November 1977

Overburden 0.4 m
Mineral 0.9 m
Waste 3.9 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
River Terrace Deposits	'Clayey' sandy gravel	0.9	1.3
	Gravel: coarse, angular to subrounded sandstone with subrounded limestone and extrusive igneous rocks and some bladed rounded mudstone		
	Sand: fine to medium quartz with coarse quartz, sandstone and dark lithic grains		
Till	Clay, mainly grey-brown, but red towards base; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	3.9	5.2
Sherwood Sandstone Group	Sandstone, red	0.8+	6.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
12	53	35	0.4–1.3	12	28	19	6	7	28	

NZ 40 NW 17 **4338 0630** **Mount Flatts** **Block D**

Surface level (+52.7 m) +173 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, chocolate-brown, weakly laminated, with few pebbles	4.4	4.7
Till	Clay, red-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	13.3+	18.0

NZ 40 NW 18 **4491 0633** **Manor Farm** **Block D**

Surface level (+64.9 m) +213 ft
Water struck at +53.4 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy, chocolate-brown to red-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks; thin lenses of sand and silt in places	10.8	11.0
	Clay, brown, laminated; with silt and sand partings	2.5	13.5
	Clay, mainly chocolate-brown, but grey in parts; angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	4.5+	18.0

NZ 40 NW 19 **4057 0595** **Moat Farm** **Block D**

Surface level (+60.0 m) +197 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown at surface, grey-brown at depth, with angular pebbles of Carboniferous sandstone	17.7+	18.0

NZ 40 NW 20 4187 0572 North-east of Carr Bridge Farm **Block D**

Surface level (+50.3 m) +165 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Deposits	Clay, brown, soft, with thin quartz sand lenses	2.0	2.2
Till	Clay, red-brown, silty from 11.0 to 11.5 m; pebbles of Carboniferous sandstone	15.8+	18.0

NZ 40 NW 21 4314 0523 Haggitt Hill **Block D**

Surface level (+67.1 m) +220 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown; small pebbles of Carboniferous Sandstone and Permo-Triassic rocks	4.0	4.3
	Clay, brown, silty	2.2	6.5
	Clay, grey-brown; pebbles of Carboniferous sandstone, Permo-Triassic rocks and grey mudstone	11.5+	18.0

NZ 40 NE 2 4681 0950 South-east of Middleton-on-Leven **Block D**

Surface level (+61.0 m) +200 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, chocolate-brown, silty at base; small pebbles of Carboniferous sandstone, Permo-Triassic rocks and other dark rocks, including coal and shale	17.8+	18.0

NZ 40 NE 3 4885 0997 Seamer Carrs **Block C**

Surface level (+65.8 m) +216 ft
Water struck at +62.1 m
November 1977

Overburden 3.7 m
Mineral 1.3 m
Waste 13.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Deposits	Clay, chocolate-brown; small pebbles of Carboniferous sandstone, Permo-Triassic rocks and dark rocks including coal and shale	3.5	3.7
Glacial Sand and Gravel	Gravel Gravel: coarse and fine, subangular to rounded sandstone with subrounded to well-rounded, limestone and some extrusive igneous rocks Sand: coarse angular quartz and lithic grains	1.3	5.0
Till	Clay, grey-brown; small pebbles of Carboniferous and Permo-Triassic rocks	13.0+	18.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
3	28	69	3.7–5.0	3	2	3	23	30	39	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
3.7–5.0	64	22	3	6	3	1	1

NZ 40 NE 4 4604 0820 High Foxton Farm **Block D**

Surface level (+68.0 m) +223 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown to 3.0 m, chocolate-brown below; pebbles of Carboniferous sandstone and Permo-Triassic rocks, the latter commoner with depth	17.7+	18.0

NZ 40 NE 5 4722 0899 Spyknave Hill Farm **Block C**

Surface level (+77.4 m) +254 ft
Water struck at +72.9 m
November 1977

Overburden 4.3 m
Mineral 4.4 m
Waste 12.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown, sandy; pebbles of Carboniferous sandstone and Permo-Triassic rocks	2.2	2.5
	Silt, yellow-brown, laminated, with brown clay bands	1.8	4.3
Glacial Sand and Gravel	'Clayey' Sand Sand: fine quartz Fines: brown 'clay' bands	4.4	8.7
Till	Clay, chocolate brown, weakly laminated and sandy in parts; small pebbles of Carboniferous and Permo-Triassic rocks	12.8+	21.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
17	83	0	4.3–5.3	20	76	4				
			5.3–6.3	16	83	1				
			6.3–7.3	15	84	1				
			7.3–8.7	17	82	1				
			Mean	17	81	2				

NZ 40 NE 6 4742 0832 Goslingmire **Block D**

Surface level (+75.6 m) +248 ft
Water struck at +59.0 m
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, pale brown to 1.5 m blue grey below, with plant debris	2.5	2.8
Till	Clay, mainly chocolate to grey-brown but red-brown at top; pebbles of Carboniferous sandstone, Permo-Triassic rocks (locally concentrated) and, towards base, dark rocks including shale	15.2+	18.0

NZ 40 NE 7 4865 0871 South-west of Carr House **Block C**

Surface level (+77.1 m) +253 ft
Water level +67.1 m
November 1977

Overburden 0.2 m
Mineral 3.1 m
Waste 9.2 m
Mineral 5.3 m
Waste 5.7 m
Bedrock 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	**a** 'Very clayey' sand, pebbly at top Gravel: fine with coarse, angular to subrounded sandstone with some limestone Sand: mainly fine quartz with some medium angular sandstone and dark lithic grains Fines: bands of brown laminated clay and silt	3.1	3.3
Till	Clay, brown, laminated, with silty partings	2.8	6.1
	Clay, brown, stony, silty and sandy	6.4	12.5
Glacial Sand and Gravel	**b** 'Clayey' sand Sand: fine quartz Fines: brown, laminated 'clay' bands	5.3	17.8
	Clay, brown, laminated, with silt and sand partings	1.7	19.5
Till	Clay, grey-brown; angular pebbles of Carboniferous sandstone and Permo-Triassic rocks, the latter dominant with depth	4.0	23.5
Mercia Mudstone Group	Mudstone and clay, red with green lenses	2.5+	26.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	31	64	5	0.2–1.2	24	36	17	9	9	5	
				1.2–2.2	35	52	10	3	0	0	
				2.2–3.3	34	64	2	0	0	0	
				Mean	31	51	9	4	3	2	
b	12	88	0	12.5–13.5	17	75	8				
				13.5–14.5	13	77	10				
				14.5–15.5	12	77	11				
				15.5–16.5	11	82	7				
				16.5–17.8	10	82	8				
				Mean	12	79	9				
a + b	19	79	2	Mean	19	69	9	1	1	1	

NZ 40 NE 8 4940 0820 Oak Hill **Block C**

Surface level (+70.7 m) +232 ft
Water struck at +65.7 m
July 1977

Overburden 1.4 m
Mineral 1.4 m
Waste 16.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown, sandy; pebbles of Carboniferous sandstone and, at base, cobbles of basalt and Carboniferous sandstone	1.2	1.4
Glacial Sand and Gravel	'Very clayey' sandy gravel Gravel: coarse and fine, angular to subrounded sandstone with some subangular to subrounded extrusive igneous rocks Sand: mainly fine, quartz	1.4	2.8
Till	Silty clay, brown, laminated; thin sand bands to 10.0 m	15.5	18.3
	Clay, red-brown, stony	1.2+	19.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
28	46	26	1.4–2.1	36	32	6	3	14	9	
			2.1–2.8	20	31	17	3	10	19	
			Mean	28	31	12	3	12	14	

NZ 40 NE 9 4605 0728 North of Rudby Wood **Block D**

Surface level (+70.1 m) +230 ft
Water struck at +52.6 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, chocolate-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	16.5	16.8
	Clay, brown, laminated, with silty partings and thin band of gravel	1.2+	18.0

NZ 40 NE 10 4781 0717 Folly Hill **Block D**

Surface level (+78.0 m) +256 ft
Water not encountered
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, red-brown, sandy; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	2.6	3.0
	Silty clay, red-brown to brown, well laminated in parts with sandy partings	15.0+	18.0

NZ 40 NE 11 4961 0940 North-east of Carr House **Block C**

Surface level (+73.2 m) +240 ft
Water not encountered
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Sandy clay, yellow-brown, pebbly at base	2.3	2.6
Till	Clay, chocolate-brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	15.4+	18.0

NZ 40 NE 12 4867 0780 Broadmire **Block D**

Surface level (+59.7 m) +196 ft
Water struck at +56.2 m
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Silty clay, grey, soft, with scattered sandy lenses and plant debris	4.9	5.1
Till	Clay, red-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	12.9+	18.0

NZ 40 NE 13 4922 0720 Thoraldby Hall **Block D**

Surface level (+67.1 m) +220 ft
Water not encountered
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits on Till	Clay, grey-brown, weakly laminated in parts; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.7+	18.0

NZ 40 NE 14 4712 0664 Hutton Bridge **Block B**

Surface level (+46.6 m) +153 ft
Water struck at +43.4 m
November 1977

Overburden 0.8 m
Mineral 2.4 m
Waste 3.3 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, with sandstone pebbles	0.4	0.4
Alluvium	Silty clay, yellow-brown; angular sandstone pebbles and cobbles at base	0.4	0.8
	'Clayey' sandy gravel Gravel: coarse and fine, angular to subrounded sandstone with subrounded to rounded limestone, quartzite and extrusive igneous rocks and some bladed, rounded mudstone Sand: mainly fine to medium quartz, with coarse dark lithic grains	2.4	3.2
	Clay, blue-grey, laminated	0.2	3.4
Till	Clay, brown with sandstone boulders	3.1	6.5
Mercia Mudstone Group	Mudstone, red	1.0+	7.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
15	53	32	0.8–1.8	10	19	10	11	19	31	
			1.8–2.8	18	34	16	14	12	6	
			2.8–3.2	20	36	13	10	12	9	
			Mean	15	28	13	12	15	17	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
0.8–1.8	62	22	1	4	2	2	7
1.8–3.2	46	6	31	11	trace	2	4
Mean	57	17	11	6	1	2	6

NZ 40 NE 15 4867 0622 South of Leap Close Wood **Block D**

Surface level (+68.0 m) +223 ft
Water struck at +55.0 m
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, yellow-brown, laminated; thin silt and sand lenses in parts	9.0	9.3
Till	Clay, chocolate-brown, with small sandstone pebbles; 0.3– m gravel band at 15.3 m	8.7+	18.0

NZ 40 NE 16 4514 0519 Broad Carr Farm **Block D**

Surface level (+76.8 m) +252 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate-brown, but red at base; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 40 NE 17 4681 0539 South of Linden Grove **Block D**

Surface level (+71.3 m) +234 ft
Water not encountered
November 1977

Waste 6.5 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, sandy, mainly yellow to chocolate-brown, but grey below 5.0 m with pebbles of angular Carboniferous sandstone and subrounded Permo-Triassic rocks	6.2	6.5
Mercia Mudstone Group	Mudstone and clay, red	1.0+	7.5

NZ 40 NE 18 4959 0536 Carlton Grove **Block D**

Surface level (+73.2 m) +240 ft
Water not encountered
July 1977

Waste 5.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Deposits on Till	Clay, red-brown, with small pebbles of Carboniferous sandstone and thin sandy partings; boulder at base	5.3+	5.5
	Borehole abandoned because of rock obstruction		

NZ 40 SW 7 4123 0416 Thrush Nest Farm **Block D**

Surface level (+52.1 m) +171 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red to grey-brown, silty in parts below 14.0 m; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.7+	18.0

NZ 40 SW 8 4217 0358 East Rounton **Block D**

Surface level (+65.8 m) +216 ft
Water not encountered
March 1978

Waste 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown to brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	18.8+	19.0

NZ 40 SW 9 4428 0376 Black Swan Public House **Block D**

Surface level (+70.1 m) +230 ft
Water struck at +62.6 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, chocolate-brown, silty from 7.5 to 8.0 m	17.8+	18.0

NZ 40 SW 10 4161 0197 South-west of Brickyard Wood **Block D**

Surface level (+75.3 m) +247 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy in parts, mainly brown to grey-brown, but yellow-brown at top; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 40 SW 11 4313 0143 Brecken Hill **Block D**

Surface level (+76.8 m) +252 ft
Water struck at +69.3 m
April 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown to brown; small pebbles of Carboniferous sandstone, Permo-Triassic rocks and dark rocks including coal	6.6	6.8
	Clay, brown, laminated, with alternating sand, silt and clay laminae	4.2	11.0
	Clay, silty in parts, chocolate brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	7.0+	18.0

NZ 40 SW 12 4451 0261 North-west of Trenholme Farm **Block D**

Surface level (+73.8 m) +242 ft
Water struck at +57.5 m
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty in parts, mainly chocolate-brown; small angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 40 SW 13 4050 0046 Violet Hill **Block D**

Surface level (+64.6 m) +212 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown to grey-brown; pebbles of Carboniferous sandstone, Permo-Triassic rocks and grey mudstone	17.8+	18.0

NZ 40 SW 14 4199 0039 Deepdale **Block D**

Surface level (+78.9 m) +259 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Lacustrine Deposits	Clay, blue-grey; sandstone cobble at base	3.3	3.5
Till	Clay, mainly brown to grey-brown, but red-brown at base; pebbles of Carboniferous sandstone and, below 9.0 m, Permo-Triassic rocks in increasing amounts	14.5	18.0

NZ 40 SW 15 4427 0056 Somerset House **Block D**

Surface level (+82.9 m) +272 ft
Water struck at +77.4 m
November 1977

Waste 19.0 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate- to grey-brown, but red-brown at top and base; pebbles of Carboniferous sandstone, Permo-Triassic rocks and grey mudstone; 0.5 m gravel band at 6.0 m	18.8	19.0
Lower Lias	Mudstone, grey, weathered	0.5+	19.5

NZ 40 SE 2 4561 0420 North-east of Thorn Farm **Block D**

Surface level (+79.8 m) +262 ft
Water struck at +77.8 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty and sandy in places, mainly chocolate-brown, but red-brown at top; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 40 SE 3 4772 0412 Goulton Grange **Block D**

Surface level (+70.1 m) +230 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, brown, weakly laminated; quartz sand partings	6.7	7.0
Till	Clay, red-brown, silty at top; small pebbles of Permo-Triassic rocks	11.0+	18.0

NZ 40 SE 4 4958 0425 North of Faceby Lodge **Block D**

Surface level (+78.5 m) +287 ft
Water not encountered
December 1977

Waste 18.0+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, grey-brown; angular pebbles of Carboniferous sandstone, Permo-Triassic rocks and few Carboniferous sandstone cobbles	17.8+	18.0

NZ 40 SE 5 **4703 0316** **North-east of Thorn Hill Farm** **Block D**

Surface level (+76.8 m) +252 ft
Water struck at +74.3 m
November 1977

Overburden 2.5 m
Mineral 2.2 m
Waste 0.2 m
Mineral 0.8 m
Waste 7.2 m
Bedrock 1.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown, pebbly at top, sandy at base	2.2	2.5
Glacial Sand and Gravel	**a** 'Clayey' to 'very clayey' pebbly sand Gravel: coarse to fine, angular to subrounded sandstone with limestone Sand: fine quartz Fines: brown 'clay' bands	2.2	4.7
	Clay, brown, laminated	0.2	4.9
	b 'Clayey' gravel Gravel: mainly fine, angular to rounded sandstone with limestone and some mudstone Sand: coarse to fine, subangular to subrounded quartz with some coarse angular dark lithic grains	0.8	5.7
Till	Clay, sandy in parts, grey; pebbles of sandstone and dark rocks	7.2	12.9
Lower Lias	Mudstone, grey, micaceous	1.1+	14.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	22	67	11	2.5–3.5	34	60	1	0	3	2	
				3.5–4.7	11	65	3	4	6	11	
				Mean	22	63	2	2	4	7	
b	11	38	51	4.9–5.7	11	9	9	20	35	16	
a + b	19	59	22	Mean	19	48	4	7	13	9	

NZ 40 SE 6 **4809 0308** **Potto Hill Farm** **Block D**

Surface level (+85.3 m) +280 ft
Water not encountered
November 1977

Waste 4.8
Bedrock 1.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly red-brown, with angular pebbles of Carboniferous sandstone and Permo-Triassic rocks; below 4.0 m grey, with grey mudstone fragments	4.6	4.8
Lower Lias	Mudstone, grey, micaceous, weathered in upper part	1.2+	6.0

NZ 40 SE 7 4624 0253 West of Ashfield House **Block B**

Surface level (+70.1 m) +230 ft
Water struck at +66.1 m
November 1977

Overburden 4.8 m
Mineral 3.2 m
Waste 10.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Silty clay, brown to yellow-brown, laminated, with sandy partings, thin peat bands and plant debris	4.6	4.8
	Sandy Gravel Gravel: fine, angular to rounded sandstone with subangular to rounded limestone and extrusive igneous rocks, rounded to well rounded dolomite, and some quartzite Sand: coarse, angular to subrounded quartz with angular rock fragments and medium subangular to subrounded quartz	3.2	8.0
Till	Clay, grey-brown; small pebbles of sandstone; boulder at base *Borehole abandoned because of rock obstruction*	10.0+	18.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
4	59	37	4.8–5.8	4	7	23	24	32	10	
			5.8–6.8	3	8	21	36	34	8	
			6.8–8.0	4	7	16	36	36	1	
			Mean	4	7	20	32	31	6	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
4.8–8.0	54	23	4	6	9	2	2

NZ 40 SE 8 4739 0225 East of West Lees Farm **Block B**

Surface level (+76.2 m) +250 ft
Water struck at +72.2 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, grey to blue-grey; thin peat bands and plant debris	4.4	4.6
	Silty clay, brown, laminated; thin sand bands from 5.2 to 6.0 m	6.4	11.0
	Silt, grey, with grey-brown clay and quartz sand partings	7.0+	18.0

NZ 40 SE 9 4523 0178 West of Summerfield House **Block D**

Surface level (+78.3 m) +257 ft
Water not encountered
November 1977

Waste 7.8 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly red-brown but grey-brown in parts; pebbles of Carboniferous sandstone and Permo-Triassic rocks (dominant below 5.0 m)	7.6	7.8
Lower Lias	Mudstone, grey-green, friable	0.7+	8.5

NZ 40 SE 10 4882 0199 North-west of Whorlton House **Block D**

Surface level (+123.4 m) +405 ft
Water struck at +120.1 m
November 1977

Overburden 0.2 m
Mineral 1.4 m
Waste 1.7 m
Mineral 0.6 m
Waste 1.7 m
Mineral 0.6 m
Waste 13.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	**a** 'Very clayey' sand Sand: mainly fine quartz Fines: brown 'clay' bands	1.4	1.6
	Clay, blue-grey, sandy, with plant debris	1.7	3.3
	b 'Very clayey' pebbly sand Gravel: fine with coarse, angular to subrounded sandstone with subrounded to rounded quartzite and limestone and tabular, angular to rounded mudstone Sand: fine and medium quartz with some angular rock fragments Fines: blue-grey 'clay' bands	0.6	3.9
Till	Clay, brown; small angular pebbles of sandstone and Permo-Triassic rocks	1.7	5.6
Glacial Sand and Gravel	**c** Sandy gravel Gravel: fine, angular to subrounded sandstone with subrounded to rounded limestone, tabular, angular to rounded mudstone and some subrounded to rounded extrusive igneous rocks Sand: mainly coarse, angular to subrounded quartz and angular dark rock fragments	0.6	6.2
Till	Clay, very sandy in parts, grey-brown and brown; pebbles of sandstone and dark lithic grains	13.8+	20.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	39	60	1	0.2–1.6	39	41	15	4	1	0	
b	29	54	17	3.3–3.9	29	23	23	8	10	7	
c	5	63	32	5.6–6.2	5	7	16	40	27	5	
a + **b** + **c**	29	59	12	Mean	29	29	17	13	9	3	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
3.3–3.9	71	5	7	2	0	1	14
5.6–6.2	62	22	1	7	2	0	6
Mean	65	16	3	5	1	1	9

NZ 40 SE 11 4546 0054 Norwood Farm **Block D**

Surface level (+85.0 m) +279 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, grey-brown; angular pebbles of Carboniferous sandstone and Permo-Triassic rocks and, below 16.0 m, grey mudstone	17.8+	18.0

NZ 40 SE 12 4659 0083 Scarth Wood Farm **Block D**

Surface level (+111.9 m) +367 ft
Water struck at +96.9 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown, sandy; rounded pebbles of sandstone and limestone and platy angular sandstone and shale	3.0	3.2
	Clay, grey-brown; angular pebbles of Carboniferous sandstone and Permo-Triassic rocks; 0.6 m gravel band at 15.0 m	14.8+	18.0

NZ 40 SE 13 4772 0100 Shepherd Hill **Block D**

Surface level (+127.7 m) +419 ft
Water struck at +121.7 m
November 1977

Overburden 6.8 m
Mineral 18.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red brown, sandy at base; rounded pebbles of ?Jurassic sandstone and limestone	6.6	6.8
Glacial Sand and Gravel	**a** 'Clayey' sandy gravel Gravel: mainly coarse, angular to subrounded sandstone with subrounded to well rounded quartzite and some subangular to rounded limestone Sand: fine quartz with medium subangular to subrounded quartz and rock fragments	2.4	9.2
	b Gravel Gravel: coarse, angular to subrounded sandstone with subrounded to well rounded quartzite and subangular to rounded limestone Sand: coarse to fine, subangular to subrounded quartz with some coarse angular sandstone and dark lithic grains	2.3	11.5
	c 'Clayey' pebbly sand Gravel: fine, subangular to rounded sandstone with limestone, angular to subangular siltstone and rounded to well rounded quartzite Sand: fine quartz, with medium and coarse quartz and sandstone and dark rock fragments	5.0	16.5
	d 'Very clayey' sand Sand: fine quartz Fines: brown 'clay' bands	8.5+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	13	58	29	6.8–7.8	17	43	17	5	12	6	
				7.8–9.2	10	30	17	6	9	28	
				Mean	13	35	17	6	10	19	
b	3	32	65	9.2–10.2	4	17	10	8	13	48	
				10.2–11.5	2	6	9	15	19	49	
				Mean	3	11	9	12	16	49	
c	17	69	14	11.5–12.5	17	22	35	14	11	1	
				12.5–13.5	18	27	23	17	13	2	
				13.5–14.5	14	29	15	13	19	10	
				14.5–15.5	20	47	17	10	5	1	
				15.5–16.5	17	65	8	5	5	0	
				Mean	17	38	19	12	11	3	
d	28	72	0	16.5–17.5	16	79	3	2			
				17.5–18.5	24	72	3	1			
				18.5–19.5	30	67	2	1			
				19.5–20.5	25	71	3	1			
				20.5–21.5	32	64	3	1			
				21.5–22.5	31	66	2	1			
				22.5–23.5	34	63	2	1			
				23.5–25.0	32	66	2	0			
				Mean	28	68	3	1			
a + b + c + d	20	64	16	Mean	20	48	10	6	6	10	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
6.8–9.2	74	4	16	2	0	2	2
9.2–11.5	67	9	20	1	0	0	3
11.5–16.5	60	13	13	2	0	2	10
Mean	67	9	17	2	0	1	4

NZ 40 SE 14 4901 0081 Huthwaite Green Farm **Block D**

Surface level (+137.5 m) +451 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	4.8	5.0
	Clay, brown, silty, stone-free	2.5	7.5
	Clay, grey-brown, with angular pebbles of Carboniferous sandstone and dark rocks	10.5+	18.0

NZ 41 SW 9 4136 1248 Holme House **Block B**

Surface level (+5.8 m) +19 ft
Water struck at +2.3 m
February 1978

Overburden 5.3 m
Mineral 2.2 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium	Silty clay, blue-grey to grey with plant debris; sandy at base	4.8	5.3
	Gravel Gravel: coarse and fine, subangular to well rounded sandstone with subrounded to rounded limestone, extrusive igneous rocks and dolomite and rounded to well rounded quartzite and chert and some shale and mudstone Sand: medium to coarse angular to subrounded quartz with coarse angular dark rocks and sandstone	2.2	7.5
Sherwood Sandstone Group	Sandstone, pale yellow, flaggy, micaceous	0.5+	8.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
8	34	58	5.3–6.3	11	8	16	13	25	27	
			6.3–7.5	6	6	15	10	27	36	
			Mean	8	7	16	11	26	32	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
5.3–6.3	33	23	9	10	10	8	7
6.3–7.5	42	23	6	10	10	6	3
Mean	38	23	7	10	10	7	5

NZ 41 SW 10 4469 1293 Sober Hall **Block D**

Surface level (+32.9 m) +108 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate-brown, but red-brown at top; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	7.8	8.0
	Clay, chocolate-brown, stone-free, laminated, with silty partings	2.2	10.2
	Clay, chocolate-brown; pebbles of mainly Permo-Triassic rocks	7.8+	18.0

NZ 41 SW 11 4138 1110 East of Morley Carr **Block D**

Surface level (+34.7 m) +114 ft
Water struck at +22.7 m
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate brown, but red-brown at top, pebbly	9.8	10.0
	Clay, chocolate brown, stone free, silty in parts, weakly laminated	2.5	12.5
	Clay, grey; small pebbles of mainly Permo-Triassic rocks and large angular pebbles of Carboniferous and Permo-Triassic sandstone	5.5+	18.0

NZ 41 SW 12 4316 1106 HM Detention Centre **Block D**

Surface level (+36.9 m) +121 ft
Water not encountered
March 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, silty in parts, red-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	14.9	15.0
	'Clayey' sand, grey-brown: fine to medium quartz	0.9	15.9
	Clay, brown, laminated in upper part, pebbly at base	2.1+	18.0

NZ 41 SW 13 4397 1060 Toft Hill **Block D**

Surface level (+50.6 m) +166 ft
Water not encountered
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown to 13.6 m, mainly grey brown below; pebbles of Carboniferous sandstone and Permo-Triassic rocks (dominant below 13.6 m)	17.7+	18.0

NZ 41 SE 15 4769 1278 East of Maltby Grange **Block D**

Surface level (+52.1 m) +171 ft
Water not encountered
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown; small angular pebbles of Permo-Triassic and Carboniferous rocks	17.7+	18.0

NZ 41 SE 16 4856 1282 Low Thornton Moor **Block D**

Surface level (+61.6 m) +202 ft
Water not encountered
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown; small angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 41 SE 17 4968 1242 North-west of Antelope Lodge **Block D**

Surface level (+79.9 m) +262 ft
Water struck at (+70.4 m)
December 1977

Overburden 9.5 m
Mineral 15.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown, sandy; small pebbles of mainly Permo-Triassic rocks	9.3	9.5
Glacial Sand and Gravel	'Clayey' sand, with silty clay bands: mainly fine quartz	15.5+	25.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
17	83	0	9.5–10.5	29	70	1	0			
			10.5–11.5	31	67	2	0			
			11.5–13.0	12	74	14	0			
			13.0–14.0	12	51	32	5			
			14.0–15.0	31	46	21	2			
			15.0–18.0	13	77	9	1			
			18.0–21.0	12	70	17	1			
			21.0–23.0	16	74	10	0			
			23.0–25.0	15	65	19	1			
			Mean	17	68	14	1			

NZ 41 SE 18 4576 1112 South-west of Hilton House **Block D**

Surface level (+53.6 m) +176 ft
Water struck at +38.3 m
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown, silty in parts; small angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 41 SE 19 4873 1138 North-west of Low Field **Block D**

Surface level (+75.0 m) +246 ft
Water not encountered
February 1978

Waste 9.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown, sandy; small pebbles and common angular cobbles of Carboniferous sandstone	8.8+	9.0
	Borehole abandoned because of rock obstruction		

NZ 41 SE 20 4949 1130 Low House **Block D**

Surface level (+75.3 m) +247 ft
Water not encountered
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown; small pebbles of Carboniferous sandstone	17.8+	18.0

NZ 41 SE 21 4867 1076 Boy Hill **Block D**

Surface level (+87.5 m) +287 ft
Water struck at +85.5 m
December 1977

Waste 11.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown; pebbles of Carboniferous sandstone, Permo-Triassic and igneous rocks	2.7	3.0
	Clay, red-brown, sandy at top, silty at base	1.5	4.5
	Clay, chocolate-brown, pebbly, sandstone cobble at 8.5 m	6.5+	11.0
	Borehole abandoned because of rock obstruction		

NZ 41 SE 22 4962 1046 West End Well **Block C**

Surface level (+76.5 m) +251 ft
Water struck at +75.0 m
February 1978

Overburden 1.2 m
Mineral 23.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.3	0.3
Till	Clay, brown, sandy, pebbly	0.9	1.2
Glacial Sand and Gravel	**a** Sandy gravel Gravel: fine with coarse, subangular to rounded sandstone with limestone and extrusive igneous rocks Sand: coarse to fine subangular to subrounded quartz with coarse angular lithic grains	1.3	2.5
	b Sand, 'clayey' in parts; fine to medium quartz	9.0	11.5
	c 'Very clayey' sand Sand: mainly fine quartz Fines: brown laminated 'clay' bands	13.5+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	4	50	46	1.2–2.5	4	10	17	23	32	14	
b	8	90	2	2.5–3.5	7	62	25	5	1		
				3.5–4.5	5	40	31	23	1		
				4.5–5.5	8	66	24	2	0		
				5.5–6.5	10	52	36	2	0		
				6.5–7.5	11	43	42	3	1		
				7.5–8.5	8	49	41	2	0		
				8.5–9.5	8	47	42	3	0		
				9.5–10.5	11	48	38	2	1		
				10.5–11.5	9	49	38	3	1		
				Mean	8	49	36	5	2		
c	32	67	1	11.5–12.5	30	57	11	2	0		
				12.5–13.5	28	58	12	2	0		
				13.5–14.5	23	39	28	8	2		
				14.5–15.5	20	40	30	5	5		
				15.5–18.5	26	45	21	7	1		
				18.5–21.5	39	56	4	1	0		
				21.5–25.0	38	50	10	2	0		
				Mean	32	50	14	3	1		
a + **b** + **c**	22	75	3	Mean	22	47	23	5	2	1	

NZ 50 NW 9 5121 0948 East of Seamer Hill **Block C**

Surface level (+78.0 m) +256 ft
Water struck at +66.5 m
June 1977

Overburden 6.0 m
Mineral 19.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown, with bands of fine quartz sand and sporadic sandstone pebbles	5.7	6.0
Glacial Sand and Gravel	**a** 'Very clayey' sand, pebbly at top Sand: fine quartz Fines: brown laminated 'clay'	7.0	13.0
	b Sand, pebbly from 20.0 m to 22.0 m Gravel: mainly coarse and cobble, angular to rounded sandstone and limestone Sand: fine to medium quartz	12.0+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	25	72	3	6.0–7.0	13	35	22	15	9	6	
				7.0–8.0	33	55	9	2	1	0	
				8.0–9.0	30	53	11	2	4	0	
				9.0–10.0	32	63	5				
				10.0–11.0	33	63	4				
				11.0–12.0	21	69	10				
				12.0–13.0	15	63	22				
				Mean	25	57	12	3	2	1	
b	9	88	3	13.0–14.0	8	71	21				
				14.0–15.0	9	70	21				
				15.0–16.0	7	54	39				
				16.0–17.0	8	69	23				
				17.0–18.0	8	67	25				
				18.0–19.0	9	54	36	1			
				19.0–20.0	21	53	26	0			
				20.0–21.0	8	35	43	9	3	2	
				21.0–22.0	6	21	44	8	3	18*	
				22.0–23.0	6	29	54	7	1	3	
				23.0–24.0	7	34	52	6	1	0	
				24.0–25.0	8	35	51	6	0	0	
				Mean	9	49	36	3	1	2	
a + b	15	82	3	Mean	15	52	27	3	1	2	

* Includes 11% cobbles

NZ 50 NW 10 5226 0920 North of Neasome House **Block A**

Surface level (+66.8 m) +219 ft
Water struck at +63.6 m
July 1977

Overburden 4.6 m
Mineral 1.2 m
Waste 14.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	Sandy clay, yellow-brown, with thin bands of quartz sand; black silt at base	4.4	4.6
Glacial Sand and Gravel	Gravel Gravel: fine with coarse, subangular to rounded sandstone with subrounded to rounded limestone and some extrusive igneous rocks, quartz, quartzite and chert Sand: coarse with medium, subangular to subrounded quartz with some coarse angular dark rock fragments	1.2	5.8
Till	Clay, brown, stony, silty in parts; laminated where silty	14.2+	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
2	43	55	4.6–5.8	2	4	12	27	37	18	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sandstone	Limestone	Quartz and quartzite	Igneous	Dolomite	Chert	Shale and mudstone
4.6–5.8	60	18	6	6	3	5	2

NZ 50 NW 11 5320 0969 Stony Hill **Block C**

Surface level (+72.5 m) +238 ft
Water not encountered
July 1977

Overburden 1.8 m
Mineral 3.5 m
Waste 14.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.8	0.8
Till	Sandy clay, yellow-brown, with plant debris and thin lenses of fine quartz sand	1.0	1.8
Glacial Sand and Gravel	'Very clayey' sand, pebbly near base Gravel: fine, angular to rounded sandstone with some subrounded to rounded limestone, dolomite and extrusive igneous rocks Sand: mainly fine quartz Fines: yellow-brown silty clay bands	3.5	5.3
Till	Clay, grey-brown; small pebbles of Carboniferous and Permo-Triassic rocks	14.7+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
31	65	4	1.8–2.8	31	62	6	1			
			2.8–4.2	35	56	8	1			
			4.2–5.3	26	35	16	10	11	2	
			Mean	31	51	10	4	3	1	

NZ 50 NW 12 5416 0926 West of Mark Hill **Block A**

Surface level (+71.6 m) +235 ft
Water struck at +69.6 m
October 1977

Overburden 0.5 m
Mineral 5.3 m
Waste 14.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium on Glacial Sand and Gravel	Gravel, 'clayey' to 1.8 m Gravel: fine with coarse, angular to rounded sandstone with subangular to rounded limestone and extrusive igneous rocks Sand: fine to coarse quartz and coarse angular dark lithic grains	5.3	5.8
Till	Clay, grey-brown; pebbles of Carboniferous sandstone, Permo-Triassic rocks and dark rocks, including coal	14.2+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
8	45	47	0.5–1.8	15	31	14	8	20	12	
			1.8–3.3	5	9	16	19	35	16	
			3.3–4.3	9	3	10	20	34	24	
			4.3–5.3	3	6	13	26	25	27	
			5.3–5.8	2	3	17	35	22	21	
			Mean	8	12	14	19	28	19	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction							
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone	Iron-stone
0.5–1.8	60	20	7	4	0	4	2	3
1.8–3.3	64	15	4	8	trace	2	5	2
3.3–5.3	54	15	3	14	5	4	4	1
5.3–5.8	37	32	5	16	1	3	5	1
Mean	53	19	4	12	2	4	4	2

NZ 50 NW 13 5495 0994 West of Angrove East **Block A**

Surface level (+75.6 m) +248 ft
Water not encountered
October 1977

Overburden 0.2 m
Mineral 2.6 m
Waste 16.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits on Glacial Sand and Gravel	'Very clayey' pebbly sand on 'clayey' sandy gravel Gravel: fine and coarse, angular to rounded, sandstone Sand: mainly fine quartz	2.6	2.8
Till	Clay, grey-brown; angular pebbles of Carboniferous and Permo-Triassic rocks and few Carboniferous sandstone cobbles	16.7+	19.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
16	56	28	0.2–1.3	22	44	18	4	8	4	
			1.3–2.4	12	20	15	14	24	15	
			2.4–2.8	14	26	13	8	12	27	
			Mean	16	31	16	9	15	13	

NZ 50 NW 14 5052 0902 South of Seamer Hill **Block C**

Surface level (+73.1 m) +240 ft
Water struck at +70.4 m
June 1977

Overburden 1.3 m
Mineral 2.0 m
Waste 16.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.5	0.5
Till	Silt, yellow-brown, with thin clay bands	0.8	1.3
Glacial Sand and Gravel	'Very clayey' sand, with yellow-brown silty clay bands; fine quartz	2.0	3.3
Till	Clay, brown, soft, silty in parts, laminated, with silt and sand partings	16.7+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
34	66	0	1.3–2.3	33	65	1	1			
			2.3–3.3	36	60	4	0			
			Mean	34	62	3	1			

NZ 50 NW 15 5154 0876 North of Crabtree Farm **Block A**

Surface level (+64.3 m) +211 ft
Water struck at +60.8 m
June 1977

Overburden 3.5 m
Mineral 3.5 m
Waste 13.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, grey-brown, laminated, with silt and sand lenses	3.2	3.5
Glacial Sand and Gravel	'Clayey' pebbly sand Gravel: fine, subangular to rounded sandstone with some subrounded to rounded limestone, dolomite and extrusive igneous rocks Sand: mainly fine to medium quartz with some coarse angular sandstone and dark rocks	3.5	7.0
Till	Clay, brown, soft, laminated, with thin silt lenses	13.5+	20.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
15	77	8	3.5–4.5	10	36	27	14	11	2	
			4.5–5.5	14	51	18	11	6	0	
			5.5–7.0	18	41	22	13	5	1	
			Mean	15	42	22	13	7	1	

NZ 50 NW 16 5273 0816 South of Stokesley **Block A**

Surface level (+66.8 m) +219 ft
Water struck at +63.8 m
July 1977

Overburden 0.2 m
Mineral 9.0 m
Waste 15.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium on Glacial Sand and Gravel	**a** 'Very clayey' sand, yellow-brown: mainly fine quartz	3.0	3.2
	b Gravel Gravel: fine with coarse, angular to rounded sandstone with subrounded to rounded limestone and some dolomite and extrusive igneous rocks Sand: medium and coarse, angular to subrounded quartz with some angular to subangular dark lithic grains	6.0	9.2
Till	Clay, red-brown with small sandstone pebbles	15.8+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	21	77	2	0.2–1.2	29	48	20	2	1		
				1.2–2.2	23	42	28	6	1		
				2.2–3.2	10	43	35	8	4		
				Mean	21	44	28	5	2		
b	4	43	53	3.2–4.2	12	22	19	10	22	15	
				4.2–5.2	1	2	9	15	40	33	
				5.2–6.2	3	2	12	24	35	24	
				6.2–7.0	2	1	7	16	35	39	
				7.0–8.0	3	7	30	22	26	12	
				8.0–9.2	3	5	25	25	29	13	
				Mean	4	7	17	19	31	22	
a + b	9	55	36	Mean	9	19	21	15	21	15	

NZ 50 NW 17 5342 0858 Villa Farm **Block A**

Surface level (+70.1 m) +230 ft
Water struck at +68.1 m
June 1977

Overburden 1.8 m
Mineral 7.3 m
Waste 11.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
River Terrace Deposits	Clay, yellow, strongly gleyed	1.5	1.8
Glacial Sand and Gravel	**a** 'Clayey' pebbly sand Gravel: fine, angular to rounded sandstone with some subrounded to rounded limestone, dolomite, quartz, quartzite and igneous rocks Sand: mainly fine and medium, subangular to subrounded quartz with some coarse angular dark lithic grains	4.5	6.3
	b Sandy gravel Gravel: fine with coarse, angular to rounded sandstone with subrounded to rounded limestone and extrusive igneous rocks and some dolomite and quartzite Sand: coarse and medium, subangular to subrounded quartz, with coarse angular to subangular dark lithic grains	2.8	9.1
	Clay, brown, soft, laminated with 0.3 m gravel band at 10.0 m	1.3	10.4
Till	Clay, brown; pebbles of Carboniferous and Permo-Triassic rocks	9.3	19.7
	Clay, brown, laminated, with sporadic sandstone pebbles	1.3+	21.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	13	69	18	1.8–2.8	22	13	22	19	18	6	
				2.8–4.1	16	28	22	13	14	7	
				4.1–5.1	8	30	37	12	10	3	
				5.1–6.3	6	23	35	21	13	2	
				Mean	13	24	29	16	14	4	
b	3	57	40	6.3–7.3	3	5	18	32	35	7	
				7.3–8.3	3	2	20	22	23	30	
				8.3–9.1	4	12	37	27	15	5	
				Mean	3	6	24	27	25	15	
a + b	9	64	27	Mean	9	17	27	20	18	9	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
6.3–9.1	44	25	9	12	6	2	2

NZ 50 NW 18 **5499 0868** **North of Mill Vale** **Block D**

Surface level (+76.8 m) +252 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy in parts, brown; angular pebbles of Carboniferous sandstone and dark rock fragments	17.7+	18.0

NZ 50 NW 19 **5028 0776** **North of Braworth Farm** **Block D**

Surface level (+65.5 m) +215 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, brown, weakly laminated, silty in parts and stony at top	13.9	14.2
Till	Clay, brown; angular sandstone pebbles	3.8+	18.0

NZ 50 NW 20 5169 0742 West of Beggar My Neighbour Farm **Block A**

Surface level (+64.0 m) +210 ft
Water struck at +61.5 m
July 1977

Overburden 2.8 m
Mineral 5.6 m
Waste 12.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Sandy clay, yellow-brown, soft, with lenses of sand	2.4	2.8
Glacial Sand and Gravel	**a** 'Clayey' pebbly sand Gravel: fine, angular to rounded sandstone with subrounded to rounded limestone and extrusive igneous rocks Sand: fine with medium, quartz Fines: brown laminated 'clay'	2.9	5.7
	b Sandy gravel Gravel: fine and coarse, angular to rounded sandstone with subangular to rounded limestone, extrusive igneous rocks and dolomite and some quartzite Sand: mainly medium and fine quartz, and coarse, angular lithic grains	2.7	8.4
Till	Clay, chocolate brown, laminated; silty in parts	12.6+	21.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	11	83	6	2.8–3.8	13	45	24	11	7	0	
				3.8–4.8	11	51	24	9	5	0	
				4.8–5.7	10	43	36	6	4	1	
				Mean	11	46	28	9	5	1	
b	5	66	29	5.7–6.7	5	18	41	25	10	1	
				6.7–7.4	10	17	29	24	16	4	
				7.4–8.4	2	8	26	12	18	34	
				Mean	5	14	32	20	15	14	
a + b	8	75	17	Mean	8	31	30	14	10	7	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
5.7–8.4	52	18	6	10	9	3	2

NZ 50 NW 21 5235 0710 East of Fir Trees Farm **Block A**

Surface level (+71.0 m) +233 ft
Water struck at +68.5 m
July 1977

Overburden 2.8 m
Mineral 0.8 m
Waste 1.8 m
Mineral 1.1 m
Waste 14.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, yellow-brown with sandy lenses and plant debris	2.3	2.8
Glacial Sand and Gravel	**a** 'Very clayey' pebbly sand Gravel: fine, angular to rounded sandstone with subangular to rounded limestone, extrusive igneous rocks and dolomite Sand: fine quartz, with medium and coarse quartz and dark lithic grains	0.8	3.6
Till	Clay, brown, sandy; pebbles of Carboniferous sandstone, Permo-Triassic rocks and dark rocks	1.0	4.6
	Silty clay, brown, laminated	0.8	5.4
Glacial Sand and Gravel	**b** Gravel Gravel: fine and coarse, as above Sand: fine quartz, with some medium and coarse quartz and dark lithic grains	1.1	6.5
Till	Clay, red-brown, sandy; pebbles of Carboniferous and Permo-Triassic rocks	14.0+	20.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	20	63	17	2.8–3.6	20	36	14	13	15	2	
b	4	23	73	5.4–6.5	4	12	4	7	34	39	
a + b	12	42	46	Mean	12	23	9	10	25	21	

NZ 50 NW 22 5357 0761 North-east of Kirkby Bridge Farm **Block D**

Surface level (+74.1 m) +243 ft
Water struck at +68.6 m
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown, sandy in parts; angular pebbles of Carboniferous sandstone	5.7	6.0
	Silty clay, brown, weakly laminated	6.0	12.0
	Clay, brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	6.0+	18.0

NZ 50 NW 23 5453 0798 Field House **Block A**

Surface level (+73.2 m) +240 ft
Water struck at +61.7 m
June 1977

Overburden 2.2 m
Mineral 2.2 m
Waste 15.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, red-brown, with sandy partings and plant debris	1.9	2.2
Glacial Sand and Gravel	'Clayey' pebbly sand and sandy gravel Gravel: fine and coarse, angular to rounded, sandstone with limestone and extrusive igneous rocks Sand: fine quartz with medium and coarse quartz and dark lithic grains	2.2	4.4
	Silty clay, yellow-brown, laminated, with fine quartz sand bands	15.6+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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	63	19	2.2–3.2	19	50	14	12	5	0	
			3.2–4.4	18	24	17	11	13	17	
			Mean	18	36	16	11	10	9	

NZ 50 NW 24 5049 0692 North of Busby House **Block B**

Surface level (+62.8 m) +206 ft
Water struck at +60.3 m
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, mainly brown, but grey in parts, with thin quartz sand bands	5.4	5.8
Till	Clay, grey-brown; pebbles of Carboniferous and Permo-Triassic rocks	3.2	9.0
	Clay, brown, laminated, with silt and sand partings	5.4	14.4
	Clay, grey-brown, sandy; pebbles of Carboniferous and Permo-Triassic rocks	3.6+	18.0

NZ 50 NW 25 5103 0635 East of Busby House **Block D**

Surface level (+66.8 m) +219 ft
Water not encountered
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, brown, weakly laminated, silty and sandy in parts	14.1	14.4
Till	Clay, brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	3.6+	18.0

NZ 50 NW 26 5352 0683 North of Kirby Lane Farm **Block D**

Surface level (+81.7 m) +268 ft
Water not encountered
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, chocolate brown, pebbly, silty and weakly laminated in parts	17.7+	18.0

NZ 50 NW 27 5459 0699 East of Railway Bridge Farm **Block D**

Surface level (+87.5 m) +287 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and fill	0.5	0.5
Till	Clay, silty in parts, brown; small pebbles of Carboniferous sandstone	17.5+	18.0

NZ 50 NW 28 5036 0580 South of Calf Close Hill **Block D**

Surface level (+69.8 m) +299 ft
Water struck at +66.8 m
July 1977

Waste 20.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Lacustrine Deposits	Clay, red-brown, laminated with bands of silt and fine sand	6.0	6.4
Till	Clay, brown; pebbles of Carboniferous and Permo-Triassic rocks	2.4	8.8
	Clay, chocolate-brown, laminated, with silt and sand partings; 0.7 m stony band at 12.0 m	11.2+	20.0

NZ 50 NW 29 5151 0541 North of Viewly Hill **Block D**

Surface level (+77.7 m) +255 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty in parts, grey-brown; small pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.7+	18.0

NZ 50 NW 30 5341 0553 South of Dromonby House **Block D**

Surface level (+96.3 m) +316 ft
Water not encountered
July 1977

Waste 18.0+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.7+	18.0

NZ 50 NE 3 5622 0950 East of Ayton Firs **Block D**

Surface level (+93.8 m) +308 ft
Water struck at +88.8 m
June 1977

Overburden 0.4 m
Mineral 2.3 m
Waste 16.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine, angular to subrounded sandstone with some limestone Sand: mainly fine quartz	2.3	2.7
	Clay, brown, soft, laminated, with regular silt and sand partings	1.6	4.3
Till	Clay, brown, sandy; pebbles of Carboniferous sandstone and Permo-Triassic rocks	15.2+	19.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
29	66	5	0.4–1.4	22	34	32	7	4	1	
			1.4–2.7	35	44	14	3	4	0	
			Mean	29	39	22	5	4	1	

NZ 50 NE 4 5804 0913 Grove Farm **Block D**

Surface level (+112.7 m) +370 ft
Water struck at +103.2 m
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, grey-brown; pebbles of Carboniferous and Permo-Triassic rocks; 1.5 m gravel band at 12.0 m	17.6+	18.0

NZ 50 NE 5 5592 0806 Crow Wood Farm **Block D**

Surface level (+88.7 m) +291 ft
Water struck at +71.7 m
June 1977

Waste 18.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellow-brown, sandy	0.7	0.9
Glacial Sand and Gravel	'Very clayey' sandy gravel Gravel: fine with coarse, angular to rounded sandstone with subangular to rounded limestone, extrusive igneous rocks and dolomite Sand: fine and medium quartz, with coarse quartz and dark lithic grains	0.8	1.7
Till	Clay, grey-brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks; gravel band 0.4 m thick at 17.0 m	16.8+	18.5

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
20	55	25	0.9–1.7	20	25	20	10	15	10	

NZ 50 NE 6 5710 0874 South of Holly Farm **Block D**

Surface level (+97.5 m) +320 ft
Water struck at +93.5 m
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate-to grey-brown, but red-brown at top; angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	8.8	9.0
	Silty clay, brown, poorly laminated	1.5	10.5
	Clay, sandy in parts, grey-brown; pebbles of Carboniferous sandstone	7.5+	18.0

NZ 50 NE 7 5528 0761 North-west of White House Farm **Block A**

Surface level (+81.1 m) +266 ft
Water struck at +77.1 m
November 1977

Overburden 0.2 m
Mineral 6.5 m
Waste 13.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	**a** 'Clayey' pebbly sand Gravel: fine, angular to rounded sandstone with subrounded to rounded extrusive igneous rocks, mudstone and quartzite Sand: fine and medium quartz, with coarse quartz and dark lithic grains	3.0	3.2
	b Gravel Gravel: mainly coarse, angular to subrounded sandstone with subangular to rounded limestone, extrusive igneous rocks and rounded to well rounded quartzite and some angular to subrounded mudstone Sand: coarse, with fine and medium, angular to subrounded quartz with some angular sandstone and dark rocks	3.5	6.7
Till	Clay, grey-brown; small pebbles of Carboniferous and Permo-Triassic rocks; 0.3– m gravel band at 19.0 m	13.8+	20.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	17	64	19	0.2–1.2	13	23	26	14	16	8	
				1.2–2.2	23	31	22	11	10	3	
				2.2–3.2	15	27	25	13	12	8	
				Mean	17	27	24	13	13	6	
b	4	34	62	3.2–4.3	7	21	16	8	16	32	
				4.3–5.4	2	4	6	17	21	50	
				5.4–6.7	3	3	6	22	29	37	
				Mean	4	9	9	16	22	40	
a + b	10	48	42	Mean	10	17	16	15	18	24	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
0.2–3.2	74	0	8	10	0	0	8
3.2–6.7	52	19	18	7	1	1	2
Mean	56	15	16	7	1	1	4

NZ 50 NE 8 5701 0752 Drummer Hill **Block D**

Surface level (+104.2 m) +342 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy to 3.5 m, brown; angular pebbles of Carboniferous and Permo-Triassic rocks	17.7+	18.0

NZ 50 NE 9 5913 0792 North-west of The Hall **Block D**

Surface level (+135.0 m) +443 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, grey-brown; angular pebbles of Carboniferous rocks and dolomite	17.7+	18.0

NZ 50 NE 10 5520 0648 Green Balk **Block D**

Surface level (+92.0 m) +302 ft
Water not encountered
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, mainly chocolate-brown, but red-brown at top; pebbles of Permo-Triassic and Carboniferous rocks, including coal	6.2	6.4
	Clay, red-brown, silty, with thin quartz sand bands	2.1	8.5
	Clay, silty in parts, red-brown; small pebbles of Carboniferous sandstone	9.5+	18.0

NZ 50 NE 11 5725 0654 Dixons Plantation **Block D**

Surface level (+115.5 m) +379 ft
Water struck at +99.0 m
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown to grey-brown; pebbles of Carboniferous sandstone; 0.3-m gravel band at 16.5 m	17.8+	18.0

NZ 50 NE 12 5851 0632 Ingleby Greenhow **Block D**

Surface level (+146.6 m) +481 ft
Water struck at +139.8 m
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown, silty and sandy, weakly laminated, pebbly in parts	17.7+	18.0

NZ 50 NE 13 5875 0698 South of Battersby **Block D**

Surface level (+140.5 m) +461 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, sandy in parts, grey-brown; angular pebbles of Carboniferous sandstone	17.6+	18.0

NZ 50 NE 14 5529 0550 East of Broughton Grange **Block D**

Surface level (+99.1 m) +325 ft
Water not encountered
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy in places, mainly brown to grey-brown, with pebbles and cobbles of Carboniferous rocks, but below 8.0 m chocolate-brown with small pebbles of Carboniferous and Permo-Triassic rocks	17.8+	18.0

NZ 50 NE 15 5701 0553 Bonny Hill **Block D**

Surface level (+130.5 m) +428 ft
Water struck at +123.0 m
June 1977

Overburden 1.3 m
Mineral 11.9 m
Waste 1.6 m
Mineral 4.4 m
Waste 4.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial Sand and Gravel	Sandy clay, brown	0.8	1.3
	a 'Clayey' pebbly sand Gravel: coarse and fine, angular to rounded sandstone with subangular to rounded extrusive igneous rocks, limestone and dolomite Sand: mainly fine quartz	6.9	8.2
	b Sandy gravel Gravel: as above Sand: mainly medium quartz, with coarse dark lithic grains	2.4	10.6
	c 'Very clayey' sand Sand: fine to medium quartz Fines: brown laminated 'clay' bands	2.6	13.2
	Clay, brown, laminated, with thin quartz sand and gravel lenses	1.6	14.8
	d 'Clayey' sand; mainly fine quartz	4.4	19.2
	Clay, brown, laminated; bands of fine quartz sand and of silt	4.8+	24.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	16	68	16	1.3–2.3	21	53	11	3	10	2	
				2.3–3.6	29	38	12	8	8	5	
				3.6–4.6	15	36	25	4	6	14	
				4.6–5.8	7	33	28	8	7	17	
				5.8–6.4	13	38	20	5	8	16	
				6.4–7.4	15	38	32	11	4	0	
				7.4–8.2	11	24	35	14	9	7	
				Mean	16	37	23	8	8	8	
b	4	59	37	8.2–9.2	4	9	22	16	25	24	
				9.2–10.6	4	10	38	20	15	13	
				Mean	4	10	31	18	19	18	
c	20	79	1	10.6–11.6	24	39	28	8	1	0	
				11.6–13.2	18	39	33	9	1	0	
				Mean	20	39	31	9	1	0	
d	19	77	4	14.8–15.8	22	46	24	7	1	0	
				15.8–16.8	16	72	8	4	0	0	
				16.8–17.8	10	40	28	6	6	10	
				17.8–19.2	25	55	17	3	0	0	
				Mean	19	53	19	5	2	2	
a + **b** + **c** + **d**	16	71	13	Mean	16	38	24	9	6	7	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
1.3–10.6	38	16	1	27	11	4	3

NZ 50 NE 16 5883 0552 South of Ingleby Manor **Block D**

Surface level (+148.1 m) +486 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty in places, mainly grey-brown, but brown at top; pebbles of Carboniferous sandstone	17.7+	18.0

NZ 50 SW 5 5258 0459 South of Cote House **Block D**

Surface level (+107.0 m) +351 ft
Water not encountered
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, mainly grey-brown, but red-brown below 15 m; angular pebbles of Carboniferous and Permo-Triassic rocks (dominant below 15 m)	17.9+	18.0

NZ 50 SW 6 5042 0367 South-west of Carlton **Block D**

Surface level (+104.5 m) +343 ft
Water struck at +99.0 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Lacustrine Deposits	Clay, brown, with angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	4.2	4.5
	Clay, brown, poorly laminated, silty in places	1.5	6.0
Till	Clay, sandy in parts, brown and pebbly to 11.0 m, red-brown with Permo-Triassic rocks below	12.0+	18.0

NZ 50 SW 7 5139 0369 North-east of Butterhill Plantation **Block D**

Surface level (+133.8 m) +439 ft
Water not encountered
November 1977

Overburden 1.6 m
Mineral 2.2 m
Waste 1.5 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown, sandy; pebbles of sandstone and dark rocks including coal	1.4	1.6
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine, subangular to well rounded sandstone and angular to subrounded mudstone Sand: mainly fine quartz	2.2	3.8
Till	Clay, red-brown, with grey patches, sandy in parts, pebbly at base	1.5	5.3
Lower Lias	Mudstone, grey, micaceous	0.5+	5.8

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
34	62	4	1.6–2.6	33	41	18	3	4	1	
			2.6–3.8	35	39	20	4	2	0	
			Mean	34	40	19	3	3	1	

NZ 50 SW 8 5062 0269 West of Plane Tree Farm **Block D**

Surface level (+129.8 m) +426 ft
Water struck at +114.8 m
November 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellow to red-brown, silty and sandy in parts; pebbles of Carboniferous sandstone and dark rocks to 9.0 m and of Permo-Triassic below; 0.6 m gravel band at 15.0 m	17.8+	18.0

NZ 50 SW 9 **5062 0046** **Fog Close** **Block D**

Surface level (+185.7 m) +609 ft
Water struck at +182.7 m
December 1977

Overburden 2.5 m
Mineral 9.4 m
Waste 10.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown, sandy to 1.0 m, silty below; angular pebbles of sandstone	2.3	2.5
Glacial Sand and Gravel	**a** 'Clayey' sandy gravel Gravel: mainly fine, angular to rounded sandstone with subangular to rounded shale, rounded to well rounded limestone and subrounded to well rounded quartzite and some ironstone Sand: mainly medium quartz with coarse lithic grains	5.0	7.5
	b 'Very clayey' sand Sand: fine, with medium, quartz Fines: chocolate- to yellow-brown, laminated, sandy silty clay	4.4	11.9
	Clay, brown, laminated, with silt and sand partings	10.1+	22.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	18	56	26	2.5–4.5	20	9	24	19	20	8	
				4.5–5.5	20	16	24	16	23	1	
				5.5–6.5	9	10	27	24	22	8	
				6.5–7.5	19	13	27	19	16	6	
				Mean	18	12	25	19	20	6	
b	23	75	2	7.5–8.5	18	31	35	13	3	0	
				8.5–9.5	18	39	30	8	3	2	
				9.5–10.5	22	37	30	9	2	0	
				10.5–11.5	28	58	11	3	0	0	
				11.5–11.9	33	53	11	3	0	0	
				Mean	23	42	25	8	2	0	
a + b	20	65	15	Mean	20	26	25	14	12	3	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction							
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone	Iron-stone
2.5–7.5	45	13	6	1	0	1	31	3

NZ 50 SE 2 5550 0451 North of Broughton Bank **Block D**

Surface level (+136.6 m) +448 ft
Water struck at +129.6 m
July 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown; pebbles of Carboniferous rocks	6.8	7.0
	Sandy clay, red-brown, silty in places	2.7	9.7
	Clay, mainly red-brown, but grey-brown at base; pebbles of Carboniferous rocks	8.3+	18.0

NZ 50 SE 3 5773 0459 Rose Cottage **Block D**

Surface level (+151.8 m) +498 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown; small pebbles of Permo-Triassic and Carboniferous rocks, including coal	17.7+	18.0

NZ 50 SE 4 5879 0443 South-west of Wood's Farm **Block D**

Surface level (+160.3 m) +526 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, yellow-brown, sandy; angular pebbles of Carboniferous sandstone	2.6	3.0
	Clay, silty in parts, chocolate-brown; pebbles of Carboniferous sandstone	15.0+	18.0

NZ 50 SE 5 5917 0361 Greenhow Botton **Block D**

Surface level (+182.9 m) +600 ft
Water not encountered
June 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
?Till	Clay, yellow-brown, sandy, with plant debris at base	1.7	2.0
Till	Clay, chocolate brown, increasingly pebbly with depth; pebbles of Carboniferous sandstone and Permo-Triassic rocks	16.0+	18.0

NZ 51 SW 8 5041 1254 West of Bromley Hill **Block D**

Surface level (+75.0 m) +246 ft
Water not encountered
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown; small angular pebbles of Carboniferous sandstone and Permo-Triassic rocks	17.8+	18.0

NZ 51 SW 9 5224 1285 Sunny Cross **Block D**

Surface level (+85.6 m) +281 ft
Water not encountered
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, mainly red-brown, but brown at top; pebbles of Carboniferous sandstone, Permo-Triassic rocks and grey mudstone	17.7+	18.0

NZ 51 SW 10 5133 1195 North-east of Spring Well Hill **Block D**

Surface level (+76.5 m) +251 ft
Water struck at +59.5 m
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
?Till	Clay, yellow-brown, with plant debris and few pebbles	2.0	2.2
Till	Clay, silty in places below 15.0 m, chocolate-brown; small pebbles of Carboniferous and Permo-Triassic rocks	15.8+	18.0

NZ 51 SW 11 5389 1163 Greenhow Hill Moor **Block D**

Surface level (+83.8 m) +275 ft
Water struck at +80.0 m
December 1977

Overburden 0.3 m
Mineral 1.3 m
Waste 1.2 m
Mineral 3.5 m
Waste 14.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvio-glacial Delta Sand	**a** 'Clayey' sand Sand: fine orange-stained quartz Fines: brown silty laminated clay with pink silt bands	1.3	1.6
	Clay, orange-brown with pink silt lenses, laminated; fine quartz sand partings	1.2	2.8
	b 'Very clayey' sand; as above	3.5	6.3
Till	Clay, mainly brown, with pebbles of Carboniferous and Permo-Triassic rocks but grey in parts with grey mudstone fragments	14.2+	20.5

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	16	80	4	0.3–1.6	16	72	5	3	2	2	
b	23	76	1	2.8–3.8	17	73	4	4	2	0	
				3.8–4.8	22	66	11	1	0	0	
				4.8–6.3	29	61	8	2	0	0	
				Mean	23	66	8	2	1	0	
a + b	21	77	2	Mean	21	68	7	2	1	1	

NZ 51 SW 12 5076 1102 Harker Hill **Block D**

Surface level (+75.3 m) +247 ft
Water not encountered
February 1978

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, red-brown; rounded Carboniferous sandstone pebbles at base	3.2	3.5
	Clay, brown; pebbles of Carboniferous sandstone and Permo-Triassic rocks	14.5+	18.0

NZ 51 SW 13 5140 1112 Howe Hill **Block C**

Surface level (+89.3 m) +293 ft
Water struck at +87.3 m
February 1978

Overburden 1.6 m
Mineral 3.4 m
Waste 0.8 m
Mineral 3.4 m
Waste 11.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, brown; small pebbles of Carboniferous sandstone	1.4	1.6
Glacial Sand and Gravel	'Clayey' sandy gravel Gravel: fine, subangular to rounded sandstone with subrounded to rounded extrusive igneous rocks and some quartzite and mudstone Sand: mainly medium and coarse, angular to subrounded quartz with some sandstone	3.4	5.0
Till	Silty clay, yellow-brown; small angular sandstone pebbles	0.8	5.8
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: fine, angular to subrounded sandstone with subrounded to rounded extrusive igneous rocks angular shale and some limestone and quartzite Sand: mainly medium, with fine and coarse quartz, with some coarse, dark lithic grains Fines: yellow-brown, laminated silty clay bands	3.4	9.2
	Silty clay, laminated, yellow-brown, with sandy partings	11.8+	21.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	15	62	23	1.6–2.6	18	9	28	17	21	7	
				2.6–3.8	9	4	30	22	24	11	
				3.8–5.0	20	11	41	22	6	0	
				Mean	15	8	33	21	17	6	
b	22	67	11	5.8–6.8	26	18	29	14	11	2	
				6.8–7.8	21	23	34	12	10	0	
				7.8–9.2	20	21	36	14	7	2	
				Mean	22	21	33	13	9	2	
a + b	19	65	16	Mean	19	15	33	17	12	4	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolo-mite	Chert	Shale and mudstone
1.6–2.6	62	1	6	27	0	0	4
2.6–5.0	60	0	6	30	0	1	3
5.8–9.2	60	3	2	23	0	1	11
Mean	60	1	5	27	0	1	6

NZ 51 SW 14 **5036 1035** **Bracken Hill** **Block C**

Surface level (+95.1 m) +312 ft
Water struck at +85.1 m
December 1977

Overburden 3.7 m
Mineral 21.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red-brown; angular pebbles of Carboniferous and Permo-Triassic rocks	2.0	2.2
	Silty clay, chocolate-brown to yellow-brown, laminated, with sandy partings	1.5	3.7
Glacial Sand and Gravel	Gravel Gravel: coarse with fine, angular to rounded sandstone, with some fine subangular to rounded limestone, extrusive igneous rocks and quartzite Sand: fine to coarse, angular to subrounded quartz and sandstone	1.2	4.9
	'Clayey' sand; mainly fine quartz	4.0	8.9
	Gravel Gravel: fine with coarse, angular to rounded sandstone with limestone and some subrounded to rounded extrusive igneous rocks and rounded quartzite Sand: coarse to fine, angular to subrounded quartz, with some angular sandstone and dark lithic grains	0.8	9.7
	'Very clayey' sand Sand: fine quartz Fines: brown laminated clay with yellow-brown silt	15.3+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	5	36	59	3.7–4.9	5	15	9	12	25	34	
b	10	88	2	4.9–5.9	10	73	13	3	1		
				5.9–6.9	9	72	18	1	0		
				6.9–7.9	10	72	17	1	0		
				7.9–8.9	11	65	14	4	3	3	
				Mean	10	70	16	2	1	1	
c	9	44	47	8.9–9.7	9	13	10	21	27	20	
d	26	74	trace	9.7–10.7	35	59	5	1			
				10.7–11.7	37	58	4	1			
				11.7–12.7	21	72	3	1	2	1	
				12.7–13.7	16	82	2	0			
				13.7–14.7	16	82	2	0			
				14.7–15.7	21	78	1	0			
				15.7–16.7	17	82	1	0			
				16.7–19.7	27	71	2	0			
				19.7–22.7	25	74	1	0			
				22.7–25.0	31	68	1	0			
				Mean	26	72	2	trace	trace	trace	
a + **b** + **c** + **d**	21	73	6	Mean	21	66	5	2	3	3	

NZ 51 SW 15 5357 1065 South of Stanley Grange **Block D**

Surface level (+85.0 m) +279 ft
Water not encountered
December 1977

Waste 18.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, red- to chocolate-brown; small pebbles of Carboniferous and Permo-Triassic rocks	8.3	8.5
	Clay, chocolate-brown, poorly laminated	1.2	9.7
	Clay, chocolate brown; small pebbles of Carboniferous and Permo-Triassic rocks	6.3	16.0
	Silty clay, yellow- to chocolate-brown, laminated; sandy partings	2.0+	18.0

NZ 51 SW 16 5466 1055 West of Bartle Bridge **Block A**

Surface level (+77.4 m) +254 ft
Water struck at +73.6 m
February 1977

Overburden 3.8 m
Mineral 1.4 m
Waste 14.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
River Terrace Deposits	Clay, red-brown, with angular pebbles of Carboniferous sandstone	3.5	3.8
Glacial Sand and Gravel	Gravel Gravel: fine with coarse, angular to rounded sandstone with limestone, extrusive igneous rocks and dolomite and bladed, mudstone Sand: coarse, quartz with some sandstone and dark rocks	1.4	5.2
	Clay, silty in parts, brown, laminated	4.2	9.4
Till	Clay, red-brown; pebbles of Carboniferous sandstone, permo-Triassic rocks and grey mudstone and basalt cobble at 13.0 m	10.6+	20.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
3	19	78	3.8–5.2	3	2	4	13	46	32	

NZ 51 SE 5 5609 1233 South-west of White Gate House **Block D**

Surface level (+102.7 m) +337 ft
Water not encountered
December 1977

Waste 2.5 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, yellow-brown with Carboniferous sandstone pebbles at top, grey at base with grey mudstone fragments	2.3	2.5
Lower Lias	Mudstone, grey, friable	1.5+	4.0

NZ 51 SE 6 5531 1080 West of Ayton Hall **Block A**

Surface level (+80.5) +264 ft
Water struck at +79.9 m
November 1977

Overburden 1.8 m
Mineral 6.4 m
Waste 12.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
River Terrace Deposits	Clay, yellow at top, grey at base, laminated; silt and sand lenses in parts	1.6	1.8
Glacial Sand and Gravel	Gravel Gravel: fine and coarse, angular to rounded, sandstone with limestone, extrusive igneous rocks, dolomite, bladed mudstone and shale Sand: coarse, with medium, angular to subrounded, quartz with sandstone and dark rocks	6.4	8.2
	Clay, brown, laminated, with yellow-brown silt bands	2.4	10.6
Till	Clay, grey-brown; pebbles of sandstone, Permo-Triassic rocks and dark grey shale	10.4+	21.0

GRADING

Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
3	44	53	1.8–2.8	8	13	15	14	22	28	
			2.8–3.8	2	3	8	25	34	28	
			3.8–4.8	2	8	22	31	27	10	
			4.8–5.8	3	5	18	19	23	32	
			5.8–6.8	1	3	18	23	31	24	
			6.8–8.2	3	3	14	25	29	26	
			Mean	3	6	15	23	28	25	

COMPOSITION

Depth below surface (m)	Percentage by weight in gravel fraction						
	Sand-stone	Lime-stone	Quartz and quartzite	Igneous	Dolom-ite	Chert	Shale and mudstone
1.8–2.8	52	13	2	7	5	5	16
3.8–4.8	49	15	5	12	7	2	10
6.8–8.2	49	12	3	27	2	2	5

NZ 51 SE 7 5771 1118 Undercliffe **Block D**

Surface level (+147.8 m) +485 ft
Water struck at +141.8 m
December 1977

Overburden 3.2 m
Mineral 7.7 m
Waste 0.7 m
Mineral 13.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, brown; pebbles of Carboniferous and Permo-Triassic rocks	2.4	2.7
	Clay, brown, laminated, with sandy partings	0.5	3.2
Glacial Sand and Gravel	**a** 'Very clayey' sand Sand: fine quartz Fines: brown laminated 'clay' bands	7.7	10.9
	Clay, red-brown, sandy; small pebbles of sandstone and dark rocks	0.7	11.6
	b 'Clayey' sand; fine quartz	13.4+	25.0

GRADING

	Mean for deposit *percentages*			Depth below surface (m)	Bulk samples *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
a	24	76	0	3.2–4.2	39	60	1				
				4.2–5.2	31	68	1				
				5.2–6.2	32	65	3				
				6.2–7.2	21	75	4				
				7.2–8.2	15	81	4				
				8.2–9.2	15	82	3				
				9.2–10.9	20	77	3				
				Mean	24	73	3				
b	17	83	0	11.6–12.6	25	72	3	0			
				12.6–13.6	23	73	3	1			
				13.6–14.6	19	76	4	1			
				14.6–15.6	17	78	4	1			
				15.6–16.6	15	80	5	0			
				16.6–17.6	16	79	5	0			
				17.6–19.6	16	80	4	0			
				19.6–21.6	18	78	3	1			
				21.6–23.6	14	81	4	1			
				23.6–25.0	18	78	4	0			
				Mean	17	78	4	1			
a + b	20	80	0	Mean	20	76	4	trace			

APPENDIX G

LIST OF WORKINGS

Sand and gravel is no longer worked in the district. Pits at the locations listed below formerly exploited Glacial Sand and Gravel; they have been restored to other uses.

Location	*Grid reference*
Great Ayton	577 112
Great Ayton	574 113
Seamer	511 111
Seamer	502 102
Castle Leavington	449 095
Ingleby Greenhow	594 067

APPENDIX H

CONVERSION TABLE, METRES TO FEET (to nearest 0.5 ft)

m	ft	m	ft	m	ft	m	ft	m	ft
0.1	0.5	6.1	20	12.1	39.5	18.1	59.5	24.1	79
0.2	0.5	6.2	20.5	12.2	40	18.2	59.5	24.2	79.5
0.3	1	6.3	20.5	12.3	40.5	18.3	60	24.3	79.5
0.4	1.5	6.4	21	12.4	40.5	18.4	60.5	24.4	80
0.5	1.5	6.5	21.5	12.5	41	18.5	60.5	24.5	80.5
0.6	2	6.6	21.5	12.6	41.5	18.6	61	24.6	80.5
0.7	2.5	6.7	22	12.7	41.5	18.7	61.5	24.7	81
0.8	2.5	6.8	22.5	12.8	42	18.8	61.5	24.8	81.5
0.9	3	6.9	22.5	12.9	42.5	18.9	62	24.9	81.5
1.0	3.5	7.0	23	13.0	42.5	19.0	62.5	25.0	82
1.1	3.5	7.1	23.5	13.1	43	19.1	62.5	25.1	82.5
1.2	4	7.2	23.5	13.2	43.5	19.2	63	25.2	82.5
1.3	4.5	7.3	24	13.3	43.5	19.3	63.5	25.3	83
1.4	4.5	7.4	24.5	13.4	44	19.4	63.5	25.4	83.5
1.5	5	7.5	24.5	13.5	44.5	19.5	64	25.5	83.5
1.6	5	7.6	25	13.6	44.5	19.6	64.5	25.6	84
1.7	5.5	7.7	25.5	13.7	45	19.7	64.5	25.7	84.5
1.8	6	7.8	25.5	13.8	45.5	19.8	65	25.8	84.5
1.9	6	7.9	26	13.9	45.5	19.9	65.5	25.9	85
2.0	6.5	8.0	26	14.0	46	20.0	65.5	26.0	85.5
2.1	7	8.1	26.5	14.1	46.5	20.1	66	26.1	85.5
2.2	7	8.2	27	14.2	46.5	20.2	66.5	26.2	86
2.3	7.5	8.3	27	14.3	47	20.3	66.5	26.3	86.5
2.4	8	8.4	27.5	14.4	47	20.4	67	26.4	86.5
2.5	8	8.5	28	14.5	47.5	20.5	67.5	26.5	87
2.6	8.5	8.6	28	14.6	48	20.6	67.5	26.6	87.5
2.7	9	8.7	28.5	14.7	48	20.7	68	26.7	87.5
2.8	9	8.8	29	14.8	48.5	20.8	68	26.8	88
2.9	9.5	8.9	29	14.9	49	20.9	68.5	26.9	88.5
3.0	10	9.0	29.5	15.0	49	21.0	69	27.0	88.5
3.1	10	9.1	30	15.1	49.5	21.1	69	27.1	89
3.2	10.5	9.2	30	15.2	50	21.2	69.5	27.2	89
3.3	11	9.3	30.5	15.3	50	21.3	70	27.3	89.5
3.4	11	9.4	31	15.4	50.5	21.4	70	27.4	90
3.5	11.5	9.5	31	15.5	51	21.5	70.5	27.5	90
3.6	12	9.6	31.5	15.6	51	21.6	71	27.6	90.5
3.7	12	9.7	32	15.7	51.5	21.7	71	27.7	91
3.8	12.5	9.8	32	15.8	52	21.8	71.5	27.8	91
3.9	13	9.9	32.5	15.9	52	21.9	72	27.9	91.5
4.0	13	10.0	33	16.0	52.5	22.0	72	28.0	92
4.1	13.5	10.1	33	16.1	53	22.1	72.5	28.1	92
4.2	14	10.2	33.5	16.2	53	22.2	73	28.2	92.5
4.3	14	10.3	34	16.3	53.5	22.3	73	28.3	93
4.4	14.5	10.4	34	16.4	54	22.4	73.5	28.4	93
4.5	15	10.5	34.5	16.5	54	22.5	74	28.5	93.5
4.6	15	10.6	35	16.6	54.5	22.6	74	28.6	94
4.7	15.5	10.7	35	16.7	55	22.7	74.5	28.7	94
4.8	15.5	10.8	35.5	16.8	55	22.8	75	28.8	94.5
4.9	16	10.9	36	16.9	55.5	22.9	75	28.9	95
5.0	16.5	11.0	36	17.0	56	23.0	75.5	29.0	95
5.1	17	11.1	36.5	17.1	56	23.1	76	29.1	95.5
5.2	17	11.2	36.5	17.2	56.5	23.2	76	29.2	96
5.3	17.5	11.3	37	17.3	57	23.3	76.5	29.3	96
5.4	17.5	11.4	37.5	17.4	57	23.4	77	29.4	96.5
5.5	18	11.5	37.5	17.5	57.5	23.5	77	29.5	97
5.6	18.5	11.6	38	17.6	57.5	23.6	77.5	29.6	97
5.7	18.5	11.7	38.5	17.7	58	23.7	78	29.7	97.5
5.8	19	11.8	38.5	17.8	58.5	23.8	78	29.8	98
5.9	19.5	11.9	39	17.9	58.5	23.9	78.5	29.9	98
6.0	19.5	12.0	39.5	18.0	59	24.0	78.5	30.0	98.5

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INSTITUTE OF GEOLOGICAL SCIENCES

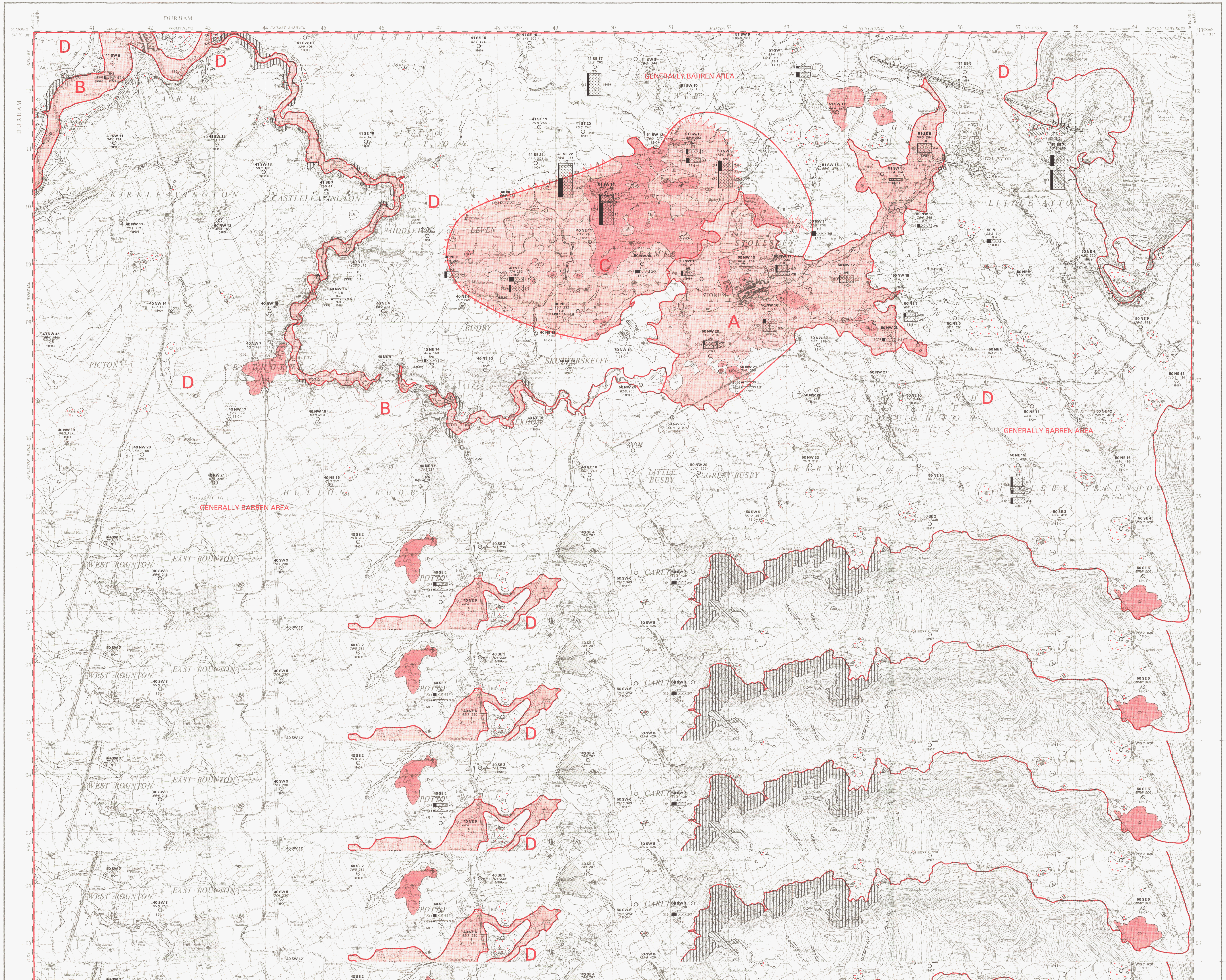
INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND & GRAVEL RESOURCES OF SHEETS NZ 40 & NZ 50 & PARTS OF NZ 41 & NZ 51 (STOKESLEY, NORTH YORKSHIRE)

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

SHEETS NZ40 & NZ50 & Parts of NZ41 & NZ51

ORDNANCE SURVEY PROVISIONAL EDITION



THE SAND & GRAVEL RESOURCES OF SHEETS NZ 40 & NZ 50 & PARTS OF NZ 41 & NZ 51 (STOKESLEY, NORTH YORKSHIRE)

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

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EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Landslip L-1

DRIFT

RECENT AND PLEISTOCENE

- **Peat** P-1
- **Alluvium** – clays and silts with sands and gravels beneath. A-50
- **Alluvial Fan** AF-4
- **River Terrace, undifferentiated** – silts and clays with sands and gravels. RT-19
- **Lacustrine Deposits** – clays with silt and sand bands and rare basal gravels. LA-5
- **Fluvio Glacial Delta Sand** – fine sand and laminated clay. FL-7
- **Glacial Sand and Gravel** – mainly sand with sporadic gravel bands. GS-54
- **Laminated Clay** – laminated clay with silt and sand bands. LC-5
- **Till** – stiff brown and grey stony clay. TL-6

SOLID

JURASSIC AND TRIASSIC

- J **Jurassic, undivided** – mudstones, sandstones, seatearths, ironstones, limestones and coals.
- Rh **Rhaetic** – grey and green shaly mudstone (not exposed).
- MMG **Mercia Mudstone Group (Keuper Marl)** – red and green mudstones, siltstones and sporadic sandstones.
- SSG **Sherwood Sandstone Group (Bunter Sandstone)** – red and yellow fine grained sandstone.

INTRUSIVE

- D **Dolerite** – quartz tholeiite (Tertiary).

Made ground MG-2

Worked areas of clay WO-19

BOUNDARY LINES

- Geological boundary, Drift
- Geological boundary, Solid
- Inferred boundary between categories of deposits
- Resource Block boundary

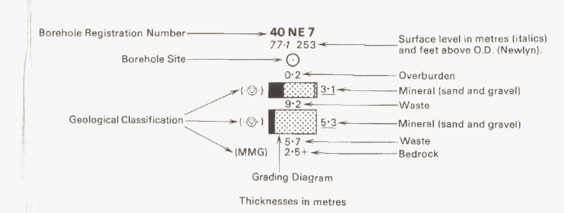
Broken line denotes uncertainty

BOREHOLE DATA

SITE LOCATIONS

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

I.M.A.U. BOREHOLES



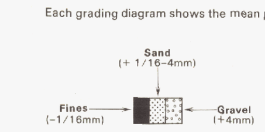
Note:
1. Figures underlined denote thicknesses used in the assessment of resources.
2. The + sign indicates that the base of the deposit was not reached.
3. The figures in *italics* are the conversions of measurements recorded in feet.
4. The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each I.M.A.U. borehole is identified by a Registration Number, e.g. **40 NE 7.** The first number and letters refer to the quarter sheet, and the second number to the I.G.S. serial number for that quarter. The unique designation for borehole **40 NE 7** is **NZ 40 NE 7.**

Grading Diagrams

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



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

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

OTHER BOREHOLES

The layout of information is the same as for I.M.A.U. boreholes, although data

3. The figures in *italics* are the conversions of measurements recorded in feet.
4. The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number
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Each grading diagram shows the mean particle-size distribution of a distinct deposit of mineral.
The height of the diagram is proportional to the mineral thickness.
The widths of the divisions show the proportions of Fines, Sand and Gravel but small amounts of gravel may be omitted or exaggerated.
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