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ASSESSMENT OF BRITISH SAND AND GRAVEL RESOURCES No. 4

The sand and gravel resources of the country around Maldon, Essex

Description of 1 : 25 000 resource sheet TL 80

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PREFACE

It has become increasingly clear in recent years that an assessment of resources of many minerals should be undertaken. This is a Report of the Mineral Assessment Unit which was set up in May 1968 to undertake such work. It describes and quantifies the resources of sand and gravel of 51 km^2 of country around Maldon, Essex, shown on the accompanying 1:25 000 resource sheet TL 80.

This survey is concerned with assessing sand and gravel resources on a regional scale at the indicated level; the deposits are not outlined completely nor their grade established throughout. The work may be regarded as the application to large areas of methods used commercially for evaluating reserves on small sites. It may also be regarded as an extension of geological mapping by providing information about the thickness and quality of deposits.

Data collected during a feasibility study conducted in the Maldon-Goldhanger area between April 1966 and September 1967 by Dr. R.G. Thurrell as Project Leader, were augmented by further drilling and sampling in 1968 under the direction of Mr. H.J.E. Haggard with Mr. A.R. Clayton as field officer, and in 1969 under the control of Mr. J.D. Ambrose with Mr. N.E. Bradbury as field officer. The preparation of this report was undertaken by Mr. J.D. Ambrose with the assistance of Mr. G.M. Bladon. The work is based on a geological survey at 1:10 560 in 1966 and 1969 by Dr. C.R. Bristow (East Anglia and South-East England Field Unit) who has also helped in the geological interpretation.

Mr. J.W. Gardner, C.B.E. (Land Agent) has been responsible for negotiating access to land for drilling. The ready cooperation of land owners and tenants in this work is gratefully acknowledged. Special thanks are due to Dr. T.L. Thomas of the Royal School of Mines, London, for his advice on methods of resource calculation.

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The geological maps of the Institute of Geological Sciences, pre-existing borehole information and seventy-three boreholes drilled specifically for assessment purposes (of which sixty-one were part of a feasibility study conducted in 1966-67 and twelve were drilled subsequently) form the basis of the assessment of sand and gravel resources in the Maldon area, Essex.

All deposits in the area which might be potentially workable for sand and gravel (mineral) have been investigated geologically and a simple statistical method has been used to estimate the volume. The reliability of the volume estimates is given at the 95 per cent confidence level.

The 1:25 000 map is divided into resource blocks, each ideally containing approximately 10 km^2 of sand and gravel. For each block the mineral bearing area, the mean thickness of overburden and mineral, and the mean grading are given and the geomorphology and geology of the deposits described.

The position of the boreholes and exposures, the geology and topography and the outlines of the blocks are shown on the accompanying map TL 80. Detailed borehole data are given.

Sommaire

Les cartes géologiques de l'Institute of Geological Sciences, les renseignements sur des trous de sonde qui existaient déjà, et soixante-treize trous de sonde, forés précisément dans le but d'évaluation, (soixante et un de ces trous faisaient partie d'une étude de practicabilité effectuée en 1966-67, et douze étaient forés plus tard) constituent la base de l'évaluation des ressources en sable et en gravier dans la région de Maldon, Essex.

Tous les dépôts dans la région, qui présentent la possibilité d'exploitation pour le sable et le gravier (minéral), ont été étudiés de point de vue géologique, et on s'est servi d'une méthode statistique simple pour en évaluer le volume. Les évaluations de volume sont tenues d'être à 95 pour cent exacts.

La carte 1:25 000 est divisée en blocs de ressources, chacun d'eux ayant idéalement environ 10 km^2 de sable et de gravier. On donne pour chaque bloc l'étendue mineralisée, l'épaisseur moyenne de recouvrement et de minéral, et la gradation moyenne. On décrit aussi la géomorphologie et la géologie des dépôts.

La situation des trous de sonde et des affleurements, la géologie et la topographie, et la configuration des blocs sont montrées sur la carte TL 80. Des données détaillées des trous de sonde sont présentées.

Zusammenfassung

Die geologischen Karten von der Institute of Geological Sciences, die vorher existierende Information im Bezug auf Bohrlöchern, auch 73 (dreiundsiebensig) Bohrlocher, die für einen bestimmten Einschätzungszweck gebohrt wurden, bilden den Grund für die Einschätzung der Sand- und Schottermittel im Malden Gebiet, Essex. Aus diesen dreiundsiebensig Bohrlöchern waren einundsechzig ein Bestandteil von einer in 1966-67 durchgefuhrten Möglichkeitsarbeit, und zwölf wurden später gebohrt.

Man hat im gebiet alle Ablagerungen, die möglich bearbeitbar für Sand und Shotter (Mineral) sind, geologisch untersucht, und man hat eine einfache statistische Methode benutzt, um das Volumen zu schätzen. Man gibt die Zuverlässigkeit der Volumenschatzungen mit 95 Prozent Vertrauens grenzwerten.

Man teilt die 1:25 000 Karte in Mittelsblöcke, wovon jeder ungefähr 10 km^2 von Sand und Schotter theoretisch einschliesst. Für jeden Block gibt man das mineral haltige Gebiet, die Durchschmittsdicke von Überlastung und Mineral, und die Durchschnittsklassifizierung, und beschreibt die Geomorphologie und Geologie der Ablagerungen.

Man zeigt die Lage von Bohrlöchern und Aufschlüssen die Geologie und Topographie und auch die Skizzen von den Blöcken auf der Begleitkarte TL 80. Man gibt auch ausführliche Bohrlöcherdaten.

The sand and gravel resources of the country around Maldon, Essex

Description of 1:25 000 resource sheet TL 80

J. D. AMBROSE,[1] BSc

Introduction

AIMS AND LIMITATIONS

National resources of many of the 'bulk' or 'industrial' minerals may seem so large that stocktaking is unnecessary, but the demand for land for all purposes and for minerals is intensifying. In contrast with other developments of land there may be little or no choice of area for the working of minerals and in the case of low-price materials such as sand and gravel transport costs will be an important factor. Whereas the economic benefit of using land for many other purposes can be assessed, hitherto little has been known of the potential value, on a regional scale, of any mineral resources which may be present. An important aim of the work is to improve the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971).

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding the most urgent attention, particularly in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. Following a short feasibility project, initiated in 1966 by the Ministry of Land and Natural Resources, the Mineral Assessment Unit began systematic surveys on a regional scale in Essex, Suffolk, and Norfolk in May 1968. This work is being supported by the Department of the Environment (which incorporates the former Ministries of Housing and Local Government, and Public Building and Works) and is being undertaken with the co-operation of the Sand and Gravel Association of Great Britain (SAGA). The detail is at the 'indicated' level, a term introduced in the United States in connection with the estimation of national mineral resources. The level is that 'for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geological 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' (Anon., 1948, p. 15).

The survey is therefore not concerned with the estimation of reserves (which can only be assessed in the light of particular or existing economic considerations), but rather with resources, which include deposits which are not currently exploitable but have a foreseeable use. Clearly the social and economic criteria used to decide whether a deposit may be workable at some time in the future cannot be rigorously defined. After discussion with the industry, the following arbitrary physical criteria were adopted for this survey:

a. the deposit should average at least 3 ft (0.9 m) in thickness
b. the ratio of overburden to sand and gravel should be no more than 3:1
c. the proportion of fines (that is, particles passing 1/16 mm (approximately No. 200 mesh B.S. sieve)) should not exceed 40 per cent.

Ground below 80 ft (24.4 m) from the surface is seldom explored, this being taken as the likely maximum working depth under most circumstances. It follows that boreholes are drilled no deeper than 60 ft (18.3 m) if they are still in overburden.

A 'deposit' of sand and gravel that broadly fulfils the above criteria is considered to be 'potentially workable' and is assessed as 'mineral'. It is recognised that small parts of such a deposit may not satisfy all the requirements.

The volume and chief characteristics of sand and gravel within defined but relatively large areas, referred to as resource blocks, are assessed. Ideally, each

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resource block contains roughly 10 km^2 of sand and gravel.

The consequent limitation of the use to which the results can be put must be emphasised. The assessments of quantity and composition apply to the resource blocks 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.

It follows that reserves, which are accurately demarcated areas of economically workable mineral, must be proved by the customary detailed exploration undertaken by the industry. However, the information provided about the resource blocks in an area may assist in the selection of the best targets for such commercial exploration and evaluation.

Thus the work can be regarded as the statistically controlled application to large areas of methods similar to those applied by industry to establish the existence of workable reserves on a relatively small site, and also as an extension of conventional geological mapping techniques, which delineate (with varying degrees of accuracy, depending, for example, on the presence of cover) the areal extent of deposits.

PROCEDURE

Trial and error during preliminary studies showed that for the complex and variable glacial deposits of East Anglia and Essex, an absolute minimum of five sample-points evenly distributed across the sand and gravel are needed to provide a worthwhile statistical assessment, but that, ideally, there should be no fewer than ten. Sample-points are any points for which there exists adequate information about the nature and thickness of the deposit and, apart from the holes drilled during the survey, may include exposures and other boreholes. In particular, the cooperation of sand and gravel operators has ensured that boreholes have not been drilled where reliable information was already available. Such data are held confidentially by the Institute and cannot be disclosed, although they may have been used in the calculations.

The mineral shown on each 1:25 000 sheet is divided into resource blocks. The arbitrary size selected, 10 km^2, is a compromise to meet the aims of the survey and to provide sufficient sample-points in each block. As far as possible the block boundaries are determined by geological boundaries; for example, wherever practicable glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology. The blocks are drawn provisionally before drilling begins.

A reconnaissance of the ground is carried out to establish whether there are 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. Ideally the distribution should be unbiassed with respect to the geology, to ensure that the data obtained are representative of any broad trends in the variation in thickness or grading, as this will govern spot values.

However, because broad trends are independently overlaid by smaller scale variations, characteristically random in form, it is unnecessary to adhere to a square grid pattern. Thus such factors as ease of access and the need to minimise disturbance to land and the public have been taken into account in siting the holes; at the same time it has been necessary to guard against the possibility that ease of access (that is, the positions of roads and farms) may reflect particular geological conditions, which may bias the drilling results. In siting the boreholes and in the subsequent calculations, no account is taken of any factors, for example, roads, villages and areas of high agricultural and landscape value, which might stand in the way of sand and gravel being exploited. The estimate of total volume of sand and gravel therefore bears no simple relationship to the amount that could be extracted in practice.

Ideally 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 100 ft (30 m) at a diameter of about 8 in (200 mm) and beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites difficult of access) and it should be fast. Although uncased continuous flight power augers can meet these requirements in some ground, they fail below the water table, in some

clay-free sand and gravel when the mineral does not stay on the flights, or when the borehole caves. On the area covered by this sheet the German Wirth B1 drill (or B0 modified) was used extensively. With this machine, casing can be advanced at the same time as the hole is being drilled, thus minimising disturbance to the ground, and avoiding contamination and caving. In difficult ground a bailer can be substituted for the auger although this method suffers from the disadvantage that there is a tendency for the pumping action to draw unwanted material into the hole either from the sides or the bottom. Other machines, including conventional 'shell and augers', were also used.

A continuous series of bulk samples is taken throughout the thickness of sand and gravel. Ideally, samples are composed exclusively of the whole of the material previously occupying the space defined by the hole's ideal dimensions, as determined by the internal diameter of the casing and the thickness penetrated. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or for every 3 ft (0.9 m) of depth. The samples are despatched in heavy-duty polythene bags to a laboratory for grading. Care is taken to discard, as far as possible, material which has caved, or been pumped from the bottom of a hole. The samples sent for analysis each weigh 60-100 lb (27-45 kg). The grading procedure is based on BS 1377: 1967. Random checks are made on the accuracy of the laboratory grading.

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

Detailed records may be consulted at the appropriate offices of the Institute, upon application to the Director.

The methods used in estimating the volume of mineral and other statistics for each of the resource blocks are described in Appendix A and the results are quoted on page 9.

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 boundary lines, symbols, etc., shown are taken from the geological map of this area, which was surveyed recently at the scale of 1:10 560. This information was obtained by detailed application of field mapping techniques by the field staff in the Institute's East Anglia and South-East England Unit. Borehole data, which include the stratigraphic relations and mean particle-size distribution of the sand and gravel samples collected during the assessment survey, are also shown.

The geological boundaries are regarded as the best interpretation of the information available at the time of survey. However, it is inevitable, particularly with glacial deposits (such as those included in the area of sheet TL 80) which change rapidly vertically and laterally, that local irregularities or discrepancies will be revealed by some boreholes (for example, at boreholes NW9 and NW12). These are taken into account in the assessment of resources.

Mineral Resource Information

For assessment purposes the map is divided into areas of mineral and areas where sand and gravel is either not potentially workable or absent (for definitions of 'mineral' and 'potentially workable' see page 1).

The mineral on TL 80 is subdivided into areas where it crops out, and areas where it is present in continuous (or almost continuous) spreads beneath overburden. The whole area of exposed sand and gravel as mapped is considered as mineral, although there may be small patches where sand and gravel is not present or is not potentially workable.

Beneath overburden mineral may be continuous (or almost continuous) or discontinuous. The recognition of these categories is subjective, depending on the importance attached to the proportion of boreholes which did not find potentially workable sand and gravel and the distribution of barren boreholes within a block. The mineral is described as 'almost continuous' if it is present in 75 per cent or more of the boreholes in a resource block. The 'discontinuous' category has not been recognised on the present sheet.

Areas where bedrock crops out, where boreholes indicate absence of sand and gravel beneath cover, where sand and gravel beneath cover is interpreted to be not potentially workable and areas not assessed, are uncoloured on the Map. Where appropriate the relevant criterion is noted. In such areas it is 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.

The area of exposed sand and gravel is measured from the mapped geological boundary lines. Inferred boundaries have been inserted around areas where sand and gravel beneath cover is interpreted to be not potentially workable or absent. Such boundaries (shown by a distinctive symbol) are drawn primarily for the purpose of volume estimation. The symbol is intended to convey 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 centre-line of the symbol is used.

Description of Sheet TL 80

GENERAL

For assessment purposes the area of the map has been divided almost exactly into halves by a line drawn along the northern shores of the Blackwater Estuary as far west as Maldon; then southward along grid line east 85 to its intersection with grid line north 05, and finally due south-west to the corner of the map. This line divides the sand and gravel bearing country to the north and west from an area to the south and east where little sand and gravel is present. This latter area, of 49.3 km^2, comprises the Blackwater Estuary and land to the south which is nearly all exposed London Clay with isolated patches of drift, mainly Head and Alluvium. Of the remaining 50.7 km^2 of ground, 32.4 km^2 are gravel bearing, and form the subject of this Report.

TOPOGRAPHY

The most important topographical feature on this map is the valley of the River Chelmer, which runs from near Ulting, where it is relatively constricted, eastward to its confluence with the River Blackwater, south of Langford, and then south-eastwards to beyond Maldon, where it broadens out to form an extensive muddy estuary. To the north of this valley the land rises fairly evenly to a height of over 125 ft (38 m) in the north-west near Ulting, and less evenly to heights of between 50 ft (15 m) and 75 ft (23 m) east of Langford.

The land also rises, quite steeply in places, to heights of over 200 ft (61 m) O.D., south of the River Chelmer where Glacial Sand and Gravel crops out, and the higher ground is extensively dissected, especially in the north between Woodham Walter, Woodham Mortimer, and Maldon. Farther south where mainly London Clay is exposed, the surface of this high ground is somewhat more even and plateau-like, and lies at heights of about 160 ft (49 m) to 180 ft (55 m).

To the east the ground is lower, the surface falling gently eastward between Maldon and Woodham Mortimer, but quite steeply eastwards between the latter and Cold Norton, to a relatively low, broad undulating area south of the Blackwater Estuary where shallow marshy valleys are developed on the London Clay.

GEOLOGY

The deposits which crop out in the sheet area are shown in Table 1. The Lower London Tertiary formations and the Chalk have been proved in boreholes.

Table 1. Deposits which outcrop in the area of resource sheet TL 80

- Drift (Recent and Quaternary)
  - Landslip
  - Alluvium, Marine and Estuarine
  - Alluvium, Marine Beach Deposits
  - River Terrace Gravels: first, second and third terraces of the Rivers Chelmer and Blackwater
  - Brickearth
  - Head and Head Brickearth
  - Glacial Sand and Gravel
  - Chalky Boulder Clay (Maldon Till of Clayton, 1957)
- Solid (Eocene)
  - Bagshot Beds
  - Claygate Beds
  - London Clay

On this sheet the mineral in blocks A and D is Glacial Sand and Gravel and in blocks B and C terrace and alluvial deposits. The following descriptive account of the deposits, their geological relations with one another and to formations forming bedrock and overburden in the area, is intended only to be of assistance in appreciating the distribution of the sand and gravel resources.

London Clay

The London Clay is the main solid formation or bedrock, upon which all the unconsolidated drift deposits rest in the area; Claygate Beds, mapped in the southern part of the sheet and Bagshot Beds in the extreme south-west, occupy relatively small areas. As the drift is mainly confined to the northern and western parts of the sheet the London Clay is extensively exposed in the south and east. When fresh, it is bluish-grey in colour but the top few feet are usually weathered to brown. As all assessment boreholes were stopped when undoubted London Clay had been reached, it is usually this weathered brown clay which is recorded in them.

The borehole information indicates that

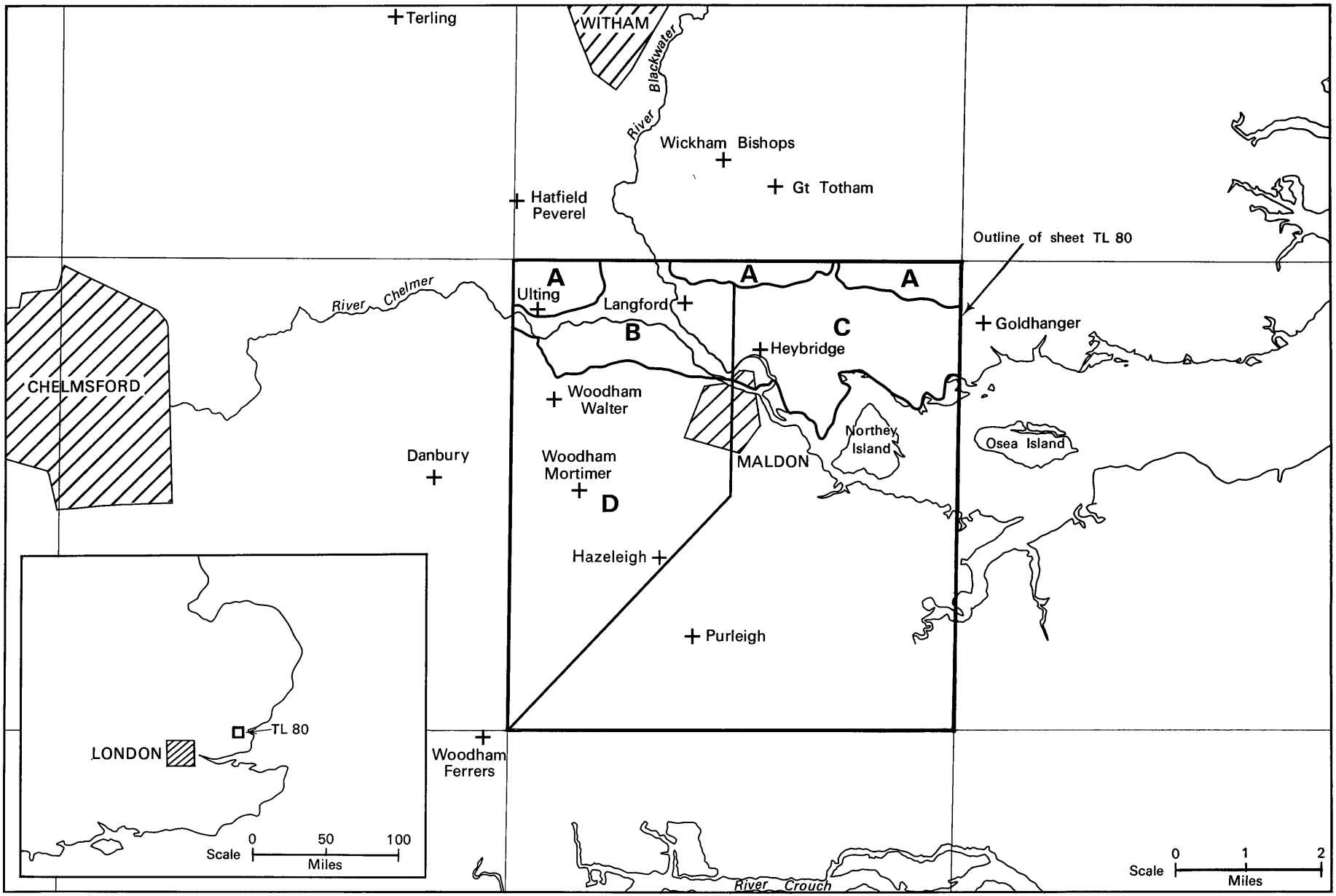


Fig. 1. Sketch map showing the location of the sheet area and the position of the resource block boundaries

the surface of the London Clay in the north, beneath the terraces of the River Chelmer, is gently undulating, with a number of shallow ridges and depressions. The axis of the largest depression roughly coincides with the course of the River Chelmer, and there is normally a gentle downward gradient from the north towards this line. Other small scale depressions interrupt this gradient in places, but they are more difficult to trace. Borehole information however, shows that the London Clay surface between the Hospital [860 089][1] and Middle Farm [865 078] ranges from about 4 ft (1.2 m) above O.D. in NE 9 to about 2 ft (0.6 m) below O.D. in NE 34 and 10 ft (3.0 m) below O.D. in NE 3, whilst in adjacent areas it is at about 7 ft (2.1 m) above O.D. in NE 1 and as much as 13 ft (4.0 m) above O.D. in NE 11. Depressions also occur near Saltcote Hall [872 079] where the surface is about 1 ft (0.3 m) above O.D. in NE 12 and about the same height in NE 29. Between Heybridge and Langford, however, the drift cover is thinner and the London Clay surface lies at 7 ft (2.1 m) above O.D. in NE 10 and NW 4 and 10 ft (3.0 m) above O.D. in NW 5 and NW 7.

To the south-west of the River Chelmer, the London Clay surface rises irregularly beneath the Glacial Sand and Gravel of block D. It becomes very uneven, especially westwards towards Danbury Hill, where it is known to have been deformed, probably by large scale frost-heaving (see Bristow, 1967, p. 62; Clayton, 1957, fig. 1, p. 25).

In borehole NW 13 London Clay was met at a height of approximately 84 ft (25.6 m) above O.D. while only 230 yd (210 m) or so to the south it crops out at a height of approximately 155 ft (47 m) above O.D.

Maldon Till

The Glacial Sand and Gravel normally rests directly on London Clay, but locally a boulder clay, the Maldon Till (Clayton, 1957), lies between them. During the present survey of this sheet, however, this boulder clay was not found in any of the boreholes, though its existence has been proved in adjacent areas.

Glacial Sand and Gravel

The Glacial Sand and Gravel is to be found mainly south of the River Chelmer in the Woodham Walter and Woodham Mortimer area, and in isolated outcrops north of the River. On adjacent 1:25 000 sheets to the north and west, these deposits are usually to be found in a continuous, even spread beneath a cover of boulder clay, the Springfield Till of Clayton (1957), whereas within this sheet area they are normally covered only sporadically by thin patches of Head or Brickearth. The absence of a protective cover of Boulder Clay on this sheet has allowed the sand and gravel to be eroded more extensively especially in the south where it rests on the highest levels of the irregular surface of the underlying London Clay. As a result, there is great variability in both the thickness and distribution of the Glacial Sand and Gravel.

In composition the mineral consists mainly of gravels or sandy gravels, which are relatively free of fines north of the River Chelmer, but become increasingly 'clayey' (see page 17) to the south, where the percentage of fine material present is frequently too high for the deposits to be considered potentially workable. In borehole SW 12 for example, the Glacial Sand and Gravel falls into this category. Distinct layers of clay are present in some of the boreholes, for example NW 12 and NW 13, but they are localised lenses rather than widespread beds.

Head

South of the River Chelmer and along the northern margin of the sheet, patches of Head occur, frequently resting on the Glacial Sand and Gravel, or occasionally directly on London Clay. The Head has been proved in a number of boreholes to be a brown clay or silty clay containing varying proportions of sand and pebbles. The variability of the deposit is demonstrated by the presence in borehole NW 80 south of the river and in two others, NE 26 (which for cartographic reasons has not been shown on the map) and NE 27, in the north-east of the sheet, of sufficient proportions of sand or gravel to render it 'potentially workable' within the terms of the survey. Such instances are regarded as exceptional, however, and are not included in the assessments.

Brickearth

Less commonly patches of Brickearth of very variable thickness rest on Glacial

[1] National Grid References in this publication all lie within the 100 km square TL (52).

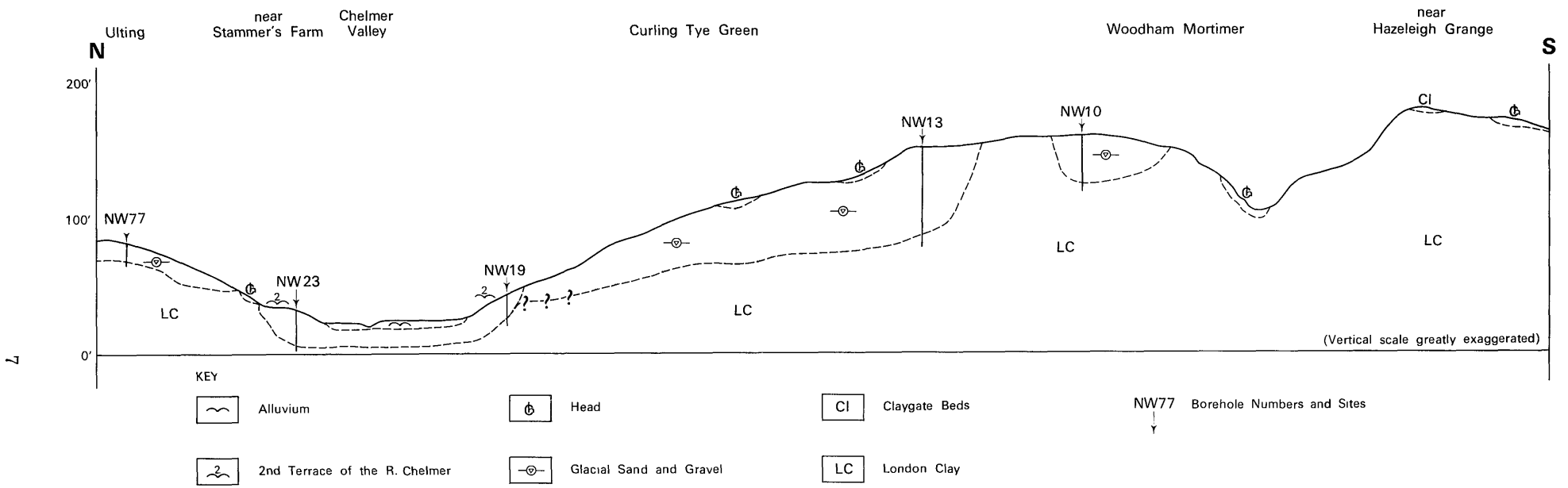


Fig. 2. Sketch section along grid line east 82, between Ulting and Woodham Mortimer

Sand and Gravel or on London Clay. Boreholes in Brickearth have proved negligible thicknesses, though in an exposure at Warren Farm Pit [805 062] 12 ft (3.7 m) of reddish or greyish-brown silty clay are present.

River Terrace Deposits

River terraces are developed on both banks of the River Chelmer west of Maldon, but generally only on the northern bank of the estuary east of Maldon. The terrace deposits rest directly on London Clay and consist of gravels or sandy gravels, sometimes with significant percentages of fines. Although the distribution of the fines does not appear to follow any distinct pattern, the highest concentrations of gravel were found in boreholes to the north and east of Chigborough Farm [878 083] and to the south-west and south-east of Langford [837 090]. The thickness of the Terrace Gravels seems to be related to the topography of the London Clay surface on which they rest, since the thickest gravels tend to occur where there are depressions in the London Clay surface.

Boreholes have frequently proved a layer of river brickearth (a local term for fine grained alluvial deposits) overlying the terrace gravels which rarely exceeds $6\frac{1}{2}$ ft (2.0 m) and is usually between 4 ft (1.2 m) and 5 ft (1.5 m) in thickness.

Other deposits of sand and gravel which occur beneath the Alluvium in this area have been termed 'Sub-alluvium Gravels'. In average thickness and grading they are very similar to the gravels of the first terrace of the River Chelmer, and probably represent part of a continuous spread of gravels deposited before the recent alluvial material of the present river was spread over them.

Alluvium

The thickness of the recent Alluvium overlying these gravels is about 5 ft (1.5 m); the Alluvium consists of brown or grey clays and silty clays with traces of sands and pebbles. It is also present in some of the tributary valleys of the Chelmer.

COMPOSITION OF THE SAND AND GRAVEL DEPOSITS

The potentially workable sand and gravel on this sheet is almost entirely confined to the following deposits: Terrace Gravels; Sub-alluvium Gravels; Glacial Sand and Gravel.

Terrace Gravels

Three terraces of the River Chelmer have been recognised on this sheet. Their mean grading is fines 8 per cent; sand 32 per cent; gravel 60 per cent. The gravel usually ranges from fine to coarse, and cobbles sometimes occur, though these do not constitute more than 3 per cent of the mineral in any borehole. The sand is medium, or sometimes medium to coarse, with a little fine sand in places. Fines are usually present but they rarely exceed 10 or 15 per cent. The mean grading figures calculated for each terrace are all similar, except that the gravel of the first terrace is somewhat coarser than that in the older spreads.

Sub-alluvium Gravels

The mean grading of the Sub-alluvium Gravels (fines 8 per cent; sand 25 per cent gravel 67 per cent) indicates that they are somewhat more gravelly than the terraces. The gravel is similar in grade to that of the terraces, while the sand is medium to coarse, with fine sand often almost absent. Fines are again commonly present, particularly near the top of the deposit, perhaps due to downward movement of the fine grained material contained in the overlying alluvial clays and silts.

Glacial Sand and Gravel

The Glacial Sand and Gravel contains more fines than either of the other types of deposit, both in the sand and gravel and as distinct clayey lenticles in some boreholes. There is normally between 10 and 20 per cent of fines recorded in the mineral in most boreholes, and over 20 per cent in a few. The gravel consists of almost equal proportions of fine and coarse grade material; the former is composed of sub-angular to sub-rounded flint and sub-rounded quartz and the latter is mainly sub-angular flint. Cobbles are rare but have been recorded in a few boreholes.

The sand is predominantly medium-grained, often accompanied by varying amounts of fine and coarse grade. When examined it is composed of sub-angular quartz and is brown or red-brown in colour. The mean grading figures for the Glacial Sand and Gravel are fines 13 per cent; sand 45 per cent; gravel 42 per cent.

RESULTS

The results of the assessment of mineral resources are summarised in Table 2. Fuller grading particulars are given in Fig. 3.

Table 2. The sand and gravel resources of sheet TL 80

Block	Area		Mean thickness				Volume of sand and gravel				Mean grading percentages		
	Block	Sand and Gravel	Overburden		Sand and Gravel		Million m^3	Million yd^3	Limits at the 95% confidence level		Fines	Sand	Gravel
	km^2	km^2	m	ft	m	ft			±%	±Vol. million m^3	$-\frac{1}{16}$ mm	$+\frac{1}{16}-4$ mm	+4 mm
A	6.8	3.1	1.3	$4\frac{1}{4}$	4.8	$15\frac{3}{4}$	14.9	19.5	80	11.9	4	36	60
B	7.5	7.5	1.3	$4\frac{1}{4}$	4.6	15	34.5	45.1	26	9.0	7	28	65
C	9.9	9.9	1.1	$3\frac{1}{2}$	3.0	10	29.7	38.8	16	4.8	9	32	59
D	26.5	11.9	1.8	6	6.3	$20\frac{3}{4}$	75.0	98.1	32	24.0	15	47	38
Total A to D	50.7	32.4					154.1	201.6	17	26.2			

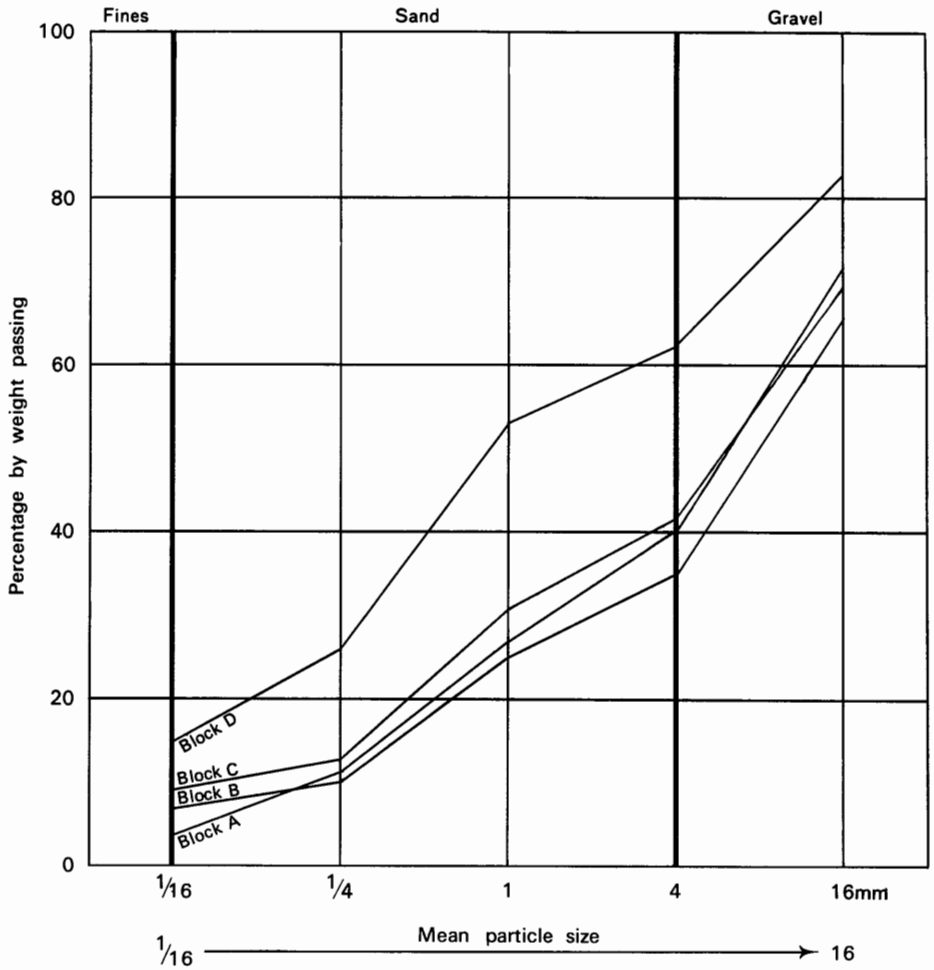
Accuracy of Results

For the resource blocks B, C and D on sheet TL 80, the accuracy of the results at the 95 per cent confidence level (that is, the probability that nineteen times out of twenty the true volume present lies within the stated limits) varies between 16 per cent and 32 per cent of the mean. For block A the accuracy is unusually poor, ±80 per cent. It should be remembered, however, that the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of volume of a very much smaller parcel of ground (say 200 acres) containing similar sand and gravel deposits if the results from the same number of sample-points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves, data from more than ten sample-points would be required, even if the area were quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel on sheet TL 80. The total volume (154 million m^3) can be estimated to limits of ± 17 per cent at the 95 per cent confidence level, by a calculation based on the data from the eighty sample-points spread across the four resource blocks. However, it must again be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be extracted in practice, because no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

NOTES ON RESOURCE BLOCKS A-D

Block A

The mineral in this block, mainly Glacial Sand and Gravel, crops out in isolated patches near the northernmost borders of the area of this sheet but is more extensive on the sheet to the north (Haggard, 1972). The most



BLOCK	Percentage by weight passing				
	1/16mm	1/4mm	1mm	4 mm	16 mm
A	4	11	27	40	72
B	7	10	25	35	66
C	9	13	31	41	70
D	15	26	53	.62	83

Fig. 3. Particle size distribution for the assessed thickness of sand and gravel in the resource blocks A to D

extensive deposit, in the north-west around Ulting, is partially covered by sheets of Head and Brickearth, but its boundary with the underlying London Clay is exposed at two places. Elsewhere the junction is not exposed and its position beneath cover has been inferred. East of the River Blackwater the isolated patches of Glacial Sand and Gravel are mainly free of cover and London Clay is also exposed more extensively. A sheet of Brickearth, present between Langford and Broad Street Green, overlaps sand and gravel near the latter place, and probably conceals the edges of the terrace deposits of blocks B and C along its southern margins. In the north-east of the block there are patches of Head concealing some of the sand and gravel. Only three assessment boreholes were put down into the Glacial Sand and Gravel in this block because of its patchy discontinuous nature and the existence of unreleased commercial records which are not shown on the map. Most of the boreholes were drilled in the largest deposit near Ulting, where mineral was found to be fairly consistent in thickness although in NW 22, which is nearer to the valley of the Chelmer, 33 ft (10.1 m) of mineral was recorded. The overburden in this area was 11 ft (3.4 m) in NW 76 and 4 ft (1.2 m) in NW 77, whilst in NW 22 the only cover was 2 ft (0.6 m) of soil.

East of the Blackwater, where the Glacial Sand and Gravel is most patchy, information about its thickness is sparse, and confined to unreleased commercial records. Two assessment holes in this area, NE 7 and NE 8 penetrated the patch of brickearth west of Broad Street Green. In the former 2 ft (0.6 m) of overburden rests on 5 ft (1.5 m) of mineral which has been classified as part of the second terrace of the River Chelmer and represents an extension beneath cover of the deposits described in block C. In the latter the same thickness of overburden is recorded resting directly on London Clay, suggesting that neither the terrace gravels nor the Glacial Sand and Gravel, which can be seen at the surface to the east, extend far beneath the Brickearth here.

In the extreme east of the area, south of Little London Farm [887 096] two holes, NE 26 and NE 27, have proved deposits classified as 'Head' resting directly on London Clay (for cartographic reasons only the latter is shown on the map) but samples proved to be sufficiently 'clay free' to be regarded as mineral within the terms of this survey.

Grading information in this block is available only for the mineral in holes NW 22, NW 76, and NW 77, all in the Ulting area, for which the mean grading figures are fines 4 per cent; sand 36 per cent; gravel 60 per cent.

The statistical assessment of the volume of mineral for this block is 14.9 million m^3 $\pm$ 80 per cent at the 95 per cent confidence level, which is a reflection of the uncertainty to be expected when attempting to assess such irregular and patchy mineral deposits from the few sampling points available.

Block B

The mineral in this block consists of Terrace and Sub-alluvium gravels. The terraces are present on both banks of the River Chelmer and also alongside the River Blackwater to the north of Langford. They narrow westwards and finally disappear near Ulting, where the valley of the Chelmer is most constricted. The second terrace, which normally occurs at a height of between 20 ft (6.1 m) and 25 ft (7.6 m) above sea level, is the better developed in this area, but remnants of a lower first terrace, at a height of about 10 ft (3.0 m), are found south of Stammer's Farm [818 091], west of Langford and at Maldon, all on the northern bank of the river, and west of Beeleigh Falls House [840 082] on the southern bank. In addition small isolated patches of the first and second terraces of the River Blackwater occur north-north-west of Langford. Frequently the terrace deposits are covered with a layer of river brickearth usually about $4\frac{1}{2}$ ft (1.4 m) thick reaching a recorded maximum of 9 ft (2.7 m) in NW 19.

The alluvial deposits in this block occur in a broad spread about 550 yd (500 m) wide bounding the River Chelmer and a smaller band of 220 yd (200 m) width bounding the River Blackwater. All the holes put down through the Alluvium have proved gravel.

The mean thickness of the Terrace Gravels is $13\frac{3}{4}$ ft (4.2 m) and the range of thickness is from 6 ft (1.8 m) in NW 5 to 36 ft (11.0 m) in NW 18. There is a marked difference between the first terrace, for which the mean thickness is $10\frac{1}{4}$ ft (3.1 m), and the second, for which it is $15\frac{3}{4}$ ft (4.8 m). The overall mean grading for the terrace deposits shows fines 8 per cent; sand 29 per cent; gravel 63 per cent. The first terrace is more gravelly and less sandy than the second, figures for the former being, fines 4 per cent; sand 22 per cent; gravel 74 per cent and for the latter, fines 9 per cent; sand 29 per cent; gravel 62 per cent.

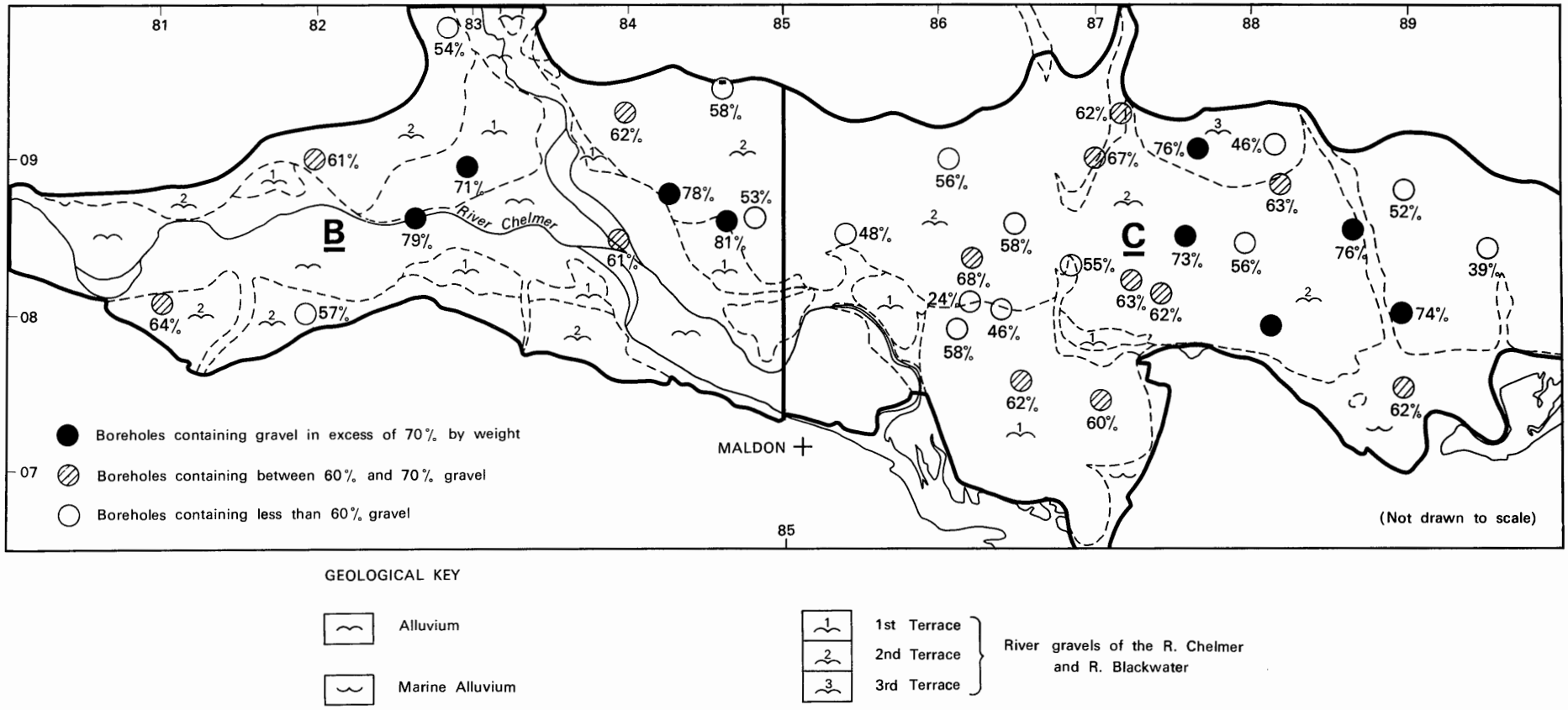


Fig. 4. Gravel percentages from mean gradings at individual Mineral Assessment Unit borehole sites in blocks B and C

The Sub-alluvium Gravels range from 4 ft (1.2 m) to 15 ft (4.6 m) in thickness with a mean figure of 9¼ ft (2.8 m), which is similar to the mean for the sand and gravel of the first terrace. In addition the mean grading of the Sub-alluvium Gravels, which is fines 5 per cent; sand 20 per cent; gravel 75 per cent, approximates to the mean grading for the first terrace, suggesting that the Sub-alluvium Gravels may be continuous with the deposits of the first terrace.

The mineral deposits in the block have been combined together for the purpose of volume assessment, because the information available for the deposits of the first terrace and for the Sub-alluvium Gravels is not considered to be sufficiently comprehensive to justify separate assessment. The volume calculated for the block is 34.5 million m^3 ± 26 per cent at the 95 per cent confidence level. The overall mean grading for the block is calculated as fines 7 per cent; sand 28 per cent; gravel 65 per cent.

Block C

This block is similar to block B in that it contains Terrace and Sub-alluvium Gravels. However, the Alluvium beneath which the latter occur is confined to a narrow strip of Marine Alluvium bordering the Blackwater Estuary, and two thin, sinuous deposits of River Alluvium running north-south across the area.

The terraces of the River Chelmer make up the remainder of the block. The first terrace occurs only between Heybridge and Heybridge Basin, while over the remainder of the block the second terrace is present, except for a small isolated remnant of the third terrace in the north between Slough House Farm [871 091] and Chappel Farm [885 089]. As in block B the terrace deposits are covered in places by a layer of River Brickearth between 4 ft (1.2 m) and 6 ft (1.8 m) in thickness. A deposit thought possibly to be Head is also recorded, for example, 4 ft (1.2 m) in boreholes NE 23 and NE 25; undoubted Head reaches 12 ft (3.7 m) in borehole NE 36.

The mean thickness of the mineral as a whole within the block is 9½ ft (2.9 m), while the mean for the mineral of the second terrace, which makes up most of the block, lies close to this at 9¼ ft (2.8 m). The mineral of the first terrace is recorded at six boreholes and these proved a range of thickness from 10 ft (3.0 m) to 15 ft (4.6 m) with a mean of 12 ft (3.7 m). The third terrace was sampled at only two sites, NE 25 and NE 36. At the former 9 ft (2.8 m) of gravel were proved beneath 4 ft (1.2 m) of brown sandy clay, and at the latter 7 ft (2.1 m) of 'clayey' gravel beneath 12 ft (3.7 m) of brown silty clay.

Mineral was penetrated beneath Alluvium in five holes, two of which, NE 24 and NE 31, lie in the valley of Spickett's Brook. In the former 7 ft (2.1 m) of mineral were recorded beneath 3 ft (0.9 m) of overburden and in the latter the thicknesses were 9 ft (2.8 m) of mineral beneath 2 ft (0.6 m) of cover. The remaining three holes were put down through Marine Alluvium bordering the Blackwater Estuary, and prove the existence of thicker mineral deposits. The holes are NE 22 and 241/38 and 241/78 (Davies and Standon Batt, 1965), and the mineral thicknesses recorded were respectively 16 ft (4.8 m), 21 ft (6.4 m) and 10 ft (3.0 m).

Grading information for the Terrace Gravels does not reveal any notable variation in mean grading between the first, second and third terraces, except that the two sample points in the last suggest that it may be slightly more gravelly. The mineral occurring beneath Alluvium cannot be distinguished from that of the terraces by grading. Consequently only the mean figures for all the mineral within the block have been calculated: fines 9 per cent; sand 32 per cent; gravel 59 per cent. The distribution of gravel within the terrace deposits here and in block B appears to show some regularity in that holes in which a high percentage of the mineral is gravel appear to be concentrated in two areas as illustrated in Fig. 4: there may not, however, be any significance in these data. All the mineral deposits within this block have been combined for the purpose of volume assessment, because of their similarity in grading and because several are restricted in occurrence and do not therefore merit separate assessment. The estimate of volume is 29.7 million m^3 ± 16 per cent.

Block D

All the mineral within this block is Glacial Sand and Gravel resting directly on London Clay, which occupies most of the south and east and is exposed by erosion in the valleys to the north and west. Elsewhere patches of Head and Brickearth provide a cover as do thin strips of Alluvium which border the rivers in most of the larger valleys.

The thickest mineral was in borehole NW 12 where 51 ft (15.5 m) was recorded and in NW 13 45 ft (13.7 m) was proved. These are composite figures, however, because in both holes two clay bands up to 6 ft (1.8 m) thick divide the mineral. This is also the case in NW 8. The presence of

clays within the Glacial Sand and Gravel sequence is a feature mainly confined to the south of the block and in SW 12 the entire thickness of sand and gravel was considered to have too high a content of fines to be regarded as mineral. As well as this increase in clay content the mineral also thins and has a patchy distribution to the south and east. As a result several holes put down in these areas, for example, SW 15 and SW 16, have proved that mineral is absent beneath cover.

The cover beneath which the mineral is sometimes concealed varies both in nature and extent. Patches of Brickearth have been mapped in places, for example, north-west of Oak Farm [811 061], but it has been recorded only in borehole SW 16 where 17 ft (5.2 m) of brown sandy clay rests directly on London Clay with no mineral between. Head, however, is more widespread in occurrence and has been penetrated in several holes, for example, NW 16 and NW 80. It consists normally of about 10 ft (3.0 m) to 13 ft (4.0 m) of brown sandy or gravelly clay, except in NW 16 where 21 ft (6.4 m) of brown, silty clay becoming increasingly sandy with depth, are recorded. The variable nature of the Head deposits is demonstrated in NW 80, where, of the 12 ft (3.7 m) of Head recorded, 3 ft (0.9 m) was found to be sufficiently sandy to be classed as mineral within the terms of reference of the survey, though it has not been included in the assessment.

The grading figures for the mineral as a whole within the block are fines 15 per cent; sand 47 per cent; gravel 38 per cent. It is difficult to distinguish any pronounced trends in grading, although there may be a general increase in sand content and a corresponding reduction in gravel in an easterly direction. The fines content of the mineral is variable; it attains maximum values of greater than 20 per cent in holes NW 15 and NW 17.

The volume of mineral within the block has been calculated as 75.0 million $m^3 \pm 32$ per cent.

LIST OF QUARRIES

In 1971 five pits were known to be in operation in the area. A list of pits believed to be still operational, and others that are abandoned, is given in Table 3.

Table 3. List of quarries on sheet TL 80 and their locations.

Working Pits

Location	Grid reference
Warren Farm, Woodham Walter	805 065
Royal Oak, Danbury	801 053
Chigborough Farm, Heybridge	875 085
Heybridge Hall, Maldon	864 070

Other Pits

Location	
Crouchman's Farm, Ulting	800 096
Manor Farm, Woodham Walter	857 116
Hoemills, Ulting Wick	806 085
Whitehouse Farm, Woodham Walter	812 073

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Appendix A: Assessment Procedure

1. Within a resource block, a statistical assessment is made for a sampled area of mineral greater than 2 km^2 and containing a minimum of five evenly-spaced boreholes.

2. If the sampled area of mineral is between 0.25 and 2 km^2 and contains one or two suitably sited boreholes an inferred assessment is made. An inferred assessment may also be attempted for any area where the deduced mineral content is small and which consequently has not been sampled by boreholes. No specific level of accuracy is claimed for such subjective assessments.

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

Statistical Assessment

4. The simple methods used in the calculations are consistent with the amount of data provided by the survey. Conventional confidence limits (that is, the tolerance on the estimate or the range within which the result falls) are calculated at the two-sided 95 per cent confidence level, that is, there is a $2\frac{1}{2}$ per cent or 1 in 40 chance that the result exceeds the stated upper limit and a corresponding $2\frac{1}{2}$ per cent chance that it is less than the stated lower limit.

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

$$S_V = \sqrt{S_A^2 + S_{\bar{l}}^2} \quad \ldots\ldots\ldots (1)$$

where S_V, S_A and $S_{\bar{l}}$ are the standard deviations for volume, area and mean thickness, expressed as proportions of V, A and $\bar{l}$, respectively.

6. The above relationship may be transposed such that

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

From this it can be seen that as $(\frac{S_A}{S_{\bar{l}}})$ tends to 0, S_V tends to $S_{\bar{l}}$. 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.

7. Given that the number of approximately evenly spaced sample points in the sampled area is n, with mineral thickness measurements l_1, l_2, ... l_n, then the best estimate of mean thickness, $\bar{l}$ =

$$\frac{\sum(l_1 + l_2 \ldots l_n)}{n}$$

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, $S_{\bar{l}}$ expressed as a proportion of the mean thickness is given by

$$S_{\bar{l}} = \frac{1}{\bar{l}} \sqrt{\frac{\sum(l - \bar{l})^2}{n\ (n - 1)}}$$ where l is any value in the series l_1 to l_n.

8. The sampled area A in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of a deposit). Generally, therefore, the only error in determining the area is the negligible planimetering error and S_A is 0. Where the area is not defined by a mapped boundary, that is, where the boundary is inferred (and the distinctive symbol is used), experience suggests that S_A is small relative to $S_{\bar{l}}$.

The relationship

$$\frac{S_A}{S_{\bar{l}}} \leqslant \frac{1}{3}$$ is assumed in all cases.

It follows from equation (2) that

$$S_{\bar{l}} \leqslant S_V \leqslant 1.05\, S_{\bar{l}} \quad \ldots\ldots\ldots (3)$$

9. The two-sided 95 per cent confidence limits, $L_{\bar{l}}$, for the estimate of mean thickness of mineral in the sampled area, for values of n between 5 and 20, may be expressed in absolute units.

$$\bar{l} \pm (t \times S_{\bar{l}} \times \bar{l}),$$

or as a percentage

$$\bar{l} \pm (t \times S_{\bar{l}} \times 100) \text{ per cent}$$

where t is Student's t at the two-sided 95 per cent confidence level for (n - 1) degrees of freedom and is evaluated by reference to statistical tables. In applying Student's t it is assumed that the measurements are distributed normally.

10. Values of t at the two-sided 95 per cent confidence level for values of n up to 20 are set out below:

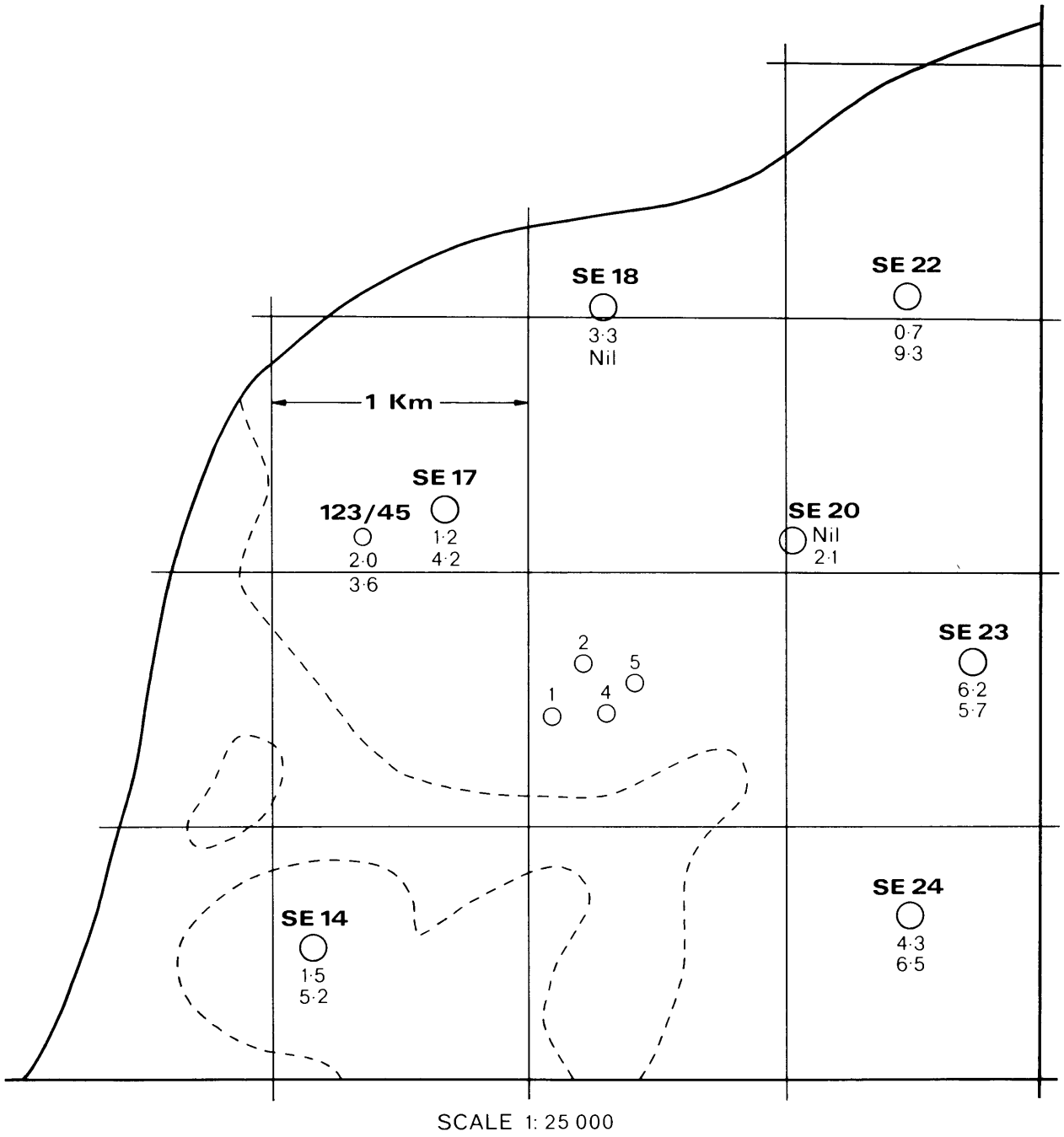


Fig. 5. Example of resource block assessment: map of a fictitious block

BLOCK CALCULATION

1:25 000 Sheet } Fictitious
Block }

Area

Block: 11.08 km^2
Mineral: 8.32 km^2

Thickness

Overburden: 2.5 m
Mineral: 4.5 m

Volume

Overburden: 21 million m^3
Mineral: 38 million m^3

95 per cent confidence limits of the estimate of mineral volume

Percentage: ± 53 per cent
Units of volume: ± 20 million m^3

Thickness estimate (l = thickness)
Measurements in metres

Sample point	Weighting w	Overburden lo	Overburden wlo	Mineral lm	Mineral wlm	Remarks
SE 14	1	1.5	1.5	5.2	5.2	MAU Boreholes
SE 18	1	3.3	3.3	nil	-	
SE 20	1	nil	-	2.1	2.1	
SE 22	1	0.7	0.7	9.3	9.3	
SE 23	1	6.2	6.2	5.7	5.7	
SE 24	1	4.3	4.3	6.5	6.5	
SE 17	½	1.2	1.6	4.2	3.9	
123/45	½	2.0		3.6		Hydrogeol. Dept. record
1	¼	2.4	2.5(25)*	3.4	3.6(25)*	Close group of four boreholes (commercial)
2	¼	4.5		0.8		
4	¼	0.4		4.3		
5	¼	2.8		6.0		
Totals	∑w = 8	∑wlo = 20.1(25)*		∑wlm = 36.3(25)*		
Averages		$\bar{l}o$ = 2.5(16)*		$\bar{l}m$ = 4.5(41)*		

Calculation of Confidence Limits

l	(l - $\bar{l}$)	(l - $\bar{l}$)^2
5.2	0.7	0.49
nil	4.5	20.25
2.1	2.4	5.76
9.3	4.8	23.04
5.7	1.2	1.44
6.5	2.0	4.00
3.9	0.6	0.36
3.6	0.9	0.81
∑l = 36.3 (25)	∑(l - $\bar{l}$)^2 = 56.15	
n = 8		
$\bar{l}$ = 4.5 (41)		
≃ 4.5		

n = 8
t = 2.365

$$L_V = 1.05 \frac{t}{\bar{l}} \sqrt{\frac{\sum(l - \bar{l})^2}{n(n-1)}} \times 100$$

$$= 1.05 \times \frac{2.365}{4.541} \sqrt{\frac{56.15}{8 \times 7}} \times 100$$

= 54.77

≃ 55%

* The figures in brackets are additional decimal places used only in the calculation of confidence limits.

Fig. 6. Example of resource block assessment: statement and calculation

n	t	n	t
1	∞	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 Ed. Cambridge University Press, 1962).

The value of t, 1.96, when n is infinity is used when n is greater than 20.

11. In calculating the two-sided 95 per cent confidence limits for volume, L_V, the following inequality corresponding to (3) is applied:

$$L_{\bar{l}} \leqslant L_V \leqslant 1.05 \; L_{\bar{l}}$$

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

$$\frac{1.05 \times t}{\bar{l}} \times \sqrt{\frac{\Sigma(l - \bar{l})^2}{n\,(n-1)}} \times 100 \text{ per cent}$$

and when n is greater than 20, as

$$\frac{1.05 \times 1.96}{\bar{l}} \times \sqrt{\frac{\Sigma(l - \bar{l})^2}{n\,(n-1)}} \times 100 \text{ per cent}$$

13. An illustration of the procedures outlined above is given in Figs. 5 and 6, where a volume estimate with confidence limits at the 95 per cent level of confidence is derived from fictitious data.

Inferred Assessments

14. If the sampled area of mineral in a resource block is between 0.25 km^2 and 2 km^2 an assessment is inferred based on geological and topographical information usually supported by the data from one or two suitably sited boreholes. The volume of mineral is calculated as the product of the sampled area, chosen from interpretation of field data as in the statistical assessment, and the judged average mineral thickness. Confidence limits are not calculated.

15. In some cases in addition to the sampled area of mineral a resource block includes an area left uncoloured on the map, generally based on interpretation of mapping and sample data. On occasions some mineral may be present in such areas and an assessment is made on the basis of the average mineral thickness deduced from exposures and any other evidence available.

Note on Weighting

16. The thickness of a deposit at any point in a sampled area may be governed solely by the position of the point in relation to a broad trend. However, most sand and gravel deposits in addition exhibit a random pattern of local, and sometimes considerable, variation in thickness.

17. Thus, in estimating mean thickness of sand and gravel from a number of data points in a sampled area only the use of simple weighting factors is justified, and the distribution of data points need be only approximately regular. In practice, equal weighting can often be applied to thicknesses at all data points within the sampled area. If, however, there is a distinctly unequal distribution of points, the thicknesses must be weighted to avoid the bias this creates. Weighting factors are determined by first 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.

Appendix B: Classification and Description of Sand and Gravel

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for the purposes of this Report. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when the proportion of sand is greater than that of gravel which must exceed 10 per cent, fines and oversize materials (that is, with diameter greater than 64 mm) being less than 10 per cent. Because deposits containing more than 10 per cent fines (material less than 1/16 mm) are not embraced by this system a modified binary classification based on Willman (1942) has been adopted.

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.

When the fines content exceeds 40 per cent the material is considered to be not potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel and 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 1/16 mm. Thus it has no mineralogical significance

1/16 mm. Thus it has no mineralogical significance and includes particles falling within the size limits of silt. Wherever the term clay does not appear in single quotation marks the normal meaning applies.

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 Fig 7). The procedure is as follows.

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

For example, a deposit grading: gravel, 11 per cent; sand, 70 per cent; fines, 19 per cent is classified as 'clayey' pebbly sand. This short description is included in the borehole log (see Note 10, p.23).

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 1/16 mm size, which approximates to the generally accepted boundary between silt and sand. In this and other respects the system shown in Table 4, used in this report, is satisfactory. It is based on Udden's geometric scale and a simplified form of Wentworth's terminology.

The fairly wide intervals in the scale are consistent with the general level of accuracy of the quantitative assessments of the resource blocks. Three sizes of sand are recognised, fine (-¼ + 1/16 mm), medium (-1 + ¼ mm) and coarse (-4 +1 mm). The boundary at 16 mm distinguishes a range of finer gravel (-16 + 4 mm), often characterised by abundance of worn tough pebbles of vein quartz, from coarser ranges often of notably different average composition. The boundary at 64 mm distinguishes pebbles from cobbles. The term 'gravel' is used loosely to denote both pebble-sized and cobble-sized material.

The size distribution of borehole samples is determined by sieve analysis, and is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standard 1377:67). In this report the grading is tabulated on the borehole record sheets (Appendix C), the intercepts corresponding with the simple geometric scale 1/16 mm, ¼ mm, 1 mm, 4 mm, 16 mm, and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

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

The relative proportions of the rock types present in the gravel fraction are indicated by 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 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.

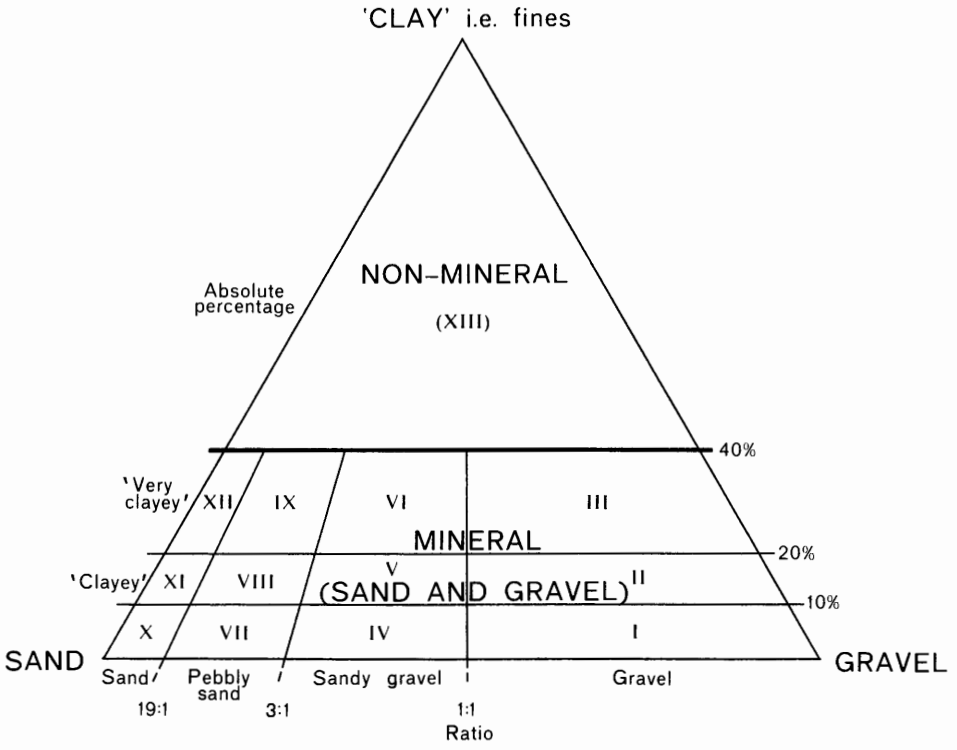
Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. Original grain shape is still distinct.

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 4. Classification of gravel, sand and fines

Size limits	Grain size description	Qualification	Primary Classification
	Cobble		Gravel
64 mm			
16 mm	Pebble	Coarse Fine	
4 mm	Sand	Coarse	Sand
1 mm		Medium	
¼ mm		Fine	
1/16 mm			
	Fines (silt and clay)		Fines



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

Fig. 7. Diagram showing the descriptive categories used in the classification of sand and gravel

Appendix C: Borehole Records

EXPLANATION

Annotated Example of a Borehole Record (fictitious)

TL 80 SE 5[1] 8594 0450[2] Woodham Walter[3]

Surface level (+50. 3 m) +165 ft*[4]
Water not struck[5]
Wirth B1, 8 inch diam.[6]
August 1969[6]

Overburden[7] (0. 9 m) 3 ft
Mineral (9. 1 m) 30 ft
Waste (11. 6 m) 38 ft
Mineral (2. 8 m+) 9 ft+[8]

			Thickness (m)	Thickness ft	Depth[11] (m)	Depth[11] ft
		Soil[10]	(0. 9)	3	(0. 9)	3
Glacial Sand and Gravel[9]	(a)	Pebbly sand. Clayey from 9 to 15 ft Gravel: medium with fine and coarse, sub-rounded to sub-angular flint, with a trace of sub-rounded quartz Sand: medium with fine and coarse, sub-angular. Light brown	(9. 1)	30	(10. 0)	33
Boulder Clay		Dark grey chalky clay, with traces of sand and gravel at the top, becoming brown and sandy near the base	(11. 6)	38	(21. 6)	71
Glacial Sand and Gravel	(b)	Sand Gravel: fine, sub-angular, mainly flint Sand: fine and medium, sub-angular. Orange to brown. Traces of grey clay	(2. 8+)	9+	(24. 4)	80

(a)[15]

	%	mm	%
Gravel	23	+64	0
		-64+16	12
		-16+4	11
Sand	73	-4+1	8
		-1+$\frac{1}{4}$	45
		-$\frac{1}{4}$+1/16	20
Fines	4	-1/16	4

(b)

	%	mm	%
Gravel	2	+64	0
		-64+16	0
		-16+4	2
Sand	95	-4+1	3
		-1+$\frac{1}{4}$	42
		-$\frac{1}{4}$+1/16	50
Fines	3	-1/16	3

Depth below surface (ft)[12]	Percentage[13] Fines	Sand	Gravel
3 - 6	2	66	32
6 - 9	1	83	16
9 - 12	12	80	8
12 - 15	10	78	12
15 - 18	11	86	3
18 - 21	No grading available[14]		
21 - 24	1	53	46
24 - 27	0	71	29
27 - 30	1	73	26
30 - 33	0	75	25
71 - 74	0	97	3
74 - 77	1	99	0
77 - 80	8	89	3

* An asterisk indicates that the surface level was estimated.

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

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

1) The number of the 1 : 25 000 sheet on which the borehole lies, for example, TL 80.
2) The quarter of the 1 : 25 000 sheet on which the borehole lies and its number in a series for that quarter, for example, SE 5.

Thus the full Registration Number is TL 80 SE 5. Usually this is abbreviated to SE 5 in the text.

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

3. Location.
The borehole location is generally referred to the nearest named locality on the 1 : 25 000 base map.

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

5. Groundwater Conditions.
Three kinds of entry are made; either, the level at which groundwater was encountered is given in metres and feet above Ordnance Datum; or, where no groundwater was encountered, this is stated; or, where there is no record of the groundwater conditions, this is stated.

6. Type of Drill and Date of Drilling.
Most of the drilling for this survey has been done by Wirth B1 machines (cased, continuous flight, powered augers) though some of the drilling for a feasibility study in 1966-67, (data from which are included in this Report), was done by a less sophisticated power auger without facilities for casing. The type of machine, the external diameter of the casing used, and the month and year of completion of the borehole 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, rock type, country rock or rock-head, below which potentially workable sand and gravel will not be found. In the Maldon area the bedrock is London Clay.

Waste is any material other than bedrock or mineral. Where waste occurs between the surface and a mineral horizon it is classified as overburden.

Thicknesses are given in metres and feet.

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

9. Geological Classification.
A geological classification of the strata encountered in drilling is given whenever possible. (For an explanation of the terms used see p. 4).

10. Lithological Description.
When sand and gravel is recorded, a general description based on the mean grading characteristics is followed by more detailed particulars. (For explanation of conventions see Appendix B). A description of other rock types is based on visual field examination.

11. Depth.
The figures relate to depths from surface to base of the strata recorded on the log.

12. Sampling.
A continuous series of bulk samples is taken throughout the thickness of sand and gravel. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or for every 3 ft of depth.

13. Grading Results.
The limits are as follows: gravel, +4 mm; sand, -4+1/16 mm; fines, -1/16 mm.

14. Exceptionally the results of the grading of a sample or horizon may not be available. No attempt has been made to estimate the probable grading of such samples and the grading diagram may not be shown on the map.

15. Mean Grading.
The mean grading for the mineral thickness is the mean of the individual sample gradings, but where the thicknesses of mineral represented by the samples are not constant each grading result is first weighted by its relative thickness.

The results are given for the three main classes, Gravel, Sand and Fines, and for the smaller ranges within these classes.

Since fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high, there may be differences between the gradings determined during the survey and the corresponding in-situ grading of the deposit. Comparison with exposures suggests that the proportion of sand in the samples collected from boreholes may be somewhat higher. Conversely the results suggest that the proportion of fines and of +16 mm material may be lower.

Note on metrication

1) All measurements were made in feet. Approximate metric conversions appear in brackets.
2) Metric conversions of measurements of the depth and thickness of beds have been rounded off to the nearest 0.1 m, because quotation to two places of decimals would imply a higher order of accuracy than could be justified by the original figures. To eliminate any discrepancy appearing after metrication between depth as recorded and depth as obtained by summing thicknesses, adjustment has been made where necessary to one or more of the thickness figures. However, the recorded mineral thickness is not adjusted.

LIST OF ASSESSMENT BOREHOLES ON SHEET TL 80

Borehole Number (by sheet quadrant)	Grid Reference (all fall in 100 km square TL)	Borehole Number	Grid Reference
TL 80 NW		TL 80 NE (cont.)	
2	8400 0933		
3	8459 0942	12	8757 0855
4	8426 0882	13	8799 0848
5	8463 0861	16	8900 0877
7	8484 0864	17	8866 0854
8	8016 0506	18	8814 0794
9	8099 0501	19	8851 0800
10	8200 0523	20	8899 0800
11	8004 0605	21	8951 0844
12	8101 0599	22	8898 0748
13	8200 0600	23	8701 0899
15	8035 0727	24	8718 0931
16	8168 0700	25	8762 0906
17	8267 0713	26	8858 0912
18	8100 0809	27	8857 0917
19	8194 0802	28	8746 0814
20	8262 0862	29	8724 0821
21	8392 0850	31	8691 0833
22	8100 0904	32	8622 0838
23	8200 0900	33	8623 0810
24	8297 0894	34	8645 0804
76	8084 0965	35	8824 0885
77	8198 0985	36	8821 0911
78	8287 0980		
79	8282 0753		
80	8347 0715		
TL 80 NE		TL 80 SW	
1	8650 0860		
2	8614 0791	11	8072 0469
3	8654 0759	12	8047 0379
4	8703 0748	13	8060 0298
7	8505 0955	14	8133 0435
8	8594 0957	15	8152 0337
9	8609 0900	16	8135 0255
10	8540 0856	17	8258 0406
11	8570 0830		

THE RECORDS

TL 80 NW 2 8400 0933 Langford

Surface level (+9.1 m) +30 ft*
Water struck at (+5.5 m) +18 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0.9 m) 3 ft
Mineral (7.6 m) 25 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and Brickearth	(0.9)	3	(0.9)	3
River Terrace	Gravel. 'Very clayey' near top. A few cobbles at base	(7.6)	25	(8.5)	28
London Clay	Clay	(0.6+)	2+	(9.1)	30

	%	mm	%
Gravel	62	+16	: 35
		-16+4	: 27
Sand	28	-4+1	: 10
		-1+$\frac{1}{4}$	: 14
		-$\frac{1}{4}$+1/16	: 4
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
Sampling	22	27	51
interval	5	37	58
not	8	23	69
known	5	23	72

TL 80 NW 3 8459 0942 Langford

Surface level (+9.1 m) +30 ft*
Water struck at (+6.4 m) + 21 ft*
Power auger, 8 inch diam.
April 1967

Overburden (3.0 m) 10 ft
Mineral (5.5 m) 18 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and Brickearth	(0.9)	3	(0.9)	3
River Terrace	Gravel	(0.6)	2	(1.5)	5
	Brown Clay	(1.5)	5	(3.0)	10
	Gravel	(5.5)	18	(8.5)	28
London Clay	Clay	(0.6+)	2+	(9.1)	30

	%	mm	%
Gravel	58	+16	: 25
		-16+4	: 33
Sand	35	-4+1	: 10
		-1+$\frac{1}{4}$	: 21
		-$\frac{1}{4}$+1/16	: 4
Fines	7	-1/16	: 7

Depth below surface (ft)	Percentage Fines	Sand	Gravel
10 - 15	No grading available		
15 - 20	5	34	61
20 - 25	9	35	56
25 - 28	No grading available		

TL 80 NW 4 8426 0881 Near Langford Station

Surface level (+6.1 m) +20 ft*
Water struck at (+4.9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0.9 m) 3 ft
Mineral (3.1 m) 10 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and sub-soil	(0.9)	3	(0.9)	3
River Terrace	Gravel	(3.1)	10	(4.0)	13
London Clay	Clay	(0.6+)	2+	(4.6)	15

	%	mm		%
Gravel	78	+16	:	50
		-16+4	:	28
Sand	18	-4+1	:	5
		$-1+\frac{1}{4}$	:	9
		$-\frac{1}{4}+1/16$	:	4
Fines	4	-1/16	:	4

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 5	No grading available		
5 - 10	4	18	78
10 - 13	No grading available		

TL 80 NW 5 8463 0861 Near Mitchell's Farm

Surface level (+6.1 m) +20 ft*
Water struck at (+5.2 m) +17 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.2 m) 4 ft
Mineral (1.8 m) 6 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and clay	(1.2)	4	(1.2)	4
River Terrace	'Clayey' Gravel. Traces of cobbles	(1.8)	6	(3.0)	10
London Clay	Clay	(0.6+)	2+	(3.6)	12

	%	mm		%
Gravel	81	+64	:	1
		-64+16	:	63
		-16+4	:	17
Sand	8	-4+1	:	4
		$-1+\frac{1}{4}$	:	3
		$-\frac{1}{4}+1/16$	:	1
Fines	11	-1/16	:	11

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 5	No grading available		
5 - 10	11	8	80

TL 80 NW 7 8484 0864 Near Heybridge

Surface level (+6.1 m) +20 ft*
Water struck at (+4.9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.2 m) 4 ft
Mineral (1.8 m) 6 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and brown clay	(1.2)	4	(1.2)	4
River Terrace	Gravel	(1.8)	6	(3.0)	10
London Clay	Clay	(0.6+)	2+	(3.6)	12

	%	mm		%
Gravel	53	+16	:	20
		-16+4	:	33
Sand	37	-4+1	:	12
		-1+$\frac{1}{4}$	:	20
		-$\frac{1}{4}$+1/16	:	5
Fines	10	-1/16	:	10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 5	No grading available		
5 - 9	10	37	53
9 - 10	No grading available		

TL 80 NW 8 8016 0506 North-west of 'Royal Oak'

Surface level (+60. 3) +198 ft*
Water struck at (+48. 2 m) +158 ft*
Wirth B1, 8 inch diam.
September 1967

Mineral (6. 7 m) 22 ft
Waste (1. 8 m) 6 ft
Mineral (0. 9 m) 3 ft
Waste (1. 0 m) 3 ft
Mineral (2. 7 m) 9 ft
Bedrock (0. 6 m+) 2 ft+

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
Glacial Sand and Gravel	(a)	Gravel. 'Clayey' towards base Gravel: fine and coarse grade Sand: mainly medium at top becoming medium to coarse at base	(6. 7)	22	(6. 7)	22
		Brown sandy clay	(1. 8)	6	(8. 5)	28
	(b)	'Clayey' Sand Sand: fine to medium, very little coarse Gravel: almost absent	(0. 9)	3	(9. 4)	31
		Brown silty clay	(1. 0)	3	(10. 4)	34
	(c)	'Clayey' Gravel. 'Very clayey' between 37 and 40 ft Sand: mainly medium with a little fine and coarse Gravel: fine to coarse	(2. 7)	9	(13. 1)	43
London Clay		Brown Clay	(0. 6+)	2+	(13. 7)	45

(a), (b) and (c)

	%	mm	%
Gravel	55	+16	: 27
		-16+4	: 28
Sand	34	-4+1	: 9
		-1+$\frac{1}{4}$	: 18
		-$\frac{1}{4}$+1/16	: 7
Fines	11	-1/16	: 11

	Depth below surface (ft)	Percentage Fines	Sand	Gravel
(a)	0 - 2	8	32	60
	2 - 5	5	38	57
	5 - 8	8	36	56
	8 - 11	4	29	67
	11 - 13	5	33	62
	13 - 16	5	33	62
	16 - 19	4	32	64
	19 - 22	17	27	56
	Mean	7	33	60
(b)	28 - 31	18	79	3
(c)	34 - 37	15	37	48
	37 - 40	22	30	48
	40 - 43	15	32	53
	Mean	17	33	50

TL 80 NW 9 8099 0501 Little Smith's, Woodham Mortimer

Surface level (+56.4 m) +175 ft*
Water not struck
Wirth B1, 8 inch diam.
September 1967

Overburden (3.0 m) 10 ft
Mineral (2.8 m) 9 ft
Waste (6.1 m) 20 ft
Bedrock (3.0 m+) 10 ft+

		Thickness (m)	ft	Depth (m)	ft
(? Head)	Brown sandy gravelly clay	(3.0)	10	(3.0)	10
Glacial Sand and Gravel	'Clayey' Sandy Gravel. Becomes increasingly sandy downwards. 'Very clayey' with almost no gravel near base Gravel: mainly fine with some coarse Sand: medium to coarse, becoming fine to medium at base	(2.8)	9	(5.8)	19
	Clayey sandy silt	(0.9)	3	(6.7)	22
	Brown-grey silty clay becoming sandy with some coarse gravel towards bottom	(1.5)	5	(8.2)	27
	Silty sandy gravel. Gravel mainly fine with medium to coarse sand	(0.9)	3	(9.1)	30
	Brown silty sandy clay	(2.8)	9	(11.9)	39
London Clay	Brown clay	(3.0+)	10+	(14.9)	49

	%	mm	%
Gravel	35	+16	: 11
		-16+4	: 24
Sand	47	-4+1	: 12
		-1+$\frac{1}{4}$	: 20
		-$\frac{1}{4}$+1/16	: 15
Fines	18	-1/16	: 18

Depth below surface (ft)	Percentage Fines	Sand	Gravel
10 - 13	13	37	50
13 - 16	10	42	48
16 - 19	31	62	7

TL 80 NW 10 8200 0523 Near School, Woodham Mortimer

Surface level (+48.8 m) +160 ft*
Water struck at (+46.0 m) +151 ft*
Wirth B1, 8 inch diam.
September 1967

Mineral (8.2 m) 27 ft
Bedrock (2.5 m+) 8 ft+

		Thickness (m)	ft	Depth (m)	ft
Glacial Sand and Gravel	'Clayey' Sandy Gravel. Gravel percentage high between 18 and 21 ft. 'Very clayey' from 13 to 18 ft but little or no clay below this Gravel: mainly fine with some coarse Sand: mainly medium, especially near bottom	(8.2)	27	(8.2)	27
London Clay	Brown clay	(2.5)	8	(10.7)	35

	%	mm	%
Gravel	42	+16	16
		-16+4	26
Sand	43	-4+1	12
		$-1+\frac{1}{4}$	25
		$-\frac{1}{4}+1/16$	6
Fines	15	-1/16	15

Depth below surface (ft)	Percentage Fines	Sand	Gravel
0 - 1	24	42	34
1 - 4	20	36	44
4 - 7	9	41	50
7 - 10	14	39	47
10 - 13	16	48	36
13 - 18	36	36	28
18 - 21	1	37	62
21 - 24	1	55	44
24 - 27	5	54	41

TL 80 NW 11 8004 0605 Near Golf Course, Woodham Walter

Surface level (+67.1) +220 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0.9 m) 3 ft
Mineral (7.3 m) 24 ft
Bedrock (1.6 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	'Clayey' Gravel Gravel: mainly fine near top becoming coarser below 12 ft, then finer again below 21 ft Sand: medium to coarse at top becoming mainly medium below 12 ft	(7.3)	24	(8.2)	27
London Clay	Brown clay	(1.6+)	5+	(9.8)	32

	%	mm	%
Gravel	53	+16	25
		-16+4	28
Sand	36	-4+1	14
		$-1+\frac{1}{4}$	17
		$-\frac{1}{4}+1/16$	5
Fines	11	-1/16	11

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 6	17	26	57
6 - 9	13	27	60
9 - 12	11	37	52
12 - 15	11	35	54
15 - 18	11	38	51
18 - 21	5	51	44
21 - 24	7	37	56
24 - 27	11	35	54

TL 80 NW 12 8101 0599 Oak Farm, Woodham Walter

Surface level (+48.8 m) +160 ft*
Water struck at (+36.0 m) +118 ft*
Wirth B1, 8 inch diam.
October 1967

Mineral (3.4 m) 11 ft
Waste (1.8 m) 6 ft
Mineral (3.6 m) 12 ft
Waste (1.0 m) 3 ft
Mineral (8.5 m+) 28 ft+

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
Glacial Sand and Gravel	(a)	'Very Clayey' Sandy Gravel. Gravelly in top 5 ft, becoming more sandy and 'clayey' below this Gravel: coarse near top, becoming finer downwards Sand: medium, or fine to medium	(3.4)	11	(3.4)	11
		Brown silty clay	(1.8)	6	(5.2)	17
	(b)	'Clayey' Sandy Gravel. A few cobbles at top Gravel: mainly fine with some coarse Sand: medium to coarse	(3.6)	12	(8.8)	29
		Brown silty clay with a trace of gravel	(1.0)	3	(9.8)	32
	(c)	'Very Clayey' Pebbly Sand. Most clayey near top and at around 50 ft. Becomes less sandy and more gravelly in lower part Sand: mainly medium Gravel: mainly fine, almost absent from top 12 ft or so	(8.5+)	28+	(18.3)	60

(a), (b) and (c)

	%	mm		%
Gravel	23	+16	:	9
		-16+4	:	14
Sand	53	-4+1	:	8
		$-1+\frac{1}{4}$	:	34
		$-\frac{1}{4}+1/16$	:	11
Fines	24	-1/16	:	24

	Depth below surface (ft)	Percentage Fines	Sand	Gravel
(a)	0 - 5	22	26	52
	5 - 8	38	49	13
	8 - 11	33	38	28
	Mean	29	36	35
(b)	17 - 20	23	33	44
	20 - 23	25	44	31
	23 - 26	16	40	44
	26 - 29	15	41	44
	Mean	20	40	40
(c)	32 - 35	37	61	2
	35 - 38	10	88	2
	38 - 41	14	81	5
	41 - 44	18	69	13
	44 - 47	15	62	23
	47 - 50	39	47	14
	50 - 53	32	58	10
	53 - 56	20	67	13
	56 - 60	30	56	14
	Mean	24	65	11

TL 80 NW 13 8200 0600 East of Lodge Farm, Woodham Walter

Surface level (+47. 2 m) +155 ft*
Water struck at (+35. 1 m) +115 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (5. 2 m) 17 ft
Mineral (2. 7 m) 9 ft
Waste (0. 9 m) 3 ft
Mineral (7. 4 m) 24 ft
Waste (1. 8 m) 6 ft
Mineral (3. 6 m) 12 ft
Bedrock (0. 7 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Glacial Sand and Gravel	Brown silty clay, gravelly in top 4 ft, becoming sandy with a trace of gravel below this	(5. 2)	17	(5. 2)	17
	(a) 'Clayey' Sandy Gravel. Becomes more 'clayey' and less gravelly downwards Gravel: fine and coarse, becoming mainly fine at base Sand: mainly medium	(2. 7)	9	(7. 9)	26
	Sandy silty clay	(0. 9)	3	(8. 8)	29
	(b) 'Clayey' Sandy Gravel. Gravel mostly in upper half. 'Very clayey' between 47 and 50 ft Gravel: fine to coarse near top, becoming mainly fine downwards Sand: mainly medium	(7. 4)	24	(16. 2)	53
	Brown sandy clay, becoming silty with traces of gravel towards base	(1. 8)	6	(18. 0)	59
	(c) 'Very clayey' pebbly sand. Most 'clayey' in middle part, i. e. around 65 ft Sand: mainly medium with some fine, and traces only of coarse Gravel: almost absent	(3. 6)	12	(21. 6)	71
London Clay	Brown clay	(0. 7+)	2+	(22. 3)	73

(a), (b) and (c)

	%	mm	%
Gravel	26	+16	10
		-16+4	16
Sand	55	-4+1	8
		$-1+\frac{1}{4}$	34
		$-\frac{1}{4}+1/16$	13
Fines	19	-1/16	19

	Depth below surface (ft)	Percentage Fines	Sand	Gravel
(a)	17 - 20	8	46	46
	20 - 23	16	47	37
	23 - 26	28	43	29
	Mean	17	46	37
(b)	29 - 32	6	41	53
	32 - 35	5	49	46
	35 - 38	8	46	46
	38 - 41	17	50	33
	41 - 44	16	69	15
	44 - 47	13	70	17
	47 - 50	35	44	21
	50 - 53	17	58	25
	Mean	15	53	32
(c)	59 - 62	24	68	8
	62 - 65	36	62	2
	65 - 68	35	61	4
	68 - 71	25	72	3
	Mean	30	66	4

TL 80 NW 15 8035 0727 Gunhill Farm, Woodham Walter

Surface level (+44. 2 m) +145 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0. 3 m) 1 ft
Mineral (6. 1 m) 20 ft
Bedrock (1. 2 m+) 4 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 3)	1	(0. 3)	1
Glacial Sand and Gravel	'Very clayey' Gravel. Most 'clayey' near base Gravel: mostly fine with some coarse Sand: medium to coarse in top 8 ft, becoming mainly medium below	(6. 1)	20	(6. 4)	21
London Clay	Brown clay	(1. 2+)	4+	(7. 6)	25

	%	mm	%
Gravel	48	+16	: 17
		-16+4	: 31
Sand	31	-4+1	: 11
		-1+$\frac{1}{4}$	: 16
		-$\frac{1}{4}$+1/16	: 4
Fines	21	-1/16	: 21

Depth below surface (ft)	Percentage Fines	Sand	Gravel
1 - 3	17	26	57
3 - 6	22	35	43
6 - 9	18	30	52
9 - 12	15	32	53
12 - 15	15	38	47
15 - 18	25	29	46
18 - 21	31	25	44

Please note: TL 80 NW 16 is on p. 60

TL 80 NW 17 8267 0713 Near Curling Tye Green, Woodham Walter

Surface level (+32. 0 m) +105 ft*
Water struck at (+25. 9 m) +85 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (3. 7 m) 12 ft
Mineral (7. 3 m) 24 ft
Bedrock (1. 2 m+) 4 ft

		Thickness (m)	ft	Depth (m)	ft
Head	Soil and grey-brown sandy silty clay	(3. 7)	12	(3. 7)	12
Glacial Sand and Gravel	'Very clayey' Sandy Gravel. Sandy near top, becoming more gravelly with depth Gravel: fine to coarse, absent in top 3 ft Sand: fine to medium, becoming mainly medium below 20 ft	(7. 3)	24	(11. 0)	36
London Clay	Brown clay	(1. 2+)	4+	(12. 2)	40

	%	mm	%
Gravel	32	+16	: 15
		-16+4	: 17
Sand	46	-4+1	: 5
		-1+$\frac{1}{4}$	: 22
		-$\frac{1}{4}$+1/16	: 19
Fines	22	-1/16	: 22

Depth below surface (ft)	Percentage Fines	Sand	Gravel
12 - 15	31	69	0
15 - 18	20	63	17
18 - 21	28	40	32
21 - 24	26	37	37
24 - 27	15	42	43
27 - 30	25	40	35
30 - 33	10	34	56
33 - 36	18	47	35

TL 80 NW 18 8100 0809 Hoemill Barns, Woodham Walter

Surface level (+15.8 m) +52 ft*
Water struck at (+5.2 m) +17 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0.6 m) 2 ft
Mineral (11.0 m) 36 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.6)	2	(0.6)	2
River Terrace	'Clayey' Gravel. Fines most common from 2 ft to 5 ft and below 26 ft Gravel: fine and coarse Sand: medium to coarse	(11.0)	36	(11.6)	38
London Clay	Brown clay	(1.5+)	5+	(13.1)	43

	%	mm	%
Gravel	64	+16	: 32
		-16+4	: 32
Sand	25	-4+1	: 9
		-1+$\frac{1}{4}$	: 13
		-$\frac{1}{4}$+1/16	: 3
Fines	11	-1/16	: 11

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	18	33	49
5 - 8	5	28	67
8 - 11	4	22	74
11 - 14	1	27	72
14 - 17	3	20	77
17 - 20	7	31	62
20 - 23	6	22	72
23 - 26	6	31	63
26 - 29	18	30	52
29 - 32	21	17	62
32 - 35	19	23	58
35 - 38	25	17	58

TL 80 NW 19 8194 0802 Manor Farm, Woodham Walter

Surface level (+13.7 m) +45 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (2.7 m) 9 ft
Mineral (2.8 m) 9 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
(? Head)	Soil and grey silty clay	(2.7)	9	(2.7)	9
River Terrace	Gravel. Silty throughout and becoming sandy in bottom 3 ft Gravel: mainly fine with some coarse Sand: medium to coarse at top, mainly medium below 15 ft	(2.8)	9	(5.5)	18
London Clay	Brown clay	(1.5+)	5+	(7.0)	23

	%	mm	%
Gravel	57	+16	: 22
		-16+4	: 35
Sand	33	-4+1	: 12
		-1+$\frac{1}{4}$	: 17
		-$\frac{1}{4}$+1/16	: 4
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
9 - 12	10	31	59
12 - 15	9	31	60
15 - 18	10	39	51

TL 80 NW 20 8262 0862 Near River Chelmer, Langford

Surface level (+6.1 m) +20 ft*
Water struck at (+4.3 m) +14 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (2.4 m) 8 ft
Mineral (3.7 m) 12 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Alluvium	Soil and firm grey silty clay	(2.4)	8	(2.4)	8
Sub-Alluvium Gravel	Gravel. A few cobbles between 11 ft and 14 ft. Below 14 ft fines are absent and sand decreases in percentage Gravel: fine to coarse at top, becoming coarser with depth Sand: medium to coarse, fine sand almost absent	(3.7)	12	(6.1)	20
London Clay	Brown clay	(0.6+)	2+	(6.7)	22

	%	mm		%
Gravel	79	+16	:	47
		-16+4	:	32
Sand	18	-4+1	:	10
		$-1+\frac{1}{4}$	:	7
		$-\frac{1}{4}+1/16$	:	1
Fines	3	-1/16	:	3

Depth below surface (ft)	Percentages Fines	Sand	Gravel
8 - 11	7	19	74
11 - 14	4	26	70
14 - 17	0	14	86
17 - 20	0	13	87

TL 80 NW 21 8392 0850 Near River Blackwater, Langford

Surface level (+6.1 m) +20 ft*
Water struck at (+3.7 m) +12 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (1.5 m) 5 ft
Mineral (4.6 m) 15 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Alluvium	Soil and stoney brown clay	(1.5)	5	(1.5)	5
Sub-Alluvium Gravel	Gravel. 'Clayey' between 8 ft and 11 ft and sandy in bottom 3 ft Gravel: coarse in top 3 ft, fine to coarse below this Sand: medium to coarse with almost no fine sand	(4.6)	15	(6.1)	20
London Clay	Brown clay	(1.5+)	5+	(7.6)	25

	%	mm		%
Gravel	72	+16	:	40
		-16+4	:	32
Sand	22	-4+1	:	11
		$-1+\frac{1}{4}$	:	10
		$-\frac{1}{4}+1/16$	:	1
Fines	6	-1/16	:	6

Depth below surface (ft)	Percentage Fines	Sand	Gravel
5 - 8	4	24	72
8 - 11	15	20	65
11 - 14	4	13	83
14 - 17	2	17	81
17 - 20	5	37	58

TL 80 NW 22 8100 0904 Ulting Hall, Ulting

Surface level (+18.3 m) +60 ft*
Water struck at (+10.7 m) + 35 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0.6 m) 2 ft
Mineral (10.1 m) 33 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	Gravel Gravel: mainly fine with some coarse at top, becoming coarser overall with depth Sand: medium to coarse throughout	(10.1)	33	(10.7)	35
London Clay	Brown clay	(0.6+)	2+	(11.3)	37

	%	mm	%
Gravel	63	+16	: 30
		-16+4	: 33
Sand	31	-4+1	: 11
		-1+¼	: 16
		-¼+1/16	: 4
Fines	6	-1/16	: 6

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	13	36	51
5 - 8	5	32	63
8 - 11	5	30	65
11 - 14	5	32	63
14 - 17	10	26	64
17 - 20	8	28	64
20 - 23	5	24	71
23 - 26	4	33	63
26 - 29	5	31	64
29 - 32	5	34	61
32 - 35	5	30	65

TL 80 NW 23 8200 0900 Near Stammer's Farm, Langford

Surface level (+9.1 m) +30 ft*
Water struck at (+3.0 m) +10 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0.6 m) 2 ft
Mineral (6.4 m) 21 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.6)	2	(0.6)	2
River Terrace	Gravel Gravel: mainly fine with some coarse, coarsest band between 11 ft and 14 ft Sand: medium to coarse	(6.4)	21	(7.0)	23
London Clay	Brown clay	(0.9+)	3+	(7.9)	26

	%	mm	%
Gravel	61	+16	: 27
		-16+4	: 34
Sand	33	-4+1	: 13
		-1+¼	: 18
		-¼+1/16	: 2
Fines	6	-1/16	: 6

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	8	36	56
5 - 8	5	36	59
8 - 11	5	38	57
11 - 14	4	26	70
14 - 17	8	36	56
17 - 20	5	34	61
20 - 23	5	28	67

TL 80 NW 24 8297 0894 Langford Reservoir

Surface level (+6.1 m) +20 ft*
Water struck at (+4.6 m) +15 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (1.5 m) 5 ft
Mineral (4.6 m) 15 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
? Head	Soil and firm brown silty clay	(1.5)	5	(1.5)	5
River Terrace	Gravel. Cobbles present between 11 ft and 14 ft and in coarse layer at base where they constitute 10% of the sample Gravel: fine and coarse near top, becoming coarser downwards Sand: medium with some coarse at top, becoming mainly coarse downwards	(4.6)	15	(6.1)	20
London Clay	Brown clay	(1.5+)	5+	(7.6)	25

	%	mm	%
Gravel	71	+64	3
		-64+16	36
		-16+4	32
Sand	27	-4+1	11
		$-1+\frac{1}{4}$	14
		$-\frac{1}{4}+1/16$	2
Fines	2	-1/16	2

Depth below surface (ft)	Percentage Fines	Sand	Gravel
5 - 8	2	32	66
8 - 11	4	34	62
11 - 14	3	15	82
14 - 17	1	32	67
17 - 20	1	23	76

TL 80 NW 76 8084 0965 Ashfield Farm, Ulting

Surface level (+38. 7 m) +127 ft
Water struck at (+32. 3 m) +106 ft
Wirth B0, 8 inch diam.
November 1968

Overburden (3. 4 m) 11 ft
Mineral (3. 9 m) 13 ft
Bedrock (0. 9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
Head	Soil and brown clay with sandy lenses	(3. 4)	11	(3. 4)	11
Glacial Sand and Gravel	Sandy Gravel. Very gravelly in top 3 ft. Sandy and 'clayey' with almost no gravel between 16 ft and 18 ft Gravel: coarse sub-angular flints, with finer sub-angular to sub-rounded flints and fine sub-rounded quartz Sand: coarse, sub-angular, brown at top, changing downwards to medium, light brown and medium to fine, orange	(3. 9)	13	(7. 3)	24
London Clay	Blue clay, weathered brown near top	(0. 9+)	3+	(8. 2)	27

	%	mm	%
Gravel	41	+16	20
		-16+4	21
Sand	56	-4+1	15
		-1+¼	21
		-¼+1/16	20
Fines	3	-1/16	3

Depth below surface (ft)	Percentage Fines	Sand	Gravel
11 - 14	0	25	75
14 - 16	0	53	47
16 - 18	16	80	4
18 - 21	2	66	32
21 - 24	2	63	35

TL 80 NW 77 8198 0985 Near The Elms, Ulting

Surface level (+25. 9 m) +85 ft
Water struck at (+22. 3 m) +73 ft
Wirth B0, 8 inch diam.
November 1968

Overburden (1. 2 m) 4 ft
Mineral (3. 4 m) 11 ft
Bedrock (0. 9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
? Head	Soil and brown clay with sandy lenses	(1. 2)	4	(1. 2)	4
Glacial Sand and Gravel	Gravel Gravel: fine sub-angular and sub-rounded flints and sub-rounded quartz, with coarse sub-angular flints Sand: brown, medium and coarse, mainly sub-angular	(3. 4)	11	(4. 6)	15
London Clay	Blue clay, weathered brown at top	(0. 9+)	3+	(5. 5)	18

	%	mm	%
Gravel	74	+16	33
		-16+4	41
Sand	25	-4+1	14
		-1+¼	10
		-¼+1/16	1
Fines	1	-1/16	1

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 7	2	22	76
7 - 10	1	34	65
10 - 12	1	25	74
12 - 15	0	20	80

TL 80 NW 78 8287 0980 Stockhall, Langford

Surface level (+10.7 m) +35 ft
Water struck at (+9.1 m) +30 ft
Wirth B0, 8 inch diam.
November 1968

Overburden (0.9 m) 3 ft
Mineral (3.4 m) 11 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and clayey sub-soil	(0.9)	3	(0.9)	3
River Terrace	Gravel. Very sandy between 6 ft and 8 ft. 'Clayey' below 11 ft Gravel: fine to coarse sub-angular flints with occasional fine sub-rounded quartz to 8 ft; mainly fine sub-angular to sub-rounded flints with occasional sub-rounded quartz below 8 ft. Sand: red-brown to brown; mainly medium to coarse, but coarse absent between 6 ft and 8 ft.	(3.4)	11	(4.3)	14
London Clay	Blue-grey clay, weathered brown near top	(0.9+)	3+	(5.2)	17

	%	mm	%
Gravel	54	+16	23
		-16+4	31
Sand	40	-4+1	13
		$-1+\frac{1}{4}$	25
		$-\frac{1}{4}+1/16$	2
Fines	6	-1/16	6

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 6	1	14	85
6 - 8	2	72	26
8 - 11	0	40	60
11 - 14	18	48	34

TL 80 NW 79 8282 0753 Near Northall Cottages

Surface level (+26.5 m) +87 ft
Water struck at (+22.9 m) +75 ft
Wirth B0, 8 inch diam.
November 1968

Overburden (0.9 m) 3 ft;
Mineral (3.4 m) 11 ft;
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and brown clayey sub-soil	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	Gravel Gravel: coarse sub-angular to sub-rounded flints with some fine sub-rounded quartz Sand: mainly medium, some coarse and fine, brown, clayey	(3.4)	11	(4.3)	14
London Clay	Blue-grey clay, weathered brown at top	(0.9+)	3+	(5.2)	17

	%	mm	%
Gravel	70	+16	41
		-16+4	29
Sand	26	-4+1	6
		$-1+\frac{1}{4}$	15
		$-\frac{1}{4}+1/16$	5
Fines	4	-1/16	4

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 6	1	25	74
6 - 9	7	26	67
9 - 12	3	25	72
12 - 14	3	29	68

TL 80 NW 80 8347 0715 Great Beeleigh Farm, Maldon

Surface level (+34.7 m) +114 ft
Water struck at (+32.6 m) +107 ft
Wirth B0, 8 inch diam.
November 1968

Overburden (2.1 m) 7 ft
Mineral (0.9 m) 3 ft
Waste (0.7 m) 2 ft
Mineral (7.9 m) 26 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Head	Soil and brown stony clay with sand lenses	(2.1)	7	(2.1)	7
	'Very Clayey' Sand Sand: brown, sub-angular, fine with some medium Gravel: almost absent, a few fine sub-angular flint pebbles only	(0.9)	3	(3.0)	10
	Brown flinty clay with traces of sand	(0.7)	2	(3.7)	12
Glacial Sand and Gravel	Sandy Gravel. Over 90% sand down to 26 ft, separated by 'very clayey' band between 26 ft and 30 ft from gravel beneath Gravel: traces of fine sub-angular flint with occasional fine sub-rounded quartz down to 30 ft. Below this mainly coarse sub-angular flints with fine sub-rounded quartz Sand: fine to medium, sub-angular, orange-brown or cream to 30 ft. Mainly medium, sub-angular, brown below	(7.9)	26	(11.6)	38
London Clay	Brown clay	(0.9+)	3+	(12.5)	41

	%	mm		%
Gravel	25	+16	:	15
		-16+4	:	10
Sand	67	-4+1	:	3
		-1+$\frac{1}{4}$	:	36
		-$\frac{1}{4}$+1/16	:	28
Fines	8	-1/16	:	8

	Depth below surface (ft)	Percentage Fines	Sand	Gravel
(a)	7 - 10	33	67	0
(b)	12 - 15	2	98	0
	15 - 18	0	92	8
	18 - 21	0	93	7
	21 - 23	0	91	9
	23 - 26	0	90	10
	26 - 30	26	56	18
	30 - 33	1	16	83
	33 - 36	2	32	66
	36 - 38	0	47	53

TL 80 NE 1 8650 0860 Near Heybridge

Surface level (+6. 1 m) +20 ft*
Water struck at (+4. 9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 9 m) 3 ft
Mineral (3. 1 m) 10 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 9)	3	(0. 9)	3
River Terrace	Gravel Gravel: fine with some coarse, especially near base Sand: mainly medium at top, becoming medium to coarse	(3. 1)	10	(4. 0)	13
London Clay	Clay	(0. 6+)	2+	(4. 6)	15

	%	mm	%
Gravel	58	+16	: 30
		-16+4	: 28
Sand	33	-4+1	: 10
		-1+$\frac{1}{4}$	: 18
		-$\frac{1}{4}$+1/16	: 5
Fines	9	-1/16	: 9

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 8	11	36	53
8 - 13	6	31	63

TL 80 NE 2 8614 0791 Opposite Jacob's Farm, Heybridge

Surface level (+3. 0 m) +10 ft*
Water struck at (+1. 2 m) +4 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 9 m) 3 ft
Mineral (3. 4 m) 11 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and sub-soil	(0. 9)	3	(0. 9)	3
River Terrace	Gravel Gravel: fine to coarse Sand: medium to coarse	(3. 4)	11	(4. 3)	14
London Clay	Clay	(0. 6+)	2+	(4. 9)	16

	%	mm	%
Gravel	58	+16	: 30
		-16+4	: 28
Sand	35	-4+1	: 11
		-1+$\frac{1}{4}$	: 18
		-$\frac{1}{4}$+1/16	: 6
Fines	7	-1/16	: 7

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 5	No grading available		
5 - 10	9	36	55
10 - 14	5	33	62

TL 80 NE 3 8654 0759 West of Canterbury Farm, Heybridge

Surface level (+2.4 m) +8 ft*
Water struck at (+0.6 m) +2 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.2 m) 4 ft
Mineral (4.3 m) 14 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and clay	(1.2)	4	(1.2)	4
River Terrace	'Clayey' Gravel. Becomes more sandy towards base Gravel: coarse, becoming fine to coarse downwards Sand: medium or medium to coarse	(4.3)	14	(5.5)	18
London Clay	Clay	(0.9+)	3+	(6.4)	21

	%	mm	%
Gravel	62	+16	: 36
		-16+4	: 26
Sand	28	-4+1	: 10
		-1+$\frac{1}{4}$	: 14
		-$\frac{1}{4}$+1/16	: 4
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 5	No grading available		
5 - 10	15	20	65
10 - 18	7	33	60

TL 80 NE 4 8703 0748 Basin Road, Heybridge

Surface level (+2.4 m) +8 ft*
Water struck at (+1.5 m) +5 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0.9 m) 3 ft
Mineral (3.1 m) 10 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and sub-soil	(0.9)	3	(0.9)	3
River Terrace	'Clayey' Gravel Gravel: fine to coarse Sand: medium to coarse	(3.1)	10	(4.0)	13
London Clay	Clay	(0.6+)	2+	(4.6)	15

	%	mm	%
Gravel	60	+16	: 28
		-16+4	: 32
Sand	25	-4+1	: 8
		-1+$\frac{1}{4}$	: 15
		-$\frac{1}{4}$+1/16	: 2
Fines	15	-1/16	: 15

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 5	No grading available		
5 - 10	15	25	60
10 - 13	No grading available		

TL 80 NE 7 8505 0955 Howell's Farm, Great Totham

Surface level (+12. 2 m) +40 ft*
Water struck at (+10. 4 m) +34 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 6 m) 2 ft
Mineral (1. 5 m) 5 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
River Terrace	Gravel	(1. 5)	5	(2. 1)	7
London Clay	Clay	(0. 6+)	2+	(2. 7)	9

No grading information available

TL 80 NE 8 8594 0957 Poplar Grove Farm

Surface level (+12. 8 m) +42 ft*
Water not struck
Power auger, 8 inch diam.
April 1967

Waste (0. 6 m) 2 ft
Bedrock (7. 6 m+) 25 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
(? London Clay)	Brown clay	(6. 7)	22	(7. 3)	24
London Clay	Blue-black clay	(0. 9+)	3+	(8. 2)	27

TL 80 NE 9 8609 0900 Isolation Hospital, Heybridge

Surface level (+7. 3 m) +24 ft*
Water struck at (+6. 1 m) +20 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (4. 9 m) 16 ft
Bedrock (1. 2 m+) 4 ft+

		Thickness (m)	ft	Depth (m)	ft
River Terrace	Soil, clay and stone	(1. 2)	4	(1. 2)	4
	'Clayey' Gravel Gravel: fine to coarse Sand: medium	(4. 9)	16	(6. 1)	20
London Clay	Clay	(1. 2+)	4+	(7. 3)	24

	%	mm	%
Gravel	56	+16	22
		-16+4	34
Sand	31	-4+1	9
		-1+¼	19
		-¼+1/16	3
Fines	13	-1/16	13

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 10	No grading available		
10 - 15	13	31	56
15 - 20	No grading available		

TL 80 NE 10 8540 0856 Wood Lane, Heybridge

Surface level (+6. 1 m) +20 ft*
Water struck at (+4. 9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 6 m) 2 ft
Mineral (3. 4 m) 11 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
River Terrace	'Very Clayey' Gravel Gravel: mainly fine with some coarse Sand: mainly medium	(3. 4)	11	(4. 0)	13
London Clay	Clay	(0. 6+)	2	(4. 6)	15

	%	mm	%
Gravel	48	+16	19
		-16+4	29
Sand	30	-4+1	8
		-1+¼	17
		-¼+1/16	5
Fines	22	-1/16	22

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	No grading available		
5 - 10	22	30	48
10 - 13	No grading available		

TL 80 NE 11 8570 0830 Heybridge

Surface level (+6. 1 m) +20 ft*
Water struck at (+4. 3 m) +14 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (0. 9 m) 3 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and brown sandy clay	(1. 2)	4	(1. 2)	4
River Terrace	Gravel	(0. 9)	3	(2. 1)	7
London Clay	Clay	(0. 6+)	2+	(2. 7)	9

No grading information available

TL 80 NE 12 8757 0855 Chigborough Farm

Surface level (+6-1 m) +20 ft*
Water struck at (+3. 1 m) +10 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (4. 6 m) 15 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and sandy clay	(1. 2)	4	(1. 2)	4
River Terrace	Gravel Gravel: fine to coarse Sand: mainly medium	(4. 6)	15	(5. 8)	19
London Clay	Clay	(0. 6+)	2+	(6. 4)	21

	%	mm	%
Gravel	73	+16	: 40
		-16+4	: 33
Sand	17	-4+1	: 5
		-1+$\frac{1}{4}$	: 10
		-$\frac{1}{4}$+1/16	: 2
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 9	No grading available		
9 - 14	10	17	73
14 - 19	No grading available		

TL 80 NE 13 8799 0848 Rook Hall

Surface level (+6.1 m) +20 ft*
Water struck at (+4.9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.2 m) 4 ft
Mineral (2.8 m) 9 ft
Bedrock (0.6 m+) 2 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and brown sandy clay	(1.2)	4	(1.2)	4
River Terrace	'Clayey' Gravel. Gravelly with some cobbles at top, becoming more sandy and 'clayey' downwards Gravel: fine to coarse Sand: medium to coarse, becoming medium	(2.8)	9	(4.0)	13
London Clay	Clay	(0.6+)	2+	(4.6)	15

	%	mm		%
Gravel	59	+64	:	3
		-64+16	:	30
		-16+4	:	26
Sand	28	-4+1	:	9
		-1+$\frac{1}{4}$	:	15
		-$\frac{1}{4}$+1/16	:	4
Fines	13	-1/16	:	13

Depth below surface (ft)	Percentage Fines	Sand	Gravel
Sampling interval not known	9	25	66
	17	31	52

TL 80 NE 16 8900 0877 North-west of Cobb's Farm, Goldhanger

Surface level (+7.6 m) +25 ft*
Water struck at (+5.8 m) +19 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.8 m) 6 ft
Mineral (1.6 m) 5 ft
Bedrock (1.2 m+) 4 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil and clay	(1.8)	6	(1.8)	6
River Terrace	'Clayey' Gravel Gravel: fine to coarse Sand: medium to coarse	(1.6)	5	(3.4)	11
London Clay	Clay	(1.2+)	4+	(4.6)	15

	%	mm		%
Gravel	52	+16	:	28
		-16+4	:	24
Sand	32	-4+1	:	10
		-1+$\frac{1}{4}$	:	17
		-$\frac{1}{4}$+1/16	:	5
Fines	16	-1/16	:	16

Depth below surface (ft)	Percentage Fines	Sand	Gravel
6 - 11	16	32	52

TL 80 NE 17 8866 0854 Little Totham

Surface level (+6.1 m) +20 ft*
Water struck at (+4.9 m) +16 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.2 m) 4 ft
Mineral (1.8 m) 6 ft
Bedrock (0.7 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and clay	(1.2)	4	(1.2)	4
River Terrace	Gravel Gravel: fine to coarse Sand: medium to coarse	(1.8)	6	(3.0)	10
London Clay	Clay	(0.7+)	2+	(3.7)	12

	%	mm		%
Gravel	76	+16	:	38
		-16+4	:	38
Sand	20	-4+1	:	9
		$-1+\frac{1}{4}$	:	10
		$-\frac{1}{4}+1/16$	:	1
Fines	4	-1/16	:	4

Depth below surface (ft)	Percentage Fines	Sand	Gravel
Sampling interval not known	4	20	76

TL 80 NE 18 8814 0794 West of Vaulty Manor, Goldhanger

Surface level (+3.7 m) +12 ft*
Water struck at (+2.4 m) +8 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1.8 m) 6 ft
Mineral (1.2 m) 4 ft
Bedrock (0.7 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and clay	(1.8)	6	(1.8)	6
River Terrace	Gravel Gravel: coarse with fine Sand: traces of all grades present	(1.2)	4	(3.0)	10
London Clay	Clay	(0.7+)	2+	(3.7)	12

	%	mm		%
Gravel	74	+16	:	44
		-16+4	:	30
Sand	16	-4+1	:	4
		$-1+\frac{1}{4}$	:	9
		$-\frac{1}{4}+1/16$	:	3
Fines	10	-1/16	:	10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
6 - 10	10	16	74

TL 80 NE 19 8851 0800 Vaulty Manor, Goldhanger

Surface level (+4. 6 m) +15 ft*
Water struck at (+3. 4 m) +11 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 9 m) 3 ft
Mineral (2. 1 m) 7 ft
Bedrock (0. 7 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and sub-soil	(0. 9)	3	(0. 9)	3
River Terrace	Gravel	(2. 1)	7	(3. 0)	10
London Clay	Clay	(0. 7+)	2+	(3. 7)	12

No grading information available

TL 80 NE 20 8899 0800 Near Gardener's Farm, Goldhanger

Surface level (+3. 7 m) +12 ft*
Water struck at (+2. 4 m) +8 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 9 m) 3 ft
Mineral (1. 8 m) 6 ft
Bedrock (1. 9 m+) 6 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and sub-soil	(0. 9)	3	(0. 9)	3
River Terrace	Gravel Gravel: fine to coarse Sand: coarse with some medium	(1. 8)	6	(2. 7)	9
London Clay	Clay	(1. 9+)	6+	(4. 6)	15

	%	mm	%
Gravel	74	+16	: 36
		-16+4	: 38
Sand	16	-4+1	: 10
		-1+$\frac{1}{4}$	: 6
		-$\frac{1}{4}$+1/16	: 0
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
Sampling interval not known	10	16	74

TL 80 NE 21 8951 0844 Cobb's Farm, Goldhanger

Surface level (+4. 6 m) +15 ft*
Water struck at (+2. 7 m) +9 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (1. 8 m) 6 ft
Bedrock (0. 7 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil and clay	(1. 2)	4	(1. 2)	4
River Terrace	'Clayey' Sandy Gravel Gravel: fine with some coarse Sand: mainly medium, some fine and coarse	(1. 8)	6	(3. 0)	10
London Clay	Clay	(0. 7+)	2+	(3. 7)	12

	%	mm	%
Gravel	39	+16	: 17
		-16+4	: 22
Sand	49	-4+1	: 11
		-1+$\frac{1}{4}$	: 30
		-$\frac{1}{4}$+1/16	: 8
Fines	12	-1/16	: 12

Depth below surface (ft)	Percentage Fines	Sand	Gravel
? 4 - 10	12	49	39

TL 80 NE 22 8898 0748 Near Blackwater Estuary, Goldhanger

Surface level (+3. 0 m) +10 ft*
Water struck at (+0. 6 m) +2 ft*
Power auger, 8 inch diam.
April 1967

Overburden (3. 7 m) 12 ft
Mineral (4. 8 m) 16 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
Alluvium	Soil and clay	(3. 7)	12	(3. 7)	12
Sub-Alluvium Gravel	'Clayey' Gravel Gravel: fine to coarse Sand: medium to coarse	(4. 8)	16	(8. 5)	28
London Clay	Clay	(0. 6+)	2+	(9. 1)	30

	%	mm	%
Gravel	62	+16	: 27
		-16+4	: 35
Sand	26	-4+1	: 10
		-1+$\frac{1}{4}$	: 14
		-$\frac{1}{4}$+1/16	: 2
Fines	12	-1/16	: 12

Depth below surface (ft)	Percentage Fines	Sand	Gravel
Sampling interval not known	12	26	62

TL 80 NE 23 8701 0899 Near Slough House Farm, Great Totham

Surface level (+7. 6 m) +25 ft*
Water struck at (+6. 4 m) +21 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (2. 8 m) 9 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
(? Head)	Soil and clay and stone	(1. 2)	4	(1. 2)	4
River Terrace	Gravel Gravel: fine to coarse Sand: medium to coarse	(2. 8)	9	(4. 0)	13
London Clay	Clay	(0. 6+)	2+	(4. 6)	15

	%	mm	%
Gravel	67	+16	: 34
		-16+4	: 33
Sand	29	-4+1	: 10
		-1+$\frac{1}{4}$	: 13
		-$\frac{1}{4}$+1/16	: 6
Fines	4	-1/16	: 4

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 5	No grading available		
5 - 10	4	29	67
10 - 13	No grading available		

TL 80 NE 24 8718 0931 North of Slough House Farm

Surface level (+9. 1 m) +30 ft*
Water struck at (+7. 9 m) +26 ft*
Power auger, 8 inch diam.
April 1967

Overburden (0. 9 m) 3 ft
Mineral (2. 1 m) 7 ft
Bedrock (0. 7 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
Alluvium	Soil, and brown clay and stone	(0. 9)	3	(0. 9)	3
Sub-Alluvium Gravel	Gravel Gravel: fine to coarse Sand: mainly medium	(2. 1)	7	(3. 0)	10
London Clay	Clay	(0. 7+)	2+	(3. 7)	12

	%	mm	%
Gravel	62	+16	: 33
		-16+4	: 29
Sand	28	-4+1	: 7
		-1+$\frac{1}{4}$	: 18
		-$\frac{1}{4}$+1/16	: 3
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 5	No grading available		
5 - 10	10	28	62

TL 80 NE 25 8762 0906 Great Totham p. h.

Surface level (+9. 1 m) +30 ft*
Water struck at (+7. 3 m) +24 ft*
Power auger, 8 inch diam.
April 1967

Overburden (1. 2 m) 4 ft
Mineral (2. 8 m) 9 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
(? Head)	Soil and brown sandy clay	(1. 2)	4	(1. 2)	4
River Terrace	Gravel Gravel: coarse with fine Sand: medium to coarse	(2. 8)	9	(4. 0)	13
London Clay	Clay	(0. 6+)	2+	(4. 6)	15

	%	mm	%
Gravel	76	+16	: 46
		-16+4	: 30
Sand	22	-4+1	: 8
		-1+¼	: 12
		-¼+1/16	: 2
Fines	2	-1/16	: 2

Depth below surface (ft)	Percentage Fines	Sand	Gravel
4 - 5	No grading available		
5 - 10	2	22	76
10 - 13	No grading available		

TL 80 NE 26 8858 0912 Little Totham

Surface level (+7. 0 m) +23 ft*
Water not struck
Wirth B1, 8 inch diameter
October 1967

Overburden (0. 6 m) 2 ft
Mineral (1. 8 m) 6 ft
Waste (1. 0 m) 3 ft
Bedrock (1. 5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
Head	Soil	(0. 6)	2	(0. 6)	2
	'Clayey' gravel. Cobbles in top 3 ft Gravel: fine to coarse, getting less coarse downwards Sand: medium to coarse	(1. 8)	6	(2. 4)	8
	Brown, slightly silty, gravelly clay	(1. 0)	3	(3. 4)	11
London Clay	Brown clay	(1. 5+)	5+	(4. 9)	16

	%	mm	%
Gravel	65	+64	: 1
		-64+16	: 35
		-16+4	: 30
Sand	21	-4+1	: 9
		-1+¼	: 11
		-¼+1/16	: 1
Fines	13	-1/16	: 13

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	12	21	64
5 - 8	14	21	65

TL 80 NE 27 8857 0917 Near Chappel Farm

Surface level (+8.5 m) +28 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0.6 m) 2 ft
Mineral (3.7 m) 12 ft
Bedrock (1.8 m+) 6 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Head	Soil	(0.6)	2	(0.6)	2
	'Clayey' Gravel. Very gravelly in top 3 ft and between 8 ft and 11 ft. Sandy in bottom 3 ft Gravel: fine to coarse Sand: medium to coarse, becoming mainly medium towards base	(3.7)	12	(4.3)	14
London Clay	Brown clay	(1.8+)	6+	(6.1)	20

	%	mm	%
Gravel	52	+16	: 21
		-16+4	: 31
Sand	36	-4+1	: 10
		$-1+\frac{1}{4}$	: 21
		$-\frac{1}{4}+1/16$	: 5
Fines	12	-1/16	: 12

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	10	28	62
5 - 8	18	35	47
8 - 11	5	31	64
11 - 14	16	50	34

TL 80 NE 28 8746 0814 Saltcote Hall, Maldon

Surface level (+4.6 m) +15 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0.9 m) 3 ft
Mineral (2.5 m) 8 ft
Bedrock (1.2 m+) 4 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.9)	3	(0.9)	3
River Terrace	Gravel. 'Clayey' at top and at base. Becoming more gravelly and less sandy downwards Gravel: mainly fine with some coarse Sand: medium to coarse	(2.5)	8	(3.4)	11
London Clay	Brown clay	(1.2+)	4+	(4.6)	15

	%	mm	%
Gravel	62	+16	: 22
		-16+4	: 40
Sand	28	-4+1	: 12
		$-1+\frac{1}{4}$	: 15
		$-\frac{1}{4}+1/16$	: 1
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 6	11	32	57
6 - 9	7	29	64
9 - 11	12	22	66

TL 80 NE 29 8724 0821 Saltcote Hall, Maldon

Surface level (+4. 6 m) +15 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0. 6 m) 2 ft
Mineral (4. 0 m) 13 ft
Bedrock (1. 5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
River Terrace	Gravel. A few cobbles at top Gravel: fine and coarse Sand: mainly medium with some coarse	(4. 0)	13	(4. 6)	15
London Clay	Brown clay	(1. 5+)	5+	(6. 1)	20

	%	mm	%
Gravel	63	+16	: 33
		-16+4	: 30
Sand	32	-4+1	: 12
		$-1+\frac{1}{4}$	: 18
		$-\frac{1}{4}+1/16$	: 2
Fines	5	-1/16	: 5

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	5	38	57
5 - 8	4	30	66
8 - 11	5	31	64
11 - 15	6	30	64

TL 80 NE 31 8691 0833 Near Draper's Farm, Maldon

Surface level (+3. 7 m) +12 ft*
Water struck at (+1. 8 m) +6 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0. 6 m) 2 ft
Mineral (2. 8 m) 9 ft
Bedrock (1. 5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
Alluvium	Soil	(0. 6)	2	(0. 6)	2
Sub-Alluvium Gravel	'Clayey' Gravel Gravel: fine to coarse Sand: mainly medium with traces of fine and coarse, especially near top	(2. 8)	9	(3. 4)	11
London Clay	Brown clay	(1. 5+)	5+	(4. 9)	16

	%	mm	%
Gravel	55	+16	: 27
		-16+4	: 28
Sand	34	-4+1	: 9
		$-1+\frac{1}{4}$	: 22
		$-\frac{1}{4}+1/16$	: 3
Fines	11	-1/16	: 11

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	9	33	58
5 - 8	10	34	56
8 - 11	14	35	51

TL 80 NE 32 8622 0838 Near Glebe Farm, Heybridge

Surface level (+6.1 m) +20 ft*
Water struck at (+1.5 m) + 5 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0.6 m) 2 ft
Mineral (4.6 m) 15 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.6)	2	(0.6)	2
River Terrace	Gravel. Sandy near top, becoming very gravelly below 11 ft. Cobbles found between 11 ft and 14 ft Gravel: mainly fine with some coarse, coarse grade dominant between 11 ft and 14 ft Sand: medium to coarse with traces of fine	(4.6)	15	(5.2)	17
London Clay	Brown clay	(1.5+)	5+	(6.7)	22

	%	mm		%
Gravel	68	+64	:	2
		-64+16	:	30
		-16+4	:	36
Sand	27	-4+1	:	9
		$-1+\frac{1}{4}$	:	13
		$-\frac{1}{4}+1/16$	:	5
Fines	5	-1/16	:	5

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	10	29	61
5 - 8	2	32	66
8 - 11	5	31	64
11 - 14	4	16	80
14 - 17	5	25	70

TL 80 NE 33 8623 0810 Jacob's Farm, Heybridge

Surface level (+4.6 m) +15 ft*
Water struck at (+2.7 m) +9 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (0.9 m) 3 ft
Mineral (4.6 m) 15 ft
Bedrock (1.5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.9)	3	(0.9)	3
River Terrace	'Clayey' Sandy Gravel. Most 'clayey' in top 3 ft. Gravelly down to 9 ft, becoming very sandy below Gravel: mainly fine with some coarse Sand: medium with some coarse at top, becoming fine to medium downwards	(4.6)	15	(5.5)	18
London Clay	Brown clay	(1.5+)	5+	(7.0)	23

	%	mm		%
Gravel	24	+16	:	8
		-16+4	:	16
Sand	62	-4+1	:	11
		$-1+\frac{1}{4}$	:	35
		$-\frac{1}{4}+1/16$	:	16
Fines	14	-1/16	:	14

Depth below surface (ft)	Percentage Fines	Sand	Gravel
3 - 6	19	39	42
6 - 9	8	53	39
9 - 12	12	83	5
12 - 15	11	69	20
15 - 18	18	67	15

TL 80 NE 34 8645 0804 East of Jacob's Farm, Heybridge

Surface level (+4. 6 m) +15 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (0. 6 m) 2 ft
Mineral (4. 6 m) 15 ft
Bedrock (1. 5 m+) 5 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
River Terrace	Gravel. 'Very clayey' near top Gravel: fine with some coarse Sand: medium to coarse; some fine between 11 ft and 14 ft	(4. 6)	15	(5. 2)	17
London Clay	Brown clay	(1. 5+)	5+	(6. 7)	22

	%	mm	%
Gravel	46	+16	: 18
		-16+4	: 28
Sand	44	-4+1	: 13
		$-1+\frac{1}{4}$	: 25
		$-\frac{1}{4}+1/16$	: 6
Fines	10	-1/16	: 10

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	28	37	35
5 - 8	5	43	52
8 - 11	5	46	49
11 - 14	8	51	41
14 - 17	5	43	52

TL 80 NE 35 8824 0885 Chappel Farm, Little Totham

Surface level (+7. 6 m) +25 ft*
Water level not recorded
Wirth B1, 8 inch diam.
October 1967

Overburden (0. 6 m) 2 ft
Mineral (2. 8 m) 9 ft
Bedrock (1. 2 m+) 4 ft+

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0. 6)	2	(0. 6)	2
River Terrace	Gravel Gravel: fine to coarse Sand: medium to coarse	(2. 8)	9	(3. 4)	11
London Clay	Brown clay	(1. 2+)	4+	(4. 6)	15

	%	mm	%
Gravel	63	+16	: 32
		-16+4	: 31
Sand	32	-4+1	: 14
		$-1+\frac{1}{4}$	: 17
		$-\frac{1}{4}+1/16$	: 1
Fines	5	-1/16	: 5

Depth below surface (ft)	Percentage Fines	Sand	Gravel
2 - 5	9	29	62
5 - 8	4	34	62
8 - 11	1	33	66

TL 80 NE 36 8821 0911 North-west of Chappel Farm, Little Totham

Surface level (+8. 3 m) +27 ft*
Water not struck
Wirth B1, 8 inch diam.
October 1967

Overburden (3. 7 m) 12 ft
Mineral (2. 1 m) 7 ft
Bedrock (0. 6 m+) 2 ft+

		Thickness (m)	ft	Depth (m)	ft
Head	Soil and brown silty clay	(3. 7)	12	(3. 7)	12
River Terrace	'Clayey' Gravel. Fines absent below 15 ft. Becomes increasingly gravelly with depth. Cobbles at base Gravel: fine at top, becoming fine to coarse downwards Sand: medium to coarse	(2. 1)	7	(5. 8)	19
London Clay	Brown clay	(0. 6+)	2+	(6. 4)	21

	%	mm		%
Gravel	46	+64	:	1
		-64+16	:	17
		-16+4	:	28
Sand	40	-4+1	:	14
		-1+$\frac{1}{4}$	:	23
		-$\frac{1}{4}$+1/16	:	3
Fines	14	-1/16	:	14

Depth below surface (ft)	Percentage Fines	Sand	Gravel
12 - 15	30	39	31
15 - 18	2	42	56
18 - 19	1	37	62

TL 80 SW 11 8072 0469 Cross Roads, Woodham Mortimer

Surface level (+53.0 m) +174 ft
Water struck at (+45.4 m) +149 ft
Wirth B0, 8 inch diam.
August 1969

Overburden (2.7 m) 9 ft
Mineral (2.8 m) 9 ft
Waste (5.5 m) 18 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
(? Head)	Soil and stoney clay	(2.7)	9	(2.7)	9
Glacial Sand and Gravel	Gravel. Becomes less gravelly and increasingly sandy downwards. 'Clayey' between 12 ft and 15 ft Gravel: fine to coarse, sub-angular to sub-rounded flints Sand: mainly medium, rusty brown	(2.8)	9	(5.5)	18
	Brown clay with fine to medium sand and traces of fine, sub-angular to sub-rounded flint, quartzite and occasionally quartz pebbles throughout	(5.5)	18	(11.0)	36
London Clay	Brown clay	(0.9+)	3+	(11.9)	39

	%	mm	%
Gravel	54	+16	: 31
		-16+4	: 23
Sand	40	-4+1	: 6
		-1+$\frac{1}{4}$	: 27
		-$\frac{1}{4}$+1/16	: 7
Fines	6	-1/16	: 6

Depth below surface (ft)	Percentage Fines	Sand	Gravel
9 - 12	2	28	70
12 - 15	16	35	49
15 - 18	1	56	43

TL 80 SW 12 8047 0379 Near Hyde Wood, Purleigh

Surface level (+50.0 m) +164 ft
Water not struck
Wirth B0, 8 inch diam.
August 1969

Waste (8.8 m) 29 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
(? Head)	Soil and brown clay with occasional flints	(3.7)	12	(3.7)	12
Glacial Sand and Gravel	Very clayey red-brown gravel, composed of flints and occasional quartz	(2.7)	9	(6.4)	21
(? London Clay)	Very silty brownish clay	(2.4)	8	(8.8)	29
London Clay	Brown clay	(0.9+)	3+	(9.7)	32

TL 80 SW 13 8060 0298 Slough House Farm, Purleigh

Surface level (+49.1 m) +161 ft
Water not struck
Wirth B0, 8 inch diam.
August 1969

Waste (1.5 m) 5 ft
Bedrock (3.1 m+) 10 ft+

		Thickness (m)	ft	Depth (m)	ft
	Made ground and soil	(1.5)	5	(1.5)	5
(? London Clay)	Brown clay containing a few flint pebbles	(2.2)	7	(3.7)	12
London Clay	Brown clay	(0.9+)	3+	(4.6)	15

TL 80 SW 14 8133 0435 Near Nursery Farm, Woodham Mortimer

Surface level (+49.4 m) +162 ft
Water struck at (+44.2 m) +145 ft
Wirth B0, 8 inch diam.
August 1969

Overburden (4.3 m) 14 ft
Mineral (5.5 m) 18 ft
Bedrock (0.9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
Glacial Sand and Gravel	Soil and very clayey gravel	(4.3)	14	(4.3)	14
	Sandy Gravel. Gravelly to 20 ft, becoming very sandy between 20 ft and 26 ft, then gravelly again below 26 ft Gravel: fine to coarse, sub-angular to sub-rounded flints with some quartz Sand: mainly medium, rusty-brown to grey colour	(5.5)	18	(9.8)	32
London Clay	Blue-grey clay, weathered brown at top	(0.9+)	3+	(10.7)	35

	%	mm	%
Gravel	38	+16	: 19
		-16+4	: 19
Sand	61	-4+1	: 12
		-1+$\frac{1}{4}$	: 41
		-$\frac{1}{4}$+1/16	: 8
Fines	1	-1/16	: 1

Depth below surface (ft)	Percentage Fines	Sand	Gravel
14 - 17	1	43	56
17 - 20	1	46	53
20 - 23	2	95	3
23 - 26	0	92	8
26 - 29	2	51	47
29 - 32	1	39	60

TL 80 SW 15 8152 0337 West of Hazeleigh Grange, Hazeleigh

Surface level (+50. 3 m) +165 ft
Water not struck
Wirth B0, 8 inch diam.
August 1969

Waste (4. 6 m) 15 ft
Bedrock (0. 9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
Head	Soil and brown clay	(3. 7)	12	(3. 7)	12
(? Head)	Brown, silty clay with some gravel	(0. 9)	3	(4. 6)	15
London Clay	Brown clay	(0. 9+)	3+	(5. 5)	18

TL 80 SW 16 8135 0255 Near Corporation Bridge, Purleigh

Surface level (+47. 2 m) +155 ft
Water not struck
Wirth B0, 8 inch diam.
August 1969

Waste (5. 2 m) 17 ft
Bedrock (0. 9 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
Head	Soil and brown sandy clay	(5. 2)	17	(5. 2)	17
London Clay	Brown clay	(0. 9+)	3+	(6. 1)	20

TL 80 SW 17 8258 0406 Loddart's Hill, Hazeleigh

Surface level (+56. 7 m) +186 ft
Water not struck
Wirth B0, 8 inch diam.
August 1969

Waste (8. 8 m) 29 ft
Bedrock (1. 0 m+) 3 ft+

		Thickness (m)	ft	Depth (m)	ft
(? Claygate Beds)	Soil and brown sandy clay	(8. 8)	29	(8. 8)	29
London Clay	Brown clay	(1. 0+)	3+	(9. 8)	32

TL 80 NW 16 8168 0700 Whitehouse Farm, Woodham Walter

Surface level (+33. 5 m) +110 ft*
Water struck at (+25. 9 m) +85 ft*
Wirth B1, 8 inch diam.
October 1967

Overburden (6. 4 m) 21 ft
Mineral (6. 4 m) 21 ft
Bedrock (1. 2 m+) 4 ft+

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
Head	Soil and firm, brown, silty clay becoming increasingly sandy with depth,	(6. 4)	21	(6. 4)	21
Glacial Sand and Gravel	Gravel. 'Clayey' to 'very clayey' in top 9 ft, becoming increasingly gravelly with depth. Cobbles occur in places, especially in very gravelly layer at base Gravel: fine to coarse at top, becoming finer downwards but very coarse in bottom 3 ft Sand: fine to medium at top, becoming medium or medium to coarse towards base	(6. 4)	21	(12. 8)	42
London Clay	Brown clay	(1. 2+)	4+	(14. 0)	46

	%	mm		%
Gravel	51	+64	:	1
		-64+16	:	24
		-16+4	:	26
Sand	41	-4+1	:	11
		$-1+\frac{1}{4}$	:	23
		$-\frac{1}{4}+1/16$	:	7
Fines	8	-1/16	:	8

Depth below surface (ft)	Percentage Fines	Sand	Gravel
21 - 24	17	55	28
24 - 27	24	29	47
27 - 30	10	47	43
30 - 33	4	59	37
33 - 36	1	41	58
36 - 39	2	33	65
39 - 42	0	18	82

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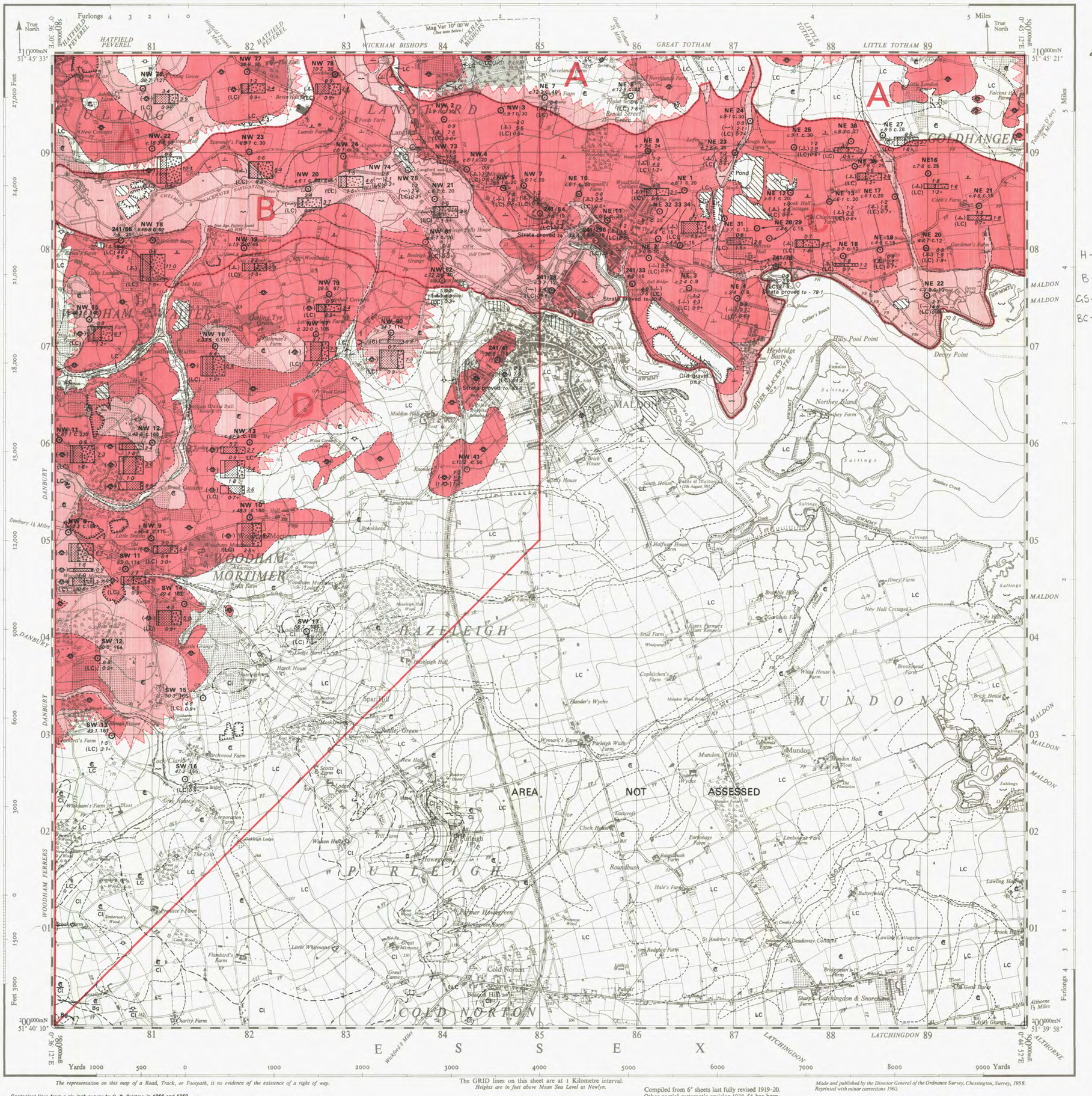
INSTITUTE OF GEOLOGICAL SCIENCES

MINERAL ASSESSMENT UNIT

THE SAND & GRAVEL RESOURCES OF SHEET TL 80 (MALDON ESSEX)

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

ORDNANCE SURVEY
SHEET TL 80
PROVISIONAL EDITION



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

4

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

	Marine Beach Deposits- mainly clayey tidal flats. MB-2	RECENT AND PLEISTOCENE
	Estuarine Alluvium- clays and silts. EA-1	
	Alluvium- clays and silty clays with traces of sand and pebbles. A-14	
	1st Terrace 1T-7	
	2nd Terrace 2T-5	
	3rd Terrace 3T-4	
	River Gravels of the Rivers Chelmer and Blackwater - gravels and sandy gravels with some clays and silts.	
H-6	**Head and Head Brickearth**- brown clay or silty clay with varying amounts of sand and pebbles.	
B-6	**Brickearth**- brownish silts or silty clays with scattered flint pebbles. MB16	
GS-13	**Glacial Sand and Gravel**- gravels and sandy gravels, very clayey in places	
BC-7	**Boulder Clay**- brown clay with traces of chalk and some flints.	

SOLID

Bg	**Bagshot Beds**- fine sands.	EOCENE
Cl	**Claygate Beds**- silty clay with intercalated sands.	
LC	**London Clay**- blue or blue-grey silty clay, weathered brown near top.	

Made Ground MG-2

Landslip L-1

Worked-out Ground (where white) WO-1

Worked Ground (where not white) WG-1

close off with artificial polygon closure if required

BOUNDARY LINES

Geological boundary, Drift.

Geological boundary, Solid. Broken line denotes uncertainty.

Inferred boundary between categories of deposits recognised.

Resource Block boundary.

BOREHOLE DATA

SITE LOCATIONS

Mineral Assessment Unit (M.A.U.) Boreholes.

Other Boreholes

M.A.U. BOREHOLES

Borehole Registration Number. NW 80
Borehole site
Grading Diagram
Geological Classification
34·7 Surface level in metres and feet above O.D. (Newlyn).
0·6 Overburden
3·7 Mineral (sand and gravel).
0·5 Waste.
2·8 Mineral (sand and gravel).
(LC) 1·5+ Bedrock

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 to metres of measurements recorded in feet.
4. The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each M.A.U. borehole is indentified by a Registration Number, eg. **NW 80**. The letters refer to the quarter sheet and the figures to the I.G.S. serial number for that quarter. The unique designation for borehole NW 80 is TL 80 NW 80.

Grading Diagrams

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

Sand (+1/16–4mm)
Fines (–1/16mm) Gravel (+4mm)

The height of the diagram is proportional to the mineral thickness

The widths of the divisions show the proportions of **Fines, Sand** and **Gravel.**

OTHER BOREHOLES

The layout of information is the same as for M.A.U. boreholes, although data available may not be as comprehensive. They are registered in the same series, except for records in the Hydrogeological Department, for example, 241/84 signifies Hydrogeological Department borehole 84 on New Series One-Inch Geological Sheet 241. The final depth of deep boreholes is quoted in metres above or below O.D.

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for boreholes, but they are located by an asterisk, thus *. Reference number and details of thickness are shown.

CATEGORIES OF DEPOSITS

Exposed sand and gravel, as mapped. CAT-E3

Continuous or almost continuous spreads of sand and gravel beneath overburden. CAT-C1

Mineral either not potentially workable (see Report) or absent. CAT-A1

Where appropriate on other sheets a fourth category, Discontinuous spreads of sand and gravel beneath overburden' is recognised.

RESOURCE BLOCKS

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

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

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

Geological lines from a six-inch survey by C. R. Bristow in 1966 and 1969.
S. C. A. Holmes, District Geologist.
Included in One-Inch Geological Sheet 241

Sand and Gravel Survey by J. D. Ambrose, N. E. Bradbury,
A. R. Clayton and H. J. E. Heggard between 1967 and 1969.
A. A. Archer and R. G. Thurrell, Heads, Mineral Assessment Unit.

1:25 000 Sand and Gravel Resource Sheet, published 1972
Sir Kingsley Dunham, D.Sc., F.R.S., *Director, Institute of Geological Sciences*
incorporating the Geological Survey of Great Britain,
the Museum of Practical Geology and Overseas Geological Surveys.
2050/72

The GRID lines on this sheet are at 1 Kilometre interval.
Heights are in feet above Mean Sea Level at Newlyn.

1 square inch on this map represents 99·639 acres on the ground.

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

Compiled from 6" sheets last fully revised 1919-20.
Other partial systematic revision 1938-54 has been incorporated.

Made and published by the Director General of the Ordnance Survey, Chessington, Surrey, 1958.
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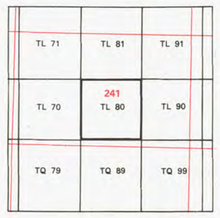

Diagram showing the relation of the National Grid 1:25 000 sheets with the One-Inch Geological Sheet 241.