NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF GEOLOGICAL SCIENCES

Report No. 73/13

ASSESSMENT OF BRITISH SAND AND GRAVEL RESOURCES No. 8

The sand and gravel resources of the country around Shotley and Felixstowe, Suffolk

Description of 1 : 25 000 resource sheet TM 23

R. Allender, BSc, PhD and S. E. Hollyer, BSc

London: Her Majesty's Stationery Office 1973

The Institute of Geological Sciences was formed by the incorporation of the Geological Survey of Great Britain and the Museum of Practical Geology with Overseas Geological Surveys and is a constituent body of the Natural Environment Research Council.

It is recommended that reference to this report be made in the following form:

ALLENDER, R. and HOLLYER, S. E. 1973. The sand and gravel resources of the country around Shotley and Felixstowe: Description of 1 : 25 000 resource sheet TM 23. *Rep. Inst. Geol. Sci.* No. 73/13. 71pp.

ISBN 0 11 880625 4

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 44.3 km^2 of country around Shotley and Felixstowe, Suffolk, shown on the accompanying 1:25 000 resource sheet TM 23.

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 be regarded also as an extension of geological mapping by providing information about the thickness and quality of deposits.

The survey was conducted during 1968 to 1970 by Dr R. Allender, assisted by Mr S. E. Hollyer as field officer, who supervised the drilling and sampling programme and helped in the preparation of data for this publication. Mr S. J. Booth also supervised drilling during the later parts of the programme.

The work is based on a 1:63 360 scale geological survey originally published in 1882 on Old Series Sheet 48 NE. The lines were transferred partly to New Series Sheet 207 (published with minor amendments in 1927) and partly to New Series Sheets 208 and 225, (published in 1928 and reprinted as a combined sheet in 1956). The geology of the area of sheet TM 23 is now presented at the 1:25 000 scale, incorporating minor amendments resulting from the present work.

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 for his advice on methods of resource calculation. Financial support for the survey was provided by the Department of the Environment.

Kingsley Dunham
Director

Institute of Geological Sciences
Exhibition Road
South Kensington
London SW7 2DE
1 September 1973

Any enquiries concerning this report may be addressed to Head, Mineral Assessment Unit, Institute of Geological Sciences, Exhibition Road, London SW7 2DE

CONTENTS

ILLUSTRATIONS

Summary

The sources of information which form the basis of the assessment of sand and gravel resources in the Shotley and Felixstowe areas of Suffolk include the geological maps of the Institute of Geological Sciences, a limited amount of field investigation and 45 new boreholes drilled by the Mineral Assessment Unit.

All deposits in the area which might be potentially workable for sand and gravel (mineral) have been investigated geologically and over most of the area a simple statistical method has been used to estimate the volume. The reliability of these volume estimates is given at the 95 per cent confidence level. For certain small areas of valley gravels it was not possible to use these methods, and an inferred assessment has been made.

The 1:25 000 map is divided into four resource blocks ranging in area from 0.5 to 19.9 km^2. For each block the mean thickness of overburden and mineral, and the mean grading are given, and the geology of the deposits is described.

The position of the boreholes, the geology and topography and the outlines of the blocks are shown on the accompanying map TM 23.

Sommaire

Parmi les sources de renseignements qui constituent la base de l'évaluation des ressources en sable et en gravier dans les régions de Shotley et de Felixstowe, Suffolk, sont les cartes géologiques de l'Institute of Geological Sciences, des recherches pratiques limitées, et 45 trous de sonde nouveaux forés par le Mineral Assessment Unit.

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 dans la plupart de la région on s'est servi d'une méthode statistique simple pour en évaluer le cubage. Ces évaluations de volume sont tenues d'être à 95 pour cent exactes. Dan les cas de quelques petites zones de graviers dans des vallées on ne pouvait pas employer ces méthodes et on a fait une évaluation par induction.

La carte 1:25 000 est divisée en quatre blocs de ressources, dont l'étendue varie de 0.5 km^2 à 19.9 km^2. On donne pour chaque bloc l'épaisseur moyenne de recouvrement et de minéral et la graduation moyenne. On décrit aussi la géologie des dépôts.

La situation des trous de sonde, la géologie, la topographie et la configuration des blocs sont montrées sur la carte TM 23.

Zusammenfassung

Die Informationsquellen, die den Grund für die Einschätzung der Sand- und Schotter-mittel in den Shotley und Felixstowe Gebieten von Suffolk bilden, enthalten die geologischen Karten der Institute of Geological Sciences, begrenzte Aussenuntersuchungen und 45 neue von der Mineral Assessment Unit gebohrte Bohrlöcher.

Alle Ablagerungen im Gebiet, die moglich bearbeitbar für Sand und Schotter (Mineral) sind, waren geologisch untersucht und im grössten Teil des Gebietes hat man eine einfache Methode benutzt, um das Volumen zu schätzen. Man gibt die Zuverlässigkeit der Volumen schätzungen mit 95 prozent Vertrauensgrenzwerten.

Für gewisse kleine Gebiete von Talschottern, konnte man diese Methoden nicht benutzen, und man hat eine gefolgerte Einschätzung gemacht.

Man teilt die 1:25 000 Karte in vier Mittelsblöcke, die Flächen von 0.5 bis 19.9 km^2 einschliessen. Für jeden Block beschreibt man die Durchschnittsdicke von Überlast und Mineral, und gibt die Durchschnittsdickeklassifiziering und beschreibt die Geologie der Ablagerungen.

Manzeigt die Lage der Bohrlöcher, die Geologie, die Topographie und die Skizzen von den Blöckern auf der Begleitkarte TM 23.

The sand and gravel resources of the country around Shotley and Felixstowe, Suffolk

Description of 1 : 25 000 resource sheet TM 23

R. ALLENDER,[1] BSc, PhD and S. E. HOLLYER,[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 Ministry of Housing and Local Government and the Ministry of Public Building and Works) and is being undertaken with the cooperation 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 concerned not 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 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

[1]Institute of Geological Sciences, 199 Knightsbridge, London, SW7 1DZ

apply to the resource block as a whole.

> Valid conclusions cannot be drawn about the mineral in parts of a block, except in the immediate vicinity of the actual sample points.

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 existance 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 borebole 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. The built-up area of Felixstowe has been avoided, but otherwise 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 of difficult 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 in Table 3.

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 and symbols shown on the map have been taken partly from Old Series Sheet 48 NE and one-inch New Series Sheet 207 (Ipswich), published in 1927, and from the combined one-inch New Series sheets 208 and 225 (Woodbridge and Felixstowe), published in 1956. The lines on the relevant parts of these New Series sheets were transferred (with minor revisions) from the Old Series sheet, which was mapped on the one-inch scale and published in 1882. Borehole data, which include the stratigraphic relations, and mean particle size distribution of the sand and gravel samples collected during the 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 TM 23) which change rapidly vertically and laterally, that local irregularities or discrepancies will be revealed by some boreholes (for example, at boreholes NW 18 and NE 9). 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 absent. (For the definition of 'mineral', see p. 1).

On TM 23 the mineral is subdivided into areas where it crops out and areas where it is believed to be present in 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 absent or not potentially workable. Areas where bedrock crops out and areas where sand and gravel is interpreted as not potentially workable are shown uncoloured on the map. In such areas it has been assumed that mineral is absent or cannot be quantitatively assessed in the context of this survey. The area of exposed sand and gravel is measured from the mapped geological boundary lines.

Description of Sheet TM 23

GENERAL

The area covered by this report is predominately agricultural. Industrial development is confined to the neighbourhood of Felixstowe, where recent improvements in the dock facilities have led to a rapid expansion of light industry and container traffic.

More than two-fifths (43.8 km^2) of the sheet area has been statistically assessed, and an inferred assessment has been made of a further 0.5 km^2 of terrace gravels. No assessment has been made of the remaining 55.7 km^2, which comprises 31.6 km^2 below mean HWM, (in the valleys of the Orwell and Stour), 12.2 km^2 south of the River Stour (consisting of London Clay) with spreads of Glacial Sand and Gravel and Red Crag, all of which are covered by the built-up area of Harwich, Dovercourt and Ramsey, and 11.9 km^2 making up the built-up area of Felixstowe (including barren ground to the west of the town).

TOPOGRAPHY

The area consists principally of coastal plains of low relief rising gently inland to form undulating ground, mainly between 50 ft (15.2 m) and 80 ft (24.4 m) above O.D., the highest point —

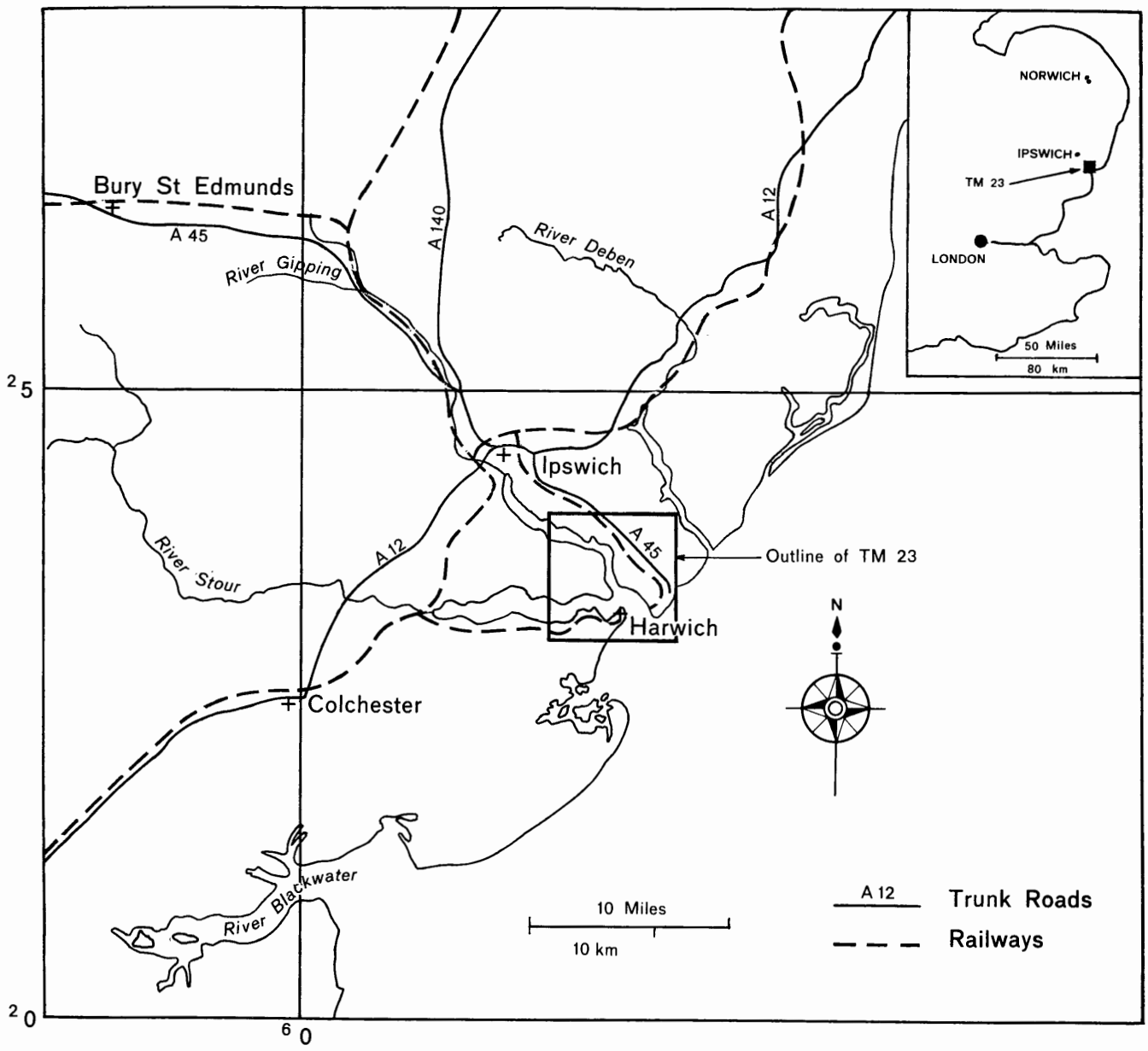


Fig. 1. Sketch map showing the location of sheet TM 23

102 ft (31.1 m) above O.D. — being in the west near Chelmondiston. The drowned valleys of the Orwell (flowing from north-west to south-east) and Stour (west to east) join at Orwell Haven and flow south into the estuary of Harwich Harbour and thence into the North Sea. These valleys cut the land area into three: a north-eastern part, from Levington to Felixstowe, a central peninsula from Chelmondiston to Shotley, and the area south of the Stour estuary, between Ramsey and Harwich. The prominent shingle spit south of Felixstowe at Landguard Point is being worked for aggregate, mainly from beneath the sea, but does not form part of the assessment.

GEOLOGY

Table 1 shows the geological succession.

Table 1. Geological succession for resource sheet TM 23

Strata	Mode of Formation
Recent and Pleistocene	
Marine Beach Deposits	River Valley deposits
Alluvium	
River Terrace Gravels	Glacial and/or river valley deposits
Brickearch	
Glacial Sand and Gravel	Glacial
?Chillesford Beds	Estuarine and/or marine
Red Crag	
Eocene	
London Clay	Marine

Apart from alluvial deposits which are still being laid down, and other valley deposits, which are of Recent and late Pleistocene age, the strata overlying the London Clay bedrock can be classified into two groups based on age and origin. The uppermost, younger deposit, the Glacial Sand and Gravel, of late Pleistocene age, consists of sand and gravel in the ratio 4:1 by weight; it is regarded as an outwash deposit associated with the decay of an ice sheet. Although thin boulder clays (commonly regarded as the ground moraine deposits of an ice sheet) are tentatively recorded in some assessment boreholes on TM 23, the edge of the main ice sheet was probably to the north of this sheet. The lower, older deposits, the Red Crag, of early Pleistocene age, are of marine origin and consist of approximately 90 per cent sand with a little gravel.

London Clay

The London Clay underlies the whole of the area. It is commonly exposed along the valley sides, forming the lower part of river cliffs in places. In the majority of assessment boreholes it consists of stiff blue-grey clay, either unweathered or weathered to a depth of only a few inches, while at outcrop the clay is weathered orange-brown to a depth of at least 10 ft (3.0 m). Although overlain by thin mineral deposits, the London Clay is also deeply weathered in assessment boreholes near Kirton, (where the London Clay surface reaches its greatest height above O.D.), as well as in boreholes close to the shorelines of the Orwell and Stour. Bands of hard 'cement-stones' can be seen in the clay in the river cliffs south-west of Levington and at Erwarton Ness, on the north side of the River Stour.

The height above O.D. of the upper surface of the London Clay, as determined from M.A.U. boreholes, varies from 24 ft (7.3 m) near Levington Hall [2405 3918][1] to 65 ft (19.8 m) at Kirton. The surface is not everywhere an evenly sloping plane, but often has the form of a series of ridges and basins (Fig. 2). The best example of this is east of Levington, where a well-marked depression occurs, its long axis trending approximately north-south.

On the basis of their stratigraphical position and of lithology sandy strata encountered in borehole NW 16 are doubtfully referred to the Chillesford Beds of Chillesford.

Red Crag

The Red Crag immediately overlies the London Clay, and was proved in 41 of the 45 assessment boreholes (of the remaining four, three show Glacial Sand and Gravel and one river terrace gravel overlying London Clay). At 37 sites the Red Crag could be divided into two distinct parts, upper Crag, containing no shells, and lower Crag containing abundant shells. The lower or shelly Crag was absent at four sites. Where present it consists mainly of fine to medium grain reddish-brown sand with varying, but often substantial, amounts of shell material. When seen in pits or natural exposures, the beds are commonly strongly current-bedded, with occasional layers of shell-free sand interbedded with the shelly sands. The amount of shell material and the degree of abrasion and comminution varies considerably, although in any one bed the size of the shell fragments is usually fairly uniform. Pebbles of flint, usually rounded, occur scattered throughout the deposit and there is some-

[1] Grid references in this publication fall within the 100-kilometre square TM (62).

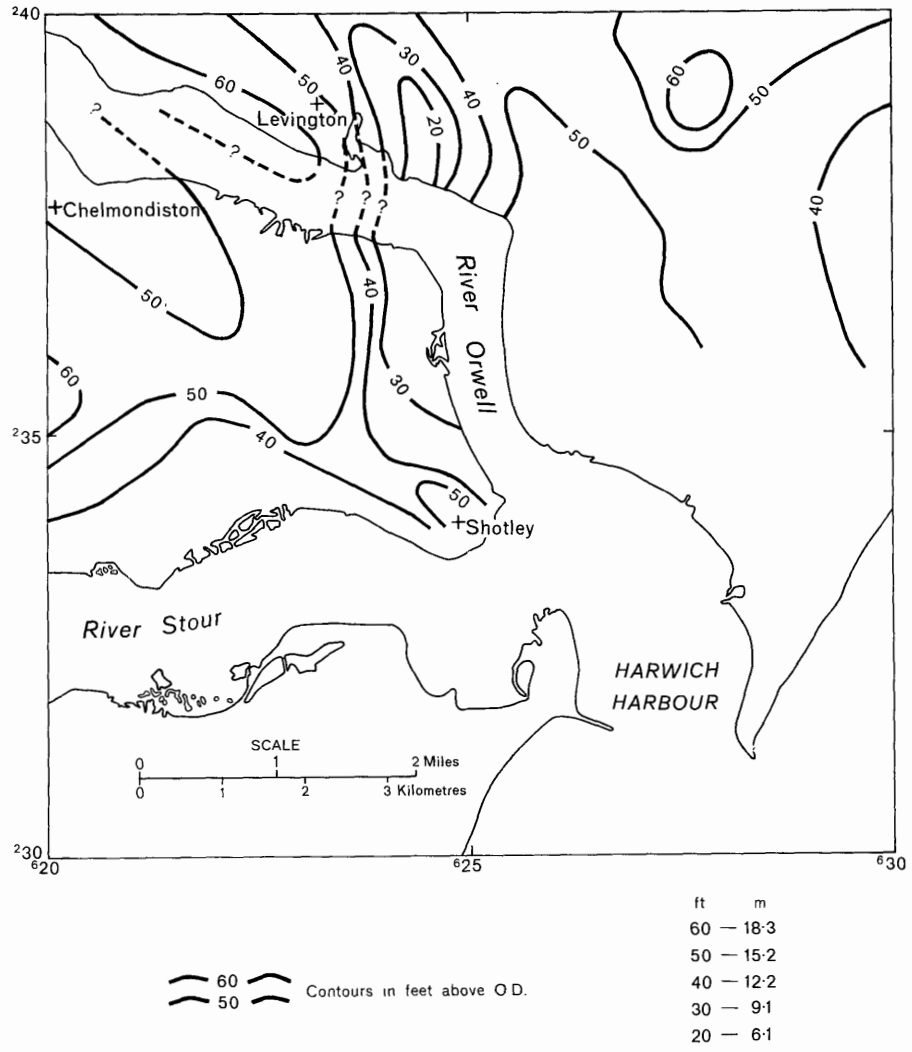


Fig. 2. Contour map showing the form of the London Clay surface, based on data from 45 assessment boreholes

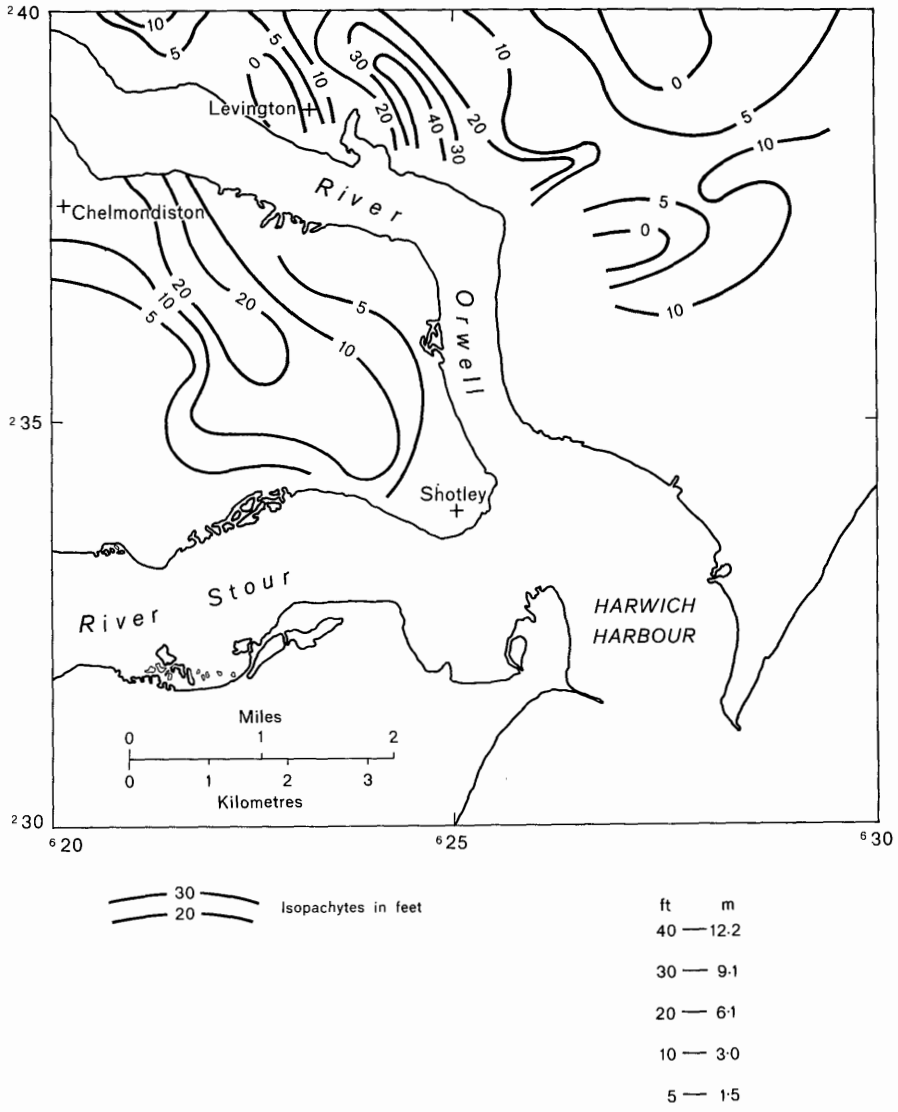


Fig. 3. Isopachytes of the lower (shelly) portion of the Red Crag, based on data from 37 assessment boreholes

times a concentration of black phosphatic pebbles at the base. The range in thickness of the lower Crag (Fig. 3) proved by assessment boreholes is 0 to 41.5 ft (12.6 m), with a mean thickness of 10 ft (3.0 m).

The upper Crag also consists of reddish-brown, fine to medium grained sand, often current-bedded, but without shells. Pebbles consisting mainly of rounded flint are sometimes present, although they are not normally an important constituent. In a few boreholes there is a concentration of pebbles at the base of the deposit. The thickness of the upper Crag ranges from 3 ft (0.9 m) to 29.5 ft (9.0 m), with a mean value of 12 ft (3.6 m).

In the Levington area there is a close relationship between the height of the London Clay surface and the thickness of the lower (shelly) part of the overlying Red Crag. As shown in Fig. 4 the shelly Crag is thickest where the London Clay surface is lowest and thinnest where the surface is highest. In contrast to the London Clay surface, which varies in height above O.D. by 37 ft (11.3 m) across the section shown in Fig. 4, the upper surface of the lower Red Crag is relatively level, varying by only 9 ft (2.7 m). Shelly Crag is absent in the Kirton area, where the London Clay surface is highest; it is possible that an island of London Clay stood out of the lower Red Crag sea, the deposits of which filled up the Levington basin and other hollows in the London Clay to a level probably very close to that of the present day upper surface of the lower Red Crag.

Glacial Sand and Gravel

Glacial Sand and Gravel overlies the Red Crag over much of the area under consideration. However, M.A.U. boreholes have shown that the outcrop of Glacial Sand and Gravel is generally less extensive than shown on the available geological maps particularly in the area between Trimley St Martin and Felixstowe. Since six-inch geological surveys have not been made of the area the limits of the Glacial Sand and Gravel are not accurately known. For assessment purposes, therefore, the Red Crag and Glacial Sand and Gravel are regarded as a single unit.

The Glacial Sand and Gravel consists of yellowish-brown sand with variable amounts of flint and quartz gravel. Thin beds of silt and clay may occur within the deposit. The mean percentage of material greater than 4 mm varies from 1 to 44 per cent in the assessment boreholes, but no consistent regional pattern in the distribution of the coarse material can be discerned (see Fig. 5).

? Boulder Clay

Although Chalky Boulder Clay is not shown on the one-inch geological map for this sheet area, till-like deposits have been recorded at the surface at three M.A.U. boreholes: NE 1, where 6 ft (1.8 m) of clay and silt with quartzite pebbles overlie Glacial Sand and Gravel, NE 7 where 6 ft (1.8 m) of light brown clay overlies Glacial Sand and Gravel, and NE 16 where 5.5 ft (1.7 m) of clay with fine sand overlie Red Crag. In borehole NE 1 a layer 1 ft (0.3 m) thick of red clay with erratics was recorded within the Glacial Sand and Gravel. This was also the case in boreholes NW 11, NE 8, and NE 10, where the thicknesses of waste were respectively 3 ft (0.9 m), 1.5 ft (0.5 m) and 2 ft (0.6 m). None of these clays contained chalk and they are not part of the extensive sheet of Chalky Boulder Clay which lies to the north and west of sheet TM 23. However, they may represent the products of the decay of isolated masses of dead ice, or eroded and decalcified pieces of till transported and redeposited by the outwash streams which deposited the Glacial Sand and Gravel.

Brickearth

Three patches of brickearth are shown on the published one-inch geological map, in the Kirton and Trimley St Martin areas. Assessment borehole NE 7 was sited on the patch near Kirton, and showed 6 ft (1.8 m) of clay overlying Glacial Sand and Gravel. Although no further lithological details are available (because no other boreholes were sited on brickearth as mapped) it is possible that the deposits may be thin tills. Areas of brickearth are also shown along the sides of the valleys of the Orwell and Stour, at a slightly higher level than the alluvial deposits. Hand augering of a number of these revealed brown clays and silts to depths of 4 to 4.5 ft (1.2-1.4 m) and in one case, south of Stratton Hall [254 384], sand and gravel was reached beneath clay. It is possible that gravels underlie the brickearth at other localities, but they are not likely to be thick and no surface indications have been found.

COMPOSITION OF THE SAND AND GRAVEL

The Glacial Sand and Gravel and the Red Crag are the two major horizons of potentially workable sand and gravel on sheet TM 23. Chillesford Beds have been tentatively identified at borehole NW 16.

Glacial Sand and Gravel

This deposit was identified in 30 M.A.U. boreholes mainly in the north and west of the assessed area. It has a mean thickness of 11.5 ft

(3.5 m). The mean grading is fines 4 per cent, sand 77 per cent, and gravel 19 per cent (for descriptions of these terms see p. 22). The sand is predominantly medium in grade, with fine and coarse sand present in minor and almost equal proportions (16 per cent and 14 per cent respectively). In the west, in block C, and around Stratton Hall in block A the Glacial Sand and Gravel shows a significantly higher gravel content than the mean, and is classed as sandy gravel. Elsewhere the deposit is classed as pebbly sand or sand (see Fig. 5).

The sand fraction is usually quartz with some flint and quartzite in the coarse sand; moderate iron staining has produced predominantly yellow to light brown colouring. Heavily iron-stained bands, deep brown or red, are occasionally encountered.

The gravel fraction is composed of flint, varying in colour from black through brown and grey to white. White vein quartz and white and brown quartzite are usually present, often in conspicuous quantities. Other rock types, including chert, sandstone, limestone, metamorphic and igneous rocks are rare. The quartz and quartzites are found in the fine gravel fraction and are subrounded to rounded, whereas the flint is subangular to angular (rarely subrounded) and forms the coarse fraction of the gravel.

Seams of clay and silt, often in the form of lenses, are occasionally encountered. These are usually not more than a few inches thick, although 6 ft (1.8 m) was recorded at borehole NW 10.

?Chillesford Beds

Some 18 ft (5.5 m) of fine to medium grained sands with clay, and silts, micaceous in the lower 3 ft (0.9 m), were encountered in borehole NW 16. These beds are referred to the Chillesford Beds of Chillesford (see also Allender and Hollyer, 1972) on the of their lithology and stratigraphical position, although no direct evidence of correlation is available. The deposit grades fines 9 per cent, sand 88 per cent, gravel 3 per cent.

Red Crag

The Red Crag was proved in 41 M.A.U. boreholes and has a mean thickness of 21.5 ft (6.6 m), that is, it is almost twice as thick as the Glacial Sand and Gravel. The mean grading of the Red Crag is fines 4 per cent, sand 91 per cent and gravel 5 per cent. At 20 boreholes the mineral is classified as sand, at 17 boreholes as pebbly sand, at three as 'clayey' sand and at one as 'clayey' pebbly sand. (See Fig. 6).

At 37 of the 41 boreholes where Red Crag was proved the deposit is divisible into upper and lower horizons. The lower division contains shells and shell fragments the frequency of which varies considerably both laterally and vertically but it tends to increase with depth. Although within the lower (shelly) horizon there are occasional shell-free bands of sand, the calcium carbonate content may be as much as 45 per cent; this figure relates to analyses carried out on samples from the area of sheet TM 24, to the north (Allender and Hollyer, 1972, p. 16). In the grading results given on the borehole record sheets the gravel percentages quoted for the lower (shelly) division of the Red Crag includes shell material greater than 4 mm. Thus, in some M.A.U. boreholes, for example, NE 11, an increase in gravel content coincides with the occurrence of large, often complete, shells (usually thick shelled bivalves and gastropods).

The mean thicknesses of the lower and upper parts of the Red Crag are respectively 10 ft (3.0 m) and 12 ft (3.6 m). The corresponding figures for the two divisions in each of the three resource blocks are given in Table 2, together with the mean gradings for the Crag as a whole. It will be noted that in blocks B and C the upper (non-shelly) Crag has a greater mean thickness than the lower (shelly) Crag, whereas in block A the reverse is the case. Also in block A there are higher percentages of medium and coarse sand, and gravel, than in the other two blocks. It is possible that this may be due to a greater proportion of shelly material in block A, so that the Red Crag as a whole has a coarser grading.

The sand fraction is composed of well-rounded and often polished quartz grains sometimes coated with iron oxide. In the lower Red Crag the ratio of comminuted shell fragments to quartz grains varies considerably, and in the coarse sand fraction the former are often predominant. Minerals other than quartz are rare.

The gravel fraction is composed of rounded black and brown flint pebbles with some quartzite and, in the lower Red Crag, the coarser shells. The gravel does not occur in such discrete beds as in the Glacial Sand and Gravel but a pebble bed which contains brown, often cylindrical, phosphatic pebbles up to 2.5 in (65 mm) across with rolled bones and teeth as well as rounded black flints, is often present at the base of the Red Crag.

The Red Crag is usually brown to red-brown, caused by variable staining by hydrated

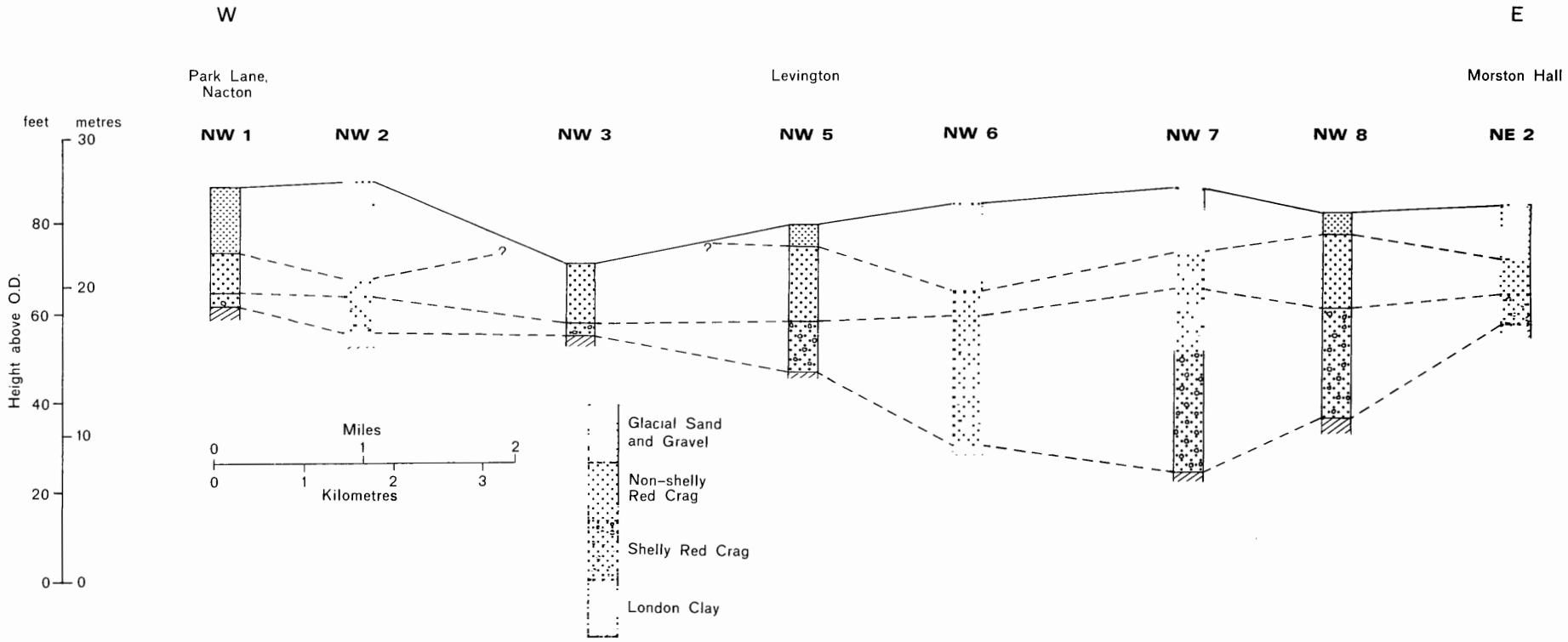


Fig. 4. West-east geological section across the Levington 'basin' showing the thickness variations of the shelly Red Crag and their relationship to the height of the London Clay surface

Table 2. Thickness and grading percentages for the lower and upper Red Crag

Block	Mean thickness (m)		Mean grading percentages (total Red Crag)				
	Lower Crag	Upper Crag	Fines	Sand			Gravel
				Fine	Medium	Coarse	
A	4.3	3.4	2	23	49	19	7
B	2.7	3.7	4	31	45	16	4
C	3.0	3.6	7	34	46	8	5

iron oxides. Many colour patterns are produced from simple layering to highly complex rings of brown, red and yellow sand. The iron oxide may be present in sufficient amounts to produce an iron cemented sandstone which in a number of cases slowed drilling considerably and sometimes prevented further progress. Silt or clay bands sometimes present in the lower part of the Red Crag are also often sufficiently indurated with iron oxide to produce a hard 'iron pan'.

RESULTS

Two methods of resource assessment are used (see Appendix A), a statistical assessment for blocks A, B and C and an inferred assessment for block D. The results are summarised in Table 3 and Figs. 7 and 8.

Accuracy of Results

For resource blocks A, B and C on sheet TM 23, the accuracy of the results at the 95 per cent confidence level (that is, the probability that 19 times out of 20 the true volume present lies within the given limits) varies between 19 per cent and 26 per cent. It should be remembered, however, that the true values 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 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, 10 boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves of part of a block, it can be expected that data from more than 10 sample-points will be required, even if the area is quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel in blocks A, B and C on sheet TM 23. The volume (268 million m^3) can be estimated to limits of ± 13 per cent at the 95 per cent confidence level, by a calculation based on the data from 44 sample-points spread across the three resource blocks. The inferred assessment of block D of approximately one million m^3 is not included in this total of volume.

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, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

NOTES ON RESOURCE BLOCKS

Block A

Most of the 7.1 km^2 of mineral in this block is mapped as Glacial Sand and Gravel, with the Red Crag outcropping as a narrow peripheral band to the south. In the extreme west, south of Orwell Park [215 393], Glacial Sand and Gravel is shown resting on London Clay, implying the absence of Red Crag. However, 12 ft (3.7 m) of Red Crag was proved in assessment boreholes NW 1 and 2 in this area. Similarly, although no Crag was mapped south-west of Levington village, borehole NW 4 proved 12 ft (3.7 m) of non-shelly Red Crag and no Glacial Sand and Gravel.

Glacial Sand and Gravel was proved at 11 of the 13 assessment boreholes in block A, its thickness ranging from 3 ft (0.9 m) to 20.5 ft (6.2 m), with a mean value of 11.5 ft (3.5 m). Red Crag was proved at all sites, the thickness ranging from 12 ft (3.7 m) to 49 ft (14.9 m), the mean value being 25.3 ft (7.7 m). Figures for the two subdivisions of the Red Crag are as follows. Non-shelly upper Red Crag: range 3 ft (0.9 m) to 16.5 ft (5.0 m), mean 11.2 ft (3.4 m). Shelly lower Red Crag: range 0 to 41.5 ft (12.6 m), mean 14.2 ft (4.3 m). The wide range of thickness in the lower Crag is believed to be the result of the filling of a basin in the London Clay in the Levington area (see Fig. 4) during lower Crag times, and restricted deposition in the areas where the surface of the

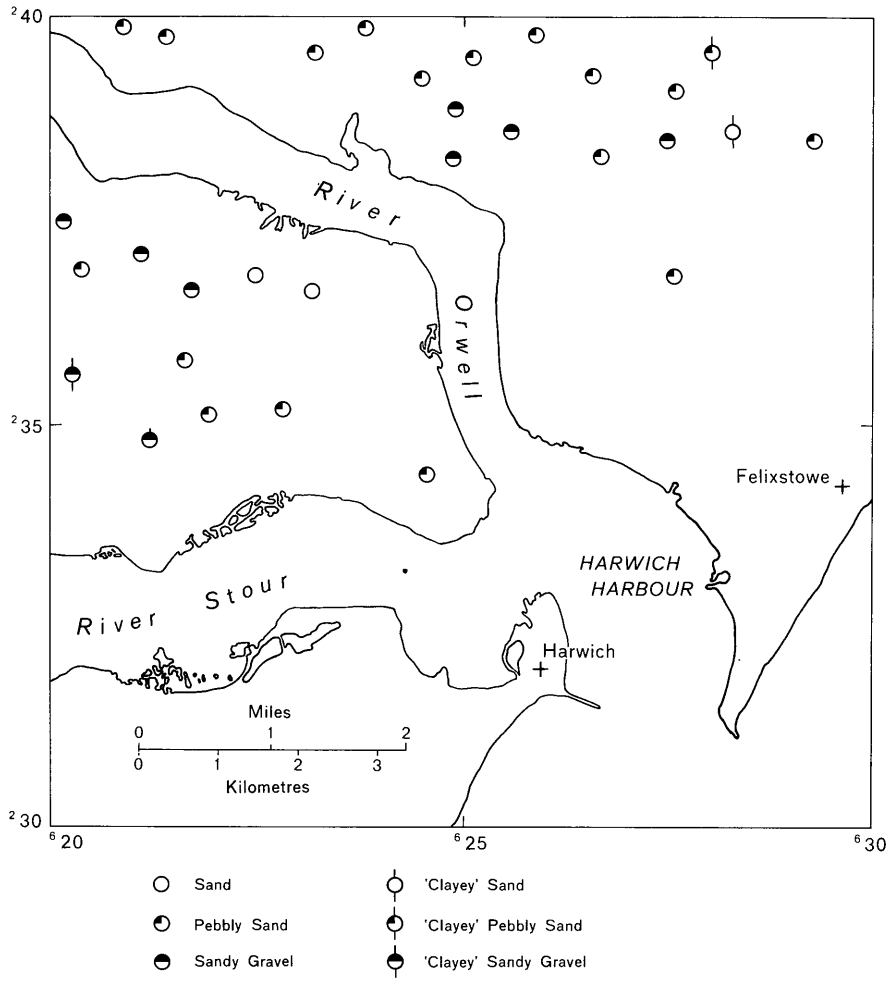


Fig. 5. Regional grading characteristics of the Glacial Sand and Gravel based on the mean grading at 30 assessment boreholes

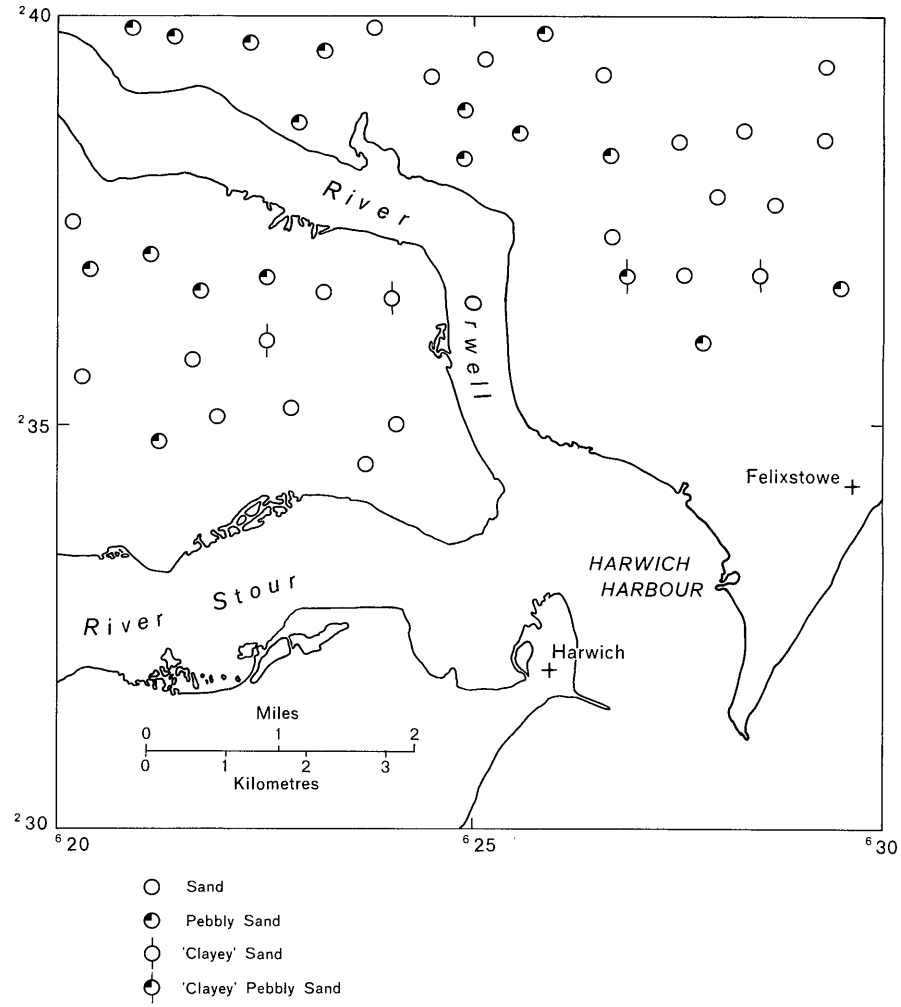
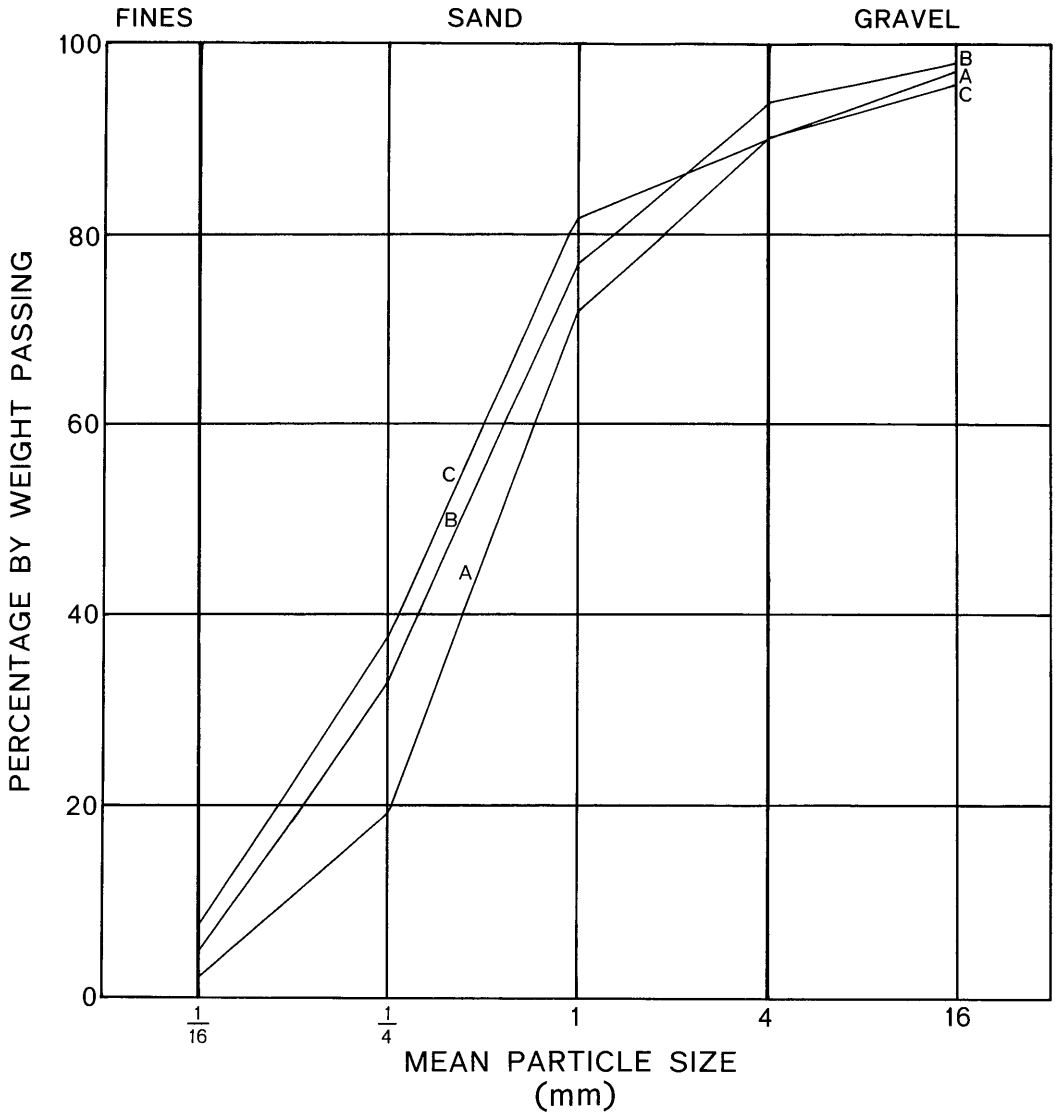


Fig. 6. Regional grading characteristics of the Red Crag based on the mean grading at 41 assessment boreholes



BLOCK	PERCENTAGE BY WEIGHT PASSING				
	$\frac{1}{16}$ mm	$\frac{1}{4}$ mm	1 mm	4 mm	16 mm
A	2	19	72	90	97
B	4	33	77	94	98
C	7	37	82	90	96

Fig. 7. Particle size distribution for the assessed thickness of sand and gravel in resource blocks A, B and C

London Clay stood at higher levels.

The percentage of gravel in the Glacial Sand and Gravel, as determined from mean grading results at assessment boreholes, ranges from 7 to 33 and the deposit at most of the boreholes falls within the pebbly sand class (see Fig. 11). At NW 8, NE 2, and possibly at NW 9 (on the evidence of the field description only) it is sandy gravel. In the Red Crag the gravel fraction ranges from 1 to 17 per cent; the deposit at four boreholes is classified as sand and at the remaining nine as pebbly sand. Mean percentage gradings for the block are given below.

	-1/16	+1/16-$\frac{1}{4}$	+$\frac{1}{4}$-1	+1-4	+4-16	+16
Glacial Sand and Gravel	2	11	54	16	10	7
Red Crag	2	23	49	19	5	2
Total mineral block A	2	17	53	18	7	3

The estimate for the total volume of mineral in block A is 75 million m^3, ± 25 per cent at the 95 per cent confidence level.

Block B

Of the 14.2 km^2 of this block, 11.9 km^2 are mapped as Glacial Sand and Gravel and Red Crag, the latter cropping out as a narrow peripheral band to most of the area of mineral. However, seven assessment boreholes sited on the Glacial Sand and Gravel outcrop as mapped, proved only Red Crag, probably due to the patchy distribution of the Glacial Sand and Gravel and to some inaccuracies in the original geological survey, which was on the one-inch scale. It is difficult to separate the Red Crag and Glacial Sand and Gravel by surface mapping without the use of augers or borehole information; in places the difficulty is heightened by the fact that a foot or so of residual gravel commonly overlies the Red Crag.

Glacial Sand and Gravel was proved in seven of the 15 assessment boreholes in block B, the thickness ranging from 5 ft (1.5 m) to 21 ft (6.4 m), with a mean value of 9 ft (2.7 m). In two, NE 7 and NE 12 near Kirton, thin Glacial Sand and Gravel rests directly on London Clay, Red Crag being absent, possibly not deposited since the London Clay surface is at its highest in this area.

The Red Crag was proved in 13 of the 15 boreholes in which its total thickness ranged from 9ft (2.7 m) to 30 ft (9.1 m), the mean value being 20.5 ft (6.2 m). The figures for the two divisions of the Red Crag are as follows. Non-shelly upper Red Crag: range 6 ft (1.8 m) to 21 ft (6.4 m), mean 12 ft (3.7 m). Shelly lower Red Crag: range 0 to 17 ft (5.2 m), mean 9 ft (2.7 m).

The gravel fraction in the Glacial Sand and Gravel at the six M. A. U. sites where grading results are available varies from 4 to 31 per cent; the deposits at three boreholes fall into the pebbly sand class (see Fig. 11): one is sandy gravel; one is clayey pebbly sand and one is clayey sand. The gravel in the Red Crag varies from 1 to 9 per cent. Of the 13 sites with Red Crag, the mineral is sand in eight, pebbly sand in three and the remaining two are clayey sand and clayey pebbly sand. Mean percentage gradings for the block are given below.

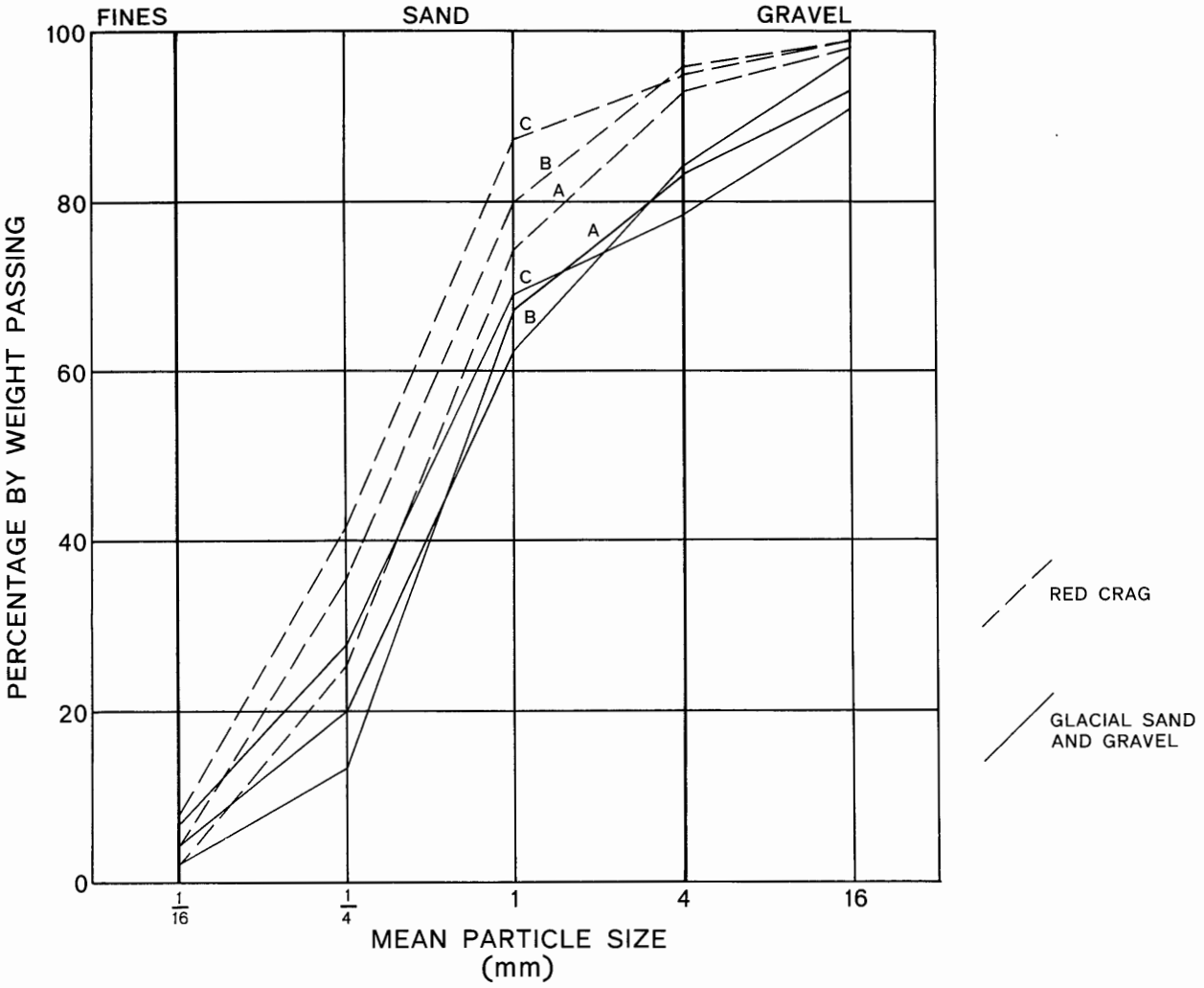
mm	-1/16	+1/16-$\frac{1}{4}$	+$\frac{1}{4}$-1	+1-4	+4-16	+16
Glacial Sand and Gravel	4	16	42	22	13	3
Red Crag	4	31	45	16	3	1
Total mineral block B	4	29	44	17	4	2

The estimate for the total volume of mineral in block B is 80 million m^3 ± 26 per cent at the 95 per cent confidence level.

Block C

Most of the 12.1 km^2 of mineral in this block is mapped as Glacial Sand and Gravel, the Red Crag generally occupying a narrow belt above the London Clay. In a few places, Glacial Sand and Gravel rests directly on London Clay: for example, in borehole SW 16 near Shotley.

The thickness of the Glacial Sand and Gravel ranges from 5 ft (1.5 m) to 27.2 ft (8.3 m) with a mean of 12.5 ft (3.8 m). The deposit occurs in 12 of the 16 boreholes in this block. The Red Crag as a whole ranges from 6.5 ft (2.0 m) to 33.1 ft (10.1 m), with a mean of 21.3 ft (6.4 m). Figures for the two parts are as follows. Non-shelly upper Red Crag: range 3.0 ft (0.9 m) to 29.2 ft (8.9 m), mean 12.5 ft (3.6 m). Shelly lower Red Crag: range 0 to 27.2 ft (8.3 m), mean 8.9 ft (2.8 m). The proportion of material coarser than 4 mm ranges from 1 per cent to 44 per cent in the



BLOCK	DEPOSIT	PERCENTAGE BY WEIGHT PASSING				
		$\frac{1}{16}$ mm	$\frac{1}{4}$ mm	1 mm	4 mm	16 mm
A	GLACIAL SAND AND GRAVEL	2	13	67	83	93
	RED CRAG	2	25	74	93	98
B	GLACIAL SAND AND GRAVEL	4	20	62	84	97
	RED CRAG	4	35	80	96	99
C	GLACIAL SAND AND GRAVEL	6	27	69	78	91
	RED CRAG	7	41	87	95	99

Fig. 8. Comparison of the particle size distribution in the Glacial Sand and Gravel and the Red Crag for the assessed thickness of sand and gravel in blocks A, B and C

Table 3. The sand and gravel resources of sheet TM 23

Statistical assessment

	Area		Mean thickness				Volume of mineral				Mean grading percentages in mm									
	Block	Mineral	Over-burden		Mineral		Million m^3	Million yd^3	Limits at the 95% confidence level		Fines	Sand					Gravel			
	km^2	km^2	m	ft	m	ft			±%	Volume in million m^3	$-\frac{1}{16}$	$+\frac{1}{16}$	$+\frac{1}{4}$	+1	-4		+4			
												$-\frac{1}{4}$	-1				-16		+16	
A	9.7	7.1	0.6	2.0	10.6	34.8	75	98	25	19	2	17	53		18		7		3	
B	14.2	11.9	0.9	3.0	6.7	23.0	80	105	26	21	4	29	44		17		4		2	
C	19.9	12.1	1.0	3.3	9.3	30.5	113	148	19	21	7	30	45		8		6		4	
A, B & C	43.8	31.1	0.9	3.0	8.6	28.2	268[1]	351	13	35										

Inferred assessment for terrace deposits (not included above)

D [2]	0.5	0.5	1.0	3.3	1.6	5.2	c.1	c.1			1	3	16		10		22		48	
Not assessed	55.7		Comprises area below mean high water (31.6 km^2), ground south of the River Stour (12.2 km^2) and Felixstowe urban area including exposed London Clay, brickearth and Alluvium to the west of the town (11.9 km^2)																	

[1] Composed of approximately 205 million m^3 of Red Crag and 63 million m^3 of Glacial Sand and Gravel.

[2] Inferred assessment: grading based on one borehole only.

Glacial Sand and Gravel, and from 1 per cent to 16 per cent in the Red Crag. In four boreholes the Glacial Sand and Gravel is classified as sandy gravel; one clayey sandy gravel; five pebbly sand and in two sand (see Fig. 11). In contrast, of the 15 boreholes in which Red Crag was proved eight are sand, two are clayey sand and five pebbly sand. Material classified as Chillesford Beds found in NW 16 is classed as sand. Mean percentage gradings for the block are given below.

mm	-1/16	+1/16-¼	+¼-1	+1-4	+4-16	+16
Glacial Sand and Gravel	6	21	42	9	13	9
Red Crag	7	34	46	8	4	1
Total mineral block C	7	30	45	8	6	4

The estimate for the total volume of mineral in block C is 113 million m^3 ± 19 per cent at the 95 per cent confidence level.

Block D

The mineral in this block comprises four small patches of terrace gravel with a total area of only 0.5 km^2. Most of this mineral is peripheral to block C. As the total area of mineral is less than 2 km^2, the block contains only one assessment borehole and an inferred rather than a statistical assessment has been made of the total volume of mineral.

Of the three terraces on the north bank of the River Stour the largest (immediately to the south and west of Beaumont Hall [205 338]) is mapped on the Old Series one-inch geological map, Sheet 48 NE as Glacial Sand and Gravel. However, borehole SW 12 proved 5.5 ft (1.7 m) of terrace deposits with up to 70 per cent gravel. Boreholes sunk for the Central Electricity Generating Board on the terrace north of Erwarton Ness [213 332] proved mineral up to 7.5 ft (2.3 m) thick. Examination in the field of the two remaining areas of terrace in block D, east-south-east of Ness Farm [2155 3396] and north of the River Orwell, west of Broke Hall, [224 391] confirmed their similarity to the Erwarton Ness terrace. The grading percentages quoted on Table 3 for block D are based only on borehole SW 12.

Total volume of mineral in block D is estimated to be approximately one million m^3.

LIST OF QUARRIES

At the time of publication there are no commercially worked quarries on sheet TM 23. Gravel is currently being extracted from shoals and submarine bars off Languard Point [283 312] but these marine deposits are beyond the terms of reference of this report.

References

ALLEN, V.T. 1936. Terminology of medium-grained sediments. Rep. natn. Res. Coun. Wash. 1935-36. App. 1, Rep. Comm. Sedimentation, pp. 18-47.

ALLENDER, R. and HOLLYER, S.E. 1972. The sand and gravel resources of the country to the south and west of Woodbridge, Suffolk: Description of 1:25 000 resource sheet TM 24. Rep. Inst. Geol. Sci. No. 72/9. 128 pp.

ANON. 1948. Mineral Resources of the United States, pp. 14-17 (Washington, D.C.: Public Affairs Press).

——— 1967. Methods of testing soils for civil engineering purposes. Br. Stand. No. 1377, 233 pp.

——— 1970. Metrication: two opposing views. Quarry Mgrs' J., Vol. 54, No. 6, p. 230.

ARCHER, A.A. 1969. Background and problems of an assessment of sand and gravel resources in the United Kingdom. Proc. 9th Commonw. Min. metall. Congr. 1969, Vol. 2, Mining and Petroleum Geology. pp. 495-508.

——— 1970a. Standardisation of the size classification of naturally occurring particles. Geotechnique, Vol. 20, pp. 103-107.

——— 1970b. Making the most of metrication. Quarry Mgrs' J., Vol. 54, No. 6, pp. 223-227.

ATTERBERG, A. 1905. Die Rationelle Klassifikation der Sande und Kiese. Chem. Z., Vol. 29, pp. 195-198.

BOSWELL, P.G.H. 1927. The geology of the country around Ipswich. Mem. Geol. Surv. G.B.

——— 1928. The geology of the country around Woodbridge, Felixstowe and Oxford. Mem. Geol. Surv. G.B.

DOUBLE, I.S. 1924. Petrography of the late Tertiary deposits of East England. Proc. Geol. Ass., Vol. 35, pp. 332-258.

HARMER, F.W. 1900. The Pliocene deposits of East England - Part II: The Crag of Essex (Waltonian) and its relation to that of Suffolk and Norfolk. Q. J. Geol. Soc. London, Vol. 56, pp. 705-738.

LANE, E.W. and others. 1947. Report of the sub-committee on sediment terminology. Trans. Am. Geophys. Un, Vol. 28, pp. 936-938.

PETTIJOHN, F.J. 1957. Sedimentary Rocks 2nd Ed. (London: Harper and Row).

PRESTWICH, J. 1871. On the structure of the Crag-beds of Suffolk and Norfolk with some observations on their organic remains. Q. J. Geol. Soc. London, Vol. 27 Part I, pp. 115-146, Part II, pp. 325-356, Part III, pp. 453-496.

THURRELL, R.G. 1971. The assessment of mineral resources with particular reference to sand and gravel. Quarry Mgr's J., Vol. 55, pp. 19-25.

TWENHOFEL, W.H. 1937. Terminology of the fine-grained mechanical sediments. Rep. natn. Res. Coun. Wash. 1936-37, App. 1, Rep. Comm. on sedimentation, pp. 81-104.

UDDEN, J.A. 1914. Mechanical composition of clastic sediments. Bull. geol. Soc. Am., Vol. 25, pp. 655-744.

WENTWORTH, C.K. 1922. A scale of grade and class terms for clastic sediments. J. Geol., Vol. 30, pp. 377-392.

———————— 1935. The terminology of coarse sediments. Bull. No. 98 natn. Res. Coun. Wash. pp. 225-246.

WILLMAN, H.B. 1942. Geology and mineral resources of the Marseilles, Ottawa and Streator quadrangles. Bull. No. 66 Ill. State Geol. Surv., pp. 343-344.

WHITAKER, W. 1885. The geology of the country around Ipswich, Hadleigh and Felixstowe. Mem. Geol. Surv. G.B.

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 limited 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

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

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

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

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:

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	
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	MAU Boreholes
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		3.4		
2	¼	4.5	2.5(25)*	0.8	3.6(25)*	Close group of four boreholes (commercial)
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. 9. Example of resource block assessment: statement and calculation

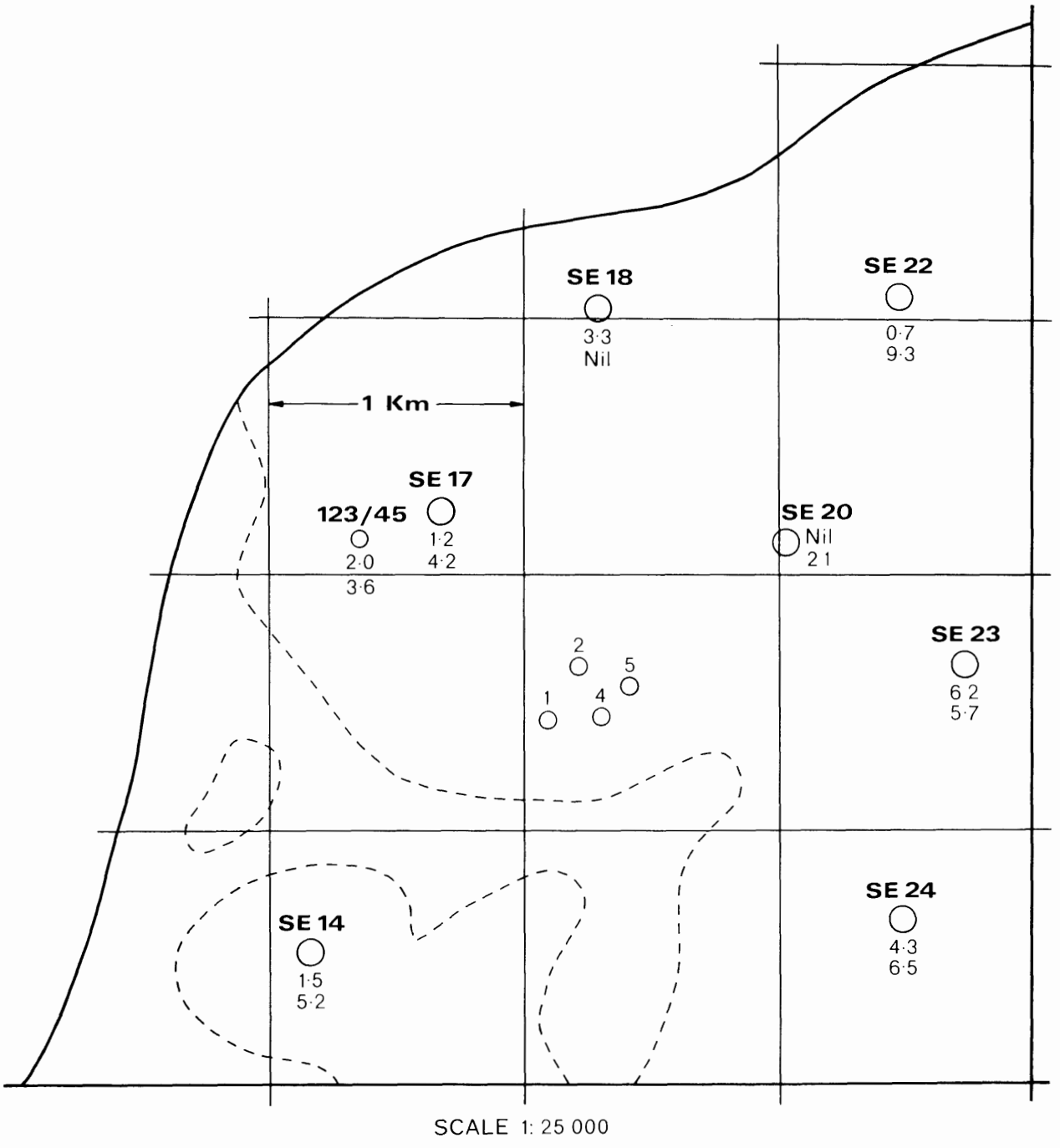


Fig. 10. Example of resource block assessment: map of fictitious block

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

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

and when n is greater than 20, as

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

13. An illustration of the procedures outlined above is given in Figs. 10 and 11, 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 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 8). 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	Designation	Qualification	Primary classification
64 mm	Cobble		Gravel
16 mm	Pebble	Coarse	
		Fine	
4mm	Sand	Coarse	Sand
1 mm		Medium	
¼ mm		Fine	
1/16 mm	Fines (silt and clay)		Fines

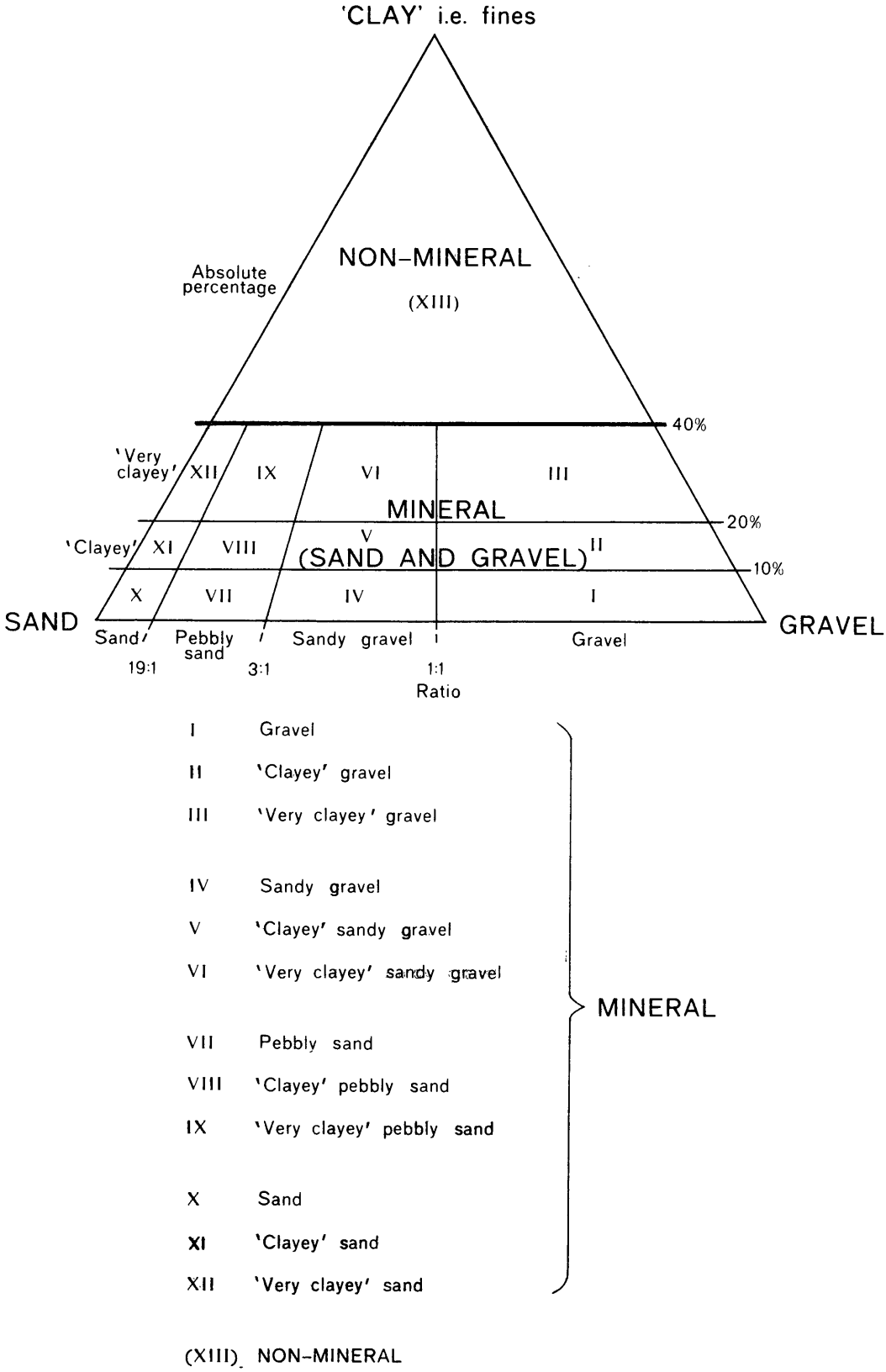


Fig. 11. Diagram to show the descriptive categories used in the classification of sand and gravel

Appendix C: Borehole Records

EXPLANATION

Annotated Example of a Borehole Record

TM 23 NW 6[1] 2378 3992[2] Levington, Suffolk [3]

Surface level (+ 25.6 m) + 84 ft[4]
Water struck at (+ 17.1 m) + 56 ft[5]
Wirth B 1, 6 - 8 inch diam.,
November 1968[6]

[7] Overburden (0.3 m) 1 ft;
Mineral (4.4 m) 14.5 ft;
Waste (1.1 m) 3.5 ft;
Mineral (11.0 m) 36 ft;
Bedrock (0.3 m +) 1 ft +[8]

			Thickness		Depth	
			(m)	ft	(m)	ft
		Soil	(0.3)	1	(0.3)	1
[9] Glacial Sand and Gravel	(a)	Pebbly Sand Medium to coarse yellow-brown[10] sand with gravel. Gravel, sub-rounded to angular brown and black flint. Largest particle size 75 mm. Basal (0.9 m) 3 ft mainly medium sand with little gravel.	(4.4)	14.5	(4.7)	15.5[11]
		Silty clay with iron concretions	(1.1)	3.5	(5.8)	19
Red Crag	(b)	Sand Medium sand, dark red-brown, with occasional clay nodules and a trace of gravel	(1.8)	6	(7.6)	25
		Mainly medium light brown sand with varying amounts of fine and coarse sand and shell fragments	(9.2)	30	(16.8)	55
London Clay		Blue-grey clay	(0.3+)	1+	(17.1)	56

		%	mm[15]	%	Depth below surface (ft)	Percentages Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	24	+ 16	8	1 – 4[12]	1	6	41	24	22	6[13]
			– 16 + 4	16	4 – 7	1	3	42	28	18	8
					7 – 10	1	7	36	17	24	15
	Sand	75	– 4 + 1	23	10 – 13	1	2	52	22	13	10
			– 1 + $\frac{1}{4}$	45	13 – 15.5	1	18	54	21	6	0
			– $\frac{1}{4}$ + $\frac{1}{16}$	7							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	3	+ 16	0	19 – 22	1	12	66	20	1	0
			– 16 + 4	3	22 – 25	1	19	62	11	5	2
					25 – 28	1	28	43	27	1	0
	Sand	96	– 4 + 1	17	28 – 31	1	16	42	32	9	0
			– 1 + $\frac{1}{4}$	58	31 – 34	1	21	61	16	1	0
			– $\frac{1}{4}$ + $\frac{1}{16}$	21	34 – 37	1	19	66	12	2	0
					37 – 40	1	30	60	7	2	0
	Fines	1	– $\frac{1}{16}$	1	40 – 43	1	13	65	16	4	1
					43 – 46	1	18	61	15	5	0
					46 – 49	1	24	59	14	2	0
					49 – 52	No grading information available[14]					
					52 – 55	2	27	59	12	0	0

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 1:25000 sheet on which the borehole lies, for example, TM 23.
2) The quarter of the 1:25000 sheet on which the borehole lies and its number in a series for that quarter, for example, NW 6.

Thus the full Registration Number is TM 23 NW 6. Usually this is abbreviated to NW 6 in the text.

2. The National Grid Reference.
All National Grid References in this publication lie within the 100 km square TM 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 1:25000 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.
Three types of drilling machine have been used in this survey; a Shell and Auger rig and Wirth B1 and B0 machines (cased power auger rigs). 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 Norwich area the bedrock is Chalk.

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.

The borehole log

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.

Grading information

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 graved, or for every 3 ft of depth.

13. Grading Results.
The limits are as follows: gravel, +4 mm; coarse sand, -4+1 mm; medium sand, -1+¼ mm; fine sand, -¼+$^1/_{16}$ 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 MINERAL ASSESSMENT UNIT BOREHOLES

Borehole Number (by sheet quadrant)	Grid Reference (all lie within 100 km square TM)	Borehole Number (by sheet quadrant)	Grid Reference (all lie within 100 km square TM)
NW 1	2089 3987	NE 16	2927 3936
NW 2	2139 3981	NE 17	2927 3850
NW 3	2228 3966	NE 18	2946 3656
NW 4	2290 3866	NE 19	2587 3975
NW 5	2320 3955		
NW 6	2378 3992		
NW 7	2446 3930	SW 12	2038 3367
NW 8	2492 3888	SW 13	2123 3478
NW 9	2489 3832	SW 15	2371 3446
NW 10	2018 3753	SW 16	2450 3438
NW 11	2037 3694	SW 17	2414 3497
NW 12	2031 3558		
NW 13	2113 3714		
NW 14	2168 3660		
NW 15	2158 3581		
NW 16	2192 3512		
NW 17	2251 3679		
NW 18	2245 3598		
NW 19	2279 3519		
NW 20	2319 3663		
NW 21	2397 3653		
NE 1	2517 3950		
NE 2	2560 3855		
NE 3	2659 3927		
NE 4	2670 3827		
NE 5	2670 3731		
NE 6	2694 3677		
NE 7	2757 3907		
NE 8	2753 3849		
NE 9	2798 3784		
NE 10	2768 3676		
NE 11	2776 3599		
NE 12	2804 3958		
NE 13	2826 3860		
NE 14	2873 3773		
NE 15	2847 3683		

TM 23 NW 1 2089 3987 Nacton, Suffolk

Surface level (+ 26.8 m) + 88 ft
Water struck at (+ 19.5 m) + 64 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (7.9 m) 26 ft;
Bedrock (1.5 m +) 5 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Pebbly Sand Mainly medium yellow sand becoming finer with depth. Gravel fraction increasing with depth; mainly subrounded flint	(4.3)	14	(4.6)	15
Red Crag	(b)	Pebbly Sand Fine to medium red sand with occasional pebbles	(2.7)	9	(7.3)	24
		Red sand with shell fragments	(0.9)	3	(8.2)	27
London Clay		Brown weathered clay	(0.3)	1	(8.5)	28
		Blue clay	(1.2 +)	4 +	(9.7)	32

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	10	+ 16	7	1 – 3	1	19	70	8	2	0
			– 16 + 4	3	3 – 6	1	14	77	5	3	0
					6 – 9	1	10	77	4	3	5
	Sand	89	– 4 + 1	7	9 – 12	1	37	30	5	2	25
			– 1 + ¼	62	12 – 15	1	20	55	12	6	6
			– ¼ + $\frac{1}{16}$	20							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	5	+ 16	0	15 – 18	1	39	42	15	3	0
			– 16 + 4	5	18 – 21	1	33	48	16	3	0
					21 – 24	2	22	55	19	2	0
	Sand	94	– 4 + 1	14	24 – 27	1	26	53	19	1	0
			– 1 + ¼	50							
			– ¼ + $\frac{1}{16}$	30							
	Fines	1	– $\frac{1}{16}$	1							

TM 23 NW 2 2139 3981 Nacton, Suffolk

Surface level (+ 27.1 m) + 89 ft
Water struck at (+ 18.6 m) + 61 ft
Wirth B 1,8 inch diam.,
December 1968

Overburden (0.5 m) 1.5 ft;
Mineral (9.8 m) 32.5 ft;
Bedrock (0.2 m +) 0.5 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.5)	1.5	(0.5)	1.5
Glacial Sand and Gravel	(a)	Pebbly Sand Medium to coarse yellow sand becoming medium with depth, gravel mainly fine subangular flint, concentrated in top half. First (0.8 m) 2.5 ft rather silty	(6.2)	20.5	(6.7)	22
Red Crag	(b)	Pebbly Sand Medium to coarse red brown sand with gravel. Gravel of rounded black flint and rounded quartzite	(0.9)	3	(7.6)	25
		Fine, medium and coarse red sand with shell fragments, rounded black pebbles and subangular flints	(2.7)	9	(10.3)	34
London Clay		Clay	(0.2+)	0.5+	(10.5)	34.5

		%	mm	%
(a)	Gravel	21	+ 16	7
			− 16 + 4	14
	Sand	78	− 4 + 1	21
			− 1 + ¼	48
			− ¼ + 1/16	9
	Fines	1	− 1/16	1
(b)	Gravel	17	+ 16	6
			− 16 + 4	11
	Sand	82	− 4 + 1	21
			− 1 + ¼	41
			− ¼ + 1/16	20
	Fines	1	− 1/16	1

Depth below surface ft	Fines	Sand			Gravel	
	−1/16	+1/16−¼	+¼−1	+1−4	+4−16	+16
1.5 − 4	4	13	32	29	20	2
4 − 7	1	8	33	15	6	35
7 − 10	1	1	41	29	24	4
10 − 13	1	8	43	16	19	3
13 − 16	1	19	51	13	16	0
16 − 19	1	8	71	14	6	0
19 − 22	1	4	62	21	8	4
22 − 25	1	3	44	15	20	17
25 − 28	1	20	46	22	9	2
28 − 31	2	16	42	23	12	5
31 − 34	1	40	33	24	2	0

TM 23 NW 3 2228 3966 Nacton, Suffolk

Surface level (+ 21.6 m) + 71 ft
Water struck at (+ 17.7 m) + 58 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (4.6 m) 15 ft;
Bedrock (0.2 m +) 0.5 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	Pebbly Sand Fine to medium red sand becoming coarser with depth. Some gravel in top (1.2 m) 4 ft.	(3.7)	12	(4.0)	13
	Red sand with shell fragments	(0.9)	3	(4.9)	16
London Clay	Clay	(0.2 +)	0.5 +	(5.1)	16.5

	%	mm	%
Gravel	6	+ 16	3
		– 16 + 4	3
Sand	92	– 4 + 1	19
		– 1 + ¼	41
		– ¼ + 1/16	32
Fines	2	– 1/16	2

Depth below surface (ft)	Percentages: Fines –1/16	Sand +1/16–¼	Sand +¼–1	Sand +1–4	Gravel +4–16	Gravel +16
1 – 5	5	25	40	12	5	13
5 – 7	1	70	25	4	0	0
7 – 10	1	19	44	28	6	2
10 – 13	1	12	63	24	0	0
13 – 16	1	36	33	27	3	0

TM 23 NW 4 2290 3866 Nacton, Suffolk

Surface level (+ 22.3 m) + 73 ft
Water struck at (+ 19.2 m) + 63 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft
Mineral (3.7 m) 12 ft;
Bedrock (0.6 m +) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	Pebbly Sand Mainly medium sand, dark yellow-brown, becoming red-brown towards the base. Subrounded to angular flint. Gravel concentrated in top (0.9 m) 3 ft	(3.7)	12	(4.0)	13
London Clay	Clay	(0.6 +)	2 +	(4.6)	15

	%	mm	%	Depth below surface (ft)
Gravel	13	+ 16	4	1 – 4
		– 16 + 4	9	4 – 7
				7 – 10
Sand	84	– 4 + 1	20	10 – 13
		– 1 + ¼	46	
		– ¼ + 1/16	18	
Fines	3	– 1/16	3	

Percentages	Fines	Sand			Gravel	
	–1/16	+1/16–¼	+¼–1	+1–4	+4–16	+16
	1	7	37	22	17	16
	3	14	59	16	7	1
	5	26	44	22	3	0
	1	28	41	21	9	0

TM 23 NW 5 2320 3955 Levington, Suffolk

Surface level (+ 24.1 m) + 79 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.5 m) 1.5 ft;
Mineral (10.0 m) 33 ft;
Bedrock (1.7 m +) 5.5 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.5)	1.5	(0.5)	1.5
Glacial Sand and Gravel	(a)	Probably Pebbly Sand Medium to coarse yellow sand with occasional rounded flint pebbles	(0.9)	3	(1.4)	4.5
Red Crag	(b)	Pebbly Sand Mainly medium to coarse sand, red. Gravel concentrated in top (0.9 m) 3 ft	(5.5)	18	(6.9)	22.5
		Medium to coarse sand, red with shell fragments. Some gravel (rounded black pebbles and irregular flints) mainly in basal (0.9 m) 3 ft	(3.6)	12	(10.5)	34.5
London Clay		Brown weathered clay.	(0.8)	2.5	(11.3)	37
		Blue grey clay	(0.9 +)	3 +	(12.2)	40

		%	mm	%	Depth below surface ft	Fines −1/16	Sand +1/16–1/4	Sand +1/4–1	Sand +1–4	Sand +4–16	Gravel +16
(a)					1.5 – 4.5	No grading information available					
(b)	Gravel	5	+ 16	1	4.5 – 7.5	1	7	25	45	13	9
			– 16 + 4	4	7.5 – 10.5	1	22	45	30	2	0
					10.5 – 13.5	2	22	57	17	2	0
	Sand	94	– 4 + 1	25	13.5 – 16.5	1	26	52	21	0	0
			– 1 + 1/4	52	16.5 – 19.5	1	15	59	25	0	0
			– 1/4 + 1/16	17	19.5 – 22.5	1	23	56	17	3	0
					22.5 – 25.5	1	15	59	24	1	0
	Fines	1	– 1/16	1	25.5 – 28.5	1	18	58	21	2	0
					28.5 – 31.5	1	13	49	35	2	0
					31.5 – 34.5	1	6	57	24	6	6

TW 23 NW 6 2378 3992 Levington, Suffolk

Surface level (+ 25.6 m) + 84 ft
Water struck at (+ 17.1 m) + 56 ft
Wirth B 1, 6-8 inch diam.,
November 1968

Overburden (0.3 m) 1 ft;
Mineral (4.4 m) 14.5 ft;
Waste (1.1 m) 3.5 ft;
Mineral (11.0 m) 36 ft;
Bedrock (0.3 m +) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Pebbly Sand Medium to coarse yellow-brown sand with gravel. Gravel sub-rounded to angular brown and black flint. Largest particle size 75 mm. Basal (0.9 m) 3 ft mainly medium sand with little gravel	(4.4)	14.5	(4.7)	15.5
		Silty clay with iron concretions	(1.1)	3.5	(5.8)	19
Red Crag	(b)	Sand Medium sand, dark red-brown, with occasional clay nodules and a trace of gravel	(1.8)	6	(7.6)	25
		Mainly medium pale brown sand with varying amounts of fine and coarse sand and shell fragments	(9.2)	30	(16.8)	55
London Clay		Blue-grey clay	(0.3 +)	1 +	(17.1)	56

		%	mm	%	Depth below surface ft	Percentages: Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+\frac{1}{4}-1$	+4–16	+16
(a)	Gravel	24	+ 16	8	1 – 4	1	6	41	24	22	6
			– 16 + 4	16	4 – 7	1	3	42	28	18	8
					7 – 10	1	7	36	17	24	15
	Sand	75	– 4 + 1	23	10 – 13	1	2	52	22	13	10
			– 1 + ¼	45	13 – 15.5	1	18	54	21	6	0
			– ¼ + $\frac{1}{16}$	7							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	3	+ 16	0	19 – 22	1	12	66	20	1	0
			– 16 + 4	3	22 – 25	1	19	62	11	5	2
					25 – 28	1	28	43	27	1	0
	Sand	96	– 4 + 1	17	28 – 31	1	16	42	32	9	0
			– 1 + ¼	58	31 – 34	1	21	61	16	1	0
			– ¼ + $\frac{1}{16}$	21	34 – 37	1	19	66	12	2	0
					37 – 40	1	30	60	7	2	0
	Fines	1	– $\frac{1}{16}$	1	40 – 43	1	13	65	16	4	1
					43 – 46	1	18	61	15	5	0
					46 – 49	1	24	59	14	2	0
					49 – 52	No grading information available					
					52 – 55	2	27	59	12	0	0

TM 23 NW 7 2446 3930 Levington, Suffolk

Surface level (+ 26.8 m) + 88 ft
Water struck at (+ 13.7 m) + 45 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (19.2 m) 63 ft;
Bedrock (0.3 m +) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Pebbly Sand Medium sand, light brown to fawn becoming finer with depth. Gravel subangular to angular brown and black flint and white quartzite	(4.3)	14	(4.6)	15
Red Crag	(b)	Sand Fine to medium ochreous brown sand with some gravel	(2.3)	7.5	(6.9)	22.5
		Mainly medium sand, red-brown becoming pale brown with depth. Abundant shell fragments and a little gravel	(12.6)	41.5	(19.5)	64
London Clay		Clay	(0.3 +)	1 +	(19.8)	65

		%	mm	%
(a)	Gravel	20	+ 16	7
			− 16 + 4	13
	Sand	76	− 4 + 1	12
			− 1 + ¼	48
			− ¼ + 1/16	16
	Fines	4	− 1/16	4
(b)	Gravel	4	+ 16	1
			− 16 + 4	3
	Sand	93	− 4 + 1	16
			− 1 + ¼	51
			− ¼ + 1/16	26
	Fines	3	− 1/16	3

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
1 − 4	6	4	40	17	27	6
4 − 7	4	5	58	17	13	3
7 − 10	3	8	62	13	11	3
10 − 13	5	37	38	6	11	3
13 − 16	1	28	41	10	4	18
16 − 19	4	42	41	9	3	1
19 − 22	4	41	45	9	1	0
22 − 25	4	40	42	11	2	1
25 − 28	1	29	53	12	5	0
28 − 31	1	12	74	8	5	0
31 − 34	4	30	48	13	4	1
34 − 37	5	29	51	12	2	1
37 − 40	1	34	47	17	1	0
40 − 43	1	13	49	35	2	0
43 − 46	1	20	60	17	2	0
46 − 49	2	19	59	18	2	0
49 − 52	2	18	50	20	9	1
52 − 55	2	18	56	17	5	2
55 − 58	4	24	27	19	6	0
58 − 61	5	22	48	16	7	2
61 − 64	6	22	53	11	5	3

TM 23 NW 8 2492 3888 Levington, Suffolk

Surface level (+ 25.0) + 82 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.6 m) 2 ft;
Mineral (13.4 m) 44 ft;
Bedrock (0.9 m +) 3 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	(a)	Sandy Gravel Medium sand, yellow, with gravel. Gravel mainly rounded to sub-rounded black and blue flints. Some rounded quartz	(0.9)	3	(1.5)	5
Red Crag	(b)	Pebbly Sand Medium sand, red-brown with gravel concentrated in top (2.7 m) 9 ft. Gravel subrounded to subangular black flint. Largest particle size 75 mm. Occasional iron and manganese cemented coarse sandstone at base	(5.0)	16.5	(6.5)	21.5
		Medium to coarse red sand with shell fragments. A (0.6 m) 2 ft non-shelly band occurs at (7.9 m) 26 ft	(7.5)	24.5	(14.0)	46
London Clay		Clay	(0.9 +)	3 +	(14.9)	49

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						−1/16	+1/16−1/4	+1/4−1	+1−4	+4−16	+16
(a)	Gravel	33 *	+ 16	20	2 – 5	3	8	42	14	13	20
			− 16 + 4	13							
	Sand	64	− 4 + 1	14							
			− 1 + 1/4	42							
			− 1/4 + 1/16	8							
	Fines	3	− 1/16	3							
(b)	Gravel	9	+ 16	3	5 – 8	1	5	57	17	11	9
			− 16 + 4	6	8 – 11	1	1	34	29	25	10
					11 – 14	1	6	46	17	11	19
	Sand	90	− 4 + 1	21	14 – 17	1	10	79	9	1	0
			− 1 + 1/4	54	17 – 20	1	14	69	10	4	2
			− 1/4 + 1/16	15	20 – 23	2	20	63	14	1	0
					23 – 26	2	27	42	22	7	0
	Fines	1	− 1/16	1	26 – 28	1	49	41	8	1	0
					28 – 31	1	10	55	30	4	0
					31 – 34	1	15	46	34	4	0
					34 – 37	1	12	56	23	8	0
					37 – 40	1	12	57	29	1	0
					40 – 43	1	11	58	28	1	1
					43 – 46	1	15	53	26	5	0

* Based on one sample only

TM 23 NW 9 2489 3832 Levington, Suffolk

Surface level (+ 23.5 m) + 77 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.6 m) 2 ft;
Mineral (13.7 m) 45 ft;
Bedrock (1.2 m +) 4 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	(a)	Probably Sandy Gravel Fine to coarse gravel with coarse yellow sand. Gravel of rounded quartz up to 50 mm and rounded to subangular flint up to 150 mm.	(0.9)	3	(1.5)	5
Red Crag	(b)	Pebbly Sand Medium to coarse red sand with gravel. Gravel and sand in equal proportion at top but gravel decreases with depth. Gravel composed of rounded white quartzite up to 75 mm and rounded to sub-angular flint. Some shell fragments at base	(3.7)	12	(5.2)	17
		Medium to coarse red sand with comminuted shells. Gravel composed of rounded to subangular flints and rounded quartzite	(9.1)	30	(14.3)	47
London Clay		Clay	(1.2 +)	4 +	(15.5)	51

(a) No grading information available

(b)

	%	mm	%
Gravel	15	+ 16	5
		– 16 + 4	10
Sand	84	– 4 + 1	26
		– 1 + ¼	44
		– ¼ + 1/16	14
Fines	1	– 1/16	1

Depth below surface (ft)	Fines –1/16	Sand +1/16–¼	Sand +¼–1	Sand +1–4	Gravel +4–16	Gravel +16
2 – 5	No grading information available					
5 – 8	1	1	20	24	43	11
8 – 11	1	3	33	21	25	17
11 – 14	1	7	43	22	13	14
14 – 17	1	7	46	30	13	3
17 – 20	1	16	39	34	8	2
20 – 23	1	8	40	29	13	4
23 – 26	1	9	45	32	10	3
26 – 29	1	18	49	30	2	0
29 – 32	1	41	31	23	4	0
32 – 35	1	10	55	28	6	0
35 – 38	1	9	66	20	4	0
38 – 41	1	24	55	18	2	0
41 – 44	1	19	54	21	5	0
44 – 47	1	19	50	25	5	0

TM 23 NW 10 2018 3753 Chelmondiston, Suffolk

Surface level (+ 27.7 m) + 91 ft
Water struck at (+ 19.2 m) + 63 ft
Pilcon shell 6 inch diam.,
December 1970

Overburden 1.0 m;
Mineral 2.9 m;
Waste 1.8 m;
Mineral 7.3 m;
Bedrock 2.0 m +

			Thickness m	Thickness ft	Depth m	Depth ft
		Soil	0.6	(2.0)	0.6	(2.0)
Glacial Sand and Gravel		Silty sand	0.4	(1.5)	1.0	(3.5)
	(a)	Sandy gravel Fine to medium brown, yellow and orange sand. Gravel concentrated in basal 0.9 m, composed of sub-angular to rounded brown and red flint and white rounded quartzite. Sand becoming coarser with depth	2.9	(9.5)	3.9	(13.0)
		Pale grey-yellow to dark brown laminated sandy silt	1.8	(6.0)	5.7	(18.5)
		Predominantly coarse gravel with medium to coarse sand. Gravel subangular to rounded black and red-brown flints and variously coloured quartzite. Largest particle size 100 mm. Sand orange-brown	3.0	(10.0)	8.7	(28.5)
Red Crag	(b)	Sand Dark red-brown shelly sand, medium with a little gravel. Rather clayey at base	4.3	(14.0)	13.0	(42.5)
London Clay		Brown clay becoming blue with depth	2.0+	(6.5+)	15.0	(49)

		%	mm	%	Depth below surface (m)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	44	+ 16	27	1 – 2	5	36	51	3	3	2
			– 16 + 4	17	2 – 3	6	14	73	3	3	1
					3 – 3.9	1	1	8	7	31	52
	Sand	53	– 4 + 1	7	5.7 – 6.7	2	12	33	9	16	28
			– 1 + $\frac{1}{4}$	34	6.7 – 7.7	2	6	15	7	24	46
			– $\frac{1}{4}$ + $\frac{1}{16}$	12	7.7 – 8.7	1	2	25	16	24	32
	Fines	3	– $\frac{1}{16}$	3							
(b)	Gravel	4	+ 16	1	8.7 – 9.7	6	8	56	23	5	2
			– 16 + 4	3	9.7 – 10.7	3	14	70	12	1	0
					10.7 – 11.7	1	26	63	8	2	0
	Sand	93	– 4 + 1	14	11.7 – 13.0	Grading information not available					
			– 1 + $\frac{1}{4}$	63							
			– $\frac{1}{4}$ + $\frac{1}{16}$	16							
	Fines	3	– $\frac{1}{16}$	3							

TM 23 NW 11 2037 3694 Chelmondiston, Suffolk

Surface level (+ 30.8 m) + 101 ft
Water struck at (+ 17.4 m) + 57 ft
Wirth B 0, 8 inch diam.,
May 1970

Overburden (1.2 m) 4 ft;
Mineral (13.7 m) 45 ft;
Bedrock (0.6 m +) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(1.2)	4	(1.2)	4
Glacial Sand and Gravel	(a) Pebbly Sand Medium, rather silty, brown sand with subrounded flint gravel	(1.5)	5	(2.7)	9
	Brown clay with occasional flint pebble	(0.9)	3	(3.6)	12
	Medium yellow to orange brown sand with gravel. Gravel of subrounded brown and black flint and rounded white quartzite	(6.8)	22	(10.4)	34
Red Crag	(b) Pebbly Sand Medium red-brown sand with occasional flint pebbles	(2.4)	8	(12.8)	42
	Fine to medium brown sand with comminuted shells	(2.1)	7	(14.9)	49
London Clay	Clay	(0.6 +)	2 +	(15.5)	51

		%	mm	%	Depth below surface (ft)	Percentage Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	Sand $+\frac{1}{4}-1$	Sand $+1-4$	Gravel $+4-16$	Gravel $+16$
(a)	Gravel	14	+ 16	4	4 – 7	12	13	50	8	10	7
			– 16 + 4	10	7 – 9	23	12	45	10	8	2
					12 – 15	4	24	52	10	9	1
	Sand	78	– 4 + 1	11	15 – 18	6	16	56	8	10	4
			– 1 + ¼	48	18 – 27	No grading available					
			– ¼ + $\frac{1}{16}$	19	27 – 30	2	7	43	22	17	9
					30 – 33	1	44	42	8	4	1
	Fines	8	– $\frac{1}{16}$	8							
(b)	Gravel	6	+ 16	1	*33 – 36	3	39	39	15	4	0
			– 16 + 4	5	36 – 39	4	8	68	8	8	4
					39 – 42	5	27	54	9	4	1
	Sand	90	– 4 + 1	10	42 – 45	10	30	36	14	8	2
			– 1 + ¼	43	45 – 48	2	57	31	7	3	0
			– ¼ + $\frac{1}{16}$	37	48 – 49	1	59	31	7	2	0
	Fines	4	– $\frac{1}{16}$	4							

* Includes 1 ft of Glacial Sand and Gravel

TM 23 NW 12 2031 3558 Harkstead, Suffolk

Surface (+ 26.8 m) + 88 ft
Water struck at (+ 21.0 m) + 69 ft
Wirth B 0, 8 inch diam.,
May 1970

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	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	'Clayey' Sandy Gravel Sand, mainly medium, clayey, with gravel. Gravel, subrounded flint and rounded quartz	(1.5)	5	(2.4)	8
Red Crag	(b)	Sand Sand, brown, fine to medium, some silt. Occasional ironstone	(5.5)	18	(7.9)	26
		Sand, brown, shelly	(0.6)	2	(8.5)	28
London Clay		Clay	(0.6 +)	2 +	(9.1)	30

		%	mm	%	Depth below surface (ft)	Percentages Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	Sand $+\frac{1}{4}-1$	Sand $+1-4$	Gravel $+4-16$	Gravel $+16$
(a)	Gravel	27	+ 16	10	3 – 5	16	14	31	10	18	11
			– 16 + 4	17	5 – 8	5	11	48	11	16	9
	Sand	62	– 4 + 1	10							
			– 1 + ¼	40							
			– ¼ + $\frac{1}{16}$	12							
	Fines	11	– $\frac{1}{16}$	11							
(b)	Gravel	4	+ 16	1	8 – 11	5	35	55	3	2	0
			– 16 + 4	3	11 – 14	1	23	71	3	1	1
					14 – 17	No grading available					
	Sand	91	– 4 + 1	7	17 – 20	1	31	55	7	5	1
			– 1 + ¼	53	20 – 23	8	37	45	6	3	1
			– ¼ + $\frac{1}{16}$	31	23 – 25	9	33	46	7	3	2
					25 – 28	8	26	46	17	3	0
	Fines	5	– $\frac{1}{16}$	5							

TM 23 NW 13 2113 3714 Chelmondiston, Suffolk

Surface level (+ 27.4 m) + 90 ft
Water not struck
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (12.8 m) 42 ft;
? Bedrock (0.9 m) 3 ft;
Bedrock (1.5 m +) 5 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	Sandy Gravel Sand, medium to coarse, orange-brown to brown. Gravel, subangular to sub-rounded flint and white quartz	(4.1)	13.5	(5.0)	16.5
Red Crag	(b)	Pebbly Sand Sand, fine to medium, brown to orange-brown, with gravel	(5.0)	16.5	(10.0)	33
		Sand, brown, with shells	(2.8)	9	(12.8)	42
? London Clay		Sand yellow-brown, silty	(0.9)	3	(13.7)	45
London Clay		Clay, blue, silty	(1.5 +)	5 +	(15.2)	50

		%	mm	%	Depth below surface (ft)	Percentages Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	38	+ 16	14	3 – 6	10	15	32	12	25	6
			– 16 + 4	24	6 – 9	No grading available					
					9 – 12	4	8	35	13	24	16
	Sand	57	– 4 + 1	13	12 – 15	3	3	36	17	26	15
			– 1 + $\frac{1}{4}$	34	15 – 18	3	14	31	11	20	21
			– $\frac{1}{4}$ + $\frac{1}{16}$	10							
	Fines	5	– $\frac{1}{16}$	5							
(b)	Gravel	8	+ 16	4	18 – 21	No grading available					
			– 16 + 4	4	21 – 24	2	33	41	6	10	8
					24 – 27	1	39	43	7	4	6
	Sand	86	– 4 + 1	5	27 – 30	5	37	45	9	4	0
			– 1 + $\frac{1}{4}$	38	30 – 33	17	48	25	4	2	4
			– $\frac{1}{4}$ + $\frac{1}{16}$	43	33 – 36	5	50	31	4	3	7
					36 – 39	5	39	49	3	2	2
	Fines	6	– $\frac{1}{16}$	6	39 – 42	8	37	42	5	6	2

TM 23 NW 14 2168 3660 Chelmondiston, Suffolk

Surface level (+ 28.0 m) + 92 ft
Water struck at (+ 15.8 m) + 52 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (13.7 m) 45 ft;
Bedrock (0.6 m +) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	Sandy Gravel Medium to coarse, grey-brown or yellow-brown sand with gravel. Gravel, sub-rounded flints, rounded quartz	(3.7)	12	(4.6)	15
Red Crag	(b)	Pebbly Sand Sand, fine to medium, brown, with some gravel	(3.3)	11	(7.9)	26
		Sand, fine to medium, brown, with shell fragments. Black pebbles numerous at (10.1 m) 33 ft	(6.7)	22	(14.6)	48
London Clay		Clay	(0.6 +)	2 +	(15.2)	50

		%	mm	%	Depth below surface (ft)	Fines −1/16	Sand +1/16−1/4	Sand +1/4−1	Sand +1−4	Gravel +4−16	Gravel +16
(a)	Gravel	29	+ 16	13	3 – 6	No grading available					
			− 16 + 4	16	6 – 9	2	21	28	9	15	25
					9 – 12	5	7	51	11	16	10
	Sand	67	− 4 + 1	10	12 – 15	5	6	58	15	11	5
			− 1 + ¼	50							
			− ¼ + 1/16	7							
	Fines	4	− 1/16	4							
(b)	Gravel	7	+ 16	2	15 – 18	8	16	51	15	7	3
			− 16 + 4	5	18 – 21	5	39	46	6	4	0
					21 – 24	12	29	37	15	7	0
	Sand	86	− 4 + 1	9	24 – 27	5	41	39	9	4	2
			− 1 + ¼	51	27 – 30	5	15	65	13	2	0
			− ¼ + 1/16	26	30 – 33	5	20	55	9	9	2
					33 – 36	7	21	60	10	2	0
	Fines	7	− 1/16	7	36 – 39	8	29	51	9	2	1
					39 – 42	5	24	39	9	4	19
					42 – 45	6	29	55	6	4	0
					45 – 48	7	28	57	7	1	0

TM 23 NW 15 2158 3581 Arwarton, Suffolk

Surface level (+ 26.5 m) + 87 ft
Water struck at (+ 19.5 m) + 64 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (1.5 m) 5 ft;
Mineral (8.2 m) 27 ft;
Bedrock (0.9 m +) 3 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel		Silt, with fine orange sand and a little gravel	(0.9)	3	(1.5)	5
	(a)	Pebbly Sand Sand, fine to medium, orange or yellow-brown, with some gravel and silt. Gravel: subrounded quartz	(2.8)	9	(4.3)	14
Red Crag	(b)	Sand Sand, fine to medium, with some silt and a little flint gravel	(5.5)	18	(9.8)	32
London Clay		Blue clay	(0.9 +)	3 +	(10.7)	35

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						−1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16
(a)	Gravel	21	+ 16	8	5 – 8	10	20	38	11	15	6
			– 16 + 4	13	8 – 11	4	11	45	11	14	15
					11 – 14	9	17	50	12	10	2
	Sand	72	– 4 + 1	11							
			– 1 + 1/4	44							
			– 1/4 + 1/16	17							
	Fines	7	– 1/16	7							
(b)	Gravel	4	+ 16	1	14 – 17	No grading available					
			– 16 + 4	3	17 – 20	4	53	33	7	2	1
					20 – 23	17	20	58	4	1	0
	Sand	89	– 4 + 1	9	23 – 26	6	19	57	16	2	0
			– 1 + 1/4	50	26 – 29	4	24	57	7	5	3
			– 1/4 + 1/16	30	29 – 32	4	36	43	12	5	0
	Fines	7	– 1/16	7							

TM 23 NW 16 2192 3512 Arwarton, Suffolk

Surface level (+ 25.9 m) + 85 ft
Water struck at (+ 15.8 m) + 52 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (12.8 m) 42 ft;
Bedrock (0.3 m +) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil, clayey	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	Pebbly Sand Sand, mainly medium, brown, with some flint gravel and a little silt and clay	(2.8)	9	(3.7)	12
? Chillesford Beds	(b)	Sand Sand, brown, fine-medium, with silt and red-brown clay. Micaceous in lower (0.9 m) 3 ft	(5.4)	18	(9.1)	30
Red Crag	(c)	Sand Sand, fine to medium, brown, with some silt	(0.9)	3	(10.0)	33
		Sand, fine to medium, brown with shell fragments	(3.7)	12	(13.7)	45
London Clay		Blue clay	(0.3 +)	1 +	(14.0)	46

		%	mm	%	Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16–1/4	Sand +1/4–1	Sand +1–4	Gravel +4–16	Gravel +16
(a)	Gravel	7	+ 16	0	3 – 6	6	17	51	12	14	0
			– 16 + 4	7	6 – 9	10	20	57	11	2	0
					9 – 12	11	26	47	12	4	0
	Sand	84	– 4 + 1	11							
			– 1 + 1/4	52							
			– 1/4 + 1/16	21							
	Fines	9	– 1/16	9							
(b)	Gravel	3	+ 16	0	12 – 15	12	17	60	9	2	0
			– 16 + 4	3	15 – 18	8	12	69	10	1	0
					18 – 21	12	41	41	3	3	0
	Sand	88	– 4 + 1	6	21 – 24	4	31	61	4	0	0
			– 1 + 1/4	53	24 – 27	6	31	58	4	1	0
			– 1/4 + 1/16	29	27 – 30	13	39	44	3	1	0
	Fines	9	– 1/16	9							
(c)	Gravel	1	+ 16	0	30 – 33	8	34	49	9	0	0
			– 16 + 4	1	33 – 36	5	47	33	14	1	0
					36 – 39	3	41	44	10	2	0
	Sand	94	– 4 + 1	8	39 – 42	1	79	17	3	0	0
			– 1 + 1/4	30	42 – 45	7	82	9	2	0	0
			– 1/4 + 1/16	56							
	Fines	5	– 1/16	5							

TM 23 NW 17 2251 3679 Shotley, Suffolk

Surface level (+ 25.3 m) + 83 ft
Water struck at (+ 19.2 m) + 63 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.3 m) 1 ft;
Mineral (8.2 m) 27 ft;
Bedrock (0.6 m +) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Sand Sand, fine – medium, brown, with some silt, and a little flint gravel in upper (0.9 m) 3 ft	(3.7)	12	(4.0)	13
Red Crag	(b)	Pebbly Sand Sand, fine to medium, dark brown, with gravel and silt	(1.8)	6	(5.8)	19
		Sand, orange-brown, with shell fragments	(2.7)	9	(8.5)	28
London Clay		Blue clay	(0.6 +)	2 +	(9.1)	30

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	5	+ 16	1	1 – 4	5	34	41	8	10	2
			– 16 + 4	4	4 – 7	No grading available					
					7 – 10	2	71	26	1	0	0
	Sand	90	– 4 + 1	4	10 – 13	7	58	29	5	1	0
			– 1 + ¼	32							
			– ¼ + $\frac{1}{16}$	54							
	Fines	5	– $\frac{1}{16}$	5							
(b)	Gravel	9	+ 16	2	13 – 16	20	29	39	6	4	2
			– 16 + 4	7	16 – 19	10	36	43	9	2	0
					19 – 22	6	57	27	8	2	0
	Sand	82	– 4 + 1	9	22 – 25	5	31	38	10	13	3
			– 1 + ¼	37	25 – 28	6	25	40	14	11	4
			– ¼ + $\frac{1}{16}$	36							
	Fines	9	– $\frac{1}{16}$	9							

TM 23 NW 18 2245 3598 Shotley, Suffolk

Surface level (+ 28.3 m) + 93 ft
Water not struck
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.3 m) 1 ft;
Mineral (10.1 m) 33 ft;
Bedrock (0.6 m +) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	'Clayey' Sand				
	Sand, fine to medium, reddish-brown with silt (especially in upper (0.9 m) 3 ft) and a little gravel	(1.8)	6	(2.1)	7
	Sand, fine to medium, brown, shelly, percentage of shell material increasing downwards	(8.3)	27	(10.4)	34
London Clay	Blue clay	(0.6 +)	2+	(11.0)	36

	%	mm	%	Depth below surface (ft)
Gravel	3	+ 16	1	1 – 4
		– 16 + 4	2	4 – 7
				7 – 10
Sand	86	– 4 + 1	10	10 – 13
		– 1 + ¼	46	13 – 16
		– ¼ + 1/16	30	16 – 19
				19 – 22
Fines	11	– 1/16	11	22 – 26
				26 – 30
				30 – 34

Depth below surface (ft)	Percentage Fines	Sand			Gravel	
	–1/16	+1/16–¼	+¼–1	+1–4	+4–16	+16
1 – 4	31	39	24	3	2	1
4 – 7	10	44	39	3	3	1
7 – 10	No grading available					
10 – 13	3	19	55	18	5	0
13 – 16	7	27	48	16	2	0
16 – 19	6	31	54	7	2	0
19 – 22	12	24	51	12	1	0
22 – 26	No grading available					
26 – 30	5	22	52	17	2	2
30 – 34	No grading available					

TM 23 NW 19 2279 3519 Shotley, Suffolk

Surface level (+ 23.5 m) + 77 ft
Water struck at (+ 19.5 m) + 64 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (1.2 m) 4 ft;
Mineral (6.4 m) 21 ft;
Bedrock (0.6 m +) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(1.2)	4	(1.2)	4
Glacial Sand and Gravel	(a)	Pebbly Sand Sand, fine to medium, yellow-brown with some flint gravel	(1.8)	6	(3.0)	10
Red Crag	(b)	Sand Sand, fine to medium, dark brown	(1.0)	3	(4.0)	13
		Sand, dark brown, shelly	(3.6)	12	(7.6)	25
London Clay		Brown clay	(0.6 +)	2 +	(8.2)	27

		%	mm	%	Depth below surface (ft)	Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	Sand $+\frac{1}{4}-1$	Sand $+1-4$	Gravel $+4-16$	Gravel $+16$
(a)	Gravel	9	+ 16	6	4 – 7	7	39	35	4	3	12
			– 16 + 4	3	7 – 10	5	61	31	1	2	0
	Sand	85	– 4 + 1	2							
			– 1 + ¼	33							
			– ¼ + $\frac{1}{16}$	50							
	Fines	6	– $\frac{1}{16}$	6							
(b)	Gravel	3	+ 16	0	10 – 13	No grading available					
			– 16 + 4	3	13 – 16	4	37	54	3	2	0
					16 – 19	6	40	42	10	1	1
	Sand	93	– 4 + 1	12	19 – 22	3	40	37	15	5	0
			– 1 + ¼	44	22 – 25	4	28	43	20	5	0
			– ¼ + $\frac{1}{16}$	37							
	Fines	4	– $\frac{1}{16}$	4							

TM 23 NW 20 2319 3663 Shotley, Suffolk

Surface level (+ 25.3 m) + 83 ft
Water struck at (+ 19.2 m) + 63 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (7.3 m) 24 ft;
Bedrock (0.6 m +) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil and made ground	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	Sand Sand, fine to medium, yellow, with some silt	(2.8)	9	(3.7)	12
Red Crag	(b)	Sand Sand, fine to medium, brown, with silt. Grey clay band, (0.9 m) 3 ft thick, at base	(3.6)	12	(7.3)	24
		Sand, brown, silty, with occasional shell fragments	(0.9)	3	(8.2)	27
London Clay		Brown clay	(0.6 +)	2+	(8.8)	29

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	1	+ 16	0	3 – 6	7	39	48	5	1	0
			– 16 + 4	1	6 – 9	No grading available					
					9 – 12	3	37	56	3	1	0
	Sand	94	– 4 + 1	4							
			– 1 + ¼	52							
			– ¼ + $\frac{1}{16}$	38							
	Fines	5	– $\frac{1}{16}$	5							
(b)	Gravel	1	+ 16	0	12 – 15	5	11	79	4	1	0
			– 16 + 4	1	15 – 18	7	57	32	3	1	0
					18 – 21	10	34	51	5	0	0
	Sand	92	– 4 + 1	4	24 – 27	8	57	32	2	1	0
			– 1 + ¼	48							
			– ¼ + $\frac{1}{16}$	40							
	Fines	7	– $\frac{1}{16}$	7							

TM 23 NW 21 2397 3653 Shotley, Suffolk

Surface level (+ 14.0 m) + 46 ft
Groundwater conditions not recorded
Pilcon Shell, 6 inch diam.,
December 1970

Overburden 2.4 m ;
Mineral 2.0 m ;
Bedrock 1.7 m +

		Thickness m	(ft)	Depth m	(ft)
	Soil, made ground and ?disturbed Red Crag	2.4	(8.0)	2.4	(8.0)
Red Crag	'Clayey' Sand Sand, fine to medium, brown, with some clay and silt and a little gravel	1.0	(3.5)	3.4	(11.0)
	Sand, fine to medium, dark brown, with shell fragments	1.0	(3.5)	4.4	(14.5)
London Clay	Brown clay, becoming pale buff downwards with development of lamination	1.7 +	(5.5 +)	6.1	(20.0)

	%	mm	%	Depth below Surface (m)	Percentages Fines	Sand			Gravel	
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
Gravel	4	+ 16	0	2.4 – 3.4	17	42	32	5	4	0
		– 16 + 4	4	3.4 – 4.4	19	29	40	9	3	0
Sand	78	– 4 + 1	7							
		– 1 + $\frac{1}{4}$	36							
		– $\frac{1}{4}$ + $\frac{1}{16}$	35							
Fines	18	– $\frac{1}{16}$	18							

TM 23 NE 1 2517 3950 Trimley, Suffolk

Surface level (+ 26.5 m) + 87 ft
Water struck at (+ 8.6 m) + 28 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (2.1 m) 7 ft;
Mineral (10.1 m) 33 ft;
Bedrock (0.6 m+) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
?Boulder Clay		Fine silty sand with flint and quartzite gravel to (0.6 m) 2 ft, resting on clay	(1.8)	6	(2.1)	7
Glacial Sand and Gravel	(a)	Pebbly Sand Fine to medium sand with gravel, sand becoming coarser with depth. Gravel, mainly fine, consisting of subrounded to angular flint and quartzite, percentage of gravel decreases with depth; (0.3 m) 1 ft band of boulder clay at (3.4 m) 11 ft	(4.0)	13	(6.1)	20
Red Crag	(b)	Sand				
		Fine to medium red-brown sand	(2.6)	8.5	(8.7)	28.5
		Coarse red-brown shelly sand	(3.5)	11.5	(12.2)	40
London Clay		Clay	(0.6+)	2+	(12.8+)	42+

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						−1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16
(a)	Gravel	9	+ 16	2	7 – 10	1	12	56	17	10	4
			– 16 + 4	7	11 – 13	Grading information not available					
					13 – 16	1	14	71	11	2	1
	Sand	90	– 4 + 1	18	16 – 19	1	4	59	26	9	1
			– 1 + 1/4	63							
			– 1/4 + 1/16	9							
	Fines	1	– 1/16	1							
(b)	Gravel	2	+ 16	0	19 – 22	1	9	55	33	2	0
			– 16 + 4	2	22 – 25	1	26	58	12	3	0
					25 – 28	1	20	60	18	1	0
	Sand	96	– 4 + 1	22	28 – 31	10	30	46	13	1	0
			– 1 + 1/4	53	31 – 34	1	13	51	34	1	0
			– 1/4 + 1/16	21	34 – 37	5	23	51	16	4	1
					37 – 40	1	19	49	30	1	0
	Fines	2	– 1/16	2							

TM 23 NE 2 2560 3855 Trimley, Suffolk

Surface level (+ 25.6 m) + 84 ft
Water struck at (+ 6.6 m) + 21.5 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (8.0 m) 26.5 ft;
Bedrock (0.6 m +) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Sandy Gravel Sand with gravel. Sand medium to coarse, red brown to yellow brown in colour. Gravel subrounded to angular, black and brown flint and some quartzite. Gravel concentrated in upper and lower parts of the deposit	(3.5)	11.5	(3.8)	12.5
Red Crag	(b)	Pebbly Sand Fine sand, yellow to pale brown becoming red-brown	(2.4)	8	(6.2)	20.5
		Medium to coarse shelly sand, red-brown	(2.1)	7	(8.4)	27.5
London Clay		Clay	(0.6+)	2+	(9.0+)	29.5+

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	25	+ 16	12	1 – 3.5	0	2	30	22	20	26
			– 16 + 4	13	3.5 – 6.5	2	9	61	8	14	6
					6.5 – 9.5	1	6	79	12	2	0
	Sand	74	– 4 + 1	14	9.5 – 12.5	18	16	14	49	2	1
			– 1 + $\frac{1}{4}$	55							
			– $\frac{1}{4}$ + $\frac{1}{16}$	5							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	7	+ 16	2	12.5 – 15.5	1	64	21	4	3	7
			– 16 + 4	5	15.5 – 18.5	1	37	57	4	1	0
					18.5 – 21.5	1	25	52	15	7	0
	Sand	92	– 4 + 1	13	21.5 – 24.5	1	24	49	18	6	2
			– 1 + $\frac{1}{4}$	44	24.5 – 27.5	1	23	45	24	7	0
			– $\frac{1}{4}$ + $\frac{1}{16}$	35							
	Fines	1	– $\frac{1}{16}$	1							

TM 23 NE 3 2659 3927 Kirton, Suffolk

Surface level (+ 25.3 m) + 83 ft
Water struck at (+ 5.5 m) + 18 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft
Mineral (11.0 m) 36 ft
Bedrock (0.2 + m) 0.5 + ft

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Pebbly Sand Sand with gravel. Medium to coarse light brown sand passing down into yellow-brown fine sand. Gravel concentrated in upper (0.9 m) 3 ft of deposit, fine, subrounded	(4.6)	15	(4.9)	16
Red Crag	(b)	Sand Fine to medium sand, red-brown, occasional flint	(4.6)	15	(9.5)	31
		Medium to coarse shelly sand	(1.8)	6	(11.3)	37
London Clay		Clay	(0.2+)	0.5+	(11.5)	37.5

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	7	+ 16	1	1 – 4	3	8	46	23	14	6
			– 16 + 4	6	4 – 7	1	24	62	8	3	2
					7 – 10	No grading information available					
	Sand	91	– 4 + 1	13	10 – 13	2	12	73	11	2	0
			– 1 + ¼	65	13 – 16	1	10	77	12	0	0
			– ¼ + $\frac{1}{16}$	13							
	Fines	2	– $\frac{1}{16}$	2							
(b)	Gravel	1	+ 16	0	16 – 19	3	54	39	2	2	0
			– 16 + 4	1	19 – 22	1	64	34	1	0	0
					22 – 25	2	63	35	0	0	0
	Sand	96	– 4 + 1	3	25 – 28	2	47	48	3	0	0
			– 1 + ¼	38	28 – 31	No grading information available					
			– ¼ + $\frac{1}{16}$	55	31 – 34	6	48	34	9	3	0
					34 – 37	No grading information available					
	Fines	3	– $\frac{1}{16}$	3							

TM 23 NE 4 2670 3827 Trimley, Suffolk

Surface level (+ 24.7 m) + 81 ft
Water struck at (+ 5.5 m) + 18 ft
Wirth B 1, 8 inch diam.,
November 1968

Overburden (0.3 m) 1 ft;
Mineral (9.7 m) 32 ft;
Bedrock (0.3 + m) 1 + ft

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Pebbly Sand Sand with gravel. Fine to medium light brown sand. Gravel fine, sub-rounded to angular black and brown flints	(2.4)	8	(2.7)	9
Red Crag	(b)	Pebbly Sand Medium to coarse red-brown sand	(2.1)	7	(4.8)	16
		Medium to coarse red-brown shelly sand. Occasional flint pebbles	(5.2)	17	(10.0)	33
London Clay		Clay	(0.3+)	1+	(10.3)	34

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	10	+ 16	2	1 – 4	1	14	53	22	8	2
			– 16 + 4	8	4 – 7	1	45	46	2	4	2
					7 – 10	1	23	39	24	10	3
	Sand	89	– 4 + 1	16							
			– 1 + $\frac{1}{4}$	46							
			– $\frac{1}{4}$ + $\frac{1}{16}$	27							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	5	+ 16	2	10 – 13	2	14	60	23	1	0
			– 16 + 4	3	13 – 16	3	37	53	5	2	0
					16 – 19	2	30	52	14	2	0
	Sand	92	– 4 + 1	15	19 – 22	1	35	50	11	3	0
			– 1 + $\frac{1}{4}$	50	22 – 25	6	29	44	9	5	7
			– $\frac{1}{4}$ + $\frac{1}{16}$	27	25 – 28	3	29	44	14	5	5
					28 – 31	2	27	55	16	0	0
	Fines	3	– $\frac{1}{16}$	3	31 – 33	1	18	46	26	8	1

TM 23 NE 5 2670 3731 Trimley, Suffolk

Surface level (+ 24.7 m) + 81 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (1.2 m) 4 ft;
Mineral (7.3 m) 24 ft;
Bedrock (0.9 m +) 3 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.6)	2	(0.6)	2
? Red Crag		(0.6)	2	(1.2)	4
Red Crag	Sand				
	Sand, medium grading down into fine, dark red-brown to yellow-brown becoming paler with depth. Fine gravel in upper (2.1 m) 7 ft with occasional cobbles	(6.4)	21	(7.6)	25
	Fine sand, light brown, slightly shelly	(0.9)	3	(8.5)	28
London Clay	Clay	(0.9+)	3+	(9.4)	31

	%	mm	%	Depth below surface (ft)
Gravel	2	+ 16	0	4 – 7
		– 16 + 4	2	7 – 10
				10 – 13
Sand	94	– 4 + 1	10	13 – 16
		– 1 + ¼	37	16 – 19
		– ¼ + 1/16	47	19 – 22
				22 – 25
Fines	4	– 1/16	4	25 – 28

Depth below surface (ft)	Percentages: Fines	Sand			Gravel	
	–1/16	+1/16–¼	+¼–1	+1–4	+4–16	+16
4 – 7	No grading information available					
7 – 10	1	15	64	18	2	0
10 – 13	3	33	46	15	3	0
13 – 16	14	31	43	10	1	1
16 – 19	2	13	62	19	3	1
19 – 22	2	81	13	3	1	0
22 – 25	2	85	10	3	0	0
25 – 28	1	73	22	4	0	0

TM 23 NE 6 2694 3677 Trimley, Suffolk

Surface level (+ 19.8 m) + 65 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.6 m) 2 ft;
Mineral (2.7 m) 9 ft;
Bedrock (1.2 m +) 4 ft +

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.6)	2	(0.6)	2
Red Crag	Clayey Pebbly Sand Dark brown clayey sand with gravel grading downwards to fine silty sand with traces of gravel	(2.7)	9	(3.3)	11
London Clay	Clay	(1.2+)	4+	(4.5)	15

	%	mm	%
Gravel	8	+ 16	1
		– 16 + 4	7
Sand	76	– 4 + 1	10
		– 1 + ¼	21
		– ¼ + 1/16	45
Fines	16	– 1/16	16

Depth below surface (ft)	Percentages Fines	Sand			Gravel	
	–1/16	+1/16–¼	+¼–1	+1–4	+4–16	+16
3 – 5	28	29	19	10	12	2
5 – 8	No grading information available					
8 – 11	3	62	23	7	4	1

TM 23 NE 7 2757 3907 Kirton, Suffolk

Surface level (+ 23.5 m) + 77 ft
Water struck at (+ 21.3 m) + 70 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (2.1 m) 7 ft;
Mineral (1.6 m) 5 ft;
Bedrock (0.6 m +) 2 ft +

		Thickness (m)	ft	Depth (m)	ft
	Soil	(0.3)	1	(0.3)	1
? Boulder Clay	Light brown clay	(1.8)	6	(2.1)	7
Glacial Sand and Gravel	Probably Pebbly Sand Sand, fine, silty, pale brown, with a little fine gravel	(1.6)	5	(3.7)	12
London Clay	Clay	(0.6+)	2+	(4.3)	14

No grading information available

TM 23 NE 8 2753 3849 Trimley Heath, Suffolk

Surface level (+ 24.7 m) + 81 ft
Water struck at (+ 4.6 m) + 15 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (7.3 m) 24 ft;
Bedrock (0.3 m+) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	(a)	Sandy Gravel An upper deposit of coarse yellow sand with fine quartz gravel separated from fine-medium yellow sand by (0.5 m) 1.5 ft of brown till with abundant erratics	(1.8)	6	(2.1)	7
Red Crag	(b)	Sand Fine to medium red and yellow sand with occasional pebbles. Becoming slightly earthy	(3.6)	12	(5.7)	19
		Red shelly sand	(1.9)	6	(7.6)	25
London Clay		Clay	(0.3+)	1+	(7.9)	26

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						−1/16	+1/16−1/4	+1/4−1	+1−4	+4−16	+16
(a)	Gravel	31	+ 16	7	1 – 4	1	2	31	35	24	7
			– 16 + 4	24	5.5 – 7	No grading information available					
	Sand	68	– 4 + 1	35							
			– 1 + 1/4	31							
			– 1/4 + 1/16	2							
	Fines	1	– 1/16	1							
(b)	Gravel	4	+ 16	1	7 – 10	2	42	37	11	5	3
			– 16 + 4	3	10 – 13	No grading information available					
					13 – 16	1	62	26	10	1	0
	Sand	93	– 4 + 1	13	16 – 19	1	58	31	9	1	0
			– 1 + 1/4	40	19 – 22	11	30	47	11	1	0
			– 1/4 + 1/16	40	22 – 25	1	8	57	27	6	1
	Fines	3	– 1/16	3							

TM 23 NE 9 2798 3784 Trimley Heath, Suffolk

Surface level (+ 23.2 m) + 76 ft
Water struck at (+ 18.3 m) + 60 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (9.1 m) 30 ft;
Bedrock (0.6 m+) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	Sand				
	Sand, coarse in upper (0.9 m) 3 ft becoming medium, pale brown with dark red bands. Gravel concentrated in upper (0.9 m) 3 ft, subrounded to angular brown and black flint	(6.1)	20	(6.4)	21
	Medium to coarse red-brown shelly sand	(3.0)	10	(9.4)	31
London Clay	Clay	(0.6+)	2+	(10.0)	33

	%	mm	%
Gravel	4	+ 16	1
		− 16 + 4	3
Sand	94	− 4 + 1	13
		− 1 + ¼	55
		− ¼ + 1/16	26
Fines	2	− 1/16	2

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
1 − 4	1	5	45	19	19	11
4 − 7	1	26	59	12	2	0
7 − 10	No grading information available					
10 − 13	1	37	59	3	0	0
13 − 16	2	40	54	4	0	0
16 − 19	4	36	50	9	1	0
19 − 22	1	28	55	16	0	0
22 − 25	4	15	59	22	0	0
25 − 28	2	23	58	16	1	0
28 − 31	No grading information available					

TM 23 NE 10 2758 3676 Trimley, Suffolk

Surface level (+ 25.9 m) + 85 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.6 m) 2 ft;
Mineral (11.9 m) 39 ft;
Bedrock (0.3 m +) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	(a)	Pebbly Sand (1.5 m) 5 ft of pale brown sand grading from fine to coarse with fine, subrounded to angular flint gravel, overlying (0.6 m) 2 ft of Boulder Clay. The deposits described above rest on medium to coarse, pale yellow to red-brown sand with gravel. Gravel mostly concentrated immediately beneath the Boulder Clay and between (4.3 - 6.1 m) 14 - 20 ft, rounded to subrounded	(6.4)	21	(7.0)	23
Red Crag	(b)	Sand				
		Fine to medium red-brown sand	(3.5)	11.5	(10.5)	34.5
		Medium, brown, shelly sand	(2.0)	6.5	(12.5)	41
London Clay		Clay	(0.3+)	1+	(12.8+)	42+

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16
(a)	Gravel	18	+ 16	4	2 – 5	No grading information available					
			– 16 + 4	14	5 – 7	1	7	31	31	25	5
					9 – 11	1	10	29	33	13	14
	Sand	81	– 4 + 1	25	11 – 14	1	29	56	12	2	0
			– 1 + ¼	43	14 – 17	1	2	39	35	23	0
			– ¼ + $\frac{1}{16}$	13	17 – 20	1	9	40	27	16	7
					20 – 23	1	19	63	15	1	1
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	1	+ 16	0	23 – 26	1	48	45	6	0	0
			– 16 + 4	1	26 – 29	1	46	45	8	0	0
					29 – 32	1	65	28	5	1	0
	Sand	98	– 4 + 1	6	32 – 35	1	29	62	7	1	0
			– 1 + ¼	51	35 – 38	1	15	77	6	1	0
			– ¼ + $\frac{1}{16}$	41							
	Fines	1	– $\frac{1}{16}$	1							

TM 23 NE 11 2776 3599 Trimley, Suffolk

Surface level (+ 22.6 m) + 74 ft
Water struck at (+ 16.8 m) + 55 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (1.2 m) 4 ft;
Mineral (6.4 m) 21 ft;
Bedrock (0.6 m +) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	Clayey red silt on fine red sand	(0.9)	3	(1.2)	4
	Pebbly Sand Fine - medium red sand	(1.8)	6	(3.0)	10
	Medium - coarse red, shelly sand	(4.6)	15	(7.6)	25
London Clay	Clay	(0.6+)	2+	(8.2)	27

	%	mm	%
Gravel	8	+ 16	4
		− 16 + 4	4
Sand	91	− 4 + 1	32
		− 1 + ¼	43
		− ¼ + 1/16	16
Fines	1	− 1/16	1

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Sand +4−16	Gravel +16
4 – 7	1	24	42	31	1	1
7 – 10	2	25	56	17	0	0
10 – 13	1	6	40	50	3	0
13 – 16	1	6	54	37	2	0
16 – 19	1	13	47	21	4	14
19 – 22	2	18	29	39	10	2
22 – 25	2	15	37	28	6	12

TM 23 NE 12 2804 3958 Kirton, Suffolk

Surface level (+ 19.8 m) + 65 ft
Groundwater conditions not recorded
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (1.5 m) 5 ft;
Bedrock (3.0 m+) 10 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Glacial Sand and Gravel	'Clayey' Pebbly Sand Fine clayey sand, red, yellow and brown with some gravel	(1.5)	5	(1.8)	6
London Clay	Clay, deeply weathered	(3.0+)	10+	(4.8)	16

Depth below surface (ft)	Percentages					
	Fines	Sand				Gravel
	$-^{1}/_{16}$	$+^{1}/_{16}-^{1}/_{4}$	$+^{1}/_{4}-1$	+1–4	+4–16	+16
1 – 4	19	36	23	11	10	1
4 – 6	No grading information available					

TM 23 NE 13 2826 3860 Trimley St. Martin, Suffolk

Surface level (+ 23.2 m) + 76 ft
Water struck at (+ 17.4 m) + 57 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (1.8 m) 6 ft;
Mineral (7.6 m) 25 ft;
Bedrock (0.3 m +) 1 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.3)	1	(0.3)	1
? Boulder Clay		Red-brown clay	(1.5)	5	(1.8)	6
Glacial Sand and Gravel	(a)	'Clayey' Sand Red, clayey silt with yellow brown clayey sand resting on medium yellow-brown sand with occasional pebbles	(1.7)	5.5	(3.5)	11.5
Red Crag	(b)	Sand Medium, red-brown sand, becoming fine towards the base, with traces of gravel	(4.1)	13.5	(7.6)	25
		Medium, red-brown, shelly sand with higher fines content towards base. Pebbly in lowest (0.6 m) 2 ft, with phosphatic nodules and flints	(1.8)	6	(9.4)	31
London Clay		Clay	(0.3+)	1+	(9.7)	32

		%	mm	%
(a)	Gravel	4	+ 16	2
			− 16 + 4	2
	Sand	85	− 4 + 1	8
			− 1 + ¼	41
			− ¼ + 1/16	36
	Fines	11	− 1/16	11
(b)	Gravel	2	+ 16	0
			− 16 + 4	2
	Sand	93	− 4 + 1	13
			− 1 + ¼	47
			− ¼ + 1/16	33
	Fines	5	− 1/16	5

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
6 − 8	21	60	17	1	0	1
8 − 11.5	1	11	66	14	5	3
11.5 − 14	1	19	56	23	1	0
14 − 17	10	24	53	11	2	0
17 − 20	2	32	52	13	1	0
20 − 23	1	43	44	11	1	0
23 − 26	1	55	34	9	1	0
26 − 29	No grading information available					
29 − 31	13	25	43	11	6	2

TM 23 NE 14 2873 3773 Trimley St. Martin, Suffolk

Surface level (+ 22.9 m) + 75 ft
Water struck at (+ 16.2 m) + 53 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (7.9 m) 26 ft;
Bedrock (1.2 m+) 4 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	Sand Fine, red-brown, silty sand resting on fine to medium red-brown sand with silty nodules at base	(5.2)	17	(5.5)	18
	Medium, red-brown shelly sand	(2.7)	9	(8.2)	27
London Clay	Clay	(1.2+)	4+	(9.4)	31

	%	mm	%
Gravel	1	+ 16	0
		- 16 + 4	1
Sand	96	- 4 + 1	22
		- 1 + ¼	43
		- ¼ + 1/16	31
Fines	3	- 1/16	3

Depth below surface (ft)	Percentages Fines	Sand			Gravel	
	-1/16	+1/16-¼	+¼-1	+1-4	+4-16	+16
1 - 4	1	43	43	12	1	0
4 - 7	2	48	41	9	0	0
7 - 10	3	15	42	40	0	0
10 - 13	2	25	46	27	0	0
13 - 16	2	38	49	6	3	2
16 - 19	1	7	53	38	1	0
19 - 22	15	28	38	17	2	0
22 - 25	1	30	40	27	2	0
25 - 27	3	46	35	14	2	0

TM 23 NE 15 2847 3683 Trimley, Suffolk

Surface level (+ 18.9 m) + 62 ft
Water struck at (+ 16.8 m) + 55 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.3 m) 1 ft;
Mineral (4.6 m) 15 ft;
Bedrock (1.2 m +) 4 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
Red Crag	'Clayey' Sand Sand, fine, red, with silt and brown and red silty clay to (1.2 m) 4 ft, then (0.9 m) 3 ft of red-brown silt, followed by (2.7 m) 9 ft of red shelly sand	(4.6)	15	(4.9)	16
London Clay	Clay	(1.2+)	4+	(6.0)	20

	%	mm	%
Gravel	2	+ 16	0
		− 16 + 4	2
Sand	86	− 4 + 1	16
		− 1 + ¼	44
		− ¼ + 1/16	26
Fines	12	− 1/16	12

Depth below surface (ft)	Fines	Percentages Sand			Gravel	
	−1/16	+1/16−¼	+¼−1	+1−4	+4−16	+16
1 − 4	16	36	42	4	2	0
7 − 10	6	37	40	16	1	0
10 − 13	10	19	52	16	3	0
13 − 16	4	12	44	27	2	1

TM 23 NE 16 2927 3936 Falkenham, Suffolk

Surface level (+ 21.6 m) + 71 ft
Water struck at (+ 14.9 m) + 49 ft
Wirth B 1, 8 inch diam.,
January 1969

Overburden (2.0 m) 6.5 ft;
Mineral (5.9 m) 19.5 ft;
Bedrock (1.2 m +) 4 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
? Boulder Clay	(0.9 m) 3 ft of clay resting on (0.8 m) 2.5 ft of fine sand with clay	(1.7)	5.5	(2.0)	6.5
Red Crag	Sand Fine - medium, red-brown sand with occasional small flints resting on fine, orange-brown sand with occasional iron nodules passing down into fine red-brown sand with some clay nodules in upper part	(4.4)	14.5	(6.4)	21
	Fine, red-brown shelly sand	(1.5)	5	(7.9)	26
London Clay	Clay	(1.2+)	4+	(9.1)	30

	%	mm	%	Depth below surface (ft)	Percentages Fines	Sand			Gravel	
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16
Gravel	1	+ 16	0	7 – 10	9	36	48	6	1	0
		– 16 + 4	1	10 – 14	1	37	50	12	0	0
				14 – 16	4	60	30	5	1	0
Sand	90	– 4 + 1	6	16 – 19	1	37	53	9	0	0
		– 1 + $\frac{1}{4}$	35	19 – 21	15	65	18	1	1	0
		– $\frac{1}{4}$ + $\frac{1}{16}$	49	21 – 24	14	59	21	4	2	0
				24 – 26	16	49	30	4	1	0
Fines	9	– $\frac{1}{16}$	9							

TM 23 NE 17 2927 3850 Falkenham, Suffolk

Surface level (+ 23.2 m) + 76 ft
Water struck at (+ 15.2 m) + 50 ft
Wirth B 1, 6 inch diam.,
December 1968

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

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	(a)	Pebbly Sand Sand, medium to coarse, red, with gravel. Gravel mainly rounded to subangular flints, up to 50 mm	(4.6)	15	(5.2)	17
Red Crag	(b)	Sand Sand, fine to medium, red with trace of gravel	(3.3)	11	(8.5)	28
		Sand, red, shelly	(2.2)	7	(10.7)	35
London Clay		Clay	(0.6+)	2+	(11.3)	37

		%	mm	%	Depth below surface (ft)	Fines	Sand			Gravel	
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16
(a)	Gravel	19	+ 16	3	2 – 5	1	3	34	28	29	5
			– 16 + 4	16	5 – 8	1	2	45	27	19	6
					8 – 11	1	9	60	22	8	0
	Sand	80	– 4 + 1	25	11 – 14	1	6	55	20	15	3
			– 1 + ¼	49	14 – 17	1	9	50	30	10	0
			– ¼ + $\frac{1}{16}$	6							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	3	+ 16	0	17 – 20	7	27	46	12	8	0
			– 16 + 4	3	20 – 23	1	21	59	18	1	0
					23 – 26	1	26	58	14	1	0
	Sand	95	– 4 + 1	21	26 – 29	1	18	57	21	3	0
			– 1 + ¼	53	29 – 32	1	12	55	27	5	0
			– ¼ + $\frac{1}{16}$	21	32 – 35	1	23	44	29	3	0
	Fines	2	– $\frac{1}{16}$	2							

TM 23 NE 18 2946 3656 Trimley, Suffolk

Surface level (18.9 m) 62 ft
Water struck at (14.3 m) 47 ft
Wirth B 1, 6 inch diam.,
December 1968

Overburden (0.9 m) 3 ft;
Mineral (6.4 m) 21 ft;
Bedrock (0.3 m+) 1 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.3)	1	(0.3)	1
? Red Crag	Clay, red, silty	(0.6)	2	(0.9)	3
Red Crag	Pebbly Sand Sand, fine – medium, red and yellow, some gravel	(2.8)	9	(3.7)	12
	Sand, medium - coarse, red, shelly. A little gravel, of rounded quartz, flint and black phosphatic pebbles	(3.6)	12	(7.3)	24
London Clay	Clay	(0.3+)	1+	(7.6)	25

	%	mm	%
Gravel	9	+ 16	4
		– 16 + 4	5
Sand	90	– 4 + 1	20
		– 1 + ¼	55
		– ¼ + 1/16	15
Fines	1	– 1/16	1

Depth below surface (ft)	Fines	Sand			Gravel	
	–1/16	+1/16–¼	+¼–1	+1–4	+4–16	+16
3 – 6	1	8	63	16	7	5
6 – 9	1	4	61	25	8	1
9 – 12	1	8	59	10	3	19
12 – 15	1	24	54	13	7	1
15 – 18	1	19	52	22	6	0
18 – 21	1	21	49	27	2	0
21 – 24	1	20	49	23	7	0

TM 23 NE 19 2587 3975 Kirton, Suffolk

Surface (+ 26.0 m) + 85 ft
Water struck at (+ 18.9 m) + 62 ft
Wirth B 1, 8 inch diam.,
December 1968

Overburden (0.6 m) 2 ft;
Mineral (11.0 m) 36 ft;
Bedrock just touched

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	(a)	Pebbly Sand Sand, fine, silty, yellow or reddish-brown, with occasional flints, to (2.4 m) 8 ft; becoming coarser downwards, with an increase in gravel content. Gravel mainly subrounded brown flints	(4.3)	14	(4.9)	16
Red Crag	(b)	Pebbly Sand Sand, pale brown to reddish brown fine to medium in upper (0.9 m) 3 ft, then medium to coarse. Gravel between (6.1 m) 20 ft and (7.9 m) 26 ft	(4.7)	15.5	(9.6)	31.5
		Sand, red-brown, shelly	(2.0)	6.5	(11.6)	38
London Clay		Clay	Touched			

		%	mm	%	Depth below surface (ft)	Fines $-\frac{1}{16}$	Sand $+\frac{1}{16}-\frac{1}{4}$	Sand $+\frac{1}{4}-1$	Sand $+1-4$	Gravel $+4-16$	Gravel $+16$
(a)	Gravel	15	+ 16	2	2 – 5	No grading information available					
			– 16 + 4	13	5 – 8	1	26	53	18	2	0
					8 – 11	1	7	62	20	9	1
	Sand	84	– 4 + 1	23	11 – 14	1	1	38	31	22	7
			– 1 + ¼	51	*14 – 17	1	5	52	24	16	2
			– ¼ + $\frac{1}{16}$	10							
	Fines	1	– $\frac{1}{16}$	1							
(b)	Gravel	10	+ 16	3	17 – 20	2	53	44	1	0	0
			– 16 + 4	7	20 – 23	1	13	52	22	8	4
					23 – 26	1	2	38	25	23	11
	Sand	89	– 4 + 1	20	26 – 29	1	28	51	19	1	0
			– 1 + ¼	47	29 – 32	1	15	54	28	2	0
			– ¼ + $\frac{1}{16}$	22	32 – 25	1	19	46	24	8	2
					35 – 38	No grading information available					
	Fines	1	– $\frac{1}{16}$	1							

* 1 ft of Red Crag included in this sample

TM 23 SW 12 2038 3367 Harkstead, Suffolk

Surface level (+ 10.1 m) + 33 ft
Water struck at (+ 6.1 m) + 20 ft
Pilcon shell, 8 inch diam.,
December 1970

Overburden 2.4 m
Mineral 1.7 m
? Bedrock 0.9 m+

		Thickness m	Depth m
	Soil	0.2	0.2
? Terrace deposits	Clay, sandy, brown, orange and red, with flints in places	2.2	2.4
Terrace Gravels	Gravel Gravel with sand. Gravel mainly flint, subangular to subrounded with some quartz. Sand medium to coarse	1.7	4.1
?London Clay	Clay, brown, streaked with blue	0.9+	5.0

	%	mm	%	Depth below surface (m)	Percentages Fines	Sand			Gravel	
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16$
Gravel	70	+ 16	48	2.4 – 3.4	1	1	18	10	22	48
		– 16 + 4	22	3.4 – 4.1	1	5	14	10	21	49
Sand	29	– 4 + 1	10							
		– 1 + ¼	16							
		– ¼ + $\frac{1}{16}$	3							
Fines	1	– $\frac{1}{16}$	1							

TM 23 SW 13 2123 3478 Arwarton, Suffolk

Surface level (+ 26.2 m) + 86 ft
Groundwater conditions not recorded
Wirth B 0, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (11.6 m) 38 ft;
Bedrock (0.6 m+) 2 ft +

			Thickness (m)	Thickness ft	Depth (m)	Depth ft
		Soil	(0.9)	3	(0.9)	3
Glacial Sand and Gravel	(a)	Sandy Gravel Sand, medium, yellow, with gravel	(1.8)	6	(2.7)	9
Red Crag	(b)	Pebbly Sand Medium sand, brown, with up to 50% fine and coarse gravel. Occasional ironstone concretions. Some silt	(4.3)	14	(7.0)	23
		Sand, fine, brown or yellow, with occasional pebbles	(4.6)	15	(11.6)	38
		Sand, fine to medium, brown, with shell fragments. Black phosphatic pebbles at base	(0.9)	3	(12.5)	41
London Clay		Clay	(0.6+)	2+	(13.1)	43

(a) One sample only, as on right

	%	mm	%
(b) Gravel	16	+ 16	5
		− 16 + 4	11
Sand	76	− 4 + 1	7
		− 1 + ¼	29
		− ¼ + 1/16	40
Fines	8	− 1/16	8

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
3 – 7	8	6	40	10	18	18
7 – 9	No grading information					
9 – 12	15	12	60	4	8	1
12 – 15	7	6	28	8	26	25
15 – 18	9	7	35	16	22	11
18 – 21	10	17	37	11	15	10
21 – 24	4	52	23	8	11	2
24 – 27	6	61	26	5	2	0
27 – 33	No grading information					
33 – 36	1	91	5	2	1	0
36 – 39	4	74	13	4	5	0
39 – 41	15	35	30	9	11	0

TM 23 SW 15 2371 3446 Shotley, Suffolk

Surface level (+ 23.8 m) + 78 ft
Water struck at (+ 16.2 m) + 53 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (0.9 m) 3 ft;
Mineral (9.8 m) 32 ft;
Bedrock (0.3 m+) 1 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.9)	3	(0.9)	3
Red Crag	Sand				
	Sand, orange-brown, medium, some silt. A little flint gravel in upper (1.8 m) 6 ft	(5.5)	18	(6.4)	21
	Sand, yellow-brown, medium, with shell fragments	(4.3)	14	(10.7)	35
London Clay	Brown clay	(0.3+)	1+	(11.0)	36

	%	mm	%
Gravel	2	+ 16	0
		− 16 + 4	2
Sand	90	− 4 + 1	5
		− 1 + ¼	62
		− ¼ + 1/16	23
Fines	8	− 1/16	8

Depth below surface (ft)	Percentages Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
3 − 6	8	11	67	8	5	1
6 − 9	8	25	61	5	1	0
9 − 12	38	14	47	1	0	0
12 − 15	9	24	65	1	1	0
15 − 18	No grading available					
18 − 21	6	18	76	0	0	0
21 − 24	2	21	75	2	0	0
24 − 27	1	33	59	6	1	0
27 − 30	1	42	47	9	1	0
30 − 33	1	23	73	2	1	0
33 − 35	7	18	55	15	5	0

TM 23 SW 16 2450 3438 Shotley, Suffolk

Surface level (+ 22.6 m) + 74 ft
Water struck at (+ 17.4 m) + 57 ft
Wirth B 1, 8 inch diam.,
May 1970

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

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil	(0.6)	2	(0.6)	2
Glacial Sand and Gravel	Pebbly Sand Sand with gravel. Sand, medium, yellow to orange brown, with some silt and occasional clay. Gravel, subangular to subrounded flint	(6.4)	21	(7.0)	23
London Clay	Clay	(0.6+)	2+	(7.6)	25

	%	mm	%
Gravel	19	+ 16	3
		– 16 + 4	16
Sand	73	– 4 + 1	12
		– 1 + ¼	45
		– ¼ + 1/16	16
Fines	8	– 1/16	8

Depth below surface (ft)	Percentages Fines –1/16	Sand +1/16–¼	Sand +¼–1	Sand +1–4	Gravel +4–16	Gravel +16
2 – 5	18	52	27	2	1	0
5 – 8	12	18	46	8	16	0
8 – 11	5	10	48	10	26	1
11 – 14	5	10	53	13	13	6
14 – 17	6	12	45	13	18	6
17 – 20	5	5	50	21	18	1
20 – 23	8	6	46	17	20	3

TM 23 SW 17 2414 3497 Shotley, Suffolk

Surface level (+ 19.5 m) + 64 ft
Water struck at (+ 14.3 m) + 47 ft
Wirth B 1, 8 inch diam.,
May 1970

Overburden (1.5 m) 5 ft;
Mineral (6.7 m) 22 ft;
Bedrock (0.6 m+) 2 ft +

		Thickness (m)	Thickness ft	Depth (m)	Depth ft
	Soil. (0.3 m) 1 ft of topsoil overlying (1.2 m) 4 ft of soft brown clay	(1.5)	5	(1.5)	5
Red Crag	Sand				
	Sand, dark brown or ochre, fine to medium, some silt. Occasional pebbles	(3.7)	12	(5.2)	17
	Sand, dark brown, fine to medium, with shell fragments	(3.0)	10	(8.2)	27
London Clay	Brown clay	(0.6+)	2+	(8.8)	29

	%	mm	%
Gravel	1	+ 16	0
		− 16 + 4	1
Sand	95	− 4 + 1	3
		− 1 + ¼	38
		− ¼ + 1/16	54
Fines	4	− 1/16	4

Depth below surface (ft)	Fines −1/16	Sand +1/16−¼	Sand +¼−1	Sand +1−4	Gravel +4−16	Gravel +16
5 − 8	No grading available					
8 − 11	5	68	25	2	0	0
11 − 14	2	41	51	6	0	0
14 − 17	5	85	10	0	0	0
17 − 20	5	50	43	2	0	0
20 − 23	1	66	29	4	0	0
23 − 26	1	37	57	4	1	0
26 − 27	9	28	53	4	3	3

Dd. 505926 K 16

Printed in England for Her Majesty's Stationery Office
by Unwin Brothers Limited, The Gresham Press, Old Woking, Surrey

Reports of the Institute of Geological Sciences

No. 69/1 Geochemistry of sedimentary rocks. 1. Petrography and chemistry of arenaceous rocks. By P. A. Sabine, Eileen M. Guppy and G.A. Sergeant. Price 45p.

No. 69/2 Preliminary report on a seismic reflection survey in the southern Irish Sea, July 1968. By W. Bullerwell and R. McQuillin. Price 15p.

No. 69/3 Cruise report: Humber investigations, 1968. By R. McQuillin, Susan E. Arnold, M. C. Tully and J. H. Hull. Price 25p.

No. 69/4 Sodic scapolite (dipyre) in the Shetland Islands. By W. Mykura and B. R. Young. Price 10p.

No. 69/5 A summary of the mineral resources of the 'Crofter Counties' of Scotland. Compiled by N.G. Berridge. Price 25p.

No. 69/6 The Tertiary welded-tuff vent agglomerate and associated rocks at Sandy Braes, Co. Antrim. By I. B. Cameron and P.A. Sabine. Price 10p.

No. 69/7 Lower Old Red Sandstone ignimbrites from Dunkeld, Perthshire. By I. B. Paterson and A. L. Harris. Price 10p.

No. 69/8 Recent sedimentation in the central north-eastern Irish Sea. By D. S. Cronan. Price 10p.

No. 69/9 Sand and gravel resources of the inner Moray Firth. By A. L. Harris and J. D. Peacock. Price 15p.

No. 70/1 Preliminary report on marine geological and geophysical work off the east coast of Scotland 1966-1968. By R. A. Eden, Anne V. F. Small and R. McQuillin. Price 25p.

No. 70/2 Regional geochemical reconnaissance of the Derbyshire area. By I. Nichol, I. Thornton, J. S. Webb, W. K. Fletcher, R. F. Horsnail, J. Khaleelee and D. Taylor. [Limited edition]. Price £2.50. *Out of print.*

No. 70/3 Geological and shallow subsurface geophysical investigations in the Western Approaches to the English Channel. By D. Curry, D. Hamilton and A. J. Smith. Price 10p.

No. 70/4 Sands and gravels of the southern counties of Scotland. By G. A. Goodlet. Price 90p.

No. 70/5 Sources of aggregate in Northern Ireland. By I. B. Cameron. Price 25p.

No. 70/6 A petrological-mineralogical code for computer use. Edited by R. K. Harrison and P. A. Sabine. Price £1.

No. 70/7 Chamosite in Weald Clay from Horsham, Sussex. By R. G. Thurrell, G. A. Sergeant and B. R. Young. Price 10p.

No. 70/8 Regional geochemical reconnaissance of the Denbighshire area. By I. Nichol, I. Thornton, J. S. Webb, W. K. Fletcher, R. F. Horsnail, J. Khaleelee and D. Taylor. [Limited edition]. Price £2.50. *Out of Print.*

No. 70/9 The drift sequence and subglacial topography in parts of the Ouse and Nene basin. By A. Horton. Price 35p.

No. 70/10 Regional magnetic anomalies: An analysis of the Smoothed Aeromagnetic Map of Great Britain and Northern Ireland. By D. H. Hall and P. Dagley. Price 50p.

No. 70/11 Perlitic obsidian at Sandy Braes, Co. Antrim : its devitrification and volumetric relationship. By P. A. Sabine. Price 10p.

No. 70/12 The Lower Old Red Sandstone of the Strathmore region. By M. Armstrong and I. B. Paterson. Price 50p.

No. 70/13 ICSU/SCOR Symposium Cambridge 1970 : The Geology of the East Atlantic Continental Margin. Part 1 : General and Economic Papers. Edited by F. M. Delany. Price 90p.

No. 70/14 ICSU/SCOR Symposium Cambridge 1970 : The Geology of the East Atlantic Continental Margin. Part 2 : Europe. Edited by F. M. Delany. Price 90p.

No. 70/15 ICSU/SCOR Symposium Cambridge 1970 : The Geology of the East Atlantic Continental Margin. Part 3 : Europe (continued). Edited by F. M. Delany. Price 90p.

No. 70/16 ICSU/SCOR Symposium Cambridge 1970 : The Geology of the East Atlantic Continental Margin. Part 4 : Africa. Edited by F. M. Delany. Price £1.

No. 70/17 Geochemistry of Recent sediments from the central north-eastern Irish Sea. By D. S. Cronan. Price 20p.

No. 71/1 Synthesis of International Geomagnetic Reference Field Values. By D. R. Barraclough and S. R. C. Malin. Price 20p.

No. 71/2 Regional geochemical reconnaissance of part of Devon and north Cornwall. By I. Nichol, I. Thornton, J. S. Webb, W. K. Fletcher, R. F. Horsnail and J. Khaleelee. [Limited edition]. Price £2.50. *Out of print.*

No. 71/3 The stratigraphy of the Upper Magnesian Limestone : a revision based on the Institute's Seaham Borehole. By D. B. Smith. Price 15p.

No. 71/4 Calcium montmorillonite (fuller's earth) in the Lower Greensand of the Baulking area, Berkshire. By E. G. Poole and B. Kelk. Price 45p.

No. 71/5 Organic geochemistry of some Carboniferous shales from the South Wales Coalfield. By T. W. Bloxam. Price 10p.

No. 71/6 The Rb : Sr age and K/Rb ratios of samples from St. Austell Granite, Cornwall. By R. R. Harding and J. R. Hawkes. Price 15p.

No. 71/7 Hydrogeochemistry of groundwaters in the Derbyshire Dome with special reference to trace constituents. By W. M. Edmunds. Price 45p.

No. 71/8 The structural and stratigraphical geology of a portion of the eastern English Channel. By R. G. Dingwall. Price 35p.

No. 71/9 A palynological investigation of the Dalradian rocks of Scotland. By C. Downie, T. R. Lister, A. L. Harris and D. J. Fettes. Price 25p.

No. 71/10 Scottish mica-schist as a possible source of ground mica. By A. L. Harris and D. C. Turner. Price 15p.

No. 71/11 Geological results of the Channel Tunnel site investigation 1964-65. By J. P. Destombes and E. R. Shephard-Thorn. Price 40p.

No. 71/12 Calcium montmorillonite (fuller's earth) in the Lower Greensand of the Fernham area, Berkshire. By E. G. Poole, B. Kelk, J. A. Bain and D. J. Morgan. Price 50p.

No. 71/13 A pilot project on the storage and retrieval by computer of geological information from cored boreholes in central Scotland. By T. N. Gover, W. A. Read and A. G. Rowson. Price 30p.

No. 71/14 A quantitative comparison, using cross-association, of vertical sections of Namurian (E_1) paralic sediments in the Kincardine Basin, Scotland. By W. A. Read and M. J. Sackin. Price 25p.

No. 71/15 Data banking of drift borehole records for the Edinburgh area. By D. W. Rhind and J. B. Sissons. Price 25p.

No. 71/16 Geological investigations with a manned submersible off the west coast of Scotland 1969-1970. By R. A. Eden, D. A. Ardus, P. E. Binns, R. McQuillin and J. B. Wilson. Price 45p.

No. 71/17 The Permian evaporites of the Langwathby Borehole, Cumberland. By R. S. Arthurton. Price 30p.

No. 71/18 The Llanbedr (Mochras Farm) Borehole. Edited by A. W. Woodland. Price £1.50.

No. 71/19 Irish Sea investigations 1969-70. By J. E. Wright, J. H. Hull, R. McQuillin and Susan E. Arnold. Price 45p.

INSTITUTE OF GEOLOGICAL SCIENCES

MINERAL ASSESSMENT UNIT

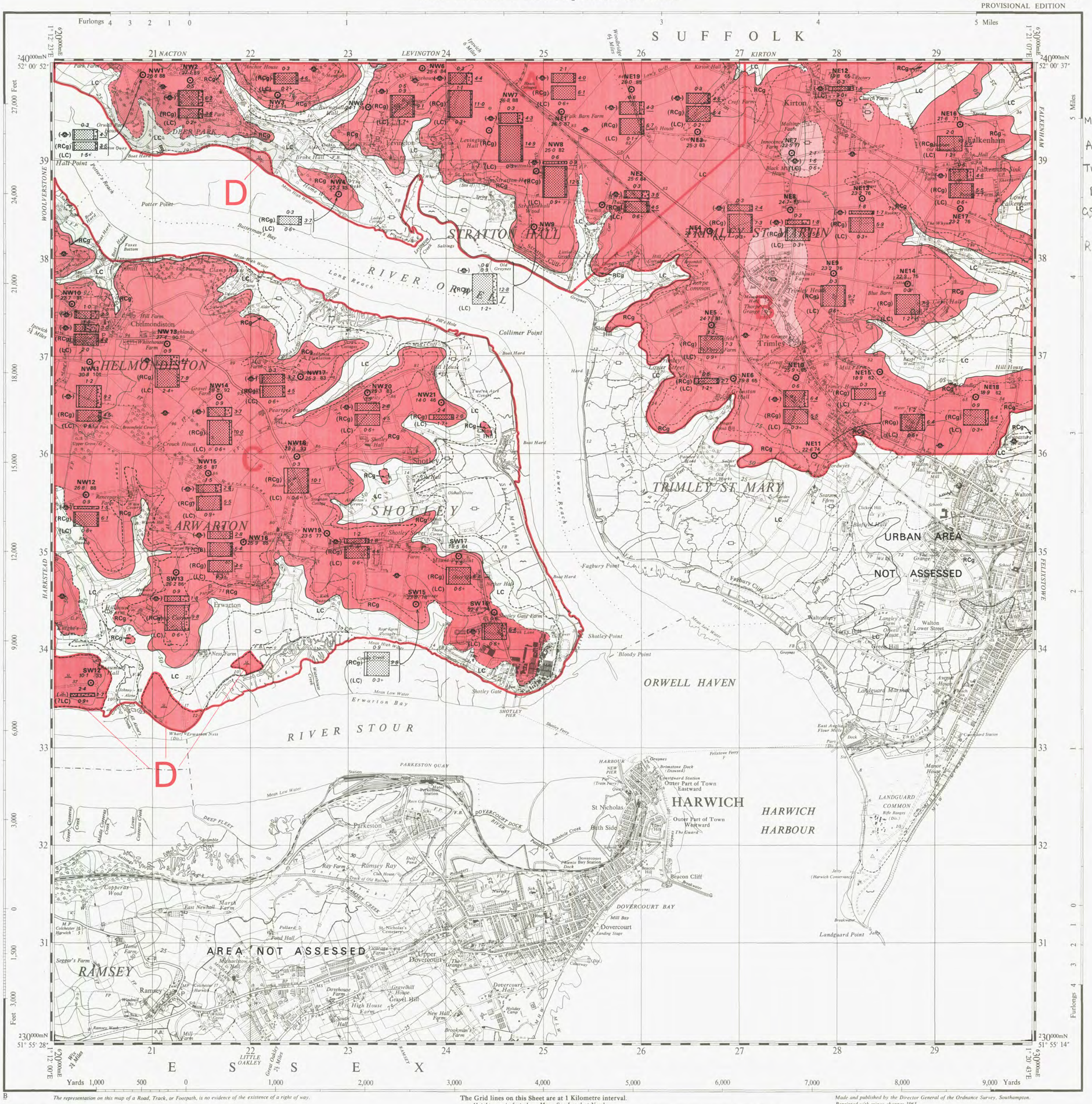
THE SAND & GRAVEL RESOURCES OF SHEET TM 23 (SHOTLEY & FELIXSTOWE, SUFFOLK)

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

ORDNANCE SURVEY
SHEET TM23
PROVISIONAL EDITION

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

8



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

RECENT AND PLEISTOCENE

MB-1 — **Marine Beach Deposits** – predominantly flint gravels.

A-3 — **Alluvium** – river clays and silts

TU-2 — **Terrace Undifferentiated** – variable flint gravel with quartz and quartzite pebbles.

B-3 — **Brickearth Undifferentiated** – laminated silt and clay.

CGS-1 — **Glacial Sand and Gravel** – medium sand with some flint gravel.

SOLID

RC-2 — **Red Crag** – fine to medium, red-brown sand with shell fragments in lower part.

EOCENE

London Clay – stiff silty, bluish grey weathering to brown, with occasional cementstone nodules.

Micaceous sands, referred tentatively to the **Chillesford Beds** (of Chillesford) – ?**CfB**– proved in borehole **NW 16**

BOUNDARY LINES

Geological boundary, Drift.

Geological boundary, Solid, broken where uncertain

Resource Block boundary.

BOREHOLE DATA

M.A.U. BOREHOLES

Borehole Registration Number → NW6 (25·6 84) ← Surface level in metres and feet above O.D. (Newlyn)
Borehole site →
0·3 — Overburden
(RCg) 4·4 — Mineral (sand and gravel)
1·1 — Waste
Grading diagram →
(RCg) 11·0 — Mineral (sand and gravel)
Geological Classification → (LC) 0·3+ — Bedrock

Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The figures in *italics* are the conversions to metres of measurements recorded in feet.
(iv) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each M.A.U. borehole is identified by a Registration Number, e.g. NW6. The letters refer to the quarter of this sheet and the figures to the I.G.S. serial number for that quarter. The unique designation for borehole NW6 is TM23 NW6.

Grading Diagrams

Each grading diagram shows the mean particle size distribution of 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**

CATEGORIES OF DEPOSIT

Exposed mineral, assessed CAT-E2

Continuous or almost continuous spreads of mineral beneath overburden CAT-C1

Sand and gravel absent or not assessed CAT-N1

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

RESOURCE BLOCKS

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

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

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 one-inch survey by W. Whitaker. Published on Old Series Sheet 48NE in 1882. Transferred in part to New Series Sheet 207 and published with minor corrections in 1927, and to New Series Sheets 208 and 225 and published in 1928. New Series Sheets 208 and 225 published as a combined sheet in 1956.

Sand and Gravel Survey by R. Allender, S.E. Hollyer and S.J. Booth in 1968 to 1970. A.A. Archer and R.G. Thurrell, Heads, Mineral Assessment Unit.

1:25,000 Sand and Gravel Resource Sheet published 1973.
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.*

2050/73

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.

The reference tables of Conventional Signs are published separately.

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 1922–25. Other partial systematic revision 1938–54 has been incorporated.
Major roads revised 1964.

Made and published by the Director General of the Ordnance Survey, Southampton. Reprinted with minor changes 1965.

	207 TM14	TM24	208 TM34	
	TM13 224	TM23	225	

Diagram showing the relation of the National Grid 1:25,000 sheets with the New Series One-Inch Geological sheets

Made and printed for the Institute of Geological Sciences by the Director General of the Ordnance Survey, Southampton.