MINERAL ASSESSMENT REPORT 146

The sand and gravel resources of the country around Aberdeen, Grampian Region

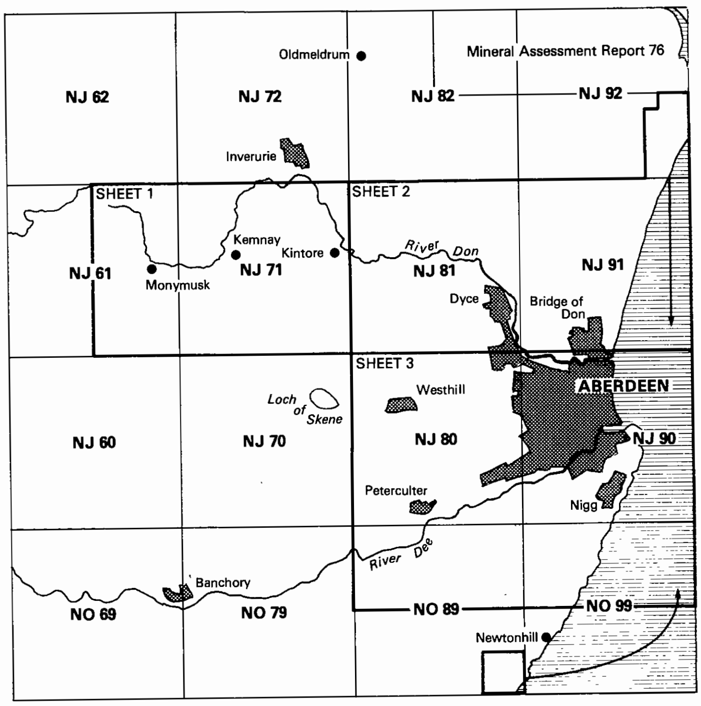
1:25 000 sheets NJ 71, 80, 81 and 91 with parts of NJ 61, 90 and 92 and parts of NO 89 and 99

C A Auton and R G Crofts

BRITISH GEOLOGICAL SURVEY

Natural Environment Research Council

Mineral Assessment Report 146



The sand and gravel resources of the country around Aberdeen, Grampian Region

Description of 1:25 000 resource sheets NJ 71, 80, 81 and 91 with parts of NJ 61, 90 and 92 and with parts of NO 89 and 99

C. A. Auton and R. G. Crofts

Contributor J. M. Hudson

This report was commissioned by the Department of the Environment with support from Grampian Regional Council, Aberdeen and Gordon District Councils and local industry

ISBN 85272089 0

Edinburgh: British Geological Survey 1986

CONTENTS

The sand and gravel resources of the country around Aberdeen, Grampian Region

Description of 1:25 000 resource sheets NJ 71, 80, 81 and 91 with parts of NJ 61, 90 and 92 and with parts of NO 89 and 99.

C. A. Auton and R. G. Crofts

SUMMARY

The geological maps of the British Geological Survey, seventy-seven boreholes and seventy-two shallow pits excavated for the British Geological Survey, together with pre-existing borehole information and data from seventeen sand and gravel workings, form the basis of the assessment of sand and gravel resources around Aberdeen, Grampian Region.

All known deposits in the area which might be potentially workable for sand and gravel have been investigated and a simple statistical method used to estimate their volume. Where possible the reliability of the volume estimates is given at the symmetrical 95 per cent probability level.

The sand and gravel resources are identified on three 1:25 000-scale resource maps. These maps are divided into 16 resource blocks, which contain between 11.73 and 0.03km^2 of potentially workable sand and gravel. 65km^2 of the assessment area are occupied by the city of Aberdeen and its dormitory settlements.

The geology of the deposits is described and the mineral-bearing area, the mean thickness of overburden and mineral, and the mean grading are stated. Detailed sample point data are given. The geology, the outlines of the resource blocks and the position of sample points used in the assessment are shown on the three accompanying resource maps.

Bibliographic reference

Auton, C.A. and Crofts, R.G. 1986. The sand and gravel resources of the country around Aberdeen, Grampian Region. Description of 1:25 000 sheets NJ 71, 80, 81, and 91, parts of NJ 61, 90 and 92 and with parts of NO 89 and 99. Miner. Assess. Rep. Brit. Geol. Surv., No. 146.

Authors and contributor

C.A. Auton, BSc. British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA

R.G. Crofts, BSc. and J.M. Hudson, BSc., British Geological Survey, Keyworth Nottingham, NG12 5GG

Note

National Grid references are given in the form *[855 156]* throughout. Figures with northings between 000 and 250 relate to places in 100-km square NJ, those with northings between 900 and 999 to places in 100-km square NO..

INTRODUCTION

The survey is concerned with the estimation of *resources,* which include deposits that are not currently exploitable but have a foreseeable use, rather than *reserves,* which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability, which this survey seeks to provide, will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974).

The survey provides information at the *indicated* level for which "tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout" (Bureau of Mines and Geological Survey, 1948, p.15).

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

The following arbitrary physical criteria have been adopted:

a The deposit should average at least 1m in thickness.

b The ratio of overburden to sand and gravel should be no more than 3:1.

c The proportion of fines (particles passing the No.240 mesh BS sieve, about $\frac{1}{16}$ (0.065)mm) should not exceed 40 per cent.

d The deposit must lie within 25m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18m if no sand and gravel has been proved.

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

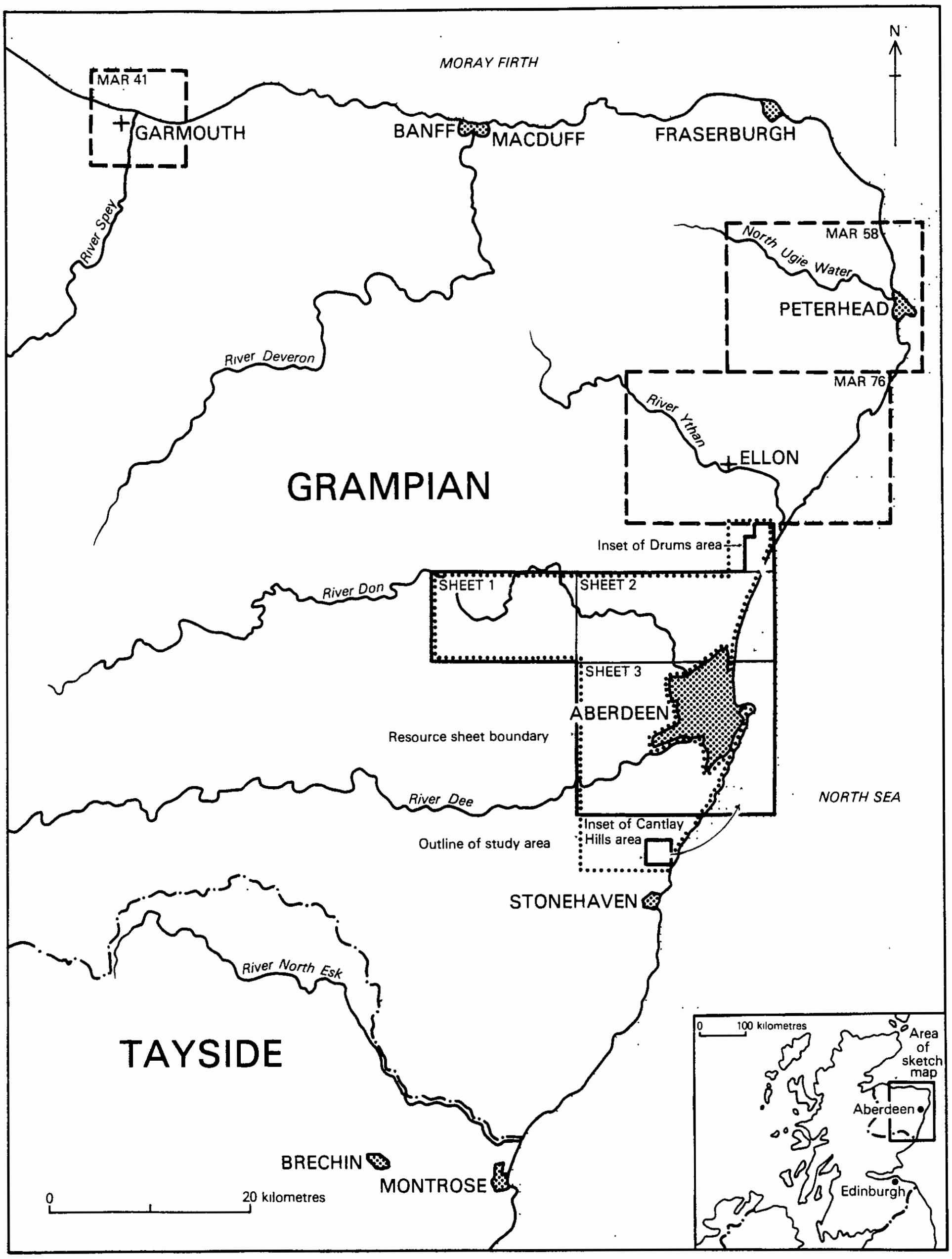


Figure 1. Sketch-map showing the location of the resource sheets

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale $\frac{1}{16}$ mm, ¼ mm, 1mm, 4mm, 16mm has been adopted. The boundaries between *fines* (that is, the clay and silt fractions) and *sand*, and between sand and *gravel* material, are placed at $\frac{1}{16}$ mm and 4mm respectively (see Appendix C).

The volume and other characteristics are assessed within *resource blocks*, each of which, ideally, contains approximately 10km^2 of sand and gravel. No account is taken of any factors, for example, roads, villages and high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

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

DESCRIPTION OF THE ASSESSMENT AREA

General

This survey is concerned with the assessment of sand and gravel resources within 660km^2 of ground around the city of Aberdeen (Figure 1) in the Grampian region of North-east Scotland. The area includes the lower reaches of the Rivers Don and Dee together with the coastal lowlands to the north and south of the urban area of Aberdeen. Other sand and gravel assessment reports in this series are available for the country around Peterhead (McMillan and Aitken, 1981) and Ellon (Merritt, 1981), the latter

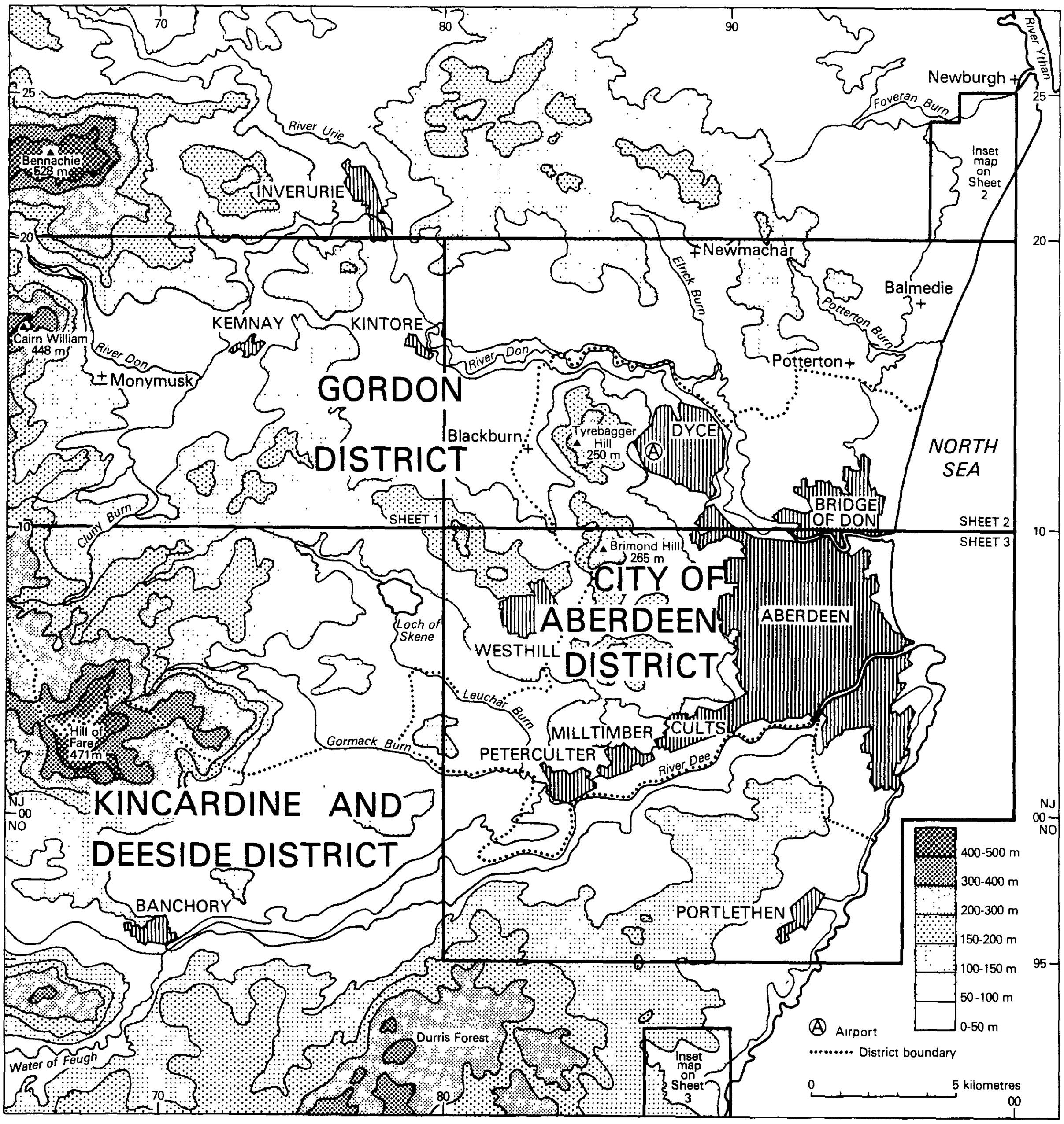


Figure 2. Topography of the district

covering ground immediately to the north of the current assessment area. Further assessment surveys are planned in adjacent areas, together with follow-up summary reports.

The Aberdeen sand and gravel resource map is subdivided into three sheets (see Figure 2) which are to be found in the back of this report.

Sheet 1: covers 1:25 000 sheets NJ 71 (whole) and 61 NE and SE.

Sheet 2: covers 1:25 000 sheets NJ 81 (whole), 91 (whole) and part of 92 SE.

Sheet 3: covers 1:25 000 sheets NJ 80 (whole), 90 (whole), NO 89 NW, NE and part of SE, and also NO 99 NW and NE.

Geography

The traditional industries of the Aberdeen area are agriculture, fishing, granite quarrying and the manufacture of textiles. Of these industries only agriculture still flourishes and a large proportion of the lower-lying ground is given over to arable farming. Stock rearing and forestry are important, especially on some of the higher ground.

In recent years the discovery of oil and natural gas in the northern North Sea has led to a rapid expansion of the city of Aberdeen, both as a centre for shore-based support industries and to provide accommodation for workers engaged in offshore oil and gas production. As a result, Aberdeen docks are now used mainly by oil rig supply and maintenance vessels rather than the traditional fishing fleet, while Dyce airport has been greatly expanded to accommodate increased traffic. New industrial estates have been built on the fringes of the urban area; as at Nigg, Dyce and Bridge of Don, to provide engineering and technical services for the oil industry.

The influx of workers resulting from this rapid industrial expansion has transformed not only the city of Aberdeen itself, but also many of the surrounding country villages, such as Westhill, Portlethen, Potterton and Balmedie, which have grown rapidly into major dormitory settlements. Established suburban settlements on Deeside, such as Peterculter, Milltimber and Bieldside, have also expanded to accommodate the increased population.

Sheet 1 The 150km^2 of ground covered by Sheet 1 includes the valley of the River Don with its adjoining interfluves and lies within the Gordon district of Grampian Region. It extends from the eastern slopes of Cairn William *[656 168]* and the southern flanks of Bennachie *[673 203]*, in the west, to the village of Kintore in the east. Cairn William (+448m OD) forms the highest ground in the district. The River Don and its northeasterwardly flowing tributary, Cluny Burn, constitute the principal drainage of the district.

Sheet 2 The main part of this resource sheet covers 183km^2 of ground from Kintore eastwards to the coast. In addition, the coastal area north of northing NJ 20 and south of Newburgh (12.25km^2 of ground) is shown by an inset map in the southeast corner of the resource sheet.

The district comprises the valley of the River Don and its tributaries between Kintore and Dyce as well as the coastal lowlands to the north of Bridge of Don. Most of the ground falls within the Gordon district of Grampian Region, apart from the southern flank of the Don valley, east of Blackburn and the northern flank of the valley, south of Potterton. This ground forms part of the City of Aberdeen district and includes the urban areas of Dyce and Bridge of Don.

The ground rises inland from the low-lying coastal area, backed by dunes, to form rolling hills. The highest ground is Tyrebagger Hill *[844 127]* which reaches 250m above OD.

Sheet 3 This resource sheet covers an area of about 286km^2 of ground which includes the urban area of Aberdeen. A further 9km^2 of ground to the west of Bridge of Muchalls *[895 913]* is shown as an inset map in the south east corner of the resource sheet. The assessment area extends from the edge of the city of Aberdeen westward to Kirkton of Skene *[804 078]*, southwestward to Peterculter and southward beyond the village of Portlethen. Most of the area south of the River Dee falls within the Kincardine and Deeside district of Grampian Region.

The principal topographic features of the area are the valleys of the River Don and the River Dee, which reach the sea immediately to the north and south of Aberdeen. East of Persley *[910 098]*, the River Don occupies a narrow, steep-sided valley, trending from west to east, which reaches the coast at Bridge of Don. The River Dee, in contrast, meanders across a broader valley, for a distance of some 21km downstream of Dalmaik *[803 985]* before reaching the coast at Aberdeen Harbour. The land between the two rivers rises from sea level at Aberdeen to reach 265m above OD at Brimmond Hill *[856 091]*. South west of Brimmond Hill, the ground falls towards Loch of Skene and the valleys of Leuchar Burn and Gormack Burn. Flowing eastwards from Hill of Fare (see Figure 2), these two burns meet west of Peterculter where, as Culter Burn, they form the main tributary of the River Dee.

South of the Dee valley the ground forms a gently rolling plateau, rising to between 100m and nearly 200m above OD in the west. The plateau is truncated abruptly at the coast to form a line of jagged cliffs up to 40m high. Much of the ground on the northern side of the Dee valley is occupied by the long established suburban settlements of Cults, Milltimber and Peterculter, whereas new industrial and housing estates have been built along the coast between Cove and Portlethen.

GEOLOGY

Mapping

The ground covered by this assessment survey falls within four sheets of the Geological Map of Scotland; Sheet 77 (Aberdeen), Sheet 76 (Inverurie), Sheet 67 (Stonehaven) and Sheet 66 (Banchory). Until the present study, only Sheet 77 had been the subject of modern systematic revision. The drift of this sheet was resurveyed on behalf of BGS, by F McLean and W Murdoch of Aberdeen University, between 1969 and 1975, as part of a research contract under the direction of M Munro. The 1:50 000 drift edition of Sheet 77 was published in 1980. The solid was resurveyed for BGS by W A Ashcroft and others of Aberdeen University, also under the direction of M Munro, and the solid edition of the sheet was published in 1982.

The one inch to one mile Sheet 67 (Stonehaven) was originally surveyed by D R Irvine and published in 1884. Minor revisions were made in 1898 by G Barrow and in 1929 by R Campbell and the fourth edition (solid and drift) was published, with minor amendments, in 1967.

The One-inch (solid and drift, hand-coloured) Sheet 76 (Inverurie) was published in 1886. The ground within the area of the current assessment was surveyed by H Skae, D R Irvine, J S Grant Wilson and L W Hinxman. Sheet 66 (Banchory) was mapped by D R Irvine and G Barrow and the One-inch map (solid and drift, hand-coloured) was published in 1897.

One-inch Soil Survey maps provide a more modern coverage for the Inverurie, Banchory and Stonehaven areas, Sheets 76 and 66/67 respectively. These maps were used in conjunction with the recently published drift map of Aberdeen, to provide the basis for a 'preliminary study' of the sand and gravel deposits around Aberdeen (Merritt and Peacock, 1983). During the present study, most of the ground previously identified by Merritt and Peacock as possibly containing deposits of potentially workable sand and gravel was resurveyed at a scale of six inches to one mile (or 1:10 000) by BGS staff. The results of this mapping, undertaken in 1984-85, form the basis of the three resource maps which accompany this report. The extent of the revision mapping, which was undertaken jointly for this resource assessment survey and for a concurrent environmental geology mapping exercise of the Aberdeen district, is shown in survey diagrams at the base of each resource map.

Summary of recent mapping:

Resource Sheet 1. Revision by D L Ross and R G Crofts in 1984, and by C G Smith, J W Merritt and C A Auton in 1985.

Resource Sheet 2. Revision by C A Auton and R G Crofts in 1984 and 1985.
Resource Sheet 3. Revision by R G Crofts and C A Auton in 1984 and 1985 and by R J O Hamblin and C A Auton in 1984.

Publications

There are at present no comprehensive modern accounts of the geology available for most of the Aberdeen assessment area, but an explanatory memoir for the Aberdeen district (Sheet 77) will be available shortly (Munro, in press). Sheet 76 (Inverurie) is described in the memoir for central Aberdeenshire (Wilson and Hinxman, 1890). No memoirs have been produced to accompany the Stonehaven and Banchory maps.

A variety of papers dealing with specific aspects of the solid and drift geology of the area have been published, many of which are referred to in the account of the geology which follows. However, the sand and gravel deposits were dealt with specifically by Anderson (1943, 1945) as part of a wartime study of resources in Scotland and in more detail, for part of the area, by Chester and others in 1974. More recently, Peacock and others (1977) provided a systematic account of the sand and gravel resources of Grampian Region. This was followed by the preliminary study of sand and gravel deposits in the Aberdeen area by Merritt and Peacock (1983).

Solid geology

The geology of the district is outlined in the British Regional Geology of the Grampian Highlands (G S Johnstone, 1966), the eastern part of which includes the area of this assessment. Most of the Aberdeen area is underlain by crystalline metamorphic rocks of the Dalradian Supergroup derived from original sediments and associated intrusive igneous rocks of late Precambrian to Cambrian age. These rocks were subjected to regional metamorphism by heat and pressure during the Caledonian orogeny, from about 510 to 480 million years ago (Dewey and Pankhurst, 1970).

The assessment area includes the eastern contact between the classical ground studied by Barrow (1893, 1912) in his pioneering work on the concept of metamorphic zonation in the Dalradian (the "Barrovian metamorphic zones") and the somewhat lower pressure and temperature metamorphism of the "Buchan type" studied by H H Read (1952), Johnson and Stewart (1960) and others.

As a result of regional metamorphism originally sandy sediments are now represented by quartz-feldspar granulites (psammites), clayey rocks by mica-schists and slates (pelites) and rocks intermediate between these two, by quartz-mica-schists (semipelites). Sandy limestone beds have been altered to calc-silicate rocks and basic igneous rocks (originally intruded in the form of dykes and sheets) have been altered to amphibolite and hornblende-schist. These dykes and sheets include material intruded both prior to and during the Grampian metamorphic episode.

On 1:50 000 Sheet 77 (Aberdeen), the sequence of Dalradian metasedimentary rocks has been subdivided into three formations: the Aberdeen Formation, the Ellon Formation and the Collieston Formation. Only the Aberdeen and Ellon formations are present within the assessment area (the Collieston Formation occurs on the coast to the north and east of Newburgh). The Aberdeen Formation constitutes the bedrock for much of the southern and western part of Sheet 77 (most of resource sheets 2 and 3) and consists principally of psammites with some pelites and semipelites with sparse calc-silicate ribs. The Ellon Formation comprises cordierite-bearing psammites, pelites and semipelites, with amphibolite bands. It occupies most of the north-eastern edge of Sheet 77 (forming the bedrock between Hatterseat and Newburgh on the inset map to Resource Sheet 2. Unfortunately these subdivisions of the Dalradian rocks cannot be traced into other parts of the assessment area (notably Resource Sheet 1 and the southern part of Resource Sheet 3) which, as yet, have not been the subject of modern revision.

During and shortly after the Caledonian orogeny, the Dalradian rocks were intruded by a number of granitic, basic and ultrabasic suites of rocks which, for convenience, have been grouped in this report, under the title of 'Younger Igneous Intrusions' (they are classed as 'Caledonian' in the appended borehole logs). These intrusive rocks are principally of two types, the 'younger basic intrusive complexes', such as the Belhelvie igneous mass *[930 180]* and 'granitic' intrusions, such as the Aberdeen Granite, which underlies much of the city of Aberdeen itself.

The Belhelvie mass is less deformed than the surrounding metasediments although its margins are defined by zones of shearing and mylonisation. It is composed of coarse-grained ultramafic rocks, notably gabbro, norite,

Table 1 Geological classification of deposits

DRIFT	
Pleistocene and Recent	Blown sand Alluvium Alluvial cone Post-Glacial beach and estuarine deposits Lacustrine alluvium Peat Older blown sand Fluvioglacial sand and gravel (usually flat or terraced at surface) Glacial sand and gravel (usually as mounds or ridges at surface) Glaciolacustrine deposits Morainic drift Till
SOLID	
Permo-Carboniferous	Igneous (intrusive) rocks - mainly dolerite and basalt dykes
Devonian	Sedimentary conglomerates with sandstone and clay, and volcanoclastic conglomerates and tuffs
Caledonian	'Younger Igneous Intrusions': syn to post-tectonic granitic, basic and ultrabasic plutonic and hypabyssal rocks
Dalradian (?late Precambrian to Cambrian)	Metasedimentary rocks (mainly psammites pelites, semi-pelites and hornfelses)

troctolite and peridotite.

The granitic intrusive rocks are of three main types:

(a) small bodies and migmatitic veins of foliated muscovite-biotite granite injected into metasediments of the type present within the Aberdeen Formation.

(b) Larger intrusions, such as the Aberdeen Granite (radiometrically dated at between 420 and 460 million years old), of similar internal structure and composition to the injected bodies and veins.

(c) Large intrusions of coarse-grained, non-foliated granodiorite (such as the Clinterty Mass *[830 110])*, which post-date the main tectonic episode.

Smaller intrusions of intermediate plutonic rocks, such as tonalite and diorite, also occur. At Altens Haven *[964 024]*, for example, an intrusion of tonalite occurs which appears to predate the nearby migmatic veins. Sheets and dykes of intermediate hypabyssal rocks, such as felsite and lamprophyre, which postdate the main metamorphic episode, are intruded into the Dalradian sequence south of the River Dee.

The Dalradian rocks have been subjected to a complex sequence of folding and deformation, before, during and after the main phase of metamorphic recrystallisation. The earliest phase appears to be represented by tightly appressed, sub-horizontal rootless folds, with an axial planar cleavage trending north-south. Folds of this type are common within the Ellon Formation. These folds were subsequently affected by a phase of open folding, the axes of which trend east-west. The period of metamorphic recrystallisation was followed by a second phase of open folding with a north-south axial trend. Because most of the Aberdeen area is drift covered it is difficult to recognise individual large scale folds in the Dalradian sequence. However the axial plane of the Buchan Anticline recognised by Read and Farquhar (1956) in the Ellon assessment area, is thought to pass to the north-west of the Belhelvie ultrabasic complex and is truncated by the mass of the Aberdeen Granite (Stewart, 1970).

The Caledonian orogeny was followed by a period of rapid uplift and erosion under semi-arid conditions which led to the deposition during the Devonian of sediments as a mollasse, in fault-controlled basins beyond the newly uplifted areas. In the Aberdeen district, these deposits are represented by coarse conglomerates, often containing volcanic clasts and tuff bands, interbedded with subsidiary sandstones and mudstones. They are found along the coast south-east of Balmedie, north-east of Bridge of Don and also overlying the Caledonian sequence between the mouths of the Rivers Don and Dee.

Two major faults, the Dee Fault and the Belhelvie Fault, trending SW-NE have been recognised in the Aberdeen area. The Belhelvie Fault forms the northern margin of the Devonian sediments at Balmedie *[965 180]*. The Dee Fault truncates the southern margin of the Aberdeen Granite and the overlying Devonian strata. It is likely that both faults were active during the Devonian and have significiantly influenced the deposition and subsequent preservation of the conglomeratic sequence.

Since the Devonian, igneous activity has been confined to the intrusion of a suite of quartz-dolerite and basalt dykes of Permo-Carboniferous age. The geological history of the district between the Permo-Carboniferous and the Pleistocene is obscure, as no deposits from this interval have survived in the area. It has been postulated (Hancock, 1975) that the eastern part of Scotland may have been submerged by the Late Cretaceous (Chalk) sea, though apart from the presence of Cretaceous flint erratics within the well-rounded quartzite gravels of the Buchan Gravels Group (McMillan and Merritt, 1980) in the Ellon district, there is little evidence to support this hypothesis. There is no evidence of Tertiary gravel of the Buchan Gravel type in the Aberdeen assessment area, but it has been suggested (Linton, 1951; Walton, 1963) that periodic uplift during the Tertiary resulted in the formation of a series of erosion surfaces. Gemmell (1975) postulates that much of the undulating uplands of the Aberdeen area (below +150m OD) represent the dissected remnants of an erosion surface at c +130m OD, known as the Buchan Plateau.

Weathering of bedrock

A characteristic of the geology of North-east Scotland is the extent to which localised areas of bedrock have been deeply weathered (Fitzpatrick, 1963; Hall, 1983, 1985). Decomposed bedrock occurs in isolated pockets and also as more extensive sheets, both at the ground surface and concealed beneath Pleistocene drift deposits (Phemister and Simpson, 1949).

There appears to be little consistent relationship between the degree of weathering and lithology or topography, although coarse-grained, well jointed igneous rocks, such as the Aberdeen Granite and the Belhelvie Gabbro, are particularly susceptible. Psammitic and pelitic metamorphic rocks are also affected although generally to a smaller degree. Devonian sandstones and conglomerates may be unaffected in some districts yet be sufficiently decomposed in other areas to resemble modern gravel (Peacock and others, 1983).

The decomposed rock may be many metres thick, for example, up to 20m of weathered anorthositic gabbro have been recorded in a borehole drilled at the eastern margin of the Inch ultrabasic mass *[8200 2617]*, 6km north of the assessment area (McLean, 1977). Elsewhere 7m of foliated Aberdeen Granite, weathered to sand, was recorded in a sewer tunnel at Springfield Road in Aberdeen by Phemister and Simpson (1949). Such decomposed rock is frequently mistaken for sand and gravel in site investigation boreholes and this has restricted the use of such information in the current survey.

Bedrock was struck in 37 of the 77 boreholes and 13 of the 72 pits sunk for this assessment. Weathered material was encountered at 20 of these sites, principally on pink granite and grey granodiorite bedrock. In the excavations, the thickest accumulation of weathered bedrock was encountered in a pit (NJ 80 SW 2) sunk at Woodside *[8081 0455]* Skene, where in excess of 2.2m of weathered granite was recorded. The granite was decomposed into a pale brown clayey sandy gravel with angular rock fragments.

Several exposures of weathered bedrock crop out on valley sides. A new road cutting at Raiths *[878 138]* showed 2m of sandy weathered material overlying Aberdeen Granite; 4m of weathered granite was exposed on the northern side of a glacial drainage channel at Swailend Wood *[883 169]*. In the south of the district, an outcrop of red granite forming the interfluve at Coalford *[824 998]*, between Temple Burn and the River Don, is weathered in places to a depth of c 5.0m to form a coarse red granitic sand. Pink granite, weathered to sand to depths of in excess of 3m, was seen in a trench near Sauchen *[689 107]*, yet 30m distant, seemingly unweathered rock of a similar type was formerly quarried.

The decompositon of the bedrock is thought to be mostly a result of weathering under tropical or sub-tropical conditions during the late Miocene (Munro, in press; Hall, 1983; 1985) modified by more temperate Pliocene and Pleistocene preglacial or interglacial weathering conditions (Fitzpatrick, 1963).

Drift geology

The proposition that North-east Scotland has been subjected to several separate glaciations was first put forward in the pioneer studies of the Scottish Quaternary by T F Jamieson (in a series of papers from 1858 to 1910) and A Bremner (from 1912 to 1943). Later workers, notably Synge (1956, 1963) and Charlesworth (1956) developed the multiple glaciation hypothesis further, using it to explain the differences (especially in till lithology) between drift sequences throughout the region. This early work is reviewed in some detail by Gemmell (1975). Other studies, including those of Simpson (1948, 1955), Clapperton and Sugden (1972, 1977), Murdoch (1977), McLean (1977) and Munro (in press) have since questioned the idea that the different till lithologies need to be attributed to more than one glacial episode.

It is now generally accepted that North-east Scotland was glaciated on several occasions during the Pleistocene (1.7 million years to 10,000 years ago) but the extent of ice-cover during each cold phase remains a matter of debate. In the Aberdeen area, for example, most of the glacial drift is thought to be the product of glaciation during the last (Devensian) glacial period. Although pre-Devensian deposits have been recorded from nearby areas, for example, at Kirkhill quarry to the west of Peterhead (Hall, 1984), their known extent is small. Deposits that can be unequivocally attributed to earlier glaciations are rare and none were identified during the present survey.

The form and internal structure of the drift around Aberdeen show most of it to be the product of deposition from ice-sheets; either whilst the ice was active or during its stagnation and rapid decay. In Scotland, Devensian ice may have reached its maximum extent at around 18,000 years BP. There followed a period of ice-retreat and in situ melting which left most of Scotland largely ice-free by 12,500 years BP (Gray and Lowe, 1977) and resulted in the deposition of fluvioglacial outwash and glacial meltwater deposits. In the Aberdeen district, the presence of ice remaining buried beneath glacial outwash later than 12,500 years BP is indicated by a plant bed at Mill of Dyce (St Fergus) gravel pit *[871 153]*, which has been radiocarbon dated at 11,550 ± 80 and 11,640 ± 70 years BP (Harkness and Wilson, 1979). The plant bed was found within a thick sequence of sand and gravel in which the bedding was highly disturbed and faulted, features strongly suggesting that ice buried within the sand and gravel had melted, resulting in collapse after the accumulation of the plant bed. The hummocky form of the surface of the sand and gravel at Mill of Dyce also indicates the local collapse of the deposit into voids left by the melting of dead ice forming kettle-holes.

During the Loch Lomond Stade (11,000 to 10,000 BP) and probably also at the end of the main glacial period, the Aberdeen area experienced periglacial conditions. Solifluxion processes caused considerable downslope redistribution of material, producing the rather smooth and featureless appearance of much of the present-day landscape. At the same time, annual snow melt in the Grampian Highlands led to increased fluvial activity in the catchments of both the River Don and River Dee.

There is clear evidence that during the existence of the last (Devensian) ice-sheet, at least two ice-streams were confluent in the Aberdeen area. Features indicating glacial erosion, such as streamlined rock knolls (elongated both north-south and east-west) are common, especially south and west of Newmachar. Similar knolls occur both to the south of Belhelvie and east of Craigingles Wood *[880 995]* (Munro, in press, Figure 31). Striated rock surfaces are widespread wherever fresh, resistant bedrock is exposed. For example, an outcrop of coarse gabbroic rock, north of Hassock's Croft *[940 183]* bears striations indicating ice movement in both a west-east and south west-north east direction.

Ice clearly overrode even the highest ground in the district. The irregular plucked appearance of the steep south-western slopes of Tyrebagger and Brimmond hills is contrasted by their more gentle leeward slopes, which are mantled with till and strewn with large boulders (Murdoch, 1975). On a smaller scale, individual bedrock outcrops may show a combination of smoothly polished surfaces towards the west and irregular craggy surfaces towards the east. Taken together these features indicate that, in general, ice moved across the area both from west to east and also from south to north. The direction of movement, however, was highly variable locally.

Less obvious evidence of glacial erosion is present in the form of glacially scoured rock basins, such as those at East Rothnick *[880 960]* and Grandhome Moss *[915 125]*, which contain extensive peat bogs. Some basins are partly infilled by till. For example, a borehole drilled in the large basin south of Blackburn showed 1.2m of lacustrine alluvium on 5.3m of till, overlying highly-weathered granodiorite.

Recent borehole and geophysical evidence (Munro, in press, Figure 35), (Law, 1962) shows that the valleys of the rivers Don and Dee are overdeepened near their mouths. A commercial borehole (NJ 90 SW 2) drilled on the floodplain of the River Dee, west of Kincorth, proved unbottomed drift deposits to a depth of -10.1m OD. The overdeepening may be directly attributable to ice scouring, but is more likely to be the result of fluvial erosion, either by subglacial meltwaters or during a period when the river graded to a considerably lower base level.

Evidence of deposition from beneath the ice-sheet is ubiquitous in the district, with most of the lower lying ground covered by till. Three lithologically distinct till types have been recognised in the area:

(a) a dark grey or olive grey overconsolidated clayey till with a strong fabric, containing angular erratics of local and more distant 'Highland' (onshore) derivation.

(b) a dark brown or yellowish brown till, with a weaker fabric, containing angular and rounded erratics, mainly of local provinance.

(c) a reddish brown till with locally derived clasts such as granite and psammite, together with pebbles thought to be derived from 'Old Red Sandstone' and offshore Jurassic strata.

In 1934 Bremner recorded a fourth till type from the Aberdeen area, a dark till containing 'arctic shells', which he found beneath dark grey boulder clay in a cutting made during the construction of part of the Aberdeen ring-road (South Anderson Drive). He equated this 'shelly boulder clay' with the 'Indigo Boulder Clay' of Jamieson, which is thought to have been deposited by ice that passed along the Moray Firth. No shelly till has been found in any boreholes or pits sunk for this survey, but 2.0m of very dark blue-grey waxy clay was seen in a trench dug west of Belhelvie sewage works *[9472 1743]* where it was overlain by brown sandy till.

The clayey dark grey till (type 'a' above) is the basal till in several assessment pits and boreholes (for example, NJ 71 SW 7 and NO 89 NW 6). In general it is stiff with a high clast content. The clasts, which range up to boulder size, are mainly of igneous and metamorphic rock types, notably granite, schist and diorite and where visible, the clasts show a strong preferred orientation towards the SE or NW. Where the base of the deposit is proved, it is usually seen to rest directly on bedrock. The over-consolidated character of the till matrix, the strong orientation of the clasts and the stratigraphic position of the deposit all indicate that it is a *lodgement* till, deposited beneath an active ice-sheet which moved across the district from the upland areas inland.

Dark brown, yellowish brown and greyish brown (type 'b' above) is the most widespread drift deposit in the assessment area. Brown tills, however, are of at least two kinds: the matrix of one kind is predominantly clayey whereas in the other it is sandy. A firm, brown clayey till, with an erratic suite similar to that of the grey till mentioned above was recorded from many exposures and assessment boreholes. In some instances it rests directly on bedrock and contains a high proportion of clasts derived from the immediate vicinity. For example, in borehole NJ 71 NW 12 clasts of the underlying grey granite are incorporated in the basal till and in pit NJ 61 SE 1, the till contains abundant angular fragments of the granodiorite bedrock.

There is some evidence to suggest that the grey and brown clayey tills are of similar origin. In borehole NJ 91 NW 44, for example, stiff bluish grey till passes downwards into pale yellowish brown till. In other boreholes the clayey till is brownish grey or greyish brown. These colour differences can be attributed in part to variation in the groundwater levels between sites; the grey till being the gleyed (unoxidized) equivalent of the brown till, which generally occurs above the permanent water table. The prominent orange mottling seen in some occurrences of grey till, as in pit NJ 81 NE 7, for instance, indicates that the till has been alternately gleyed and oxidized as a result of seasonal variations in the height of the groundwater level. The proportions and types of bedrock debris incorporated in a till also affects its colour and texture. For example, till deposited from ice that has passed over an outcrop of dark pelitic schist may be clayey and dark grey in colour, whereas till deposited from ice that has passed over weathered granitic rock will tend to be gritty and lighter in colour.

Little or no sand and gravel seems to have been deposited in association with the clayey tills, whether they be brown or grey.

A sandy and less cohesive brown till also occurs throughout the district. It is typically yellowish brown, greyish brown or pale brown in colour. The fabric is highly variable, but broadly shows a preferred orientation of clasts towards the west. Unlike the clayey tills, the sandy till often contains lenses of glacial sand and gravel which may be workable for aggregate locally. In some areas the whole deposit may be sufficiently sandy to be potentially workable. Potentially workable till is classed as 'Mineral II' in the appended borehole logs (see 'composition of the mineral deposits'). Beds of brown sandy till are present locally within thick sequences of sand and gravel and they often separate material of fluvioglacial and glacial origin (as in borehole NJ 71 SE 2, for instance). More commonly (as in borehole NJ 80 SW 3), brown sandy till rests directly on brown clayey till; or on bedrock, as in pit NJ 61 SE 1.

In recognition of its weak fabric, sandy matrix and its stratigraphic position, most recent workers have judged the brown sandy till to be a predominantly *melt out* or *flow* till (or a combination of both). The fact that sandy till rests on clayey till at many sites tends to support this interpretation. More complicated sequences in which the brown sandy till is interbedded with sand and gravel may represent the *supraglacial morainic till complex* facies (flow till and melt out till, associated with glacial outwash) described by Boulton and Eyles (1979).

A reddish brown till (type 'c') is present along the coast to the north and south of Aberdeen, where it has been recorded at twelve assessment sites. This till, which has been mapped up to 5km inland from the coast in the survey area, forms part of the Red Series of Synge (1956) or Red Clay Series of Jamieson (1906). More recently the terms 'red drift' or 'red glacial drift' have been used by Murdoch (1975), Merritt (1981) and Glentworth, Mitchell and Mitchell (1964), to describe a complex suite of glacial, glaciolacustrine and possibly glaciomarine sediments (all characteristically of a vivid red-brown colour) of which till is only a part.

Like the brown tills described above, the red-brown till is also broadly of two kinds: one being highly consolidated and clayey, the other sandy and less coherent. The clayey till has a strong fabric with clasts orientated north-south and is thought to be principally a lodgment till. The sandy till has a weaker fabric and comprises beds of flow till and melt out till interstratified with sand and gravel and debris flow deposits. Both the clayey and sandy tills contain a distinctive suite of erratics. In addition to clasts of inland provenance, both contain pebbles of sandstone, quartzite and vein-quartz which are thought to have been derived mainly from 'Old Red Sandstone' bedrock offshore. Pebbles of Jurassic limestone and shale are also common and these are definately derived from off-shore. Deposits of sand and gravel associated with the red-brown till, such as those at Drums pit, Foveran *[990 225]* and Fife Hill pit *[957 144]* also contain abundant cobbles and pebbles of quartzite, vein-quartz and sandstone.

Bremner (1934) referred to the red-brown till as 'Strathmore Drift' because he believed that the ice responsible for its deposition moved into the Aberdeen area from Strathmore, 25km to the south, where 'Old Red Sandstone' bedrock crops out extensively. Studies of the mineralogy of the red-brown clay by Glentworth and others (1964), however, showed that the argillaceous material has affinities with red Triassic clay rather than 'Old Red Sandstone'. Triassic strata are known to crop out in the bed of the North Sea adjacent to North-east Scotland. In any case, 'Old Red Sandstone' bedrock crops out along the coast in the Aberdeen area and immediately off-shore (D Evans and others, 1981), thus precluding the necessity for the 'red drift' ice to have passed along Strathmore. The distinctive clay mineralogy of the deposits, taken together with the presence of limestone and shale erratics, firmly indicate that there was an onshore (east to west) component in the movement of the ice-sheet responsible for the deposition of 'red-drift'.

The stratigraphic relationship between the 'red drift' and the brown and grey tills is complicated. Murdoch (1977) states that "Typically the red drift forms a thin capping on top of grey drift. Isolated particles of red till have been found in grey till and in one or two locations red and grey drift are interbedded". These relationships were confirmed during the re-mapping of the assessment area and are recorded in several of the assessment pits and boreholes. For example, in borehole NJ 91 NE 14, 12.0m of reddish brown silt and clay containing fine rounded pebbles (thought to be dropstones) of weathered schist, basic igneous rock, pale grey limestone and shale, rest on 1.7m of greyish brown till. In a gravel pit at Dubford (NJ 91 SW 12) reddish brown till overlies 6.3m of glacial sand and gravel resting on brown till. In most cases, the red-drift deposits (of glaciolacustrine or flow-till origin) overlie grey or brown till but occasionally sandy brown till overlies red-brown clayey lodgement till, (as, for example, in borehole NJ 81 SW 2, at Burnside Crofts near Newhills.

The interdigitation of red-brown, grey and brown tills is best seen in the area between Corby Loch and Belhelvie. Here, large mounds of glacial sand and gravel form a ridge of high ground between the 'red drift' of the coastal area from the brown and grey tills inland. This distribution of tills suggests that two streams of ice, bearing lithologically distinct debris loads, coalesced in the area during at least part of the main phase of glaciation.

Glacial sand and gravel that was deposited within and beneath the ice sheet as it melted is of restricted extent in the area. At Kemnay a large esker forms a steep sided discontinous ridge over 3km in length and rising between 8 and 13m above the adjacent ground. A section and pit in this esker (NJ 71 NW 13) shows it to be composed of poorly sorted cobble gravel. Smaller eskers floor the valley occupied by the Ton Burn, to the west; they may represent a western extension of the Kemnay Esker. Another large esker, trending NE-SW and approximately 4km in length, is present near the coast between Newburgh and Foveran. A borehole drilled in the Foveran Esker at Pitscaff Croft, proved 9.4m of sandy gravel (not bottomed), overlain by till and laminated silty clay. Small eskers are also present at South Womblehill, Kintore *[782 132]* and to the north of Cottown *[772 153]*.

Sediment-laden meltwaters, issuing from subglacial or englacial tunnels at the margin of the ice sheet during periods of still-stand or ice-retreat, left large accumulations of glacial sand and gravel at or near the ice margin. This material forms complexes of lenticular mounds (kames), steep sided eskers and flat-topped mounds of sand and gravel. The meltwaters often disgorged into ice-marginal (temporary) lakes, where they built deltas of sand and gravel; clay and silt grade material was deposited contemporaneously in less turbulent parts of the lakes. Many of the moundy deposits of glacial sand and gravel in the coastal area, north of Bridge of Don, are of deltaic origin and are intimately associated with finely laminated glaciolacustrine silt and clay. The form of these mounds is illustrated in cross-section F-F', on the margin of Resource Sheet 2. The glacial sand and gravel is often capped by flow till and debris flow deposits. Many of the mounds have been, and are currently, worked for sand and gravel.

Exposures in moundy glacial sand and gravel at Strabathie pit *[957 136]* have been described in detail by Thomas (1984) who concluded that the sand and gravel had been deposited by meltwaters, issuing from beneath the ice-sheet into a large body of water, where they constructed sub-aqueous esker-deltas. Thomas also described small depressions in the laminated water-lain sediments at Strabathie, which he interpreted as ice-berg grounding structures. He postulated that the small cones of poorly sorted gravel, within the silts and clays, may have been deposited from floating or grounded ice-bergs.

Many of the exposures in the gravel pits of the coastal area show that the sand and gravel occurs in one or more fining-downward sequences. In the pits at Leuchlands (NJ 91 SW 11) and Dubford (NJ 91 SW 12), for instance, gravel showing well developed trough cross-bedding passes down into beds of medium and fine-grained (often clayey) sand, with ripple-drift cross lamination. At Leuchlands Pit, the sand overlies laminated sandy silt and clay. These fining-downward sequences typify sand and gravel deposited in a deltaic, glaciolacustrine environment.

The positions of still-stands of individual glacier lobes are often marked by hummocky moraines. Such lobes often occupied small depressions in the interfluves as well as the main valleys of the district. The moraines are generally composed of very poorly sorted cobble gravel in a sandy or clayey matrix. These deposits of morainic drift occasionally form ridges across the smaller valleys of the district. For example, Corby Loch *[925 145]* is drained by a small stream that cuts through such a ridge of morainic drift, which crosses the valley to the south east of the loch. Corby Loch may occupy the site of a formerly more extensive proglacial lake that was dammed behind the moraine. Alternatively, it may occupy a large kettlehole formed by the melting of dead ice.

As the ice-sheet melted, the Aberdeen area was subjected to intensive fluvial erosion, as is indicated by the numerous glacial meltwater channels that cross the district. The valleys occupied by the principal rivers today were also the primary routes of meltwater drainage.

Secondary drainage channels are very common, ranging in size from linear depressions a few metres deep and a few hundreds of metres in length, to steep-sided valleys, tens of metres deep and several kilometres in length. The orientation of the secondary channels shows that much of the meltwater followed routes widely differing from the present drainage pattern.

Many of the larger drainage channel systems, such as the valleys now occupied by Ord Burn and Culter Burn (on Resource Sheet 3), are cut through the drift into resistant bedrock and form gorges for part of their courses. These large channels may have been partially formed beneath the ice-sheet, by meltwaters under hydrostatic pressure. Such channels characteristically show an arched long profile, good examples of which are seen in the channels originating in Tulloch col *[848 096]* and north of Swailend Wood *[880 168]*. Terraces of sand and gravel at Wynford *[844 089]*, Borrowstone *[849 078]* and Westholme *[852 066]* are thought to have been deposited from the meltwater which cut the Tulloch Col drainage channels.

Smaller drainage channels, such as those on the northern flank of the valley of the River Dee at Oldtown *[838 995]* and those trending northwards from Tyrebagger Hill towards the River Don, are generally concordant with the modern drainage pattern. These smaller channels are normally cut into, rather than through, the drift deposits, and were probably formed by meltwater streams beyond the margin of the ice.

The high ground became ice-free before the major valleys, which would have contained glaciers during the earliest stages of deglaciation of the district. Ice marginal drainage in the main valleys led to the deposition of kame-terraces.

The kame-terraces, which now flank the valleys, are underlain by extensive spreads of fluvioglacial sand and gravel. Many show fining-downwards sequences, suggesting deltaic deposition into ice marginal lakes. Others are composed of poorly sorted matrix-rich deposits, suggesting that they may have been deposited as alluvial fans. Examples of braided-river gravels are also seen (as in the recently opened gravel pit at Blairs College *[878 010]*).

The kame-terraces which flank the valleys of the rivers Dee and Don are underlain by considerable thicknesses of sand and gravel and form the principal sources of aggregate in the district (see 'composition of the mineral deposits' and the description of resource blocks B, F, H and O). The terrace surfaces are often irregular, being pitted with kettleholes that may contain thin deposits of peat and silt. An extensive kame-terrace forms the southern bank of the River Don to the north and also to the east of Kintore. It contains many kettleholes, some of which penetrate into the underlying till or bedrock. Most kame terrace deposits, such as those at Milltimber (section H - H', Resource Sheet 3), rest on benches cut in till or bedrock. The fluvioglacial sand and gravel which forms the terrace between Dyce and Badgers' Hill, however, (section E - E', Resource Sheet 2) overlies glacial sand and gravel.

Fluvioglacial deposits also occur beneath the alluvium of the main river valleys. They are chiefly braided-river gravels.

Along the coast north of Aberdeen, the glacial drift is overlain by spreads of blown sand, which extend up to 1km inland. Present-day beach sand also rests on glacial drift between the mean high-water mark and the belt of active sand dunes. South of Aberdeen, the coastline features wave-cut rock platforms and small sandy coves. Between Newburgh and Bridge of Don, the recent blown sand also overlies Post-Glacial beach and estuarine deposits, which have been recorded in three assessment pits and one borehole sunk at Menie Links *[990 213]* (see 'composition of the mineral deposits'). Post-Glacial beach and estuarine deposits also crop out between the mouth of the River Don and the mouth of the River Dee in the city of Aberdeen.

The youngest superficial deposits in the district (apart from blown sand) include alluvium and peat, much of which is associated with the courses of the present rivers and streams. Spreads of lacustrine alluvium and peat also flank many of the small lochs, such as Bishop's Loch *[913 143]*, north east of Badgers' Hill and Pool of Cluny *[686 127]* in the valley of the Ton Burn. Hill peat is still accumulating on top of till or bedrock in the upland areas, where it forms extensive peat mosses such as Red Moss and Harestone Moss. During the present survey, up to 5.5m of peat was recorded at Red Moss, to the south west of Moss-side of Milden *[918 165]*, where it has been dug for domestic fuel.

COMPOSITION OF THE MINERAL DEPOSITS

Potentially workable sand and gravel is found in deposits classified as fluvioglacial sand and gravel, glacial sand and gravel, blown sand (including 'older' blown sand), Post-Glacial beach and estuarine deposits and alluvium (including lacustrine alluvium). In addition, some occurrences of till and weathered bedrock form potential sources of unconsolidated aggregate.

The bulk of the potentially workable sand and gravel occurs within deposits of fluvioglacial sand and gravel deposited by glacial meltwaters within the valleys now occupied by the Rivers Don and Dee. Details of the particle size distribution of the five principal mineral-bearing deposits of the district are given in Table 2 and Figure 3. Also included is the grading of potentially workable till that has been recognised in the area, but which has not been included in the volumetric assessment. The graphs show the cumulative mean gradings of all of the potentially workable sand and gravel sampled from each deposit, together with the envelopes within which the range of values from individual sample points fall. The mean gradings are also shown as histograms in this figure and they are summarised in Table 2.

Petrological analyses (pebble-counts) were carried out on eighteen composite samples from assessment boreholes, pits and working quarries in the district. The source of each composite sample and the size fraction examined are indicated in Table 3. In order to have sufficient material for petrological analyses as well as for mechanical and physical testing, samples from more than one sample point were often amalgamated. In general, the composite samples represent deposits regarded as being geologically or geomorphologically distinct. Most pebble-counts were made on the 10 to 14-mm size fraction of the aggregate which allows a comparison to be made with the results of the mechanical and physical tests, also carried out on this size range. Further pebble-counts were made on coarser size-ranges (14 to 32mm and 32 to 64mm) from some samples (see Table 5) to

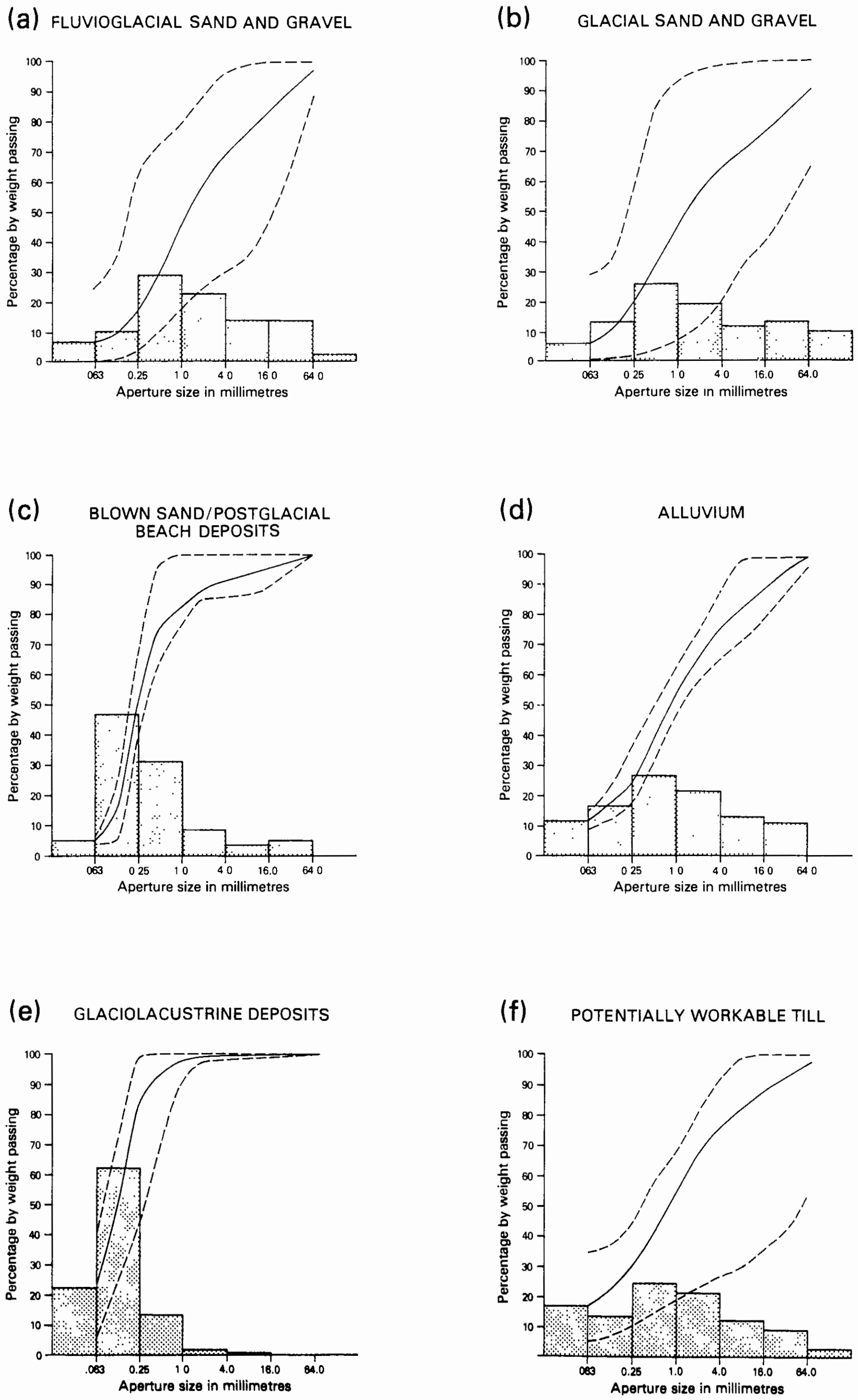


Figure 3. Grading characteristics of potentially workable sand and gravel in six types of mineral deposits. The continuous line represents the mean grading for the mineral deposit; the broken lines denote the envelope within which the mean grading curves for individual data points fall. The mean grading for each deposit is also shown as a bar graph

Table 2 Mean gradings of potentially workable deposits

Deposits	Number of data points*	Number of samples	Mean grading percentage						
			Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm	Medium sand $+\frac{1}{4}$-1mm	Coarse sand +1-4mm	Fine gravel +4-16mm	Coarse gravel +16-64mm	Cobbles and boulders +64mm
Fluvioglacial sand and gravel	45	141	7	10	29	23	14	14	3
Glacial sand and gravel	60	195	6	13	27	19	12	13	10
Alluvium (river gravels and lacustrine alluvium)	4	6	11	16	29	23	12	9	0
Blown sand and Post-Glacial beach and estuarine deposits	3	10	5	46	31	9	4	5	0
Glaciolacustrine deposits	8	14	22	63	13	2	0	0	0
Potentially workable till	15	27	17	13	25	21	12	9	3

* including assessment boreholes, trial pits and measured sections

establish whether lithology is governed in any way by grain size. Some minor differences in composition between the three size-fractions examined are evident in individual samples, but no clear relationship between composition and grain size can be discerned overall.

The rock classification used for pebble-counting is shown in Table 4. The scheme combines many of the parameters used to establish the *trade* groups of aggregates used in BS 812.1:1975, with the classification of aggregates proposed by Knill (1963, Table 4). Some of the rock groups listed in Table 4 are not present in the Aberdeen district, whereas others broadly coincide with amalgamations of British Standard Groups. For example, the *granite group* in this study combines the 'granite', 'quartzite' and part of the 'gritstone' groups of the British Standard. A more comprehensive subdivision of the pebble lithologies present can be found by consulting the logs for individual boreholes, pits and sections given in Appendix E.

The compositional analyses show that, for every sample tested, the highest proportion of clasts fall within the *granite* rock group. Overall, the main accessory rock types are from the *porphyry, basalt* and *gabbro* rock groups. Fissile rock clasts are relatively sparse, despite the fact that pelitic rocks, mainly schist and quartz-mica-schist, are common bedrock types within the survey area. It is probable that these rocks, being less resistant to abrasion and weathering than many of the crystalline igneous rocks of the district, have disintegrated during transportation and subsequent exposure. This interpretation is supported by the relative abundance of micaceous minerals within the sand and silt fractions of many of the sand and gravel deposits; these minerals having been largely derived from the comminution of micaceous pelitic rocks.

Fluvioglacial sand and gravel The main spreads of fluvioglacial sand and gravel occur as kame-terraces flanking the valleys of the River Don and River Dee and their tributaries. The deposit also occurs filling channels buried beneath floodplain alluvium and forms outwash plains surrounding the Tuach and Tillackae burns, the principal tributaries of the River Don, south of Kintore (Figure 4). An outwash plain of fluvioglacial sand and gravel also occurs between Blairdaff *[696 176]* and Rothens *[172 689]*, north of Monymusk.

Overall, the deposit grades as sandy gravel , with a mean of 7 per cent fines, 62 per cent sand and 31 per cent gravel. The mean gradings for deposits of fluvioglacial sand and gravel from the Don valley and the Dee valley both yield similar values (8:61:31 and 6:62:32 respectively) indicating similar depositional conditions in both areas. There is, however, a relatively wide range of values between individual sample points, as shown by the broad envelope in Figure 3a, which indicates considerable variation in the grading of the deposit locally.

The deposit, as a whole, is moderately well sorted with a mode developed in the medium sand range. In the gravel fraction, fine and coarse gravel (see Appendix C) appear in equal proportions (14 per cent) whereas cobbles are relatively sparse (3 per cent). Cobbles, however, may be more abundant locally, as for example, in borehole NJ 71 NW 6, where they account for 11 per cent by weight of the deposit: they also tend to be under-estimated in borehole samples as a result of the drilling process.

The greatest recorded thicknesses of fluvioglacial sand and gravel are found in the terrace deposits associated with the River Dee, with a maximum of 19.4m recorded in borehole NO 89 NW 3. Assessment boreholes sited on the Dee terraces, such as NO 89 NW 5, proved fining downward sequences within the fluvioglacial sand

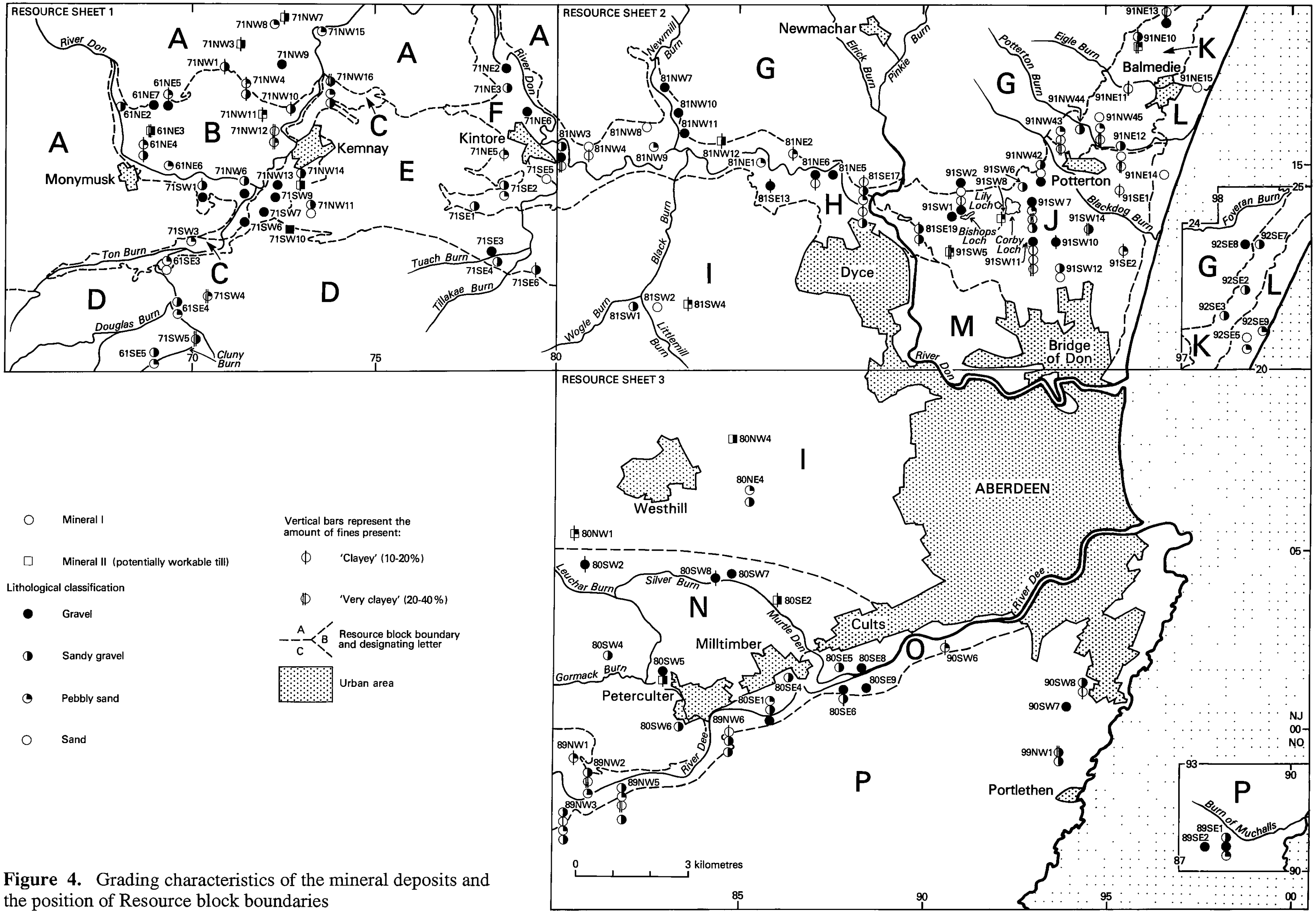


Figure 4. Grading characteristics of the mineral deposits and the position of Resource block boundaries

Table 3 Source and geological classification of composite samples used in pebble counts and mechanical and physical tests

Source	Composite sample number	Geological classification of composite sample	Boreholes and pits from which samples were taken	Depth range (m)	Number of bulk samples
Rothens area	1	Fluvioglacial sand and gravel	stockpile in working pit	-	1
Kemnay Esker	2	Esker, glacial sand and gravel	NJ 71 NW 13	0.0- 7.2	4
			NJ 71 NW 14	0.3- 3.0	2
			NJ 71 SW 6	1.0- 5.0	3
			NJ 71 SW 7	0.3- 2.1	2
			NJ 71 SW 9	0.1- 1.6	1
			NJ 71 SW 11	0.3- 6.2	6
Kintore - Cairnhall area	3	Fluvioglacial sand and gravel	stockpile in working pit	-	1
Kirkton of Dyce	4	Glacial sand and gravel	stockpile in working pit	-	1
Foveran Esker	5	Esker, glacial sand and gravel	NJ 92 SE 2	4.4- 5.8	2
			NJ 92 SE 3	0.1- 7.2	5
			NJ 92 SE 7	5.8-15.2	11
Corby Loch area (north)	6a	Glacial sand and gravel	stockpile in working pit	-	1
Corby Loch area (south)	6b	Glacial sand and gravel	stockpile in working pit	-	1
Lochmore - Newtonhill area	6c	Glacial sand and gravel	stockpile in working pit	-	1
Potterton area	7	Glacial sand and gravel	stockpile in working pit	-	1
Don floodplain (Inverurie - Dyce)	8	Fluvioglacial sand and gravel	NJ 71 NE 2	0.3- 5.0	3
			NJ 71 NE 6	1.4- 4.3	3
			NJ 81 NW 3	2.8- 4.9, 5.1-5.9	3
Don floodplain (Kemnay - Monymusk)	9	Mainly fluvioglacial sand and gravel	NJ 61 NE 4	0.4- 6.5, 6.7-8.0	4
			NJ 71 NW 6	0.1- 2.4, 2.9-4.5	3
			NJ 71 SW 1	0.2- 2.8, 6.2-8.0	3
Kintore - Tofthills area	10	Mainly fluvioglacial sand and gravel	NJ 71 NE 5	0.4- 5.5	5
			NJ 71 SE 1	0.3- 3.9	3
			NJ 71 SE 2	0.2- 2.8, 6.2-7.6	3
			NJ 71 SE 5	0.3- 4.3	3
Coastal area (Newburgh - Bridge of Don)	11	Post-Glacial beach and estuarine deposits	NJ 92 SE 9	0.6- 1.1	1
			NJ 92 SE 5	3.2- 6.0	3
Dee terraces (Peterculter - Aberdeen)	12	Fluvioglacial sand and gravel	NJ 80 SE 4	0.4- 3.5	2
			NJ 80 SE 5	0.5- 1.9	1
			NJ 80 SE 6	0.0- 5.9	3
			NJ 80 SE 9	0.3- 2.0	2
			NJ 90 SW 6	1.5- 2.5	1
			NO 89 NW 6	3.6- 5.3	2
Dee floodplain	13	Fluvioglacial sand and gravel	NJ 80 SE 1	0.4-14.3	14
			NO 89 NW 2	0.3- 8.5	8
Dee terraces (Durris area)	14	Fluvioglacial sand and gravel	NO 89 NW 1	0.3- 3.0, 0.4-5.3	6
			NO 89 NW 3	0.3- 3.3, 14.0-19.7	8
			NO 89 NW 5	0.3- 3.2	3
Nigg area	15	Glacial sand and gravel	NJ 90 SW 7	0.1- 3.1	1
			NJ 90 SW 8	2.0- 6.5, 7.5-8.5	4
			NO 99 NW 1	0.1- 3.0, 4.5-6.9	4
Cantlayhills area	16	Glacial sand and gravel	NO 89 SE 1	4.0- 7.3	2
			NO 89 SE 2	0.1- 3.3	3

Table 4 Lithological classification of pebbles used in this report

Toughness	**Composition**	**Fissility**	**Grain size**	**Colour**	**Group**
Friable					1. Soft rock. Mudstone, shale, coal, poorly-cemented sandstone, badly weathered igneous or metamorphic rocks
Tough	Silicate	Homogeneous or bonded but not fissile	Coarse- to medium-grained rocks	pale	2. Granite, granodiorite, syenite, pegmatite, vein-quartz, quartzite, coarse-grained sandstone, arkose, quartzo-feldspathic granulite (psammite), gneiss
				dark	3. Gabbro, norite, diorite, dolerite, peridotite, coarse-grained greywackes and metagreywackes, amphibolite
			Fine-grained rocks (disregarding phenocrysts or porphyroblasts)	pale	4. Porphyry, quartz porphyry, aplite, felsite, rhyolite, trachyte, pale hornfels, calc-silicate rock, fine-grained sandstones
				dark	5. Basalt, andesite, serpentinite, microdiorite, lamprophyre, fine-grained greywackes and metagreywackes, semipelitic granulite, dark hornfels
			Cryptocrystalline		6. Flint, chert, pitchstone
		Fissile rocks	Coarse- to medium-grained rocks		7. Schist, mica-schist, quartz-mica-schist, hornblende-schist
			Fine-grained rocks (disregarding porphyroblasts)		8. Phyllite, slate, chlorite-schist, schistose extrusive rocks.
	Non-silicate				9. Limestone, dolomite, marble, ironstone
Tough rocks known to be deleterious in concrete					10. Special. Rocks known to shrink in concrete e.g. some greywackes. Rocks which react with cement e.g. those containing pyrite or sulphates

and gravel deposits suggesting that many of the deposits may have formed as deltas in ice-marginal lakes.

Glacial sand and gravel Deposits of glacial sand and gravel are present throughout much of the assessment area, although those which are both thick and extensive enough to be considered potentially workable are generally associated with the major routes taken by glacial meltwaters. Occurrences of glacial sand and gravel range in size from small, isolated mounds and ridges to more extensive spreads of hummocky sand and gravel, such as those occurring between Dyce and the coast to the east, which have been worked extensively. Some ridges are laterally extensive, such as the steep-sided Foveran and Kemnay eskers, which mark the former courses of meltwater within the ice-sheet which once covered the area. Glacial sand and gravel also occurs as lenses concealed within the till sheet.

The deposit has a mean grading of 6 per cent fines, 59 per cent sand and 35 per cent gravel; this is remarkably similar to that of the fluvioglacial sand and gravel from which it is distinguished principally on geomorphological criteria, rather than by grading or composition. On closer inspection, however, the glacial sand and gravel (Figure 3b) is seen to be less well sorted than the fluvioglacial deposits and shows only a poorly developed mode in the medium sand fraction. The proportion of cobbles within the gravel fraction is significantly higher; fine gravel, coarse gravel and cobbles being present in almost equal amounts (12 per cent, 13 per cent and 10 per cent of the deposit respectively). In a few instances (for example, the pit at Milton Croft, Kemnay (NJ 71 NW 13) and borehole NJ 81 NW 11), cobble gravel has been recorded as forming more than a third of the whole deposit.

The wide grading envelope indicates even greater local variations in grading between individual sample points in glacial sand and gravel than in the fluvioglacial sand and gravel. This is confirmed by the fact that in pits and assessment boreholes the deposit is seen to range in grading from 'gravel' (with gravel accounting for 80 per cent by weight) in

Table 5 Compositional analyses (pebble-counts) of samples of sand and gravel (see Table 4 for lithological classification)

Source	Composite sample number	Size fraction (mm)	Soft rock (1)	Granite (2)	Gabbro (3)	Porphyry (4)	Basalt (5)	Schist (7)	Phyllite (8)	Total weight (g)	Total number	Angularity and shape of pebbles
Rothens area	1	10–14	0* *0**	90 *91*	4 *3*	3 *2*	0 *0*	3 *4*	0 *0*	2080	799	a - sr
Kemnay Esker	2	10–14	3 *4*	68 *70*	5 *5*	9 *8*	14 *13*	trace	0 *0*	5360	2012	a - r
		14–32	2 *2*	60 *63*	9 *9*	11 *11*	18 *15*	trace	0 *0*	12420	963	sa - r
		32–64	0 *0*	57 *57*	18 *11*	16 *20*	7 *10*	2 *2*	0 *0*	14860	102	sa - r
Kintore - Cairnhall area	3	10–14	0 *0*	75 *79*	4 *4*	18 *14*	0 *0*	3 *3*	0 *0*	2650	956	a - r
Kirkton of Dyce area**	4	10–14	0 *0*	88 *89*	1 *1*	10 *9*	trace	1 *1*	0 *0*	2590	1242	a, p
Foveran Esker	5	10–14	trace	63 *60*	7 *6*	2 *2*	26 *30*	2 *2*	0 *0*	3270	1265	a - wr(p)
		16–32	2 *4*	72 *73*	4 *3*	7 *7*	14 *12*	1 *1*	0 *0*	2460	163	sa - r
Corby Loch area (North)	6a	10–14	trace	69 *70*	5 *4*	3 *4*	22 *20*	1 *2*	0 *0*	2290	898	a - r
Corby Loch area (South)	6b	10–14	1 *2*	73 *75*	7 *6*	4 *4*	15 *13*	trace	0 *0*	2560	918	sa - r
Lochmore - Newtonhill area	6c	10–14	trace	61 *62*	10 *9*	5 *5*	23 *23*	1 *1*	0 *0*	2220	864	sa - wr
Potterton area	7	10–14	0 *0*	75 *76*	6 *5*	12 *11*	6 *6*	2 *2*	0 *0*	2510	954	a - wr
Don floodplain (Inverurie-Dyce)	8	10–16	trace	79 *80*	5 *4*	3 *3*	12 *11*	1 *2*	0 *0*	5280	1823	a - r(p)
		16–32	trace	79 *80*	5 *4*	2 *3*	12 *11*	2 *2*	0 *0*	5230	394	sr - r
Don floodplain (Kemnay - Monymusk)	9	10–16	0 *0*	66 *69*	10 *9*	2 *1*	21 *20*	1 *1*	0 *0*	3830	1502	a - wr
		16–32	trace	63 *63*	15 *14*	6 *5*	16 *18*	0 *0*	0 *0*	9020	582	a - r
Kintore - Tofthills area	10	10–14	trace	79 *80*	6 *6*	1 *1*	13 *12*	1 *1*	0 *0*	2940	1089	a - wr
		16–32	trace	59 *66*	7 *7*	7 *5*	27 *22*	trace	0 *0*	7320	557	a - wr
Coastal area (Newburgh - Bridge of Don)	11	10–16	trace	69 *65*	6 *6*	6 *7*	17 *19*	2 *3*	0 *0*	1086	292	wr(p)
		16–32	trace	78 *76*	2 *2*	9 *10*	9 *10*	2 *2*	0 *0*	2300	179	wr(p)
Dee terraces (Peterculter - Aberdeen)	12	10–14	trace	78 *79*	6 *5*	4 *4*	12 *12*	trace	0 *0*	4000	1616	a - r(p)
Dee floodplain	13	10–14	trace	79 *80*	5 *5*	5 *5*	11 *10*	trace	0 *0*	4440	1624	a - wr
		16–32	0 *0*	71 *73*	7 *6*	9 *9*	13 *12*	0	0 *0*	9770	644	a - wr
Dee terraces (Durris area)	14	10–14	trace	87 *88*	2 *2*	3 *3*	8 *7*	trace	0 *0*	2960	1139	a - r
		16–32	0 *0*	84 *87*	4 *5*	4 *3*	8 *5*	0	0 *0*	1350	95	a
Nigg area	15	10–14	1 *1*	63 *62*	6 *5*	2 *2*	24 *24*	4 *6*	trace	3020	1182	a - r(p)
Cantlayhills area	16	10–14	trace	64 *64*	6 *6*	4 *4*	25 *24*	1 *2*	0 *0*	3070	1137	a - r(p)

a = angular sa = subangular sr = subrounded r = rounded wr = well rounded p = platy

* Results are given in weight per cent with corresponding frequency per cent in italics
** includes a proportion of crushed material

borehole NJ 80 SW 5 to 'very clayey' sand in borehole NJ 91 NW 43.

The greatest recorded thicknesses of glacial sand and gravel are from sites in the hummocky deposits of the valley of the River Don, north of Dyce. At Liddell's Monument *[8708 1529]*, the sequence measured in quarry faces and in a pit excavated in the floor of Mill of Dyce Quarry recorded in excess of 15.2m of glacial sand and gravel; a borehole (81 SE 17) drilled on a sand and gravel mound, at Goval Villa, failed to bottom the deposit at a depth of 20.1m.

Blown sand and Post-Glacial beach and estuarine deposits In this survey, grading data for these deposits is only available from three sites (NJ 91 NE 14, 92 SE 5 and 92 SE 9; see Figure 3c). At the coast, blown sand forms partially stabilised dunes up to 15m high. These extend in a belt up to 400m wide inland from the high water mark along the coast north of the mouth of the River Dee. Behind this belt, blown sand also overlies a low-lying flat area up to 500m wide, the sand being stabilised here by the relatively high groundwater table. Post-Glacial beach and estuarine deposits are generally present beneath these sand-covered flats and range in character from silt and peat to fine-grained sand with pebbles (see borehole NJ 92 SE 5 and pit 92 SE 6).

North of Murcar golf course *[960 130]* and inland from the blown sand, an area of 'older' blown sand forms a prominent ridge which includes lenses of glacial sand and gravel. The stratigraphic relationship between the two deposits is complex and they have been treated as a single unit for the purposes of this assessment. The ridge of 'older' blown sand is particularly prominent at the coastguard lookout at Menie Links *[986 210]*, where it is thought to represent a belt of fossil sand dunes related to an earlier coastline. No grading data is available for the 'older' blown sand, but it has been worked in pits at Blackdog Rifle Ranges *[962 153]* and Blackdog Rock *[964 138]*.

The blown sand is generally clean and composed almost entirely of fine and medium-grained quartz sand (47 per cent and 45 per cent respectively). The potentially workable Post-Glacial beach deposits grade as 'pebbly sand' and may contain up to 15 per cent gravel. The graphical representation in Figure 3c shows the combined grading figures for both the blown sand and Post-Glacial beach deposits

Alluvium Generally thin, this deposit is mainly composed of silt, clay and peat. Although sand and gravel invariably underlies the floodplains of the major valleys, these deposits are classified as 'fluvioglacial' sand and gravel and not alluvium in this report. Alluvial sand and gravel, however, was recorded in three boreholes in the valley of the River Don upstream from Kemnay (Resource Sheet 1) and in one borehole at Burnside Crofts, Newhills (NJ 81 SW 2), (Resource Sheet 2) where it consists of 1.0m of humic sand. The humic sand is thought to be lacustrine alluvium from a Post-Glacial lake which occupied the low-lying ground south of Blackburn.

The alluvial sand and gravel of the Kemnay district is generally a 'dirty' deposit with a mean grading of 13 per cent fines, 63 per cent sand and 24 per cent gravel (Figure 3d). Its overall grading is 'clayey' sandy gravel. The grading envelope is narrow, but this probably reflects a lack of sample data rather than being an indication of homogenity.

Glaciolacustrine deposits Deposits classified as being of glaciolacustrine origin are recorded in 25 borehole and pit sites throughout the assessment area. Of these, only 8 proved potentially workable material (mainly fine sand). Sandy beds are found in the glaciolacustrine sequences within the 'red drift' of the coastal areas to the north and south of Aberdeen: they are also present in the valley of the River Don (upstream from Dyce) on Resource Sheet 2.

Near the coast, the glaciolacustrine sediments range in composition from stiff, homogeneous red-brown clay, to laminated, brown, micaceous silty clay interbedded with fine-grained quartz sand. The sand beds may contain stringers of fine gravel. Glaciolacustrine deposits occur in association with a wide variety of glacially-derived clayey sediments, but in general, they are only potentially workable when they are found adjacent to glacial sand and gravel as in Broom Hill pit (NJ 91 NE 12), Potterton.

The red-brown clay has been worked as a source of brick clay at Blackdog brick pit *[962 139]*. In the Ellon district (Merritt, 1981) broadly similar deposits are currently worked for brick making at Errolston *[089 368]*, near Cruden Bay, and were used as brick clay in the recent past at Tipperty *[969 267]*.

The complex nature of the 'red drift' deposits is described in more detail in the section of this report on drift geology and in the descriptions of Resource blocks J and K, which follow.

Glaciolacustrine deposits occurring beneath the fluvioglacial sand and gravel underlying the floodplain of the River Don, generally comprise olive-grey and greyish brown micaceous sandy silt and contain very little potentially workable sand and gravel. Sandier beds are occasionally present, for example in borehole NJ 81 NE 3. Such material is, in theory, potentially workable, but as it is nearly always encountered below the water table, its value as a source of aggregate is negligable.

Fine-grained sand of glaciolacustrine origin crops out on the northern side of the valley of the River Don at Milton of Fintray *[826 164]*. A pit (NJ 81 NW 8) excavated in the deposit hereabout proved 2.0m of horizontally laminated sand, overlying silty clay. It appears that much of the upper part of the exposed glaciolacustrine sequence in this vicinity constitutes a source of potentially workable fine-grained sand lying above the water table.

Glaciolacustrine deposits that have been classed as potentially workable have a mean grading of 'very clayey' sand. The range of grading is generally small, as shown by the tight grading envelope of Figure 3e. The range in the proportions of fines recorded between individual data points, however, is quite large (4 per cent to 38 per cent). This is mainly due to variation in the frequency and thickness of discrete clay and silt partings within individual sand beds at different localities. The sand is generally fine-grained, with a mean of 64 per cent of graded material >0.063mm and <0.5mm.

Potentially workable till Till is present over much of the assessment area but it is generally too clayey to be regarded as a mineral resource. Locally, however, where the till is particularly sandy, it meets the grading criteria which define mineral in this survey (see Appendix C): in such situations the deposit can be regarded as potentially workable although of limited use.

Potentially workable till has been proved in fifteen pits and assessment boreholes (Table 23). No readily predictable pattern is discernable and no attempt has been made to delineate the potentially workable deposits separately. Grading characteristics are, however, shown in Figure 3f where the wide grading envelope and poorly developed modes are typical of an ill-sorted deposit. Overall, the material has a mean grading of 'clayey' sandy gravel, comprising 17 per cent fines, 59 per cent sand and 24 per cent gravel.

Weathered bedrock Significant thicknesses of weathered bedrock have been noted in the area. Trial pit NJ 80 SW 2 provided a sample of weathered granite which had a grading of fines 14 per cent, sand 48 per cent and gravel 38 per cent. Deeply weathered bedrock is often very localised, but in some instances it may provide a source of low-grade aggregate as elsewhere in North-east Scotland.

MECHANICAL AND PHYSICAL PROPERTIES OF THE AGGREGATE

A series of mechanical and physical tests have been conducted in accordance with BS 812 parts 2 and 3 (British Standards Institution, 1975), on the 10 to 14-mm gravel fraction from 17 of the 18 samples listed in Table 3. As pebble counts were also undertaken on the 10 to 14-mm fraction a direct comparison between the petrographic composition of the gravel and the mechanical and physical properties of the aggregate can be made. The material for testing was obtained both from working quarries and as composite samples from assessment boreholes and pits sunk in a wide variety of deposits of potentially workable sand and gravel throughout the assessment area. The grouping of the samples was designed to provide a basic evaluation of the mechanical and physical properties of aggregates currently being worked; to provide comparison between worked deposits and nearby sources of potentially workable material and to compare deposits formed in similar depositional environments (for example, the Kemnay and Foveran eskers: samples 2 and 5, Table 3).

The samples for testing were obtained from graded stockpiles of aggregate at working pits and by sieving the residues of bulk samples taken for particle size analysis. The tests carried out comprise measurements of aggregate impact value (AIV), 10 per cent fines, relative density (on both an oven-dried and surface-dried basis), apparent relative density and water absorption. In addition, the aggregate impact value residue (AIVR) as defined by Ramsey (1965) and Ramsey, Dhir and Spence (1973, 1974) was determined. Approximately 12kg of material is required for a complete series of tests and only composite sample number 11, representing the Post-Glacial beach and estuarine deposits (Resource Sheet 2), yielded insufficient material for testing.

The work of Ramsey, and Ramsey, Dhir and Spence has shown that the main petrographical factor influencing the strength of an aggregate composed of clasts of sedimentary rock types is the strength of the intergranular cement; whereas in clasts of igneous rocks, strength is dependant upon the degree of crystal interlocking, which is inversely proportional to grain size. In clasts of metamorphic rocks, which are derived from either sedimentary or igneous rocks, the relative importance of both factors is dependent on the original rock type and also the grade and type of metamorphism (and hence the degree of recrystallisation) that they have undergone. In coarse-grained igneous and metamorphic rocks the strength of individual crystals is important. This is influenced by twinning, cleavage and the presence of microfracture planes within the crystals. In clasts of finer grained metamorphic rocks planes of weakness, caused by cleavage and schistosity, influence not only the strength of the clasts but also their shape and angularity.

The strength of an aggregate is also affected by the shape and degree of weathering of the clasts. This is partly controlled by petrography, but is also dependent on the distance and mode of transportation and the environment of deposition.

The resistance of an aggregate to both sudden impact and slowly applied compressive-load effects its suitability for various end-uses, particularly as a roadstone. AIV is an indicator of impact resistance and measures the relative amount of comminuted material passing a 2.36mm sieve, after the sample has been subjected to fifteen blows of standard magnitude. The 10 per cent fines value is the load required to produce 10 per cent by weight of the original sample as comminuted material passing through a 2.36mm sieve, in ten minutes and indicates the resistance of the aggregate to compressive-load.

Although the above tests give an indication of the strength of intergranular bonding, the results may be misleading because the tests only assess the proportion of comminuted material passing a 2.36mm sieve, yet ignore any breakdown of the aggregate that produces a coarser residue. For this reason the aggregate impact value residue number was introduced by Ramsey (1965). The AIVR gives an indication of the amount of material exceeding 10mm remaining after testing. Often, it is the ability of aggregate clasts to withstand impact and loading relatively intact (thus yielding high AIVR values), rather than to fragment (and yield low AIVR values), that is the most important attribute.

The results of the mechanical testing of the aggregate are given in Table 6. The AIV values range from 22 to 34 with an average of 28. The range of AIV values is quite large, though less than that (14 to 31) recorded for the adjoining Ellon area (Merritt, 1981). It is well above the average of 19, quoted by Edwards (1970), for worked Scottish gravels. The highest values are 34 (sample 8), for fluvioglacial sand and gravels occurring beneath the floodplain of the River Don between Inverurie and Dyce, and 32 (sample 2) for the glacial sand and gravel from the Kemnay Esker. The lowest AIV value, 22, is recorded from the fluvioglacial sand and gravel beneath the floodplain of the River Dee (sample 13) and from the glacial sand and gravel of Cantlayhills (sample 16). The AIV results indicate that the variation in impact resistance between the naturally occurring aggregates of the Aberdeen area is unlikely to be simply a consequence of differing modes of transport or environment of deposition. It is probably related more to the degree of weathering of the clasts.

The results of the 10 per cent fines test and the AIVR values generally show the expected inverse relationship to the AIV values and indicate that the samples with the greatest impact resistance also have the greatest compressive strength.

The pebble counts (Table 5) suggest that there is little variation in petrography between the samples. There are relatively few potentially deleterious 'soft rock' types, whereas by far the largest proportion of clasts in each sample tested fall within the more durable 'granite' rock group. The proportion of the subsidiary rock types in the samples is small. The relative petrographic homogeneity of the samples, however, may be somewhat over-emphasised by the pebble counting method employed. The 'granite' rock group, for example, includes a variety of coarse- and medium-grained igneous, metamorphic and sedimentary rocks (see Table 4), differing proportions of which might be expected to produce aggregates with significantly different strengths. Thus an aggregate (such as sample 2) containing a large proportion of weathered, coarsely crystalline granite clasts will be weaker than an aggregate (such as sample 16) in which the dominant clasts are of fine-grained quartzite and vein-quartz, which are less

Table 6 Results of mechanical and physical tests conducted in accordance with BS 812 (1975)

Source	Composite sample number and deposit type		AIV	AIVR	10% fines value (kN)	Relative density oven-dried	Relative density surface-dried	Apparent relative density	Water absorption %	Inferred shrinkage* %
Rothens area	1	Fluvioglacial sand and gravel	27	33	170	2.60	2.64	2.69	1.4	0.059
Kemnay Esker	2	Esker, glacial sand and gravel	32	33	130	2.52	2.56	2.62	1.5	0.060
Kintore - Cairnhall area	3	Fluvioglacial sand and gravel	31	33	140	2.60	2.63	2.67	1.4	0.059
Kirkton of Dyce area	4	Glacial sand and gravel	26	33	170	2.56	2.67	2.70	1.0	0.050
Foveran Esker	5	Esker, glacial sand and gravel	28	30	140	2.56	2.60	2.66	1.6	0.063
Corby Loch area (North)	6a	Glacial sand and gravel	29	32	170	2.62	2.65	2.70	1.1	0.052
Corby Loch area (South)	6b	Glacial sand and gravel	30	39	150	2.59	2.63	2.68	0.8	0.046
Lochmore - Newtonhill area	6c	Glacial sand and gravel	28	33	160	2.60	2.64	2.69	1.3	0.056
Potterton area	7	Glacial sand and gravel	30	29	180	2.61	2.63	2.67	1.0	0.050
Don floodplain (Inverurie - Dyce)	8	Fluvioglacial sand and gravel	34	29	140	2.55	2.59	2.66	1.6	0.063
Don floodplain (Kemnay - Monymusk)	9	Fluvioglacial sand and gravel	31	33	120	2.60	2.63	2.69	1.3	0.056
Kintore - Tofthills area	10	Fluvioglacial sand and gravel	27	35	170	2.58	2.61	2.67	1.2	0.054
Coastal area (Newburgh - Bridge of Don)	11	Post-Glacial beach deposits	Insufficient material for tests							
Dee terraces (Peterculter - Aberdeen)	12	Fluvioglacial sand and gravel	26	38	190	2.60	2.62	2.67	1.1	0.052
Dee floodplain	13	Fluvioglacial sand and gravel	22	43	230	2.59	2.62	2.66	1.0	0.050
Dee Terraces (Durris area)	14	Fluvioglacial sand and gravel	26	41	200	2.58	2.61	2.65	1.1	0.052
Nigg area	15	Glacial sand and gravel	27	37	170	2.57	2.61	2.68	1.6	0.063
Cantlayhills area	16	Glacial sand and gravel	22	40	220	2.55	2.59	2.65	1.6	0.063

* The derivation of these values is explained in the text

susceptible to weathering and are consequently stronger. Examination of the angularity of the clasts shows little evidence that the degree of rounding will have any significant effect on the strength of the material.

The suitability of an aggregate for use in concrete manufacture depends not only on its impact and crushing strength, but also on its water absorption and drying shrinkage (Table 6). The water absorption value is a measure of the amount of water absorbed by the aggregate after 24 hours of immersion, expressed as a percentage of its oven-dried weight: it is thought to have a broadly linear relationship to the drying shrinkage, both of the aggregate itself and of any concrete manufactured from it (Edwards, 1970). The drying shrinkage, in turn, is a key factor effecting the stress-carrying ability and resistance to weathering of concrete. The water absorption values of the aggregates from the Aberdeen area range from 0.8 to 1.6 per cent, with an average of 1.3. This is below the average of 1.48 per cent quoted by Edwards for various Scottish and English gravels. The low water absorption levels are due in part to the lack of highly porous clasts, such as weathered basalt or sandstone within the gravels, together with an absence of clayey rock types such as shales and mudstones, which absorb water readily and swell when immersed. Although many of the granite clasts show a marked degree of weathering, which should in theory increase the water absorption potential of the aggregate, this appears to be off-set by the paucity of porous sedimentary rock types in the gravels of the district.

Table 7 Concrete drying shrinkage, moisture expansion and moisture absorption tests*

Combined composite samples	Source	Deposit type	Dry shrinkage %	Moisture expansion %	Moisture absorption %
A	Corby Loch area	Glacial sand and gravel	0.039	0.038	5.2
B	Rothens area	Fluvioglacial sand and gravel	0.054	0.052	5.1
C	Blairs area (Dee terraces)	Fluvioglacial sand and gravel	0.045	0.043	5.2
D	Kintore (Cairnhall Pit)	Fluvioglacial sand and gravel	0.054	0.051	5.1
E	Kemnay area (including Kemnay Esker)	Glacial sand and gravel	0.052	0.051	5.1
F	Dee floodplain	Fluvioglacial sand and gravel	0.043	0.040	5.0

* conducted commercially, according to the method described in Building Research Station Digest No 35 (second-series), 1968; outlined in text.

A graph showing the linear relationship between water absorption and concrete drying shrinkage is given by Edwards (1970, Figure 1). By using the water absorption values of the seventeen test samples, the inferred shrinkage of concrete produced from them can be determined (Table 6, column 11). This shows that the samples have a range of inferred shrinkage values from 0.046 per cent to 0.063 per cent with an average of 0.055 per cent. The results mainly lie in the category defined by the Building Research Station Digest 35 (1968) as being potentially suitable for most applications, although "special care" should be taken in the design of certain precast products required to be of low shrinkage, such as thin reinforced sections, cladding panels and concrete floors cast *in situ*. It should be emphasised, however, that derived shrinkage values must be interpreted with caution and that the quality of an aggregate may often be improved by washing and crushing after stockpiling to remove deleterious, weathered and friable components.

Definitive values for concrete drying shrinkage, moisture expansion and moisture absorption are given (Table 7) for six composite samples of aggregate from the study area. The tests involved the manufacture of concrete prisms (200 x 50 x 50mm) using Ordinary Portland cement (BS 12, 1978), <5mm "Zone M" sand and 20mm to 5mm graded gravel from each separate sample provided. The tests were carried out in a commercial laboratory, using the method described in Building Research Station Digest 35.

The laboratory procedure involves immersing the prisms in water for a period of four days at a temperature of between 14 and 19 C with one of the larger (200mm) faces just breaking the surface of the water. The length of each prism is then measured (this is the 'original wet measurement'). Each prism is dried in an oven for a period of three weeks, cooled for four hours in a dessicator (containing solid calcium chloride in a saturated solution of calcium chloride) and its length measured. After a further week in the oven the cycle of drying, cooling and measurement is repeated (the final reading being taken as the 'the dry measurement'). The test measurements are then used to calculate the values for moisture absorption and moisture expansion. The 'dry shrinkage' is calculated as the "difference between the original wet measurement and the dry measurement expressed as a percentage of the dry length". The 'dry shrinkage' values obtained for the Aberdeen samples range from 0.039 per cent to 0.054 per cent and average 0.048 per cent. These definitive values indicate that the derived shrinkage values given in Table 6 (ranging from 0.046 per cent to 0.063 per cent) seem to be a little high, yet, are sufficiently accurate to provide a meaningful guide as to the suitability of aggregates from the assessment area for use in concrete manufacture.

Relative density values were obtained for the 17 composite samples, on both an over-dried and a saturated surface-dried basis. The apparent relative density of the samples was also calculated (Table 6, columns 7 - 9). As expected there was little difference between the oven-dried and surface-dried measurements. The range of apparent relative density values was small (2.62 to 2.69, average 2.67) again reflecting the comparative petrographic homogeneity of the samples. These values are comparable to those obtained by Merritt (1981), for the Ellon area. It is also clear that in the Aberdeen assessment area there appears to be no direct correlation betwen the strength of an aggregate and the density of its components.

THE MAPS

The three sand and gravel resource maps are folded into pockets at the end of this report. The topographic base is the Ordnance Survey 1:25 000 Outline Edition, which, together with the contours, is printed in grey: the geological lines and symbols are in black. Mineral resource information, is presented in shades of red.

Geological data The geological boundary lines are taken from geological maps surveyed at the scale of 1:10 000 or 1:10 560; these offer the latest interpretation of the available data but, because the deposits are highly variable, the accuracy of the map will be improved as new evidence from boreholes and excavations becomes available.

Borehole data, which include the stratigraphical relations and mean particle-size analysis of the sand and gravel samples collected during the assessment, are also shown on the maps.

Mineral resource information The maps are divided into resource blocks (see Appendix A) within which the extent of mineral-bearing ground is shown in shades of red. The dark shade denotes where mineral is exposed, that is, the overburden averages less than 1.0m in thickness: a lighter tone is used to identify where mineral is present in relatively continuous spreads beneath overburden averaging more than 1.0m in thickness. Within these areas, however, there may be small patches where sand and gravel is absent or not potentially workable.

Areas where sand and gravel is deemed to be not potentially workable, where superficial deposits do not contain mineral, or where bedrock crops out, are shown uncoloured. Sand and gravel within built-up areas is indicated by red stipple.

For the most part the distribution of resource categories is based on mapped geological boundaries. Where transitions between categories cannot be related to the geological map, inferred boundaries have been inserted. Such boundaries, drawn primarily for the purpose of volume estimation, are shown by a distinctive zigzag symbol, which is intended to convey an approximate location within a likely zone of occurrence rather that to represent the breadth of the zone; its width is dictated by cartographic considerations. For the purpose of measuring areas the centre-line of the symbol is used.

The areas of assessment

The resource sheets are divided into 16 resource blocks for assessment; the principal built-up areas are excluded. The block boundaries have been drawn both to provide sufficient sample points on which to base an assessment and to group together deposits of broadly similar origin and composition. As far as possible the block boundaries are determined by geological lines.

Seven types of potentially workable aggregate are recognised in the survey area, namely blown sand, Post-Glacial beach and estuarine deposits, older blown sand, fluvioglacial sand and gravel, glacial sand and gravel, glaciolacustrine deposits and till: in the borehole records deposits of the first six categories are identified as 'Mineral I' and till as 'Mineral II'. Because they pose different problems in terms of resource planning and exploitation they have been considered separately. No volumetric assessment is offered for the resources of potentially workable till; in the survey area till is considered to be potentially workable only locally, so no attempt is made on the resource map to show its disposition and extent.

Fluvioglacial sand and gravel (mainly gravel underlying floodplain alluvium and forming kame-terraces) is the most extensive potentially workable deposit within the resource area. Glacial sand and gravel (deposited as kames, eskers and spreads of glacial outwash) forms the second major source of workable sand and gravel. The remaining four deposits classified as 'Mineral I' constitute less important sources of potentially workable material (mainly fine sand).

The mineral resources are described more fully below in the notes on the resource blocks.

RESULTS OF THE VOLUMETRIC ASSESSMENT

The results of the volumetric assessment of resources are summarised in Table 8; more detailed grading and thickness data are given block by block in Tables 9 to 22. At the level of sampling allowed for in the present survey, only in 6 of the 16 resource blocks are the potentially workable deposits extensive enough for there to be sufficient sample points on which to base statistical assessments, the procedure for which is outlined in Appendix B. Inferred or speculative assessments are offered for the other resources.

Accuracy of results For a statistical assessment, such as for Block B on Resource Sheet 2, the accuracy of the estimated volume at the 95 per cent probability level is ±45 per cent (that is, it is probable that on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral). However, the real value is more likely to be near the median than near the limits. Moreover, it is probable that roughly the same percentage limits would apply to the estimate of mineral volume within a very much smaller parcel of ground (for example, 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say ten boreholes) were used in the calculation. Thus, if closer limits are needed for the quotation of reserves, data from more sample points would be required, even if the area is quite small.

For each block the total volume present in the ground is given in millions of cubic metres. An impression of the quantities present over part of a block may be gained by careful examination of the thickness of mineral proved in boreholes lying within or close to a particular area of interest, but such data must be considered within the context of the mean thickness and range of values proved for the block as a whole. It cannot be over-emphasized that any attempt to use the data presented in this report to evaluate parts of a block must be undertaken most cautiously, for data quoted for an individual borehole or pit refer strictly to that site.

The amount of recoverable resources will depend on many factors not least of which are working practice, the size and shape of the area for exploitation, planning and judicial constraints. Because there are so many variables, it is not possible to suggest what proportion of the *in-situ* resources either for a block as a whole, or for part of it, may prove to be recoverable.

NOTES ON THE RESOURCE BLOCKS

In the following description eskers are generally sinuous, steep-sided ridges of poorly sorted sand and gravel These features are composed of debris (carried by subglacial, supraglacial, or englacial meltwater streams) which was deposited on the exhumed land surface as the ice sheet decayed; as a result, esker ridges frequently cut obliquely across the present topography and their internal stratification often shows evidence of post-depositional collapse.

Kames are generally isolated hemispherical or lenticular mounds of sand and gravel deposited by meltwater emerging from a retreating ice front.

Table 8 The sand and gravel resources: summary of statistical, inferred and speculative assessments

Resource block	Area of assessed ground*		Mean thickness		Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Over-burden	Mineral		Limits at the 95% probability level		Fines	Sand + $\frac{1}{16}$	Gravel
	km^2	km^2	m	m	m^3x10^6	±%	$\pm m^3x10^6$	$-\frac{1}{16}$ mm	-4 mm	+4 mm
STATISTICAL ASSESSMENTS										
Resource Sheet 1										
Block B	13.6	7.3	0.5	4.0	29	45	13	8	56	36
Block F	9.0	8.2	0.5	6.1	50	62	31	6	64	30
Total (Sheet 1)	**22.6**	**15.5**	**0.5**	**5.0**	**79**	**35**	**28**	**7**	**61**	**32**
Resource Sheet 2										
Block H	14.0	11.4	1.2	5.3	60	51	31	7	63	30
Block J	23.0	5.0	0.7	6.1	31	53	16	7	63	30
Block K	11.1	3.3	2.2	4.5	15	51	8	8	66	26
Total (Sheet 2)	**48.1**	**19.7**	**1.0**	**5.0**	**99**	**29**	**29**	**7**	**64**	**29**
Resource Sheet 3										
Block O	14.1	11.7	0.3	7.6	89	36	32	6	61	33
Overall Total (Sheets 1 to 3)	**84.8**	**46.9**	**0.8**	**6.0**	**281**	**6**	**17**			
INFERRED AND SPECULATIVE (NON-VOLUMETRIC) ASSESSMENTS										
Resource Sheet 1										
Block A	53.2	1.6	0.9	3.3	5	Inferred		5	62	33
Block C	6.4	6.1	0.3	5.1	31	Inferred		7	54	39
Block D	45.8	3.2	2.7	3.4	11	Inferred		10	73	17
Block E	20.7	2.5	0.3	3.0	7**	Inferred		6	60	34
Total (Sheet 1)	**126.1**	**13.4**	**0.9**	**4.0**	**54**			**7**	**61**	**32**
Resource Sheet 2										
Block G	67.9	<0.1	-	-	-	Speculative		-	-	-
Block L	10.1	8.4	0.1	2.0	17	Inferred		5	86	9
Resource Sheet 3										
Block N	39.3	2.9	0.2	2.0	6	Inferred		6	41	53
Block P	150.8	3.5	0.6	5.5	19**	Inferred		8	52	40
Resource blocks on Sheets 2 & 3										
Block M	9.5	1.4	-	-	-	Speculative		-	-	-
Block I	86.8	3.4	0.3	3.0	10	Inferred		7	70	23
Total (Sheets 2 & 3)	**364.4**	**19.7**	**0.3**	**3.0**	**59**			**7**	**60**	**33**
Overall Total (Sheets 1 to 3)	**490.5**	**33.1**	**0.6**	**3.4**	**113**					

* excluding urban areas
** figures differ slightly from those presented in individual inferred assessments due to rounding

In the Aberdeen area, fluvioglacial terraces generally form flat topped bodies of sand and gravel on the sides of valleys which were formerly filled with glacier ice. Many high-level terraces were deposited by meltwater streams flowing down-valley at the contact between the glacier and the valleyside and are analalgous to kame terraces. Terraces formed at lower levels were deposited on the freshly exhumed valley floor by glacial meltwaters at a distance beyond the snouts of retreating valley glaciers.

Many of the deposits underlying kames or kame-terraces are of deltaic origin and reveal classic fining-downwards sequences. Many of the glacial deposits in the district contain marshy hollows known as kettle-holes which may be many metres deep and can cause considerable local thinning of the sand and gravel Kettle-holes were formed by the melting of large blocks of ice trapped within the glacial deposits as they were laid down.

The data from boreholes, sections and shallow pits (referred to collectively as sample points) have been used to give mean thicknesses and mean gradings for the sand and gravel deposits, whenever possible.

Block A (Table 9)

Most of the ground within Block A is mantled by till, which overlies bedrock, and is barren of sand and gravel. An inferred volumetric assessment is given for the potentially workable sand and gravel of this block, which includes the kame terraces and alluvium of the valley of the River Don between Keithney *[727 193]* and Crichie *[771 194]*, and upstream from Lower Woodend *[674 189]*. The assessment also includes glacial sand and gravel found on the southern side of the tributary valley drained by Burn Hervie and in two small outcrops, near Holylind *[725 183]*.

The granite bedrock in the north eastern corner of the block is deeply weathered (notably on the flanks of Bennachie, and at Craigton Wood *[660 190]*) and may be regarded as a potential source of low grade aggregate. The granite was worked in the past as a source of clayey fine gravel in a small pit *[6835 1791]*, north of Braehead.

A total of five sample points were sited between Holylind and Crichie. Two shallow pits (NJ 71 NW 3 and NW 7) proved potentially workable till (Mineral II), which graded as 'clayey' sandy gravel. Another pit (NJ 71 NW 8) in the flat spread of sand and gravel at Keithney proved 3.7m of pebbly sand (not bottomed). The sand and gravel sequence at Keithney was deposited by glacial meltwaters which cut the nearby drainage channels that join the valley of the River Don to the east.

The most important resources in the block underlie the kame-terraces of the River Don to the north east of Whitehaugh *[732 189]*. These deposits were not sampled but the fluvioglacial sand and gravel has been worked in small pits at Burnhervie *[731 195]* and is probably of good quality.

Potentially workable glacial sand and gravel is present beneath the floodplain of the River Don at Backhill *[736 192]*, where a borehole (NJ 71 NW 15) proved 1.9m of pebbly sand resting on granite bedrock. The deposit is of minor importance as a resource compared with the kame-terrace deposits in the vicinity. An isolated patch of glacial sand and gravel crops out at Holylind, where a pit (NJ 71 NW 9) proved 4.2m of coarse gravel resting on till.

Sand and gravel is thought to occur beneath the alluvium of the River Don upstream of Lower Woodend. The floodplain is very narrow in this vicinity and as any mineral deposits would constitute a resource of only minor significance, no sample points were sited here. Mapping, however, has proved sand and gravel beneath the kame-terraces that flank the northern side of the valley; it also underlies the broad terrace that floors the small tributary valley to the south of Craigton Wood *[658 189]* where 1.0m of imbricated coarse gravel was seen.

Table 9 Block A: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	(see the diagram in Appendix C)
NJ 71 NW 8	3.7+	0.1	-	8	16	39	24	9	4	0	PS
NJ 71 NW 9	4.2	0.1	-	4	6	13	21	14	18	24	G
NJ 71 NW 15	1.9	2.5	-	3	10	40	25	7	5	10	PS
Mean	**3.3**	**0.9**	-	**5**	**11**	**28**	**23**	**11**	**10**	**12**	**SG**

Inferred assessment of Resource Block A (Fluvioglacial sand and gravel, glacial sand and gravel and alluvium of the Don Valley, north west of Lower Woodend [674 189] and between Keithney [727 193] and Crichie [771 194]

Total area (excluding Monymusk)	53.16km²
Monymusk village (including 0.01km² sand and gravel, not assessed)	0.19km²
Area of exposed mineral	1.02km²
Area of concealed mineral	0.53km²
Total area of mineral-bearing ground	1.55km²
Area of ground worked for sand and gravel	<0.01km²
Area of barren ground (excluding Monymusk village)	51.60km²
Mean thickness of overburden	0.9m
Mean thickness of mineral	3.3m
Estimated volume of mineral	**5.1 million m³**

Table 10 Block B: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ −1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	
Alluvium and fluvioglacial sand and gravel of the River Don between Monymusk and Kemnay											
NJ 61 NE 2	8.3+	2.0	-	5	5	23	25	21	20	1	SG
NJ 61 NE 4	7.4+	0.4	0.2	11	9	27	34	17	2	0	CPS
NJ 61 NE 6	1.0	1.3	-	5	7	49	22	13	4	0	PS
NJ 71 NW 6	3.9	0.1	0.5	6	7	21	16	15	30	5	G
NJ 71 NW 10	1.3	0.2	-	11	14	26	18	12	12	7	CSG
NJ 71 NW 12	2.3	0.4	0.5	24	39	17	10	9	1	0	VCPS
NJ 71 SW 1	4.4	0.2	3.4	10	8	23	17	18	24	0	CG
Mean	**4.0**	**0.7**	**0.7**	**9**	**11**	**24**	**23**	**17**	**15**	**1**	**SG**
Alluvium, glacial sand and gravel and fluvioglacial sand and gravel between Rothens and Fetternear House											
NJ 61 NE 5	5.8+	0.2	1.0	6	7	16	29	25	13	4	SG
NJ 61 NE 7	6.1+	0.3	-	5	3	20	24	19	24	5	G
NJ 71 NW 1	1.6	0.2	-	11	10	17	25	14	8	15	CSG
NJ 71 NW 4	2.2	0.3	0.1	11	26	25	23	11	4	0	CPS
Mean	**3.9**	**0.3**	**0.3**	**7**	**8**	**19**	**26**	**20**	**15**	**5**	**SG**
Overall Mean	**4.0**	**0.5**	**0.5**	**8**	**9**	**22**	**24**	**18**	**15**	**3**	**SG**

Inferred assessment of Resource Block B: alluvium and fluvioglacial sand and gravel of the River Don between Monymusk and Kemnay

Total area	5.63km^2
Area of exposed mineral	4.35km^2
Area of concealed mineral	0.91km^2
Total area of mineral-bearing ground	5.26km^2
Area of ground worked for sand and gravel	<0.01km^2
Area of barren ground	0.37km^2
Mean thickness of overburden	0.7m
Mean thickness of mineral	4.0m
Estimated volume of mineral	**21.0 million m^3**

Inferred assessment of Resource Block B: alluvium, glacial sand and gravel and fluvioglacial sand and gravel between Rothens and Fetternear

Total area	8.00km^2
Area of exposed mineral	1.85km^2
Area of concealed mineral	0.16km^2
Total area of mineral-bearing ground	2.01km^2
Area of ground worked for sand and gravel	0.12km^2
Area of barren ground	5.87km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral	3.9m
Estimated volume of mineral	**7.8 million m^3**

Note. A statistical assessment of volume for the whole block is given in Table 8 .

Block B (Table 10)
Two inferred volumetric assessments have been made of the sand and gravel in Block B. The first concerns the alluvium and fluvioglacial deposits of the valley of the River Don together with the lower reaches of the valley of Ton Burn, to the west of Kemnay. The second inferred assessment accounts for the sand and gravel in the tributary valleys between Rothens *[689 173]* and Fetternear House *[723 171]*. A statistical assessment is also offered for the block as a whole; this is given in Table 8.

Monymusk to Kemnay
Ten assessment boreholes were drilled in the valley of the River Don upstream from Kemnay, of which, nine proved potentially workable sand and gravel. Two boreholes (NJ 71 NW 6 and 61 NE 4) sited on the floodplain proved mineral virtually from the surface, and a third (NJ 61 NE 2) proved 8.3m of sandy gravel (not bottomed), beneath 2.0m of clayey alluvium. The drift sequence beneath the floodplain of the River Don is shown in cross-section B-B' (at the foot of Resource Sheet 1). East of Nether Mains *[704 147]*, the sandy alluvium and the underlying sand and gravel are separated by a thin bed of sandy till. (Till also underlies the kame-terrace at Nether Mains). The sand and gravel rests in turn on a thick sequence of sandy silt overlying

lodgement till. Potentially workable sand and gravel is also thought to be present beneath the clayey alluvium of Ton Burn.

Although the mineral deposits beneath the floodplain are generally composed of clean, well sorted sand and gravel (which averages approximately 6.5m in thickness), their value as a resource is limited by the high groundwater table.

Five assessment boreholes sited on the terraces between Kemnay and Monymusk show the terrace-features to be underlain by fluvioglacial sand and gravel. These fluvioglacial deposits, unlike many others elsewhere in the assessment area, do not show well developed fining-downward sequences, and are considered to be mainly braided-river gravels rather than deltaic deposits. The sand and gravel underlying the terraces is generally thinner than that found beneath the floodplain, but it is often present beneath very thin overburden and occurs above the water table. The terrace deposits therefore constitute the principal source of easily obtainable aggregate in Block B.

One borehole (NJ 71 NW 5), however, drilled on the terrace-feature east of Stoneyfield, recorded 4.7m of till resting on Dalradian bedrock. The reliability of this record is questionable because sand and gravel was mapped in the surrounding ground and has also been recorded from a pipeline trench nearby.

Rothens to Fetternear House

Fluvioglacial sand and gravel forms a broad, gently undulating terrace flooring much of the valley of the Burn of Blairdaff and the valleys of its tributaries between Burnside *[704 183]* and Tillywater *[684 169]*. The deposit is worked in a sand and gravel pit at Rothens *[692 173]*. The exposed sequence, together with that recorded from a shallow pit (NJ 61 NE 7) excavated in the floor of the workings, proved 6.1m of gravel (not bottomed). A borehole (NJ 61 NE 5) nearby, proved 1.6m of 'clayey' sand overlying 5.2m of gravel, with an intervening waste parting (peat and silt) 1.0m thick. The gravel became coarser with depth.

The valley of Marshes Burn, upstream from Fetternear House, is also floored by fluvioglacial deposits. A borehole (NJ 71 NW 4) drilled in the valley proved 2.2m of sand and gravel resting on glaciolacustrine deposits. On the northern side of the valley at Moss-side *[710 182]*, hummocky spreads of glacial sand and gravel rest on top of till. Moundy deposits of glacial sand and gravel are also present near Blairdaff *[696 176]*, where 5.0m of coarse cobble gravel (not bottomed) was exposed in the face of the working sand and gravel pit. It was thought that glacial sand and gravel might be concealed beneath peat deposits at Red Moss, but a pit (NJ 71 NW 2) showed that the peat rests directly on till.

Potentially workable fluvioglacial sand and gravel was mapped on the floor of a small tributary valley near Cairnley *[706 172]* but it was not sampled.

Two sample points (NJ 61 NE 3 and 71 NW 11) proved potentially workable till in Block B. The deposit is very dirty and would require washing before being considered as a source of aggregate.

Block C (Table 11)

This block includes the glacial sand and gravel on the southern bank of the River Don to the north and the south of Kemnay, and the sand and gravel deposits within the upper part of the valley drained by the Ton Burn. All eight

Table 11 Block C: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Intervening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand $+1$ -4 mm	Fine gravel $+4$ -16 mm	Coarse gravel $+16$ -64 mm	Cobbles and boulders $+64$ mm	
NJ 61 SE 3	2.8	0.2	-	2	11	50	26	9	2	0	PS
NJ 71 NW 13	7.2+	-	-	0	2	9	17	14	22	36	G
NJ 71 NW 14	5.8*	0.2	-	5	7	26	16	11	14	21	SG
NJ 71 NW 16	14.3+	0.4	0.6	19	9	24	24	13	9	2	CSG
NJ 71 SW 3	3.0	0.4	-	5	7	42	37	8	1	0	PS
NJ 71 SW 6	4.0+	1.0	-	2	3	16	26	16	19	18	G
NJ 71 SW 7	1.8	0.3	-	2	5	21	22	14	19	17	G
NJ 71 SW 9	1.5	0.1	-	3	5	20	18	9	15	30	G
Mean	**5.1**	**0.3**	**<0.1**	**7**	**7**	**24**	**23**	**12**	**13**	**14**	**SG**

* overlies 5.9m of potentially workable till

Inferred assessment of Resource Block C (mainly glacial sand and gravel of the Kemnay Esker and in the valley of the Ton Burn)

Total area (excluding Kemnay urban area)	6.40km^2
Kemnay urban area (including 0.78km^2 sand and gravel, not assessed)	0.83km^2
Area of exposed mineral	4.40km^2
Area of concealed mineral	1.74km^2
Total area of mineral-bearing ground	6.14km^2
Area of barren ground (excluding Kemnay)	0.21km^2
Area of ground worked for sand and gravel	0.05km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral	5.1m
Estimated volume of mineral	**31.3 million m^3**

sample points sited in Block C proved mineral beneath negligible overburden. Concealed mineral probably occurs beneath the floodplain of the Ton Burn and the alluvial flat east of Home Farm (see cross-sections A-A′ and B-B′). Small spreads of alluvium and peat to the north of Kemnay also conceal potentially workable sand and gravel. The ridges of morainic drift that flank the valley of Ton Burn around Nether Glenton *[128 670]* are considered to be too coarse and ill-sorted to be a viable resource.

The main mineral resources of Block C include the Kemnay Esker and the deposits beneath the surrounding glacial outwash terrace. The latter is kettled, especially to the north of Kemnay. Together, these features extend for approximately 3km to the south west of the Kemnay and are underlain by clean gravel, with an average thickness of at least 4.0m. Sample points (NJ 71 NW 13 and 14), sited on the esker ridge, proved 7.2m of cobble gravel (not bottomed) and 5.8m of sandy gravel (overlying 5.9m of potentially workable till) respectively.

The Kemnay Esker and the adjacent outwash deposits also extend up to 3km to the north and east of Kemnay. An assessment borehole (NJ 71 NW 16) sited on the moundy deposits of glacial sand and gravel at Loanend, proved 14.3m of 'clayey' sandy gravel (not bottomed). The deposit has been worked at Mill Farm *[738 178]*.

Eskers of boulder gravel occur on both sides of the valley of Ton Burn to the west of Cluny Castle *[689 127]*; glacial sand and gravel is probably also present beneath thin deposits of peat which floor linear depressions between the eskers and ridges of morainic drift. Large mounds of boulder gravel are also present on the north side of the valley at Old Crow Wood *[699 136]*. A pit (NJ 71 SW 3) sited to the east of the most prominent mounds proved 3.0m of sand draped over large boulders resting on bedrock. A similar deposit was proved to the west of Cunnigar Wood where a shallow pit (NJ 61 SE 3), sited in a small working in glacial sand and gravel, proved 2.8m of pebbly sand resting on boulders overlying till.

Most of the gravel in the upper reaches of the valley of the Ton Burn is probably too coarse to be a very attractive source of aggregate. Around Monyroads *[673 129]*, however, a dissected kame-terrace is underlain by finer-grained sand and gravel. A section measured in a small pit in the vicinity, showed over 5m of clean, well bedded sand and gravel. The pit is worked intermittently. The kame-terrace merges upstream into an alluvial flat, which is underlain by sand and gravel that coarsens rapidly westwards.

A small spread of glacial sand and gravel occurs on the southern side of the valley of Ton Burn to the south of the Pool of Cluny *[685 127]*. Up to 3m of coarse gravel was recorded in exposures in the deposit. The gravel was deposited by glacial meltwater which cut the complex of drainage channels north of Prospect House *[684 122]*.

Most of the exposed mineral in Block C occurs above the water table. It probably constitutes the principal source of aggregate in the area covered by Resource Sheet 1.

Block D (Table 12)

Block D covers the southern part of Resource Sheet 1. Most of the ground is barren, being covered by thin spreads of till on bedrock. The eastern half of the block is dominated by a deep topographic depression, centred on Skene Moss *[756 107]* and drained by Bogendinny Burn and its tributaries. The depression is floored by extensive spreads of alluvium and peat overlying gravelly till.

Potentially workable sand and gravel is confined to the valleys of Cluny Burn and its tributary streams towards the west of the block, where it was proved in four assessment boreholes. Deposits of fluvioglacial sand and gravel with negligible overburden crop out on both sides of the valley and form isolated mounds up to 2m high on the valley floor. The main spreads of sand and gravel occur between Home Farm *[685 120]* and Cairnfold *[705 115]*. A borehole (NJ 71 SW 4) near the eastern edge of

Table 12 Block D: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
NJ 61 SE 4	4.0	1.2	-	8	17	37	33	4	1	0	SG
NJ 61 SE 5	6.2	7.9	2.5	4	6	30	36	10	11	3	SG
NJ 71 SW 4	2.1	0.3	-	25	7	35	26	5	2	0	VCPS
NJ 71 SW 5	1.4	1.2	-	23	4	20	18	13	17	5	VCSG
Mean	**3.4**	**2.7**	**0.6**	**10**	**9**	**32**	**32**	**8**	**7**	**2**	**CSG**

Inferred assessment of Resource Block D (Fluvioglacial sand and gravel and alluvium of Cluny Burn)

Total area	45.79km^2
Area of exposed mineral	1.13km^2
Area of concealed mineral	2.05km^2
Total area of mineral-bearing ground	3.18km^2
Area of ground worked for sand and gravel	0.01km^2
Area of barren ground	42.60km^2
Mean thickness of overburden	2.7m
Mean thickness of mineral	3.4m
Estimated volume of mineral	**10.8 million m^3**

the deposit, to the north of Cairnfold, proved 2.1m of 'very clayey' pebbly sand resting on till. Well sorted, fine gravel overlying sand was worked in small pits to the west of the borehole site. Fine-grained sand with gravel is also exposed in the alluvial cone that has developed where the Cluny Burn meets the valley of the Ton Burn.

Thicker deposits of concealed mineral are present beneath the alluvium that floors the valley to the south of Sauchen *[700 108]* and also beneath the terraces that flank the upper part of the valley. Two boreholes (NJ 71 SW 5 and 61 SE 4) to the south of Mains of Linton (see cross-section A-A') show the mineral to range in grade from 'very clayey' pebbly sand to sandy gravel. Farther upstream at Burnside, assessment borehole NJ 61 SE 5 proved 4.3m of sandy gravel beneath 7.9m of overburden. The sandy gravel rested on till, which was underlain by a further 1.9m of pebbly sand.

Block E (Table 13)

Most of the ground within Block E is underlain by till overlying bedrock. Three large drainage channels (with arched long-profiles) cross the area. The channels mark the principal routes of sub-glacial drainage across the district. The northern, most prominent channel lies to either side of a col *[757 171]* at Tom's Forest and is occupied by the Gourock Burn to the west and the Bridgealehouse Burn to the east. A less clearly defined drainage route lies between Pictillum *[745 166]* and Hallforest *[778 153]*, whereas a well-defined channel forms the southern boundary of the block, running eastwards from Craigearn *[723 143]* to a col near Bandshed Moss *[755 141]*. These channels are significant because they carried the meltwaters which laid down large fans of sand and gravel in the valley of the River Don to the east, in block F.

An inferred volumetric assessment is given for the sand and gravel deposits in this block. Five sample points were sited in the area; all proved mineral with negligible overburden. The main resource is formed by a flat spread of fluvioglacial sand and gravel lying within the broad topographic depression drained by the Tillakae Burn and Park Burn, to the north of Aquherton *[784 125]*. Assessment pits (NJ 71 SE 4 and SE 6) proved 1.0m of sandy gravel and 1.1m of 'clayey' sandy gravel respectively, resting on till. A pit (NJ 71 SE 3) in a small esker to the north of Park Burn proved 2.9m of poorly sorted cobble gravel on top of till. The mineral deposits between Tillakae Burn and Park Burn, and in the esker to the north of Park Burn, generaly lie above the water table.

The southern glacial drainage channel, which trends eastwards from Craigearn, is floored by peat, alluvium and fluvioglacial deposits. These deposits mark the position of a lake which occupied the valley soon after the ice had retreated. Potentially workable sand and gravel is judged to be present beneath both the peat of Lauchintilly Moss *[737 136]*, and the flat area to the west, but there is no borehole evidence. A borehole (NJ 71 SW 11) sited on a small flat-topped mound of glacial sand and gravel near Wester Leschangie proved 6.9m of mineral; it revealed a fining-downward sequence of 5.0m of sandy gravel, overlying 1.9m of sand resting on laminated glaciolacustrine silt. The sand and gravel is thought to represent a proglacial delta deposited by meltwater which flowed into the lake. A similar deltaic deposit is seen at Todfold *[748 140]*.

The other two drainage channels do not contain potentially workable sand and gravel lying in this resource block, apart from two small areas of hummocky glacial sand and gravel, which crop out to the east of Pictillum.

Table 13 Block E: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
NJ 71 SW 11	6.9	0.3	-	6	13	42	20	8	7	4	PS
NJ 71 SE 3	2.9	0.1	-	1	2	7	24	20	15	31	G
NJ 71 SE 4	1.0	0.3	-	9	15	28	15	11	17	5	SG
NJ 71 SE 6	1.1	0.3	-	15	13	17	18	13	17	7	CSG
Mean	**3.0**	**0.3**	**-**	**6**	**11**	**29**	**20**	**12**	**11**	**11**	**SG**

Inferred assessment of Resource Block E (Fluvioglacial sand and gravel and glacial sand and gravel of Muchalls, Tillakae and Park burns)

Total area	20.66km^2
Area of exposed mineral	1.60km^2
Area of concealed mineral	0.86km^2
Total area of mineral-bearing ground	2.46km^2
Area of barren ground	18.20km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral	3.0m
Estimated volume of mineral	**7.4 million m^3**

Block F (Table 14)
The boundaries of Block F are drawn to include the kame-terraces and the alluvium of the River Don together with the fans of sand and gravel occupying the valleys of its tributaries, the Bridgealehouse, Torry and Tuach burns in the vicinity of Kintore. A statistical assessment for the sand and gravel in this block is based on the records of two commercial boreholes, six assessment boreholes and two shallow pits.

Most of Block F is mineral-bearing, but bedrock knolls protrude through the surface of the kame-terraces to the south east of Kintore. Small areas of till to the north of Hallforest also form barren ground. At nine of the ten sample points sited in the block mineral was proved within a metre of the surface.

The principal sand and gravel resources in Block F are found beneath the kame-terraces on the western side of the River Don and also beneath the fans associated with its tributaries (see cross-section F-F').

The fluvioglacial sand and gravel beneath the Cairnhall Kame-Terrace (Chester, 1975) has been worked in several places. The terrace extends for approximately 3.5km along the western side of the Don valley, upstream from Kintore. A sampled section and a shallow pit (NJ 71 NE 3) in the floor of the workings at Cairnhall Pit proved 5.2m of clean, well bedded sandy gravel resting on till. A previous section in the pit *[787 177]* was described by Chester in 1975, who recorded 7m of coarse sand containing lenses of gravel. A commercial borehole (NJ 71 NE 1) on the front edge of the terrace to the east of Broomend *[779 192]*, recorded 20.1m of sand and gravel overlying till. A second commercial bore (NJ 71 NE X1) to the north of Kintore proved 4.4m of exposed sand and gravel (not bottomed).

The fans in the tributary valleys were deposited by meltwater that flowed into the valley of the River Don from the three drainage channels mentioned in the description of Block E. The fans slope gently downwards towards the east where they merge into the Cairnhall Kame-Terrace, the surface of which lies at between 6 and 8m above the floodplain of the River Don.

The fluvioglacial deposits beneath the northernmost fan have been extensively worked for sand and gravel near Black Hillock *[783 170]*. A section and pit (NJ 71 NE 4) in these deposits revealed 7.0m of well bedded sand and gravel with no overburden, resting on till.

The fan in the valley of the Torry Burn is extensively kettled and dissected. An assessment borehole (NJ 71 NE 5) was sited on the northern side of the valley, where it proved 5.1m of 'clayey' pebbly sand on top of till. As the surface of the fan is uneven, the deposit will range widely in thickness locally.

Three boreholes (NJ 71 SE 1, 2 and 5) were sunk in the fluvioglacial deposits underlying the southernmost fan in the valley of Tuach Burn. The boreholes proved between 3.6m and 4.0m of sandy gravel with little overburden, overlying till. (Potentially workable pebbly sand occurs beneath the till in borehole NJ 71 SE 2). In the lower part of the fan, the sand and gravel thins rapidly against bedrock at Tuach Hill.

Most of the sand and gravel beneath the kame-terraces and fans occurs above the water

Table 14 Block F: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	(see the diagram in Appendix C)
NJ 71 NE 1	20.1	–	–	No grading data available							
NJ 71 NE X1	4.4+	0.6	–	No grading data available							
NJ 71 NE 2	4.7+	0.3	–	3	4	18	24	21	23	7	G
NJ 71 NE 3	5.2	0.5	–	1	4	33	28	16	15	3	SG
NJ 71 NE 4	7.0	0.5	–	No grading data available							
NJ 71 NE 5	5.1	0.4	–	17	19	39	20	4	1	0	CPS
NJ 71 NE 6	2.9	1.4	–	2	7	22	19	19	30	1	G
NJ 71 SE 1	3.6	0.3	–	5	7	26	15	12	24	11	SG
NJ 71 SE 2	4.0	0.2	3.4	3	7	34	30	14	11	1	SG
NJ 71 SE 5	4.0	0.3	–	8	15	47	26	4	0	0	S
Mean*	**6.1**	**0.5**	**0.3**	**6**	**9**	**31**	**24**	**13**	**14**	**3**	**SG**

* commercial data have been used in the calculations

Statistical assessment of Resource Block F (Mainly fluvioglacial sand and gravel and alluvium of the River Don and its tributaries in the vicinity of Kintore)

Total area (excluding Kintore)	8.97km^2
Kintore urban area (including 0.26km^2 sand and gravel, not assessed)	0.26km^2
Area of exposed mineral	6.41km^2
Area of concealed mineral	1.78km^2
Total area of mineral-bearing ground	8.19km^2
Area of ground worked for sand and gravel	0.38km^2
Area of barren ground (excluding Kintore)	0.40km^2
Mean thickness of overburden	0.5m
Mean thickness of mineral	6.1m
Estimated volume of mineral	**50 million m^3 ± 62% or 31.0 million m^3**

table. In borehole NJ 71 NE 1, however, much of the 20.1m of mineral must occur beneath groundwater level.

Braided-river gravels are present beneath the floodplain of the River Don. An assessment borehole (NJ 71 NE 2) at Fullerton, proved 4.7m (not bottomed) of gravel with negligible overburden, whereas 2.9m of gravel was recorded beneath 1.1m of clayey alluvium overburden at Tavelty (borehole NJ 71 NE 6). Potentially workable sand and gravel is also judged to be present beneath the alluvium of the tributary valleys. The value of these resources is limited, however, by the high groundwater table beneath the floodplains.

Coarse glacial sand and gravel forms a small sinuous esker on the floor of the valley of Torry Burn. The deposit is poorly sorted but, in general, it becomes finer with depth. Mounds of sandy gravel also flank the southern side of the valley, to the east of Hallforest. Exposures in these moundy deposits in the vicinity of a small backfilled sand and gravel pit at Gauch-hill *[786 154]*, show them to be composed of clean, coarse sand and gravel. Most of the glacial sand and gravel in the valley of Torry Burn occurs above groundwater level.

A narrow, sloping terrace-feature is present on the eastern side of the valley of the River Don. This terrace, which rises up to 10m above the level of the floodplain, is underlain by glacial sand and gravel.

Resource Block G

Total area (excluding Newburgh, Kingseat Hospital and Newmachar urban areas)	67.90km^2
Urban areas	0.71km^2
Area of exposed mineral	0.03km^2
Area of barren ground (excluding urban areas)	67.16km^2

Block G

This block covers a large area of generally barren ground between the valley of the River Don and the northern and western margins of Resource Sheet 2. Block G is flanked to the east by the prominent mounds and ridges of glacial sand and gravel that extend in a narrow belt south from Newburgh, through Belhelvie towards Corby Loch.

Six pits and one assessment borehole were sited in Block G within the valleys drained by the Goval Burn, Elrick Burn, Pinkie Burn and the Burn of Straloch. These burns meet to the south of Newmachar and join the River Don near Bridge of Dyce *[889 142]*. No potentially workable sand and gravel was found at any of the assessment sites. Pits excavated in the hummocky terrain to the south and to the west of Newmachar, showed the hummocks to be bedrock knolls covered by thin spreads of till, whereas a pit (NJ 81 NE 4) at Causewayend showed the hummocky ground west of Swailend Wood to be morainic drift.

Very small mounds of sand and gravel flank the glacial drainage channel at Swailend Wood and an isolated mound of glacial sand and gravel was mapped to the north west of Gaucyhillock *[878 197]* in the valley of the Burn of Straloch. A metre of sand and gravel has been recorded beneath 1.5m of alluvium and till in a pipeline trench at Bridge of Steps *[892 161]*, but it is thought to be an isolated occurrance. A small mound of glacial sand and gravel was also mapped west of Linnhead *[984 242]*, on the western edge of the inset map.

All of the mapped occurrances of sand and gravel in Block G, taken together, are insignificant in terms of regional mineral resources.

Block H (Table 15)

The boundaries of Block H are drawn to include the kame-terraces and alluvium of the valley of the River Don between Kintore and the built-up area of Dyce (Figure 4). The block also includes the moundy deposits of glacial sand and gravel that occur on the sides of the valley at Beidleston *[857 152]* and Newmill *[860 160]*, as well as the glacial sand and gravel flanking the valley of Newmill Burn. The isolated areas of hummocky glacial sand and gravel on the valley floor at Liddell's Monument *[870 151]* and to the south of Wester Fintray *[810 164]* are also included.

The kame-terraces, together with the mounds and hummocks of glacial sand and gravel, contain mineral with negligible overburden. In contrast, clayey alluvium that is generally more than one metre thick, conceals the potentially workable sand and gravel beneath the floodplains of the River Don and Newmill Burn.

Barren ground is restricted to the outcrops of till and bedrock on the sides of the Don valley, east and west of Hatton of Fintray and on the southern flank of the valley between Woodlands Wood *[850 154]* and Dyce Airport. Bedrock also crops out in kettleholes and forms rock knolls protruding through the kame-terrace at Tofthills *[802 152]*.

The fluvioglacial sand and gravel beneath the kame-terraces in Block H was deposited by glacial meltwater during the retreat of ice which covered the high ground. The mounds and hummocks of glacial sand and gravel occur at positions of still-stand during the retreat of glacier ice which filled the valley bottom. These hummocky deposits have been worked extensively at Mill of Dyce (St Fergus) Pit *[874 147]*. Exposures in the working pit show considerable thicknesses of generally poorly-sorted sand and gravel which shows a crude fining-downward sequence. The sampled section and trial pit at this locality (NJ 81 NE 6) proved 10m of poorly bedded cobble gravel overlying cross-bedded 'clayey' sand (not bottomed); the sequence may represent a fan-delta deposited at (or near) the snout of the glacier which occupied the valley during the late stages of deglaciation.

Upstream of Mill of Dyce, the valley is underlain by glaciolacustrine sandy silt and clay that was deposited in water ponded behind mounds of sand and gravel and morainic debris at Mill of Dyce. The glaciolacustrine deposits that crop out on the northern side of the valley, west of Hatton of Fintray, contain potentially workable deposits of sand in their upper part.

A cone of alluvial debris is present on the floor of the valley of the River Don at Kinaldie *[833 156]*. The alluvial cone is thought to have been deposited by the glacial meltwaters that cut the drainage channel trending north from Blackburn, as well as by the stream which now occupies the valley.

Data from sixteen sample points (including information from two commercial boreholes) has been used in the volumetric resource assessment of Block H. Potentially workable sand and

Table 15 Block H: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
NJ 81 NW 1	4.9	7.9	-	No grading available							
NJ 81 NW 3	5.9	2.8	0.2	13	43	10	12	18	4	0	CSG
NJ 81 NW 4	8.0	0.3	-	8	49	37	5	1	0	0	S
NJ 81 NW 7	1.5	0.5	-	2	5	12	16	17	38	10	G
NJ 81 NW 8	2.0	0.1	-	4	85	11	0	0	0	0	S
NJ 81 NW 9	2.8	1.8	-	5	3	12	58	22	0	0	PS
NJ 81 NW 10	3.0+	0.1	-	2	3	18	23	18	23	13	G
NJ 81 NW 11	3.0	0.2	-	1	3	17	11	10	22	36	G
NJ 81 NE 1	3.9	1.9	-	3	5	42	39	11	0	0	PS
NJ 81 NE 2	1.0	0.3	-	12	37	34	5	1	11	0	CPS
NJ 81 NE 5	3.2+	0.3	-	2	2	10	15	15	28	28	G
NJ 81 NE 6	15.2+	1.0	-	4	13	28	11	8	14	22	SG
NJ 81 SE 13	2.2	0.2	-	11	12	19	11	12	25	10	CG
NJ 81 SE 17	17.9+	0.9	1.3	8	19	32	17	10	11	3	SG
NJ 81 SE 19	5.1	0.2	2.0	17	10	25	18	11	12	7	CSG
NJ 81 NW X1	4.5	0.5	-	No grading available							
Mean*	**5.3**	**1.2**	**0.2**	**7**	**20**	**27**	**16**	**10**	**11**	**9**	**SG**

* commercial data have been used in the calculations

Statistical assessment of Resource Block H (Fluvioglacial terraces and alluvium of the River Don and glacial sand and gravel in the Don valley from Kintore to Dyce) Don)

Total area	14.00km^2
Area of exposed mineral	6.81km^2
Area of concealed mineral	4.56km^2
Total area of mineral-bearing ground	11.37km^2
Area of ground worked for sand and gravel	0.39km^2
Area of barren ground	2.24km^2
Mean thickness of overburden	1.2m
Mean thickness of mineral	5.3m
Estimated volume of mineral	**60.3 million m^3 $\pm$ 51% or 31 million m^3**

gravel was proved at every site. It ranges in thickness from 1.0m, in borehole NJ 81 NE 2, to 17.9m (unbottomed) in borehole NJ 81 SE 17. The latter was sited on top of a large mound of glacial sand and gravel standing on the floor of the valley of the River Don, south of Goval Villa.

One assessment borehole and two pits (NJ 81 NW 7, 10 and 11) were excavated in the terrace-feature on the eastern side of the tributary valley occupied by Newmill Burn (See Figure 4). They show the terrace to be underlain by up to 3.0m of clean coarse gravel resting on till and bedrock. In contrast, the terrace-features on the northern side of the Don valley between Home Farm *[855 165]* and Cothall *[874 156]* are underlain only by thin spreads of clayey sand and gravel resting on till and bedrock.

Bedrock crops out in the northern bank of the River Don at Cothall (a few metres below the terrace surface) and forms steep cliffs between Cothall and Goval House.

The kame-terrace at Dovecot Wood *[898 138]* is underlain by fluvioglacial sand and gravel and glacial sand and gravel to a depth of 7.3m. This terrace is graded to a small col lying between Parkhill Wood and Stoneyhill Wood, which was cut by glacial meltwaters that drained along the Don valley and debouched into the sea to the north of the present river mouth.

The small isolated mounds of poorly sorted clayey gravel to the south of Beidleston constitute a minor source of poor quality aggregate. Geological mapping and data from assessment borehole NJ 81 SE 13 show that the mounds are composed of coarse cobble gravel, passing down into a mixture of till and morainic drift.

In general, the fluvioglacial sand and gravel beneath the floodplain of the River Don is of minor importance as a mineral resource; the deposits are composed of thin spreads of pebbly sand lying beneath the water table at Beidleston (NJ 81 NE 1) and Milton of Fintray (NJ 81 NW 9). A borehole (NJ 81 NW 3) at Hindland, however, proved 2.9m of gravel and sandy gravel overlying sandy glaciolacustrine deposits. A thin (20cm) peat bed was recorded at a depth of 4.9m within the fluvioglacial deposits at this site.

Block I (Table 16)
This block covers a large area of ground to the west of Aberdeen and Dyce. It stretches westwards from the built-up areas to reach the western margins of Resource Sheets 2 and 3. A little under half of the block falls in Resource Sheet 2, where it is bounded to the north by the valley of the River Don. On Resource Sheet 3, the block extends to the boundary of Block N (just south of Westhill).

Most of the sand and gravel is found on the low ground to the west of Tyrebagger Hill and Brimmond Hill. Two assessment boreholes and seven shallow pits were sited in the block; three proved potentially workable sand and gravel at the surface and three proved

Table 16 Block I (on Resource Sheets 2 & 3): Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
NJ 80 NE 4	6.8	0.5	3.2	7	13	34	23	12	10	1	PS
NJ 81 SW 1	1.2	0.3	-	6	11	23	22	19	19	0	SG
NJ 81 SW 2	1.0	0.2	-	5	23	57	13	2	0	0	S
Mean	**3.0**	**0.3**	**1.1**	**7**	**14**	**34**	**22**	**12**	**10**	**1**	**PS**

Inferred assessment of Resource Block I (Lacustrine alluvium, fluvioglacial terraces and glacial sand and gravel between Blackburn and Westhill)

Total area (excluding Westhill urban area)	86.80km^2
Westhill urban area (not assessed)	2.19km^2
Area of sand and gravel in Westhill urban area, not assessed	0.51km^2
Area of exposed mineral	2.41km^2
Area of concealed mineral	1.03km^2
Total area of mineral-bearing ground	3.44km^3
Area of ground worked for sand and gravel	0.15km^2
Area of barren ground (excluding Westhill urban area)	82.21km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral	3.0m
Estimated volume of mineral	**10.3 million m^3**

potentially workable till.

At Blackburn, a large spread (almost 2km^2) of sandy lacustrine alluvium marks the position of a former lake. A borehole (NJ 81 SW 2) sited on these lacustrine deposits north of Burnside Crofts, proved 1m of humic sand overlying till. Geological mapping in the vicinity indicates that much of the lacustrine alluvium consists of silt and clay overlying potentially workable sand. The sand is of only minor importance as a resource, being thin and occurring close to, or below the groundwater table. The lake would have drained northwards through a narrow valley at Blackburn, to debouch into the valley of the River Don at Kinaldie.

A small valley lying to the west of the lake-basin forms the lowest part of a glacial drainage channel that is now occupied by the Wogle Burn. The valley is flanked by low kame-terraces and is floored by gravelly alluvium. A pit (NJ 81 SW 1) dug in the kame-terrace to the north of Backhill proved 1.2m of fluvioglacial sand and gravel resting on till.

Mounds of glacial sand and gravel occur at the southern end of the lake-basin, near Mill of Birsack *[831 106]*, but most of the deposit has been worked out. An assessment pit (NJ 81 SW 3) excavated immediately to the west of the restored sand and gravel pit proved 3.4m of till, not bottomed.

An isolated spread of hummocky sand and gravel occurs at Little Clinterty, but a pit (NJ 81 SW 4) sited nearby only proved 2.0m (not bottomed) of potentially workable till. Till is very sandy in this area.

Small lakes (now marked by hollows filled with peat and alluvium) also once existed around Westhill. These hollows are flanked by flat spreads of sand and gravel that were deposited as deltas or kame-terraces by meltwaters draining into the lakes. Several hollows have been filled with waste earth.

Thicker, moundy deposits of sand and gravel flank the slopes of the hills to the east of Westhill, notably Brimmond Hill, where they form the principal sources of sand and gravel in the block. The most prominent mounds have been worked by Grampian Regional Council at a pit *[850 080]* near Borrowstone. The pit face once revealed 15m of well bedded, clean sand and gravel but the deposit is now largely worked out. Pebbles of granite predominate, closely followed by psammite; the sand is sharp and composed mainly of disaggregated granite. Other deposits in the area are of broadly similar composition, being derived mainly from granite. A trial pit (NJ 80 NW 4) sited to the west of Borrowstone Pit proved 3.5m of mixed, generally clayey deposits.

A borehole (NJ 80 NE 4) in the moundy sand and gravel at Westholme proved 3.0m of pebbly sand overlying till and sandy gravel.

A small spread of sand and gravel occurs beneath alluvium and peat in the low-lying ground to the south of Kirkton of Skene *[803 077]*.

Block J (Table 17)

The boundaries of Block J are drawn to include the glacial sand and gravel between the valley of the River Don and the coast to the north of Bridge of Don. The block is bounded to the north by Potterton village and by a steep-sided glacial drainage channel occupied by the Millden Burn.

Block J includes many large sand and gravel pits, both active and disused; it covers the ground where most of the aggregate produced in the Aberdeen area is currently won. On the published 1:50 000 drift map (sheet 77), most of the area covered by the block is shown as sand and gravel. Mapping undertaken as part of this assessment, however, indicates that less than 32 per cent of the area previously mapped as sand and gravel is actually mineral-bearing. Of this mineral-bearing ground, 69 per cent remains to be worked and 31 per cent has been (or is currently being) worked.

In terms of accessibility, thickness,

Table 17 Block J: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Intervening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
NJ 91 NW 42	4.7	0.3	-	3	6	29	21	13	16	12	SG
NJ 91 NE 12	10.2+	0.3	1.1	10	38	35	7	4	4	2	CPS
NJ 91 SW 1	2.9	0.1	-	5	7	14	12	12	21	29	G
NJ 91 SW 2	13.9+	1.1	-	4	16	28	21	9	9	13	SG
NJ 91 SW 6	6.0	0.3	-	1	3	27	29	16	12	12	SG
NJ 91 SW 7	15.3	1.0	-	5	7	23	20	15	18	12	SG
NJ 91 SW 10	2.8	0.3	-	11	11	12	18	23	22	3	CG
NJ 91 SW 11	6.7+	0.3	1.5	16	42	18	7	5	4	8	CPS
NJ 91 SW 12	6.3	2.3	-	6	28	44	12	2	3	5	PS
NJ 91 SW 14	1.1	0.2	-	29	10	17	12	12	20	0	VCSG
NJ 91 SE 1	1.0	2.0	-	13	83	4	0	0	0	0	CS
NJ 91 SE 2	1.9	0.4	-	12	12	31	21	10	11	3	CPS
Mean	**6.1**	**0.7**	**0.2**	**7**	**19**	**27**	**17**	**10**	**11**	**9**	**SG**

Statistical assessment of Resource Block J (Glacial sand and gravel between Dyce, Potterton and Bridge of Don)

Total area (excluding Potterton urban area)	23.00km^2
Potterton urban area (including 0.1km^2 sand and gravel, not assessed)	0.30km^2
Area of exposed mineral	3.97km^2
Area of concealed mineral	1.06km^2
Total area of mineral-bearing ground	5.03km^2
Area of ground worked for sand and gravel	2.26km^2
Area of barren ground (excluding Potterton urban area)	15.71km^2
Mean thickness of overburden	0.7m
Mean thickness of mineral	6.1m
Estimated volume of mineral	**30.7 million m^3 ± 53% or 16 million m^3**

extent and grading, the present workings are undoubtedly concentrated within the best deposits of sand and gravel in the block. This is underlined by comparing the mean thickness of sand and gravel recorded from working pits (9.7m) with the mean thickness of 6.1m calculated for potentially workable material from the block as a whole. The resource map (and cross-sections E-E', F-F') shows at a glance that many of the largest sand and gravel deposits have been extensively quarried, and that many of the workings have been either partially backfilled or completely restored. The amount of reclaimed ground in some parts of the area (for example, around Annfield pit *[930 141]* and between the Hill of Strabathie *[958 134]* and Fife Hill *[958 147]* now makes interpretation of the original morphology of the sand and gravel outcrops extremely difficult.

The statistical volumetric assessment of the sand and gravel deposits in Block J is based on data from eighteen sample points. Of these, twelve proved potentially workable sand and gravel and two proved potentially workable till (Mineral II). Three of the four remaining sites proved thin till resting on bedrock. (These sample points were sited close to sand and gravel pits and show that concealed sand and gravel does not usually extend beyond the mapped outcrop. A borehole (NJ 91 SW 9) sited between the gravel pits at Leuchlands Croft *[930 149]* and Annfield, for example, proved 3.6m of waste (mainly till) resting on Dalradian bedrock.

The mineral deposits have a wide variety of form and internal structure, but they can be subdivided into three main types:

(a) Linear ridges and lenticular mounds of sand and gravel, orientated north-south, which were deposited by glacial meltwater or debris-flow at the margin of the ice sheet. The deposits are often poorly sorted and clayey.

(b) Flat-topped mounds and hummocky ridges, orientated east-west, representing outwash fans and deltas that were deposited by meltwater draining eastwards across the district into standing water beyond the margin of the ice-sheet.

(c) Small eskers, such as the steep ridges of poorly sorted gravel which formerly trended southwards from Newton of Shielhill *[935 144]* towards Hillhead of Mundurno *[938 134]*. (The sand and gravel has been largely quarried away).

Mineral deposits of type (a) include the cones of gravel at Strabathie Pit (see the chapter on drift geology) and the isolated mounds of sand and gravel between Leuchlands Pit *[930 135]* and the Hill of Tramaud *[947 134]* (see cross-section F-F'). Larger mounds of glacial sand and gravel, such as the Hill of Tramaud and Fife Hill *[957 144]*, are thought to represent outwash fans and deltas deposited into ice-marginal lakes. The sand and gravel occurs in fining-downwards sequences, and atypically, it is thought to extend for some distance beneath the surrounding till at both localities.

Faces in the sand and gravel pit at Potterton (Broom Hill) show gravel deposits fining-downwards into sand. A shallow pit (NJ 91 NE 12) dug in the floor of the working quarry showed fine-grained sand resting on silt and clay. The bedding of the sand and gravel is highly contorted and faulted, indicating that the sediments have collapsed into voids, formed by the melting of masses of ice incorporated in the original deposit.

Sand and gravel of type (b) is found underlying the wide ridge of hummocky terrain between Corby Loch and Dovecot Wood. This hummocky ground probably contains the largest deposit of unworked mineral remaining in Block J. The mineral is thought to generally rest directly on bedrock (see cross-section E-E[1]), as it does in the north-eastern corner of Bishop's Loch Pit *[912 145]*, for instance, where the sand and gravel rests on weathered schist. A measured section and pit (NJ 91 SW 2) in the south west of the quarry proved 1.1m of flow-till overlying 2.9m of cobble gravel. The cobble gravel passed down into sand and 'clayey' sand, which in turn rested on a further 5.0m of cobble gravel (not bottomed). Similar deposits have been extensively worked at Kaim Hill Pit *[925 150]* and Annfield.

Small mounds of glacial sand and gravel are associated with the glacial drainage channels that are occupied by the Blackdog Burn and the Burn of Mundurno. Ridges and hummocks of poorly sorted cobble gravel also flank several enclosed areas of low ground, which mark the positions of former lakes, lying to the west of Sheilhill *[935 129]* and near Butterywells *[942 151]*. These former lake basins are floored by peat, alluvium and glaciolacustrine deposits and may contain concealed deposits of sand and gravel locally. Any mineral present will occur beneath the water table and will be of only minor importance as a resource.

Glaciolacustrine deposits within the 'red-drift' sequence to the east of grid line 93, also contain isolated deposits of potentially workable sand and gravel. For example, an assessment borehole (NJ 91 SE 1) sited to the east of the reinstated gravel pit at Middlefield *[951 149]* proved 1.0m of 'clayey' sand beneath 2.0m of overburden (mainly till). In general, however, any sand and gravel within the 'red-drift' is of negligable importance as a resource.

Table 18 Block K Data from sample points and the assessment of resources

Sample point: Borehole	Recorded thickness: Total mineral (m)	Depth of burial (m)	Intervening waste (m)	Mean grading percentage: Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	Descriptive category (see the diagram in Appendix C)
SUB-BLOCK K[1] (Glacial sand and gravel from Pettens to Potterton)											
NJ 91 NW 43	8.7	0.3	-	20	51	20	5	2	2	0	VCS
NJ 91 NW 44	1.7	0.3	-	7	6	23	18	10	29	7	SG
NJ 91 NW 45	5.9	2.3	2.4	11	32	30	14	5	8	0	CPS
NJ 91 NE 10	3.3*	0.2	-	19	14	21	14	15	15	2	CSG
NJ 91 NE 11	2.1	2.9	-	12	31	48	8	1	0	0	CS
NJ 91 NE 13	3.9	4.8	4.4	9	12	19	15	21	19	5	SG
Mean	**4.3**	**1.8**	**1.1**	**15**	**31**	**25**	**11**	**8**	**9**	**1**	**CPS**
SUB-BLOCK K[2] (Glacial sand and gravel between Newburgh and Menie House including the Foveran Esker - inset map on Resource Sheet 2)											
NJ 92 SE 2	1.4	4.4	-	8	13	36	16	6	10	11	SG
NJ 92 SE 3	7.1	0.1	-	2	4	19	30	16	13	16	SG
NJ 92 SE 7	9.4+	5.8	-	1	3	34	41	12	8	1	SG
NJ 92 SE 8	1.7+	1.3	-	5	3	12	17	21	38	4	G
Mean	**4.9**	**2.9**	**-**	**2**	**4**	**27**	**33**	**14**	**12**	**8**	**SG**
Overall Mean	**4.5**	**2.2**	**0.7**	**8**	**17**	**26**	**23**	**11**	**10**	**5**	**SG**

* overlies 1.3m potentially workable till

Inferred assessment of sub-block K[1] (Glacial sand and gravel between Pettens and Potterton)

Total area (excluding Balmedie urban area)	7.60km²
Balmedie urban area (not assessed)	0.29km²
Area of exposed mineral	2.15km²
Area of concealed mineral	0.30km²
Total area of mineral-bearing ground	2.45km²
Area of ground worked for sand and grvel	0.04km²
Area of barren ground (including Balmedie)	5.40km²
Mean thickness of overburden	1.8m
Mean thickness of mineral	4.3m
Estimated volume of mineral	**10.5 million m³**

Inferred assessment of sub-block K[2] (Glacial sand and gravel between Newburgh and Menie House including the Foveran Esker)

Total area	3.50km²
Area of exposed mineral	0.76km²
Area of concealed mineral	0.05km²
Total area of mineral-bearing ground	0.81km²
Area of ground worked for sand and gravel	0.04km²
Area of barren ground	2.65km²
Mean thickness of overburden	3.0m
Mean thickness of mineral	4.9m
Estimated volume of mineral	**4.0 million m³**

Note. A statistical assessment of volume for the whole block is given in Table 8

Block K (Table 18)
Block K is divided in two for the purpose of assessment. An inferred volumetric assessment is given for the glacial sand and gravel and glaciolacustrine deposits that crop out between Potterton and Pettens. An inferred assessment has also been made for the sand and gravel (principally the Foveran Esker) of sub-block K2, which lies between Newburgh and Menie House (shown on the inset map on Resource Sheet 2). Finally, a statistical assessment for the block, as a whole, is given in Table 8.

Sub-block K1
The main resource of this sub-block is the glacial sand and gravel, which forms a prominent belt of hummocky terrain to the north of Potterton, taking the form of a ridge in places. The features mark the contact between the 'red-drift' deposits of the coast and the grey and brown drift inland. They are composed of sand and gravel and debris-flow deposits of both 'red-drift' and inland provenance. Sub-block K1 also includes small mounds of glacial sand and gravel, which crop out in the generally barren ground to the north of Balmedie.

All of the six sample points sited on the glacial sand and gravel proved mineral, but mapping undertaken in conjunction with the assessment showed that the deposits are less widespread than as shown on the recently published 1:50 000 drift map (Sheet 77). The sand and gravel is concealed locally by thin spreads of flow till and solifluxion deposits as, for example, at borehole NJ 91 NE 11.

Glaciolacustrine deposits are often associated with the glacial sand and gravel. These may also contain potentially workable material (generally clayey sand) as, for example, in borehole NJ 91 NW 45, which was, sited on a prominent ridge to the north of Home Farm, Belhelvie. Glacial sand and gravel has been worked in a small pit near Belhelvie Sewage Works *[949 175]* and also at Milton of Potterton *[944 161]*. In the latter case, the gravelly deposits are overlain by sand, interbedded with reddish brown silt and clay.

The mineral deposits of sub-block K1 are highly variable both in terms of thickness and grading but many of the spreads of potentially workable material do occur above the groundwater table.

Sub-block K2
The most important resource in this sub-block is the glacial sand and gravel forming the Foveran Esker, which is currently worked in a small pit at Drums *[988 225]*. Sections in the working pit show the esker to be composed of poorly sorted cobble gravel containing quartzite and 'Old Red Sandstone' erratics, together with pebbles of granite, schist and vein-quartz. Two assessment boreholes and one shallow pit were sited on the esker ridge. The borehole at Pitscaff Croft (NJ 92 SE 7) proved 9.4m of sandy gravel (not bottomed) overlain by 5.8m of till and glaciolacustrine deposits, whereas a pit (NJ 92 SE 8) sited nearby proved 0.9m of reddish-brown till overlying coarse gravel. A borehole (NJ 92 SE 3) at Hatterseat proved 7.1m of gravel resting on bedrock.

At Drums, the glacial sand and gravel extends for at least a short distance beneath the surrounding till, as proved by a borehole (NJ 92 SE 2), sited to the east of the esker ridge, which showed 1.4m of sandy gravel beneath 4.4m of till and glaciolacustrine deposits.

Isolated mounds of glacial sand and gravel are present between Delfrigs *[970 211]* and Mill of Menie, and also at East Pitscaff *[992 231]*, where the gravel contains abundant 'red-drift' erratics. The remainder of the area is covered by 'red-drift' (till and glaciolacustrine deposits) and is considered to be barren.

Block L (Table 19)
This block includes blown sand and Post-Glacial beach and estuarine deposits between Newburgh and Bridge of Don. Block L is approximately 14km long and extends up to 1km inland from the mean high-water mark. The present-day beach and estuarine deposits occurring below the mean high-water mark are not assessed. Most of the block contains exposed mineral; barren ground is restricted to spreads of 'red-drift' (glaciolacustrine silts and clays) to the south of Balmedie, and to the alluvium of streams, which cut through the blown sand near the coast.

Block L is divided in two for descriptive purposes. Six data points were sited in the block; four proved potentially workable sand and gravel. The value of the resources in the block, as a whole, is limited; most of the mineral consists of thin spreads of blown sand close to sea level. Coarse-grained aggregate is confined to isolated lenses of sand and gravel occurring within the underlying clayey 'red-drift' deposits; beds of pebbly sand within the Post-Glacial beach and estuarine deposits; and small mounds of glacial sand and gravel (largely concealed beneath 'older' blown sand). The figures given in Table 19 for mean thickness and estimated volume of mineral must be treated with caution as the potentially workable deposits (especially the blown sand) range in thickness considerably within very short distances (tens of metres).

Sub-block L1
Blown sand from Pettens Links to Balgownie Golf Course
The mineral deposits in this sub-block comprise blown sand and 'older' blown sand. They overlie 'red-drift' and Post-Glacial beach and estuarine deposits, which may all contain some potentially workable sand and gravel, though none was recorded from the two sample points in the area.

The blown sand, which forms a belt of partially stabilised sand dunes up to 15m high, constitutes the principal resource of the area. The dunes extend up to 400m inland from the coast at Millden Links *[967 159]*. They are composed of clean, fine and medium-grained quartzose sand. The blown sand thins markedly in the deflation hollows between the dunes.

At Murcar Golf Course *[961 129]*, and between Blackdog Links *[964 147]* and Millden Links, the modern dunes abut a ridge of 'older' blown sand, that conceals beds of glacial sand and gravel locally. For instance, 2 to 3m of 'older' blown sand was seen on top of 1m of sandy gravel in the bank of a stream at Millden Links *[9662 1597]*. The gravel included pebbles and cobbles of granite, quartzite, schist and 'Old Red Sandstone', all typical of material associated with the 'red-drift'.

A borehole (NJ 91 NE 14) at Blackdog Rifle Ranges proved 1.5m of blown sand resting on reddish-brown glaciolacustrine deposits.

North of Millden Links, the modern dunes are separated from the 'older' blown sand by a low-lying area, up to 500m wide, mantled by thin spreads of blown sand. A shallow pit (NJ 91 NE

Table 19 Block L Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ −1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	
SUB-BLOCK L[1] (Blown sand from Pettens Links to Balgownie Golf Course)											
NJ 91 NE 14	1.5	–	–	4	58	38	0	0	0	0	S
NJ 91 NE 15	0.9	0.2	–	No grading data available							
SUB-BLOCK L[2] (Blown sand and Post-Glacial beach and estuarine deposits from St Peter's Well to Mill of Menie – on inset map)											
NJ 92 SE 4	0.7	0.1	–	No grading data available							
NJ 92 SE 5	5.1	0.3	0.6	6	34	36	15	5	4	0	PS
NJ 92 SE 6	1.1	0.1	–	No grading data available							
NJ 92 SE 9	2.5+	–	–	4	63	17	1	4	11	0	PS
Mean*	**2.0**	**0.1**	**0.1**	**5**	**46**	**31**	**9**	**4**	**5**	**0**	**PS**

* figures for whole of Resource Block L

Inferred assessment for Resource Block L (Blown sand between Pettens Links and Balgowrie Golf Course and also Post-Glacial beach and estuarine deposits and Blown sand between St. Peters Well and Mill of Menie - on inset map)

Total area	10.10km^2
Area of exposed mineral	8.00km^2
Area of concealed mineral	0.10km^2
Total area of mineral-bearing ground	8.40km^2
Area of ground worked for sand and gravel	0.20km^2
Area of barren ground	1.10km^2
Mean thickness of overburden	0.1m
Mean thickness of mineral	2.0m
Estimated volume of mineral	**16.8 million m^3**

medium to fine-grained quartzose sand. Small mounds of glacial sand and gravel also occur, mainly concealed beneath a cover of blown sand. locally conceals blown sand and Post-Glacial beach and estuarine deposits at Pettens Links.

The sand dunes have been worked in a pit at Blackdog Links. 'Older' blown sand, together with underlying deposits of glacial sand and gravel, have been worked in pits at Blackdog Rifle Ranges and Blackdog Rock *[964 138]*.

Sub-block L^2

Blown sand and Post-Glacial beach and estuarine deposits from St Peter's Well to Mill of Menie.

Sub-block L^2 covers the coastal zone of the inset map on Resource Sheet 2. The ground is predominantly mineral-bearing, but to the south of Drums Links *[996 224]*, the blown sand is thin and overlies non-mineral Post-Glacial beach and estuarine deposits consisting mainly of beds of peat, silt and clay. A borehole and three shallow pits on Menie Links *[990 213]* proved up to 3.8m of Post-Glacial beach and estuarine deposits (consisting of pebbly sand with thin beds of coarse gravel) beneath a thin cover of blown sand and overlying till.

The blown sand occurs as sand dunes which show considerable variations in size and morphology. The deposit consists of clean, medium to fine-grained quartzose sand. Small mounds of glacial sand and gravel also occur, mainly concealed beneath a cover of blown sand.

Speculative (non-volumetric) assessment of Resource Block M (Alluvium and fluvioglacial sand and gravel between Dyce and Bridge of Don exluding all urban areas)

Total area	9.50km^2
Area of exposed mineral	0.12km^2
Area of concealed mineral	1.24km^2
Total area of mineral-bearing ground	1.36km^2
Area of ground worked for sand and gravel	0.09km^2
Area of barren ground	8.15km^2

Block M

The boundaries of block M are drawn to include the valley of the River Don between Dyce and the river's mouth. The block straddles resource sheets 2 and 3. It is confined by the urban developments of Dyce, Bucksburn and Aberdeen on the southern bank of the river and by Bridge of Don on the northern bank. Although no assessment pits or boreholes were sunk in the block, potentially workable sand and gravel does occur, especially beneath the river alluvium.

Upstream, the River Don flows eastwards and has cut through large mounds of sand and gravel at Mill of Dyce. In block M, however, the river no longer follows the principal route of glacial meltwater drainage, which was eastwards from Dyce, straight towards the coast to the north of Bridge of Don. Instead, the modern river flows southwards until it meets the glacial drainage channel now occupied by the Bucks Burn, which carried meltwaters eastwards towards the coast.

Terraces underlain by fluvioglacial sand and gravel occur downstream of the confluence of the River Don and the Bucks Burn, but they are almost entirely built-over. The deposits were formerly worked at Woodside Pit *[912 095]*. Moundy deposits of glacial sand and gravel lie immediately to the north west of Bridge of Don, but they too are largely built-over. These deposits were formerly worked in the large Roadside Pit *[938 105]*.

Unsterilized resources of sand and gravel are restricted to the alluvial deposits underlying the floodplain and low-lying terraces of the River Don. Sand and gravel was recorded beneath alluvium in excavations for a new bridge at Persley and the deposit is probably widespread, albeit mainly below water table.

Block N (Table 20)
Block N lies to the north of the River Dee and south of a line drawn from the western margin of Resource Sheet 3 towards Cults. The sand and gravel deposits of this block are closely associated with a series of major glacial drainage channels that cross the area and that are now occupied by small mis-fit streams draining southwards into the River Dee. Bedrock crops out on the interfluves, forming small hills such as Hill of Ardbeck *[840 013]*, Beans Hill *[845 037]* and Hill of Ord *[825 037]*. The lower hill-slopes are till covered and include small peat-filled rock basins.

Eleven sample points were sited in the block, of which, seven proved potentially workable sand and gravel with negligible overburden. Two proved potentially workable till (Mineral II). No concealed sand and gravel was found at the assessment sites, though thin spreads of fluvioglacial sand and gravel probably lie beneath the alluvium of the Gormack, Culter and Temple burns.

The main sources of mineral in Block N occur within lenticular mounds of glacial sand and gravel in the valleys of the Gormack, Temple and Culter burns. Sand and gravel also forms steep-sided mounds and ridges in the valley of the Ord Burn and in the broad valley between Blacktop *[861 042]* and Bieldside. Extensive spreads of glacial sand and gravel flank the valleys of Redwell Burn and Leuchar Burn in the north-west of the block, but these deposits are generally thin.

An inferred volumetric assessment is offered for the sand and gravel in Block N as a whole, but the block has been subdivided into four areas for descriptive purposes.

Temple, Gormack and Culter burns
The thin spreads of glacial sand and gravel in the valley of Temple Burn (south west of Peterculter) have a hummocky, extensively kettled surface. This indicates that they were deposited over dead ice, by glacial meltwater which flowed eastwards to join the valley of the River Dee south of Peterculter. An assessment pit (NJ 80 SW 6) in these deposits proved only 0.9m of sand and gravel overlying till.

The glacial sand and gravel around the Gormack and Culter burns (north west of Peterculter) occurs as a series of low lenticular kames. The sand and gravel is generally thin. A borehole (NJ 80 SW 4) sited on a low mound to the north of Easter Anguston *[816 017]* proved 2.8m of sandy gravel overlying grey-brown till. A trial pit (NJ 80 SW 5) sited near West Craigton *[828 018]* also showed 2.8m of gravel, resting here on 3m of potentially workable till (not bottomed). One of the larger mounds of sand and gravel in the area has been worked on a small scale near West Wardmill *[812 011]*. To the west of Peterculter, where the Culter Burn flows between the Hill of Ardbeck

Table 20 Block N: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ −1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	(see the diagram in Appendix C)
NJ 80 SW 2	1.2*	0.2	–	10	11	14	11	11	36	7	CG
NJ 80 SW 4	2.8	0.5	–	4	7	33	32	12	9	3	SG
NJ 80 SW 5	2.8**	0.2	–	1	1	5	13	33	31	16	G
NJ 80 SW 6	0.9	0.1	–	1	2	25	31	30	11	0	SG
NJ 80 SW 7	3.2+	0.1	–	8	3	12	21	12	23	21	G
NJ 80 SW 8	1.0	0.2	–	13	2	9	11	11	22	32	CG
Mean	**2.0**	**0.2**	**–**	**6**	**4**	**16**	**21**	**18**	**22**	**13**	**G**

* overlies 2.2m+ decomposed granite, potentially workable
** overlies 3.0m+ potentially workable till

Inferred assessment of Resource Block N (Glacial sand and gravel in the valleys of the Leuchar, Ord, Gormack, Culter and Temple Burns)

Total area	35.29km^2
Area of exposed mineral	2.55km^2
Area of concealed mineral	0.31km^2
Total area of mineral-bearing ground	2.86km^2
Area of ground worked for sand and gravel	0.01km^2
Area of barren ground	32.42km^2
Mean thickness of overburden	0.2m
Mean thickness of mineral	2.0m
Estimated volume of mineral	**5.7 million m^3**

and Newmill Hill, a thick sequence of glacial sediment has been deposited. Exposures in these deposits to the east of Newmill Hill show them to consist at least in part of sand and gravel, largely built over.

The sub-alluvial sand and gravel of the stream valleys is of minor importance as a resource, occurring as thin spreads predominantly below the water table.

Leuchar and Redwell burns
In the valleys of Leuchar Burn and Redwell Burn, the glacial sand and gravel is extensively kettled and appears to have been let down on to an undulating surface following the melting of buried ice. The sand and gravel ranges greatly in thickness and is seen to thin rapidly against bedrock near Broadwater *[808 041]*. In trial pit NJ 80 SW 2, 1.2m of sand and gravel was seen to rest directly on granitic bedrock sufficiently disaggregated to grade as 'clayey' sandy gravel. The most important resource in this area is probably the ridge of sand and gravel lying to the north of the Ord Burn, north of West Lasts *[821 038]*.

Ord and Silver burns
Around East Brotherfield *[844 043]* glacial sand and gravel forms a complex of esker ridges and kames up to 12m high within the valleys of the Ord Burn and Silver Burn. The kames and eskers are composed of poorly sorted sand and gravel varying widely in both grading and thickness. The area is strewn with boulders and many of the deposits will be very coarse indeed. The depressions between the ridges and mounds are filled with water-logged peat.

Blacktop to Beildside
The floor of the valley between Blacktop and Bieldside is occupied by kames and eskers of similar dimensions to those in the valleys of the Ord Burn and the Silver Burn, but the deposits are generally less coarse. The form of sand and gravel deposits is seen in cross-section H – H', on Resource Sheet 3. Some of the sand and gravel mounds are partially capped by till.

BLOCK O (Table 21)
This block includes the floodplain and low-lying alluvial terraces of the River Dee together with the fluvioglacial kame-terraces within the valley. The block extends from the western margin of Resource Sheet 3, downstream to the city of Aberdeen. All of the mineral deposits within the block are concealed beneath negligible overburden.

The sand and gravel was deposited, in the main, at the end of the Devensian glaciation, when large volumes of meltwater escaped into the North Sea basin via the Dee Valley. The kame-terraces are underlain by fluvioglacial sand and gravel and were formed during deglaciation when meltwaters flowed along the margins of stagnant ice that occupied the valley floor. The fluvioglacial deposits beneath the floodplains are thought to have formed a little later, when most of the valley had become ice free. Post-glacial drainage has only slightly modified the valley cut by the glacial meltwaters.

Fluvioglacial sand and gravel forms a major resource in the valley of the River Dee and it has only been exploited locally. Small disused

Table 21 Block O: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ −1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	
NJ 80 SE 1	13.7	0.4	0.2	2	5	30	21	17	22	3	SG
NJ 80 SE 4	3.1	0.4	–	5	21	26	16	12	17	3	SG
NJ 80 SE 5	1.4	0.5	–	9	3	24	29	18	13	4	SG
NJ 80 SE 6	5.9	–	–	5	8	20	20	18	21	8	SG
NJ 80 SE 8	7.7+	0.3	–	2	2	25	18	19	29	5	G
NJ 80 SE 9	4.7	0.3	–	1	3	21	23	18	28	6	G
NJ 80 SW 1	9.3	0.2	–	No grading data available							
NJ 90 SW 1	13.3+	0.1	–	No grading data available							
NJ 90 SW 2	6.6	0.3	–	No grading data available							
NJ 90 SW 6	2.0	0.5	–	11	17	36	15	9	12	0	CPS
NO 89 NW 1	4.9	0.4	–	18	4	25	40	10	3	0	CPS
NO 89 NW 2	10.0	0.3	–	9	11	26	20	14	16	4	SG
NO 89 NW 3	19.4	0.3	–	6	15	37	19	11	11	1	SG
NO 89 NW 5	6.9	0.3	2.6	8	24	31	18	10	5	4	PS
NO 89 NW 6	4.7	0.6	–	8	33	31	15	7	6	0	PS
Mean*	**7.6**	**0.3**	**–**	**6**	**12**	**29**	**20**	**14**	**16**	**3**	**SG**

* commercial data have been used in calculation of mean

Statistical assessment of Resource Block O (Fluvioglacial sand and gravel in the Dee valley)

Total area	14.11km^2
Area of exposed mineral	11.72km^2
Area of concealed mineral	0.01km^2
Total area of mineral-bearing ground	11.73km^2
Area of ground worked for sand and gravel	0.08km^2
Area of barren ground	2.30km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral	7.6m
Estimated volume of mineral	**89.1 million m^3 $\pm$ 36% or 32.1 million m^3**

sand and gravel pits occur in the kame-terraces to the north of the river, at Moss-side *[805 989]* and near Milton of Murtle *[873 023]*. On the south side of the valley, sand and gravel has been worked at Stony Hill *[845 993]* and Templars Park *[850 999]*. A sand and gravel pit has recently been opened in the kame-terrace to the north west of Blairs College *[878 010]*.

Information from fifteen sample points (including three commercial boreholes) shows that the potentially workable sand and gravel in Block O ranges in thickness from 1.4m (in borehole NJ 80 SE 5) to 19.4m (in borehole NO 89 NW 3). The wide range in the thickness of sand and gravel in the kame-terraces of the Dee Valley is typical of the fluvioglacial deposits in the district as a whole. This results partly from the highly irregular floor on which the deposits rest and partly from the irregular form of the terrace surfaces, which are often extensively kettled.

Braided-river gravels such as those recorded in boreholes NJ 80 SE 1, 80 SE 5 and 90 SW 1, lie within a buried channel concealed beneath the floodplain of the River Dee. The deposits appear to range considerably in thickness, but this is mainly due to the location of individual sample points relative to the deepest part of the channel. The gravels are overlain locally by spreads of clayey alluvium but overburden is generally thin. Most of these deposits, however, lie beneath the water table and are therefore less important as a source of aggregate than the kame-terrace deposits until such time as dredging operations are allowed.

The kame-terraces rest on benches cut into lodgement till or bedrock. Assessment boreholes show that the thickest mineral deposits occur upstream of Peterculter, especially around Gallowhill *[803 978]*. Here, the sand and gravel generally rests on till and may include thick beds of laminated glaciolacustrine silt (see cross-section G-G' on Resource Sheet 3). These fluvioglacial deposits consist of fining-downwards sequences of sandy gravel overlying pebbly or 'very clayey' sand. Downstream of Peterculter, the kame-terraces generally rest on bedrock and the mineral deposits are deposits are considerably thinner (see section H-H').

BLOCK P (Table 22)

Block P covers the whole of Resource Sheet 3 to the south of Block O and the city of Aberdeen. Most of the ground is barren. Isolated deposits

Table 22 Block P: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	(see the diagram in Appendix C)
SUB-BLOCK P^1 (Glacial sand and gravel along coast between Girdle Ness and Downies; also glacial and fluvioglacial sand and gravel in the valley of the Crynock Burn)											
NJ 90 SW 7	3.0+	0.1	-	6	5	7	9	13	28	32	G
NJ 90 SW 8	8.2+	2.0	-	7	16	32	16	11	13	5	SG
NO 99 NW 1	5.9+	1.0	-	14	17	22	15	14	14	4	CSG
Mean	**5.7**	**1.0**	**-**	**9**	**15**	**24**	**15**	**12**	**16**	**9**	**SG**
SUB-BLOCK P^2 (Glacial sand and gravel at Cantlayhills)											
NO 89 SE 1	7.1+	0.2	-	6	17	28	14	15	13	7	SG
NO 89 SE 2	3.2+	0.1	-	3	4	11	17	21	31	13	G
Mean	**5.2**	**0.1**	**-**	**5**	**13**	**22**	**16**	**17**	**18**	**9**	**SG**
Overall mean	**5.5**	**0.7**	**-**	**8**	**14**	**23**	**15**	**14**	**17**	**9**	**SG**

Inferred assessment of Resource sub-block P^1 (Glacial sand and gravel along the coast between Girdle Ness and Downies; also glacial and fluvioglacial sand and gravel in the valley of the Crynoch Burn)

Total area (excluding Portlethen urban area)	141.94km^2
Portlethen urban area (not assessed)	0.79km^2
Area of exposed mineral	3.06km^2
Area of ground worked for sand and gravel	0.18km^2
Area of barren ground excluding Portlethen	138.98km^2
Mean thickness of overburden	1.0m
Mean thickness of mineral	5.7m
Estimated volume of mineral	**17.4 million m^3**

Inferred assessment of Resource sub-block P^2 (glacial sand and gravel at Cantlayhills)

Total area	8.85km^2
Area of exposed mineral	0.43km^2
Area of barren ground	8.42km^2
Mean thickness of overburden	0.1m
Mean thickness of mineral	5.2m
Estimated volume of mineral	**2.2 million m^3**

of glacial sand and gravel lie within a belt of ground which extends up to 2km inland from the coast between Girdle Ness *[973 054]* and Downies *[925 951]*; they also flank the Burn of Muchalls at Cantlayhills (see inset map). Small spreads of fluvioglacial sand and gravel crop out at Eastland Bridge *[863 992]* and near Polston *[864 980]*, bordering the glacial drainage channel now occupied by the Crynoch Burn. Upstream from Polston, the burn is also flanked by small, scattered patches of glacial sand and gravel.

Sub-block P1

An inferred assessment is offered for the glacial sand and gravel in the coastal area between Girdle Ness and Downies, together with the mineral deposits of Crynoch Burn.

Girdle Ness to Downies

Much of the sand and gravel of the coastal strip to the south of Aberdeen occurs as north-south trending linear features considered to be kames by Clapperton and Sugden (1977). They are thought to relate to the coallescence of 'red drift' ice and 'inland' ice along the coast.

'Red drift' deposits have been recorded at Nigg Bay by many authors, including Simpson (1948) and a detailed description of the Nigg Bay section is given by Chester in the Quaternary Research Association Field Guide to the Aberdeen area (1975, pages 2-4 and Figure 1), which show 'Lower Sands and Gravels' overlain by 'Grey Till'; 'Red Till' overlies the 'Grey Till' and is in turn overlain by 'Upper Bedded Sands' and 'Upper Morainic Gravels'. Further occurrances of 'red drift' have been recorded during this assessment, but their extent has not been mapped in detail.

Field mapping has shown that the spreads of glacial sand and gravel between Girdle Ness and Downies constitute the principal resource in Block P, but that the deposits are of quite variable quality.

Three assesment pits were sited in the area. One of them (NO 99 NW 1), sited by a section in the disused sand and gravel workings at Mains of Cairnrobin showed 5.9m (unbottomed) of potentially workable sand and gravel overlain by silty, matrix-rich cobble gravel (thought to be equivalent to Chester's 'Upper Morainic Gravels'). The combined section and pit (NJ 90 SW 8) at South Loirston quarry showed 6.5m of sandy gravel in two fining-downwards cycles, overlying 1.7m of 'clayey' sand, not bottomed.

The glacial sand and gravel between Torry and Girdle Ness conceals a deep channel formerly cut by glacial meltwater flowing eastwards, through the valley between Torry and Tullos Hill. Borehole evidence (Munro, in press) shows that the channel contains drift deposits, principally till, but including some sand and gravel.

The flat-topped spread of sand and gravel near Middleton *[939 985]* has been interpreted by Peacock and others (1977) as representing a fining-downwards, deltaic sequence deposited by glacial meltwater.

Crynoch Burn

The sand and gravel deposits in the valley of the Crynoch Burn are of very minor importance as sources of sand and gravel. No pits or assessment boreholes were sited in the area. Field mapping revealed that small kame-terraces underlain by fluvioglacial sand and gravel and small flat-topped mounds of glacial sand and gravel are present between Polston and Cairnieburn *[843 955]*.

Table 23 Data from sample points for potentially workable till (whole assessment area)

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
Borehole	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{4}$mm	Medium sand $+\frac{1}{4}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
Resource Sheet 1											
NJ 61 NE 3	4.2	2.8	-	34	7	20	18	10	8	3	VCSG
NJ 71 NW 3	3.1+	0.2	-	12	16	21	21	20	10	0	CSG
NJ 71 NW 7	2.1	1.4	-	17	20	23	19	9	12	0	CSG
NJ 71 NW 11	2.8+	0.2	-	18	24	21	17	11	8	1	CPS
NJ 71 NW 14	5.9	6.6*	-	10	8	24	29	18	8	3	CSG
NJ 71 SW 10	1.8+	0.2	-	5	5	9	8	9	18	46	G
Resource Sheet 2											
NJ 81 NW 12	9.6+	0.4	-	16	13	29	22	12	8	0	CSG
NJ 81 SW 4	2.0+	1.4	-	11	13	32	36	8	0	0	CPS
NJ 91 NE 10	1.3	5.2**	-	28	11	24	18	10	9	0	VCPS
NJ 91 SW 5	2.9+	0.3	-	22	22	24	14	10	8	0	VCPS
NJ 91 SW 8	5.1	0.3	-	17	14	30	26	6	7	0	CPS
Resource Sheet 3											
NJ 80 NW 1	1.8+	0.2	-	17	19	29	20	10	5	0	CPS
NJ 80 NW 4	1.1	0.2	-	7	18	25	17	12	9	12	SG
NJ 80 SW 5	3.0+	3.0§	-	10	4	13	16	23	24	10	CSG
NJ 80 SE 2	1.8	0.2	-	12	14	20	29	14	11	0	CSG
Mean	**3.2**	**1.5**	**-**	**17**	**13**	**25**	**21**	**12**	**9**	**3**	**CSG**

* includes 5.8m potentially workable glacial sand and gravel
** includes 3.3m potentially workable glacial sand and gravel
§ includes 2.8m potentially workable fluvioglacial sand and gravel

Sub block P^2

Cantlayhills

An investigation of the 9 km^2 of ground near Bridge of Muchalls (inset map to Resource Sheet 3) shows that potentially workable material occurs as isolated mounds of glacial sand and gravel between Burnside *[874 918]* and the coast at Easter Muchalls *[898 913]*. Larger spreads of moundy sand and gravel crop out between Howieshill *[871 906]* and Cantlayhills *[881 905]*. Two assessment pits were excavated at Cantlayhills, one of which, together with a measured section, showed the deposit to consist of at least 7.1m of sandy gravel.

NOTES ON THE SAND AND GRAVEL WORKINGS

The industry has shown a high level of interest in the sand and gravel deposits around Aberdeen over many years. The largest active workings in the district are listed in Table 24 and the principal disused and worked-out pits are listed in Table 25. These tables also show the type of sand and gravel and the approximate area of worked ground for each pit. Many of the active workings have been so for up to twenty years, although some (the pit at Blairs College, for example) have opened recently.

The extraction of sand and gravel has generally been confined to deposits lying above the water table and many pits contain a few metres of unworked gravel (in their floors) lying below the water table. It is the proximity of the water table, rather than the presence of waste partings or variation in the quality of the sand and gravel, that is the principal factor limiting the depth of working.

At present, as well as in the past, sand and gravel extraction is concentrated within the coastal area to the north of Bridge of Don. This is confirmed by a glance at Tables 24 and 25, which show more active and disused pits in the area covered by Resource Sheet 2 than are present within the whole of the remainder of the assessment area. The average size of the pits in the coastal area is also greater than elsewhere in the district. The total area of worked ground on Resource Sheet 2 is approximately 285 hectares compared with 52 hectares on Resource Sheet 1 and 28 hectares on sheet 3.

The anticipated life of an active pit is said to be just over five years on average, but this figure varies considerably for individual workings. At many disused pits (such as Middlefield and Belhelvie, for example) restoration has followed extraction. Some of the worked ground, notably around Westhill, has been used for urban development and other pits, such as Fife Hill, have become industrial estates. The worked out areas at Mill of Dyce and Blackdog Rifle Ranges have been used as land-fill sites.

Table 24 List of the larger active sand and gravel workings

Location	Grid reference	Deposit worked	Areas of worked ground* at November 1984, in hectares
RESOURCE SHEET 1			
Blairdaff	NJ 700 179	Glacial sand and gravel	2.8
Cairnhall	NJ 787 178	Fluvioglacial sand and gravel	5.3
Kintore	NJ 783 173	" " " "	14.3
Rothens	NJ 692 173	" " " "	2.9
RESOURCE SHEET 2			
Annfield (Newton of Shielhill)	NJ 930 141	Glacial sand and gravel	27.1
Bishops Loch	NJ 912 145	" " " "	17.5
Drums (Foveran)	NJ 988 225	" " " " (Esker)	4.0
Dubford	NJ 938 125	" " " "	8.3
Hill of Strabathie (incl. Rose Cottage Pit)	NJ 957 136	" " " "	17.5
Leuchlands	NJ 930 135	" " " "	40.0
Mill of Dyce (St. Fergus)	NJ 874 147	" " " "	29.0
Newtonhill (including Kaim Hill)	NJ 925 150	" " " "	14.3
Potterton (Broom Hill)	NJ 955 157	" " " "	31.5
RESOURCE SHEET 3			
Blairs College	NJ 878 010	Fluvioglacial sand and gravel	1.0**
Easter Mains	NJ 852 078	Glacial sand and gravel	2.0

* including reinstated ground
** production just starting

Table 25 List of the larger disused sand and gravel workings

Location	Grid reference	Deposit worked	Areas of worked ground* at November 1984, in hectares
RESOURCE SHEET 1			
Black Hillock	NJ 783 170	Fluvioglacial sand and gravel	1.6
Broomend	NJ 778 191	" " " "	5.5
Cairnfold	NJ 701 117	" " " "	1.0
Crichie Cottages	NJ 779 198	" " " "	0.9
Dalbraidie	NJ 688 170	" " " "	3.6
Fullerton	NJ 780 186	" " " "	1.9
Gauch Hill	NJ 786 154	Glacial sand and gravel	1.1
Glenhead	NJ 752 177	" " " "	1.1
Mains of Coullie	NJ 699 174	Fluvioglacial sand and gravel	0.8
Mill Farm	NJ 738 178	Glacial sand and gravel	3.4
Ratch-hill	NJ 778 171	Fluvioglacial sand and gravel	5.9
RESOURCE SHEET 2			
Belhelvie	NJ 949 175	Glacial sand and gravel	0.8
Blackdog Rifle Ranges	NJ 962 153	Older blown sand and glacial sand and gravel	2.4
Blackdog Links	NJ 965 144	Blown sand	6.8
Blackdog Rock	NJ 964 138	Older blown sand	3.7
Fife Hill	NJ 957 144	Glacial sand and gravel	16.0
Hill of Tramaud	NJ 947 134	" " " "	22.5
Leuchlands Croft	NJ 930 149	" " " "	4.3
Middlefield	NJ 951 149	" " " "	2.8
Middleton of Potterton	NJ 935 161	" " " "	1.9
Mill of Birsack	NJ 830 105	" " " "	2.8
Milton of Potterton	NJ 944 161	Glaciolacustrine deposits	0.8
Nether Kirkton	NJ 880 143	Fluvioglacial sand and gravel	
North Tarbothill	NJ 951 135	Glacial sand and gravel	9.1
Roadside	NJ 938 105	Glacial sand and gravel	7.6
Shielhill	NJ 938 129	Glacial sand and gravel	5.3
RESOURCE SHEET 3			
Mains of Cairnrobin	NO 935 991	Glacial sand and gravel	8.0
Moss-side	NO 805 989	Fluvioglacial sand and gravel	3.0
South Loriston	NO 944 012	Glacial sand and gravel	10.0
Stony Hill	NO 845 993	Fluvioglacial sand and gravel	0.8
Templar's Park	NO 850 999	Fluvioglacial sand and gravel	1.8
Woodside	NJ 912 095	Fluvioglacial sand and gravel	1.8

* including reinstated ground

Fixed processing plant, which used to be commonplace in large operations, is found only at two working pits (Mill of Dyce and the Hill of Strabathie). The other pits have mobile machinery for grading; some also have mobile crushing and washing plant. Mobile plant allows greater flexibility in production, and enables the industry to respond quickly to changes in the overall demand for aggregate in the district. It also allows the industry to exploit smaller deposits than would otherwise be economically viable. Most operators still process material on-site, but some are now working deposits at satelite pits and transporting material several kilometres for processing.

Crushed rock is not generally added to the natural aggregate produced in the Aberdeen area, although some plants that manufacture concrete building blocks do use a large proportion of crushed granite.

Excessive amounts of cobble and boulder grade material in the sand and gravel is one of the main geological problems in many pits. This coarse material either requires expensive crushing or has to be dumped as waste. Irregularities in the bedrock surface, upon which the sand and gravel deposits rest, causes difficulties in working the aggregate at some pits.

The principal end-use for aggregate from a third of the workings is in concrete manufacture. It is also a minor end-use for material produced from several other pits. Building sand and (to a lesser extent) asphalting sand are the sole products from one in eight of the workings and are important in a further fifth of the sites. 'Pipe-fill' and 'trough-fill' are the main end-uses for aggregate from a further twenty per cent of the pits in the area; 'road grit' and stone chippings are also produced, but are of relatively minor importance.

CONCLUSIONS

The sand and gravel resources of the Aberdeen district have been described systematically and the results of the volumetric assessment summarised in Table 8. It must be repeated that the survey concerns the estimation of *resources* rather than *reserves* and that the assessment of the deposits is judged solely in terms of the arbitrary physical criteria stated in the introduction to the report. No account is taken of prevailing environmental or economic considerations and the quoted volumetric estimates bear no simple relationship to the amount of sand and gravel that might be extracted in practice. The chief aim of the survey is to provide a factual, geologically-based assessment of the sand and gravel resources, against which the economic, social and environmental costs in developing the resource can be weighed.

Because it is customary not to permit the dredging of wet deposits in Scotland, the most important geological factor governing the future development of sand and gravel resources in the area is probably the position of the material relative to the water table. An attempt has been made in the resource block descriptions to distinguish resources that are mainly above the water table from those predominantly below, but these accounts are often highly generalised. Water-saturated deposits are mainly restricted to the floodplains of the major rivers and streams but they also underlie many of the low-lying areas of *peat* and *alluvium* that mark the positions of former lakes and which also surround the present-day lochs. Potentially workable sand and gravel within the *Post-Glacial beach and estuarine* deposits of the coastal area also occurs below the water table.

Perhaps the second most important geological factor governing future exploitation of the resources is grading. The grading of the mineral deposits is shown in Table 2 and in Figures 3 and 4 but it is summarised again here in order to emphasize the close relationships that exist between geological classificiation and grading. For example, potentially workable material within the *glaciolacustrine* deposits of Block H consists principally of fine-grained silty sand, whereas the *glacial* sand and gravel comprises on average over 44 per cent gravel (clasts retained on a 4-mm sieve); the *fluvioglacial* sand and gravel comprises, on average, over 20 per cent gravel. The first deposit has a foreseeable use as building or asphalting sand, whereas the last two deposits will provide coarse and fine aggregate. Glacial sand and gravel is inherently variable in compositon and any one deposit might provide a range of aggregates, although in the Aberdeen area the material is generally gravelly. The glaciolacustrine deposits that occur within the 'red drift' of the coastal area and within the valley of the River Don are very fine-grained (generally over 30 per cent passing a 0.125-mm sieve) and would find very few markets. (Pebble-free silty clay within these sequences, however, constitutes a potential source of brick-clay).

The *potentially workable till* (Table 23) likewise is not an attractive resource, but the material might be used as bulk fill to replace other more expensive and versatile aggregates which may be in short supply.

After the grading and the position of the resources relative to the water table have been taken into account, the next factors to be considered in making a comparative evaluation of the resources are deposit thickness and continuity. To some extent these factors have been taken into account in locating sample points during this assessment, because most of the very small, thin, or patchy deposits of sand and gravel were not sampled. Other geological factors that should be taken into account include composition and quality, but it has not been possible to make any comprehensive statement on these aspects owing to insufficient sampling and testing data.

On the whole, the gravels of the Aberdeen area should be suitable for most purposes provided that an appropriate form of processing is used and the petrography and soundness of the material is duly taken into account in the choice of end-use applications. The results of the limited number of pebble counts and mechanical and physical tests that were undertaken are given in Tables 5,6 and 7. They indicate little apparent variation in aggregate quality across the assessment area and what variation there is cannot be easily correlated with petrography. The soundness of the aggregate will be partially determined by the proportions of schist, mudstone, friable sandstone and weathered granitic pebbles present. All of these rock types may deteriorate rapidly when incorporated in concrete. The susceptability of an aggregate to premature failure, however, is largely dependant on the degree to which the material is weathered, which is often a very localised phenomenon, rather than to its original petrography.

Many of the resources identified on the accompanying maps will repay further investigation by the industry as reserves for future exploitation. These *target resources* will be considered in more detail in a future study collating the results of all the sand and gravel assessment surveys that have been conducted in North East Scotland. This report will identify and rank target resources; it is required for the formulation of coherent mineral planning policies. Selecting targets will be difficult as there are many variables to consider and judgements cannot be wholly objective.

The more important resources of the assessment area include:- kame-terrace deposits of the River Dee, especially to the west of Peterculter; the glacial sand and gravel in Block C (notably the Kemnay Esker); the mounds of glacial sand and gravel between Mill of Dyce and Bishop's Loch; and the glacial sand and gravel on the eastern side of the valley of Newmill Burn. The kame-terraces of Block F and Block B (especially between Rothens and Fetternear House) also contain considerable quantities of potentially workable coarse-grained aggregate. The coastal area to the north of Bridge of Don (blocks J and K) contains thick deposits of sand and gravel occurring above the groundwater table, but much of the ground has been worked out or is currently being worked.

More isolated spreads of clean sand and gravel occur throughout the assessment area and although small compared to the deposits listed above, some of these resources would still repay detailed investigation by the industry.

REFERENCES

ALLEN, V. T. 1936. Terminology of medium-grained sediments. *Rep. Natl. Res. Counc. Washington, 1935-1936,* App.1, Rep. Comm. Sediment. 18-47.

ANDERSON, J. G. C. 1943. Sands and gravels of Scotland: Quarter-inch sheet 9, Elgin-Banff-Aberdeen. *Wartime Pamph. Geol. Surv. G.B.*, No. 30, Part 1, 27pp.

______ 1945. Sands and gravels of Scotland: Quarter-inch Sheet 12, Stonehaven-Perth-Dundee. *Wartime Pam. Geol. Surv. G.B.*, No. 30, Part 2, 30pp.

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

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

______ 1970b. Making the most of metrication. *Quarry Managers' J.*, Vol. 54, 223-227.

ATTERBERG, A. 1905. Die rationelle Klassifikation der Sande und Kiese. *Chem. Ztg.*, Vol. 29, 195-198.

BARROW, G. 1893. On an intrusion of Muscovite-biotite greiss in the south eastern highlands of Scotland and its accompanying metamorphism. *Quart. J. Geol. Soc.*, Vol. 49, 330-358.

______ 1912. On the geology of Lower Deeside and the southern highland border. *Proc. Geol. Assoc.*, Vol. 23, 274-290.

BREMNER, A. 1912. The physical geology of the Dee valley. Survey of the natural history and antiquities of the valley of the Dee. *Aberdeen Nat. Hist. and Antiq. Soc.*, Vol. 1, pt. 2. 89 pp. (Aberdeen: Univ. Press)

______ 1915. Problems in the glacial geology of N.E. Scotland and some fresh facts bearing on them. *Trans. Edinb. Geol. Soc.*, Vol. 10, 334-347.

______ 1921. The physical geology of the Don basin. *Aberdeen Nat. Hist. and Antiq. Soc* No. 2. 129pp. (Aberdeen: Univ. Press)

______ 1928. Further problems in the glacial geology of north-eastern Scotland. *Trans. Edinb. Geol. Soc.*, Vol.12, 147-164.

______ 1934. The glaciation of Moray and ice movements in the north of Scotland. *Trans. Edinb. Geol. Soc.*, Vol. 13, 17-56.

______ 1938. The glacial epoch in north-east Scotland. *The Deeside Field,* No.8, 64-68.

______ 1939. Notes on the glacial geology of east Aberdeenshire. *Trans. Edinb. Geol. Soc.*, Vol. 13, 474-475.

______ 1943. The glacial epoch in the North-East. Pp. 10-39. In *The Book of Buchan* (Jubliee Volume). Tocher, J.F. (Ed.). 330pp. (Aberdeen: Univ. Press)

BOULTON, G. S. and EYLES, N. 1979. Sedimentation by valley glaciers, a model and genetic classification. Pp. 11-24. In *Moraines and Varves*. C. Schluchter (Ed.), 441 pp. (Rotterdam: A. A. Balkema)

BRITISH STANDARDS INSTITUTION. 1975. *BS 812: Methods for sampling and testing of mineral aggregates, sands and fillers*. 104 pp. (London: British Standards Institution)

______ 1975. *BS 1377: Methods for testing soils for civil engineering purposes*. 143 pp. (London: British Standards Institution)

BUILDING RESEARCH ESTABLISHMENT. 1968. *Shrinkage of natural aggregates in concrete. Dig. Build. Res. Establ.* Ser. 2, No. 35, 7 pp.

BUREAU OF MINES AND GEOLOGICAL SURVEY. 1948. *Mineral resources of the United States,* 14-17. (Washington D.C., Public Affairs Press)

CHARLESWORTH, J. K. 1956. The late-glacial history of the Highlands and Islands of Scotland. *Trans. R. Soc. Edinb.*, Vol. 62, 769-928.

CHESTER, D. K. 1975. In Field excursion guide to the Aberdeen Area, April 1975. *Quarternary Research Association*. 25 pp. (Cambridge)

______, CLAPPERTON, C., GEMMELL, A., MURCOCH, W. and SUGDEN, D. 1974. *The sand and gravel reserves in the Aberdeen and Ellon Districts*. Report commissioned by Joss (Aberdeen) Ltd. and John Fyfe Ltd. (Dept. Geography, Univ. Aberdeen)

CLAPPERTON, C. M., and SUGDEN, D. E. 1972. The Aberdeen and Dinnent glacial limits reconcidered. Pp. 5-11. In *North East Scotland Geographical Essays*. C. M. Clapperton (Ed.), (Dept. Geography, Univ. Aberdeen).

______ 1977. The late Devensian glaciation of north-east Scotland. Pp. 1-13. In *Studies in the Scottish late glacial environment*. Gray, J.M., and Lowe, J.J. (Ed.). 197 pp. (Oxford: Pergamon Press)

DEWEY, J. F. and PANKHURST, R. J. 1970. The evolution of the Scottish Caledonides in relation to their isotopic age pattern.

Trans. R. Soc. Edinb., Vol. 68, No. 11, 361-89.
EDWARDS. A. G. 1970. Scottish aggregates: their suitability for concrete with regard to rock constituents. *Curr. Pap. Build. Res. Stn.* No. 28/70.
EVANS, D., CHESHIRE, J. A., DEEGAN, C. E. and FANNIN, N. G. T. The offshore geology of Scotland in relation to the IGS. Shallow drilling programme 1970-78. *Rep. Inst. Geol. Sci.*, 81/12, 36 pp.
FITZPATRICK, E. A. 1963. Deeply weathered rock in Scotland, its occurrence, age and contribution to the soils. *J. Soil Sci.*, Vol. 14, 33-43.
GEMMELL, A. M. D. 1975. Quaternary studies in north-east Scotland: an introduction. Pp. 1-13. In *Quaternary studies in north-east Scotland.* Gemmell, A.M.D. (Ed.), 87 pp. (Dept. Geography, Univ. Aberdeen)
GLENTWORTH, R., MITCHELL, W. A., and MITCHELL, B. D. 1964. The red glacial drift deposits of north-east Scotland. *Clay Mineral. Bull.*, Vol. 5, 373-381.
GRAY, J. M., AND LOWE, J. J. 1977. The Scottish lateglacial environment: a synthesis. Pp 163-181. In *Studies in the Scottish lateglacial environment.* Gray, J.M. and Lowe, J.J. (Ed.), 197 pp. (Oxford: Pergamon Press)
HALL, A. M. 1983. Weathering and landform evolution in north-east Scotland. *Unpubl. Ph.D. thesis*, Univ. of St. Andrews.
_________, (Ed.) 1984. Buchan Field Guide. *Quaternary Research Association.* 120 pp. (Cambridge)
_________ 1985. Cenozoic weathering covers in Buchan, Scotland and their significance. *Nature*, Vol. 315, 392-395.
HANCOCK, J. M. 1975. The petrology of the Chalk. *Proc. Geol. Assoc.*, Vol. 86, 499-535.
HARKNESS, D. D., and WILSON, H. W. 1979. Scottish Universities Research and Reactor Centre Radiocarbon Measurements III. *Radiocarbon*, Vol. 21, 203-256.
HARRIS, P. M., THURRELL, R. G., HEALING, R. A., and ARCHER, A. A. 1974. Aggregates in Britain. *Proc. R. Soc.*, Ser. A, Vol. 339, 329-353.
HULL, J. H. 1981. Methods of calculating the volume of resources of sand and gravel. Appendix (pp. 192-193) to THURRELL, R.G. 1981. Quarry resources and reserves: the indentification of bulk mineral resources: the contribution of the Institute of Geological Sciences. *Quarry Management* for March 1981, 181-193.
JAMIESON, T. F. 1858. On the Pleistocene deposits of Aberdeenshire. *Q. J. Geol. Soc. Lond.*, Vol. 14, 509-532.
_________ 1860. On the drift and rolled gravels of the North of Scotland. *Q. J. Geol. Soc. Lond.*, Vol. 16, 347-371.
_________ 1865. On the history of the last geological changes in Scotland. *Q. J. Geol. Soc. Lond.*, Vol. 21, 161-203.
_________ 1874. On the last stage of the glacial period in north Britain. *Q. J. Geol. Soc. Lond.*, Vol. 30, 317-338.
_________ 1882. On the red clay of the Aberdeenshire coast and the direction of the ice-movement in that quarter. *Q. J. Geol. Soc. Lond.*, Vol. 38, 160-177.
_________ 1906. The glacial period in Aberdeenshire and the southern border of the Moray Firth. *Q. J. Geol. Soc. Lond.*, Vol. 62, 13-39.
JOHNSON, M. R. W. and STEWART, F. H. 1960. On Dalradian structures in North-East Scotland. *Tran. Edinb. Geol. Soc.* Vol. 18, 94-103.
JOHNSTONE, G. S. 1966. The Grampian Highlands, (3rd Ed. 1972), *Handb. Br. Reg. Geol., Geol. Surv. G.B.* 103 pp. (Edinburgh: H.M.S.O.)
KNILL, D. C. 1963. A review of the petrological basis of the trade group classification of rocks. *Quarry Managers' J.*, Vol. 47, 61-70.
LANE, E. W., and others 1947. Report of the sub-committee on sediment terminology. *Trans. Am. Geophys. Union*, Vol. 28, 936-938.
LAW, G. R., 1962. The sub-surface geology of the Bay of Nigg - Tullos area. *Unpul. Msc. Thesis*, Univ. of Aberdeen, 88pp.
LINTON, D. L. 1951. Problems of Scottish scenery. *Scott. Geogr. Mag.*, Vol.67, 65-85.
McLEAN, F. 1977. The glacial sediments of a part of east Aberdeenshire. *Unpubl. Ph.D. thesis*, Univ. of Aberdeen, 152pp.
McMILLAN, A. A. and AITKEN, A. M. 1981. The sand and gravel resources of the country west of Peterhead, Grampian Region. Description of 1:25,000 Sheet NK 04 and parts of NJ 94 and 95, NK 05, 14 and 15. *Miner. Assess. Rep. Inst. Geol. Sci.* No. 58, 99 pp.
_________ and MERRITT, J. W. 1980. A reappraisal of the 'Tertiary' deposits of Buchan, Grampian Region. *Rep. Inst. Geol. Sci.* 80/1, 18-25.
MERRITT, J. W. 1981. The sand and gravel resources of the country around Ellon, Grampian Region. Description of 1:25,000 resource sheets NJ 93 with parts of NJ 82, 83 and 92, and NK 03 and parts of NK 02 and 13. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 76, 114 pp.
_________ and PEACOCK, J. D. 1983. A preliminary study of the sand and gravel deposits around Aberdeen (1:25 000 sheets NJ 71, 80, 81, 90, 91 and parts of 61 and 92; NO 69 and 79 and parts of 89) *Open File Report Inst. Geol. Sci.*, 28 pp.
MUNRO, M. (in press). Geology of the Aberdeen area. *Mem. Brit. Geol. Surv.*
MURDOCH, W. M. 1975. The geomorphology and glacial deposits of the area around Aberdeen. Pp. 14-18. In A.M.D. Gemmell (Ed.) *Quaternary Studies in North East Scotland.* 87 pp. (Dept. Geography, Univ. Aberdeen)
_________ 1977. The glaciation and deglaciation of south-east Aberdeenshire, *Unpubl. Ph.D. thesis*, Univ. of Aberdeen, 238pp.
PEACOCK, J. D., CLARK G. C., MAY F., MENDUM J. R., ROSS D. L., and RUCKLEY A. E. 1977. Sand and gravel resources of the Gampian region. *Rep. Inst. Geol. Sci.* No. 77/2, 24pp.
PETTIJOHN, F. J. 1975. *Sedimentary rocks.* Third edition. (London: Harper and Row.)
PHEMISTER, T. C. and SIMPSON S. 1949. Pleistocene deep weathering in North-East Scotland. *Nature*, Vol. 164, 318-319.
RAMSAY, D. M. 1965. Factors influencing aggregate impact value in rock aggregate. *Quarry Managers' J.*, Vol. 49, 129-134.
_________, DHIR R. K. and SPENCE I. M. 1973. The

reproducibility of results in the aggregate impact test: The influence of non-geological factors *Quarry Managers' J.*, Vol. 57, No. 5, 179-181.

________________________ 1974. The role of rock and clast fabric in the physical performance of crushed-rock aggregate. *Eng. Geol.*, Vol. 8, 267-285.

READ, H. H. 1952. Metamorphism and migmitisation in the Ythan Valley, Aberdeenshire. *Trans. Edinb. Geol. Soc.* Vol. 15, 265-279

________ and FARQUHAR O. C. 1956. The Buchan anticline of the Banff nappe of Dalradian rocks in north-east Scotland. *Q.J. Geol. Soc. Lond.*, Vol. 112, 131-156.

SIMPSON, S. 1948. The glacial deposits of Tullos and the Bay of Nigg, Aberdeen. *Trans. R. Soc. Edinb.*, Vol. 61, 687-698.

______ 1955. A re-interpretation of the drifts of north-east Scotland. *Trans. Edinb. Geol. Soc.*, Vol. 16, 189-199.

STEWART, F. H. 1970. The 'younger' basic igneous complexes of north-east Scotland and their metamorphic envelope. *Scott. J. Geol.* Vol. 6, 3-6.

SYNGE, F. M. 1956. The glaciation of north-east Scotland. *Scott. Geogr. Mag.*, Vol. 72, 129-143.

_______ 1963. The Quaternary succession round Aberdeen, north-east Scotland. *Rep. 6th Int. Quarternary Congr. Geomorphol.*, Section 3, 353-361.

THOMAS, G. S. P. 1984. Sedimentation of a sub-aqueous esker-delta at Strabathie, Aberdeenshire. *Scott. J. Geol.* Vol. 20, 9-20.

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

________ 1981. Quarry resources and reserves: the identification of bulk mineral resources: the contribution of the Institute of Geological Sciences. *Quarry Management*, Vol. 8, No. 3, 181-192.

TWENHOFEL, W. H. 1937. Terminology of the fine-grained mechanical sediments. *Rep. Natl Res. Counc. Washington 1936-37.* App. 1, Rep. Comm. Sediment., 81-104.

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

WALTON, K. W. 1963. Geomorphology. Pp. 16-31. In The North-East of Scotland. *Br. Assoc. Handbook.* 256pp. (Aberdeen: Central Press)

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

__________ 1935. The terminology of coarse sediments. *Bull. Natl. Res. Counc. Washington*, No. 98, 225-246.

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

WILSON, J. S. G. and HINXMAN L. W. 1890. Explanation of Sheet 76: Central Aberdeenshire. *Mem. Geol. Surv.* 43 pp.

APPENDIX A

FIELD AND LABORATORY PROCEDURE

Trial and error during initial studies of the complex and variable glacial deposits of East Anglia and Essex showed that an absolute minimum of five sample points evenly distributed across the sand and gravel are needed to provide a worthwhile statistical assessment, but that, where possible, there should not be less than ten. Sample points are any points for which adequate information exists about the nature and thickness of the deposit and may include boreholes other than those drilled during the survey and exposures. In particular, the cooperation of sand and gravel operators ensures that boreholes are not drilled where reliable information is already available; although this may be used in the calculations, it is held confidentially by BGS and cannot be disclosed.

The mineral shown on each 1:25000 sheet is divided into resource blocks. The arbitrary size selected, 10 km^2, is a compromise to meet the aims of the survey by providing sufficient sample points in each block. As far as possible the block boundaries are determined by geological boundaries so that, for example, glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology. The blocks are drawn provisionally before drilling begins.

A reconnaissance of the ground is carried out to record any exposures and inquiries are made to ascertain what borehole information is available. Borehole and trial pit sites are then selected to provide an even pattern of sample points at a density of approximately one per square kilometre. However, because broad trends are independently overlain by smaller scale characteristically random variations, it is unnecessary to adhere to a square grid pattern. Thus such factors as ease of access and the need to minimise disturbance to land and the public are taken into account in siting the holes; at the same time it is necessary to guard against the possibility that ease of access (that is, the positions of roads and farms) may reflect particular geological conditions, which may bias the drilling results.

The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30m at a diameter of between 200 and 300mm, beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites of difficult access). Shell and auger rigs have proved to be almost ideal.

The rigs are modified to enable deposits above the water table to be drilled 'dry', (instead of with water added to facilitate the drilling), to minimise the amount of material drawn in from outside the limits of the hole. The samples thus obtained are representative of the in-situ grading, and satisfy one of the most important aims of the survey. Below the water-table the rigs are used conventionally, although this may result in the loss of some of the fines fraction and the pumping action of the bailer tends to draw unwanted material into the hole from the sides or the bottom.

Thin spreads of sand and gravel, recognised during the revision mapping of the district, are sampled by means of shallow trial pits.

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole or pit, between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of boreholes. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or at every 1m depth. The samples, each weighing between 25 and 45kg, are despatched in heavy duty polythene bags to a laboratory for grading. The grading procedure is based on British Standard 1377 (1975). Random checks on the accuracy of the grading are made.

All data is coded up for analysis by computer. Abbreviated logs together with grading data are reproduced in Appendix E.

Detailed records may be consulted at the appropriate office of BGS: the address is shown next to the preface.

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment 1 A statistical assessment is made of an area of mineral greater than $2km^2$, if there is a minimum of five evenly spaced boreholes in the resource block (for smaller areas see paragraph 12 below).

2 The simple methods used in the calculations are consistent with the amount of data provided by the survey (Hull, 1981). Conventional symmetrical confidence limits are calculated for the 95 per cent probability level, that is, there is a 5 per cent or one in twenty chance of a result falling outside the stated limits.

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

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

4 The above relationship may be transposed such that

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

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

If, therefore, the standard deviation for area is small with respect to that for mean thickness, the standard deviation for volume approximates to that for mean thickness.

5 Given that the number of approximately evenly spaced sample points in the sampled area is n, with mineral thickness measurements d_{m_1}, d_{m_2} ... d_{m_n}, the the best estimate of mean thickness, $\bar{d}_m$, is given by

$$\sum (d_{m_1} + d_{m_2} \ldots d_{m_n})/n.$$

Block calculation

Scale: 1:25000
Block: Fictitious

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

Mean thickness
Overburden: 2.5m
Mineral: 6.5m

Volume
Overburden: 21 million m^3
Mineral: 54 million m^3

Confidence limits of the estimate of mineral volume at the 95 per cent probability level: ±20 per cent. That is, the volume of mineral (with 95 per cent probability): 54 ± 11 million m^3

Thickness estimate (measurements in metres)
d_o = overburden thickness d_m = mineral thickness

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

Calculation of confidence limits

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

$\Sigma(\omega d_m - \overline{\omega d_m})^2 = 15.82$

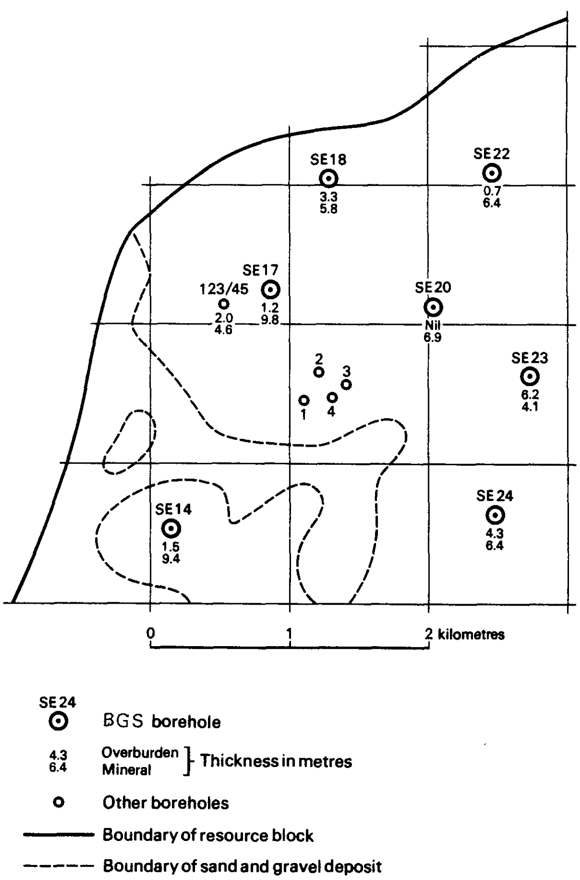
n = 8
t = 2.365
L_v is calculated as

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

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

$$= 20.3$$

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



Example of resource block assessment: map of a fictitious block

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

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

where d_m is any value in the series d_{m_1} to d_{m_n}.

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are usually small relative to those in thickness. The relationship $S_A/S_{\bar{d}_m} \leqslant 1/3$ is assumed in all cases. It follows from equation [2] that $S_{\bar{d}_m} \leqslant S_V \leqslant 1.05S_{\bar{d}_m}$.

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

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

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

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

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

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

$$[(1.05t)/\bar{d}_m]\times[\sqrt{\sum(d_m-\bar{d}_m)^2/n(n-1)}]\times 100 \text{ per cent,}$$

and when n is greater than 20, as

$$[(1.05\times 1.96)/\bar{d}_m]\times[\sqrt{\sum(d_m-\bar{d}_m)^2/n(n-1)}]\times 100 \text{ per}$$

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

11 The application of this procedure to a fictitious area is illustrated.

Inferred assessment
12 If the sampled area of mineral in a resource block is between $0.25km^2$ and $2km^2$ an assessment is inferred, based on geological and topographical information usually supported by the data from one or two boreholes. The volume of mineral is calculated as the product of the area, measured from field data, and the estimated thickness. Confidence limits are not calculated.

Speculative assessment
13 In some cases a resource block may include deposits for which little information is available or it may include an area within which mineral (as defined) is interpreted to be patchy or generally absent. If there is reason to believe that some mineral may be present, a speculative assessment may be made.

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

15 **Note on weighting** The thickness of a deposit at any point may be governed solely by the position of the point in relation to a broad trend. However, most sand and gravel deposits also exhibit a random pattern of local, and sometimes considerable, variation in thickness. Thus the distribution of sample points need be only approximately regular and in estimating the mean thickness only simple weighting is necessary. In practice, equal weighting can often be applied to thicknesses at all sample points. If, however, there is a distinctly unequal distribution of points, bias is avoided by dividing the sampled area into broad zones, to each of which a value roughly proportional to its area is assigned. This value is then shared between the data points within the zone as the weighting factor.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

For the purposes of assessing resources of sand and gravel a classification should take account of economically important characteristics of the deposits, in particular the absolute content of fines and the ratio of sand to gravel.

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (less than $\frac{1}{16}$ mm) and coarser than pebbles (more than 64 mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system a modified binary classification based on Willman (1942) has been adopted.

When the fines content exceeds 40 per cent the material is not considered to be potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel but qualified in the light of the fines content, as follows: less than 10 per cent fines - no qualification; 10 per cent or more but less than 20 per cent fines - 'clayey'; 20 to 40 per cent fines - 'very clayey'.

The term 'clay' (as written, with single quote marks) is used to describe all material passing $\frac{1}{16}$ mm. Thus it has no mineralogical significance and includes particles falling within the size range of silt. The normal meaning applies to the term clay where it does not appear in single quotation marks.

The ratio of sand to gravel defines the boundaries between sand, pebbly sand, sandy gravel and gravel (at 19:1, 3:1 and 1:1).

Thus it is possible to classify the mineral into one of twelve descriptive categories (see the figure at the end of this Appendix). The procedure is as follows:

1 Classify according to ratio of sand to gravel.

2 Describe fines.

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

Many differing proposals exist for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1974). 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

Classification of gravel, sand and fines

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

the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$-mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology, which is used in this report. It appears at the end of this Appendix.

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 (+$\frac{1}{16}$-$\frac{1}{4}$mm), medium (+$\frac{1}{4}$-1mm) and coarse (+1-4 mm). The boundary at 16mm distinguishes a range of finer gravel (+4-16 mm), often characterised by abundance of worn tough pebbles of vein-

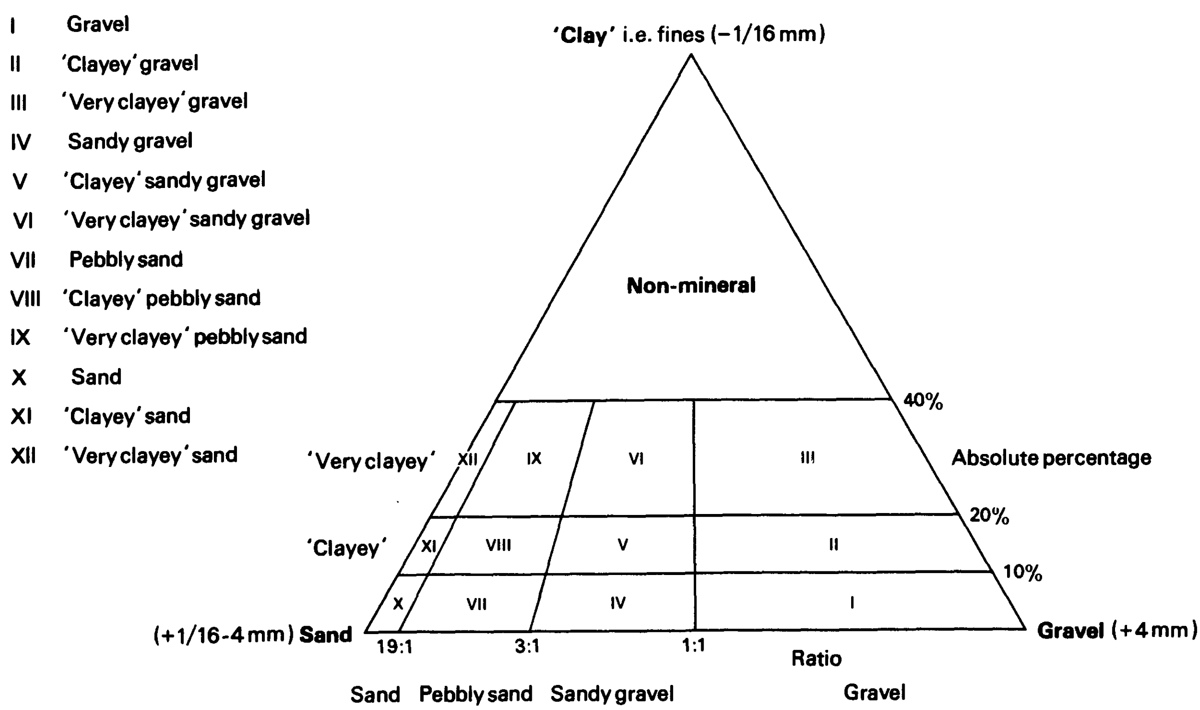


Diagram showing the descriptive categories used in the classification of sand and gravel quartz, from larger pebbles often of notably different materials. The boundary at 64mm distinguishes pebbles from cobbles. The term 'gravel' is used loosely to denote both pebble-sized and cobble-sized material.

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standard 1377:1975). In this report the grading is tabulated on the borehole record sheets (Appendix E), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on, as required. Original sample grading curves are available for reference at the appropriate office of BGS.

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 necesssary, when the laboratory results become available.

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'gabbro and schist' indicates very approximate equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'gabbro with schist' indicates that gabbro is dominant and schist, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constituents are referred to as 'trace'.

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

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

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

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

Rounded: original faces 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.

APPENDIX D

EXPLANATION OF THE ASSESSMENT ASSESSMENT RECORDS

NJ 91 NE 10 [1] **9588 1897** [2] **South Orrock, Belhelvie** [3] **Block K**

Surface level +83m [4]
Water not struck [5]
250 and 200mm percussion and shell [6]
September 1984

Overburden	0.2m [7]
Mineral I	3.3m
Waste	1.7m
Mineral II	1.3m
Waste	2.9m
Bedrock	0.4m+ [9]

LOG

Geological classification [10]	Lithology [11]	Thickness m	Depth [8] m
	Soil, clayey and sandy, pale brown	0.2	0.2
?Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine, with some cobbles, subangular to rounded, red and pink granite, basic igneous rocks and pink quartzite; some schist and grey granite Sand: medium with coarse and fine, angular quartz and rock Fines: silt and clay, loosely binding the deposit; reddish brown becoming moderate yellowish brown with depth	3.3	3.5
Glaciolacustrine deposits	Clay, sandy, moderate reddish brown, interlaminated with clayey silt; thin stringers of vein quartz and red granite pebbles	0.5	4.0
	Silt, clayey, sandy, laminated, reddish to olive brown, abundant pebbles (?dropstones) of granite, quartz and schist	1.2	5.2
Flow-till	b 'Very clayey' pebbly sand, cleaner with depth Gravel: fine and coarse, rounded, red quartzite and schist with some granite Sand: medium and coarse with fine, angular, quartz and rock Fines: silt and clay binding deposit, olive brown to dark yellowish brown	1.3	6.5
Till	Clay, sandy, very compact, brown. Angular pebbles of schist, brown (Devonian) sandstone, vein quartz and granite	2.9	9.4
Caledonian	Basic rock, hard, greenish black, possibly metamorphosed	0.4+	9.8

Grading

	Mean for Deposit percentages [14]			Depth below surface (m) [12]	percentages [13]						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	19	49	32	0.2- 1.2	14	20	27	12	17	10	0
				1.2- 2.5	30	11	24	14	11	10	0
				2.5- 3.5	11	11	12	16	18	26	6
				Mean	19	14	21	14	15	15	2
b	28	53	19	5.2- 6.0	37	10	27	16	8	2	0
				6.0- 6.5	14	12	20	21	14	19	0
				Mean	28	11	24	18	10	9	0
a&b	22	50	28	Mean	22	13	22	15	14	13	1

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

1 Borehole registration number
Each British Geological Survey (BGS) borehole or shallow pit is identified by a registration number. This consists of two statements.

1 The number of the 1:25 000 sheet on which the borehole lies, for example NJ 91
2 The quarter of the 1:25 000 sheet on which the borehole lies and its number in a series for that quarter for example NE 10

Thus the full registration number is NJ 91 NE 10.

2 The National Grid reference
All National Grid references in this publication lie within the 100-km square NJ & NO. Grid references are given to eight figures, accurate to within 10m for borehole locations. (In the text, six-figure grid references are used for more approximate locations, for example, for quarries.)

3 Location
The position of the borehole is referred to the nearest named locality on the 1:25 000 base map, usually followed by the name of the parish. The resource block in which it lies is also stated.

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

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

6 Type of drill and date of drilling
Modified shell and auger rigs were used in this survey. The drilling method, 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 Introduction). Mineral I is potentially workable sand and gravel; Mineral II is potentially workable till. Bedrock is the 'formation', 'country rock' or 'rock head' below which potentially workable sand and gravel will not be found. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8 Thickness and depth
All measurements were made in metres.

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

10 Geological classification
The geological classification is given whenever possible.

11 Lithological description
When sand and gravel is recorded a general description based on the mean grading characteristics (for details see Appendix C) is followed by more detailed particulars. The description of other rocks is based on visual examination, in the field.

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

13 Grading results
The results are expressed as per cent by weight passing on British Standard sieves whose aperture sizes are given in millimetres or fractions thereof.

14 Mean grading
The grading of the full thickness of the mineral deposit identified in the log is the mean of the individual sample gradings weighted by the thickness represented. The classification used is shown in the Table in Appendix C. Where two or more units of mineral are distinguished, the mean gradings for each is given in addition to the combined calculation for the log. For multiple mineral units, each is designated by a letter, for example, a, b, etc.

APPENDIX E

BRITISH GEOLOGICAL SURVEY BOREHOLE AND SHALLOW PIT RECORDS

NJ 61 NE 1 | **6881 1728** | **Rothens, Monymusk** | **Block B**

Surface level +94m
Water not struck
250 and 200mm percussion and shell
October 1984

Waste 7.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy and stony, yellow-brown; pebbles of quartzite, granite and basic igneous rocks, sand and gravel lens between 3.0 and 3.8m	6.8+	7.0
	Borehole terminated owing to slow progress		

NJ 61 NE 2 | **6815 1719** | **Tillywater, Monymusk** | **Block B**

Surface level +87m
Water struck at +84m
250 and 200mm percussion and shell
October 1984

Overburden 2.0m
Mineral I 8.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Sand and cobbles, clay bound	1.8	2.0
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine and coarse, subrounded granite with basic igneous rocks and felsite Sand: coarse and medium, subangular to subrounded quartz	8.3+	10.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	53	42	2.0- 3.0	15	4	17	14	19	31	0
			3.0- 5.5	6	7	27	27	14	19	0
			5.5- 7.5	2	4	14	24	30	26	0
			7.5- 8.5	3	3	22	26	33	13	0
			8.5-10.3	2	5	30	31	16	12	4
			Mean	5	5	23	25	21	20	1

NJ 61 NE 3 **6898 1658** **Delab, Monymusk** **Block B**

Surface level +93m
Water not struck
250 and 200mm percussion and shell
October 1984

Overburden 2.8m
Mineral II 4.2m
Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy and stony, brown to greyish brown, clasts of schists, quartzite, granitoids and quartz	2.5	2.8
	'Very clayey' sandy gravel Gravel: coarse and fine, granites and quartzites Sand: coarse and medium, subangular to subrounded quartz and granite fragments Fines: clay and silt, greyish brown	4.2	7.0
Caledonian	Granite, medium grained, grey; weathered to 7.8m	1.0+	8.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
34	45	21	2.8- 4.9	37	5	17	16	10	9	6
			4.9- 7.0	32	8	23	20	10	7	0
			Mean	34	7	20	18	10	8	3

NJ 61 NE 4 | 6877 1602 | **Gallowhill Wood, Monymusk** | **Block B**

Surface level +83m
Water struck at +82m
250 and 200mm percussion and shell
October 1984

Overburden 0.4m
Mineral I 6.1m
Waste 0.2m
Mineral I 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	a 'Clayey' pebbly sand Gravel: fine, subangular to rounded quartzite, granites and quartz Sand: coarse and medium, subangular to subrounded quartz and rock fragments	6.1	6.5
	Silt, sandy, laminated; some sand lenses	0.2	6.7
	b 'Clayey' sandy gravel Gravel: fine, subrounded to rounded quartzite and granite Sand: coarse, medium and fine, angular to subangular, quartz Fines: silt, greyish brown	1.3+	8.0
	Borehole terminated because of running sand		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	11	70	19	0.4- 3.0	6	8	31	38	13	4	0
				3.0- 5.0	15	8	27	26	21	3	0
				5.0- 6.5	14	10	26	37	13	0	0
				Mean	11	8	28	34	16	3	0
b	13	62	25	6.7- 8.0	13	14	21	27	24	1	0
a&b	11	70	19	Mean	11	9	27	34	17	2	0

NJ 61 NE 5 **6946 1741** **Blairdaff, Monymusk** **Block B**

Surface level +89m
Water struck at +87m
250 and 200mm percussion and shell
October 1984

Overburden 0.2m
Mineral I 1.6m
Waste 1.0m
Mineral I 5.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	a 'Clayey' pebbly sand Gravel: fine, subangular to rounded quartzite and granite Sand: coarse, medium and fine, subangular to subrounded quartz	1.6	1.8
	Peat, silty, medium brown	0.4	2.2
	Clay, silty, greyish brown	0.6	2.8
Fluvioglacial sand and gravel	b Gravel, coarsing downwards and cobbly at base Gravel: fine and coarse with cobble, subrounded to rounded quartzite, granite with quartz and schist Sand: coarse with medium, angular to subrounded quartz	5.2+	8.0
	Borehole terminated due to slow progress in cobble gravel		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	14	70	16	0.2- 1.0	16	18	30	30	6	0	0
				1.0- 1.8	11	12	29	23	17	8	0
				Mean	14	15	28	27	12	4	0
b	4	46	50	2.8- 3.8	3	2	14	42	33	6	0
				3.8- 4.8	4	3	8	32	37	16	0
				4.8- 5.8	2	4	12	30	27	17	8
				5.8- 7.0	6	7	13	19	21	23	11
				7.0- 8.0	No grading data available						
				Mean	4	4	12	30	29	16	5
a&b	6	52	42	Mean	6	7	16	29	25	13	4

NJ 61 NE 6 **6946 1563** **Enzean, Monymusk** **Block B**

Surface level +86m
Water not struck
250mm percussion and shell
October 1984

Overburden 1.3m
Mineral I 1.0m
Waste 9.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil and made ground	0.3	0.3
Till	Clay, sandy, pebbly, brown	1.0	1.3
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine with coarse, rounded granite Sand: medium and coarse, quartz	1.0	2.3
Glaciolacustrine deposits	Clay, silty, laminated, stiff, grey-brown	2.0	4.3
Till	Clay, sandy and pebbly, dark brown; pebbles of granite and schist	7.7+	12.0
	Borehole terminated due to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	78	17	1.3- 2.3	5	7	49	22	13	4	0

NJ 61 NE 7 | **6904 1726** | **East of Rothens, Monymusk** | **Block B**

Water struck at a depth of 5.5m
Section and pit
September 1984

Overburden 0.3m
Mineral I 6.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel, 'clayey' in parts Gravel: coarse and fine, subangular to subrounded granite with schist, quartzite and psammite Sand: coarse and medium, subangular to subrounded quartz, feldspar and lithic fragments	6.1+	6.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	47	48	0.3- 1.5	0	2	24	14	22	38	0
			1.5- 3.5	14	6	25	31	21	3	0
			3.5- 4.5	3	2	16	20	16	37	6
			4.5- 6.4	1	2	14	24	15	31	13
			Mean	5	3	20	24	19	24	5

NJ 61 SE 1 | **6792 1136** | **Tirrygowan, Cluny** | **Block D**

Water not struck
Pit
September 1984

Waste 1.8m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Sandy, silty and clayey, hard, yellowish brown; many angular clasts of granodiorite with boulders below 1.0m	1.4	1.8
Caledonian	Granodiorite, coarse grained, hard	0.1+	1.9

NJ 61 SE 2 **6878 1159** **Strath Wood, Cluny** **Block D**

Water not struck
Pit
September 1984

Waste	2.2m
Bedrock	0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Sandy clay, with sand lenses and clasts and boulders of gneiss and granodiorite	2.0	2.2
Caledonian	Granodiorite, coarse, grained, hard	0.1+	2.3

NJ 61 SE 3 **6943 1297** **Cunningar Wood, Cluny** **Block C**

Water not struck
Pit
September 1984

Overburden	0.2m
Mineral I	2.8m
Waste	0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a Pebbly sand Gravel: fine with coarse, subrounded to rounded granites and granodiorite with some quartzite and felsite Sand: coarse and medium, angular to subangular quartz and feldspar	1.0	1.2
	b Sand, medium and coarse, angular to subangular quartz and feldspar	1.8	3.0
Till	Clay, silty and sandy, yellowish olive-brown, with boulders of granodiorite	0.2+	3.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand				Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm	
a	2	75	23	0.2- 1.2	2	6	37	32	18	5	0	
b	1	95	4	1.2- 2.2	1	11	58	26	4	0	0	
				2.2- 3.0	2	18	57	20	3	0	0	
				Mean	1	14	58	23	4	0	0	
a&b	2	87	11	Mean	2	11	50	26	9	2	0	

NJ 61 SE 4 **6972 1172** **Burnside, Sauchen** **Block D**

Surface level +88m
Water not struck
250 and 200mm percussion and shell
October 1984

Overburden 1.2m
Mineral I 4.0m
Waste 5.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, sandy and silty, brownish grey and thin peaty layers; becoming increasingly sandy with depth	0.9	1.2
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine and coarse, angular to well rounded granite and quartzite Sand: medium and coarse, angular to subangular quartz and feldspar	4.0	5.2
Till	Clay, sandy, stony, grey-brown; pebbles of granite	4.5	9.7
Glacial sand and gravel	b Pebbly sand Gravel: fine, angular to subrounded granite Sand: fine to coarse, angular to subangular quartz, feldspar and rock fragments	0.6+	10.3
	Borehole terminated on rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	3	68	29	1.2- 2.2	7	3	20	24	20	26	0
				2.2- 3.2	4	4	47	31	8	6	0
				3.2- 4.2	1	15	25	35	17	7	0
				4.2- 5.2	1	5	27	36	21	10	0
				Mean	3	7	30	31	17	12	0
b	8	87	5	9.7-10.3	8	17	37	33	4	1	0
a&b	4	70	26	Mean	4	8	31	31	15	11	0

NJ 61 SE 5 **6904 1017** **Burnside, Sauchen** **Block D**

Surface level +106m
Water struck at +104.1m
250 and 200mm percussion and shell
October 1984

Overburden 7.9m
Mineral I 4.3m
Waste 2.5m
Mineral I 1.9m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, sandy, yellowish brown with sparse granite pebbles	2.7	2.9
Till	Clay, stony, firm, grey-brown; pebbles of quartzite	5.0	7.9
Glacial sand and gravel	a Sandy gravel Gravel: coarse and fine with cobble, angular to rounded granite Sand: coarse and medium, angular to subangular quartz	4.3	12.2
Till	b Clay, silty, yellow-brown with cobbles of granite; sandy between 13.3 and 13.9m	2.5	14.7
Glacial sand and gravel	c Pebbly sand Gravel: fine with coarse, angular to subrounded granite, metamorphic rocks and quartz Sand: medium and coarse, angular to subangular quartz and rock fragments	1.9	16.6
Caledonian	Granite, grey	0.2+	16.8

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	5	67	28	7.9-10.0	9	7	38	25	9	7	5
				10.0-12.2	1	6	29	30	10	19	5
				Mean	5	6	33	28	10	13	5
b	2	76	22	13.3-13.9	2	5	22	49	11	6	5
c	2	80	18	14.7-16.0	2	5	22	51	14	6	0
				16.0-16.6	2	8	27	49	9	5	0
				Mean	2	6	24	50	12	6	0
a&c	4	72	24	Mean	4	6	30	36	10	11	3
a-c	4	72	24	Mean	4	6	30	36	10	10	4

NJ 71 NW 1 **7099 1835** **Moss-side, Kemnay** **Block B**

Surface level +113m
Water not struck
250 and 200mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 1.6m
Waste 8.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	'Clayey' sandy gravel Gravel: fine, coarse and cobble, subrounded to rounded granite and schist Sand: fine to coarse, subangular to subrounded quartz and rock fragments Fines: silty, brown	1.6	1.8
Till	Clay, sandy with many boulders of granite and schist	8.7+	10.5
	Borehole terminated due to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	52	37	0.2- 1.8	11	10	17	25	14	8	15

NJ 71 NW 2 **7064 1761** **Red Moss, Blairdaff** **Block B**

Water struck at a depth of 1.5m
Pit
September 1984

Waste 2.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Peat, fiberous with twigs and bark, dark brown	2.4	2.4
Till	Clay, sandy and stony, greyish brown; pebbles of granite and metamorphic rocks	0.5+	2.9

NJ 71 NW 3 **7142 1893** **Gallowshill Wood, Kemnay** **Block A**

Water not struck
Pit
September 1984

Overburden 0.2m
Mineral II 3.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	'Clayey' sandy gravel Gravel: fine with coarse, subangular to rounded granite and schist with quartzo-feldspathic rock Sand: coarse to fine, angular to subangular quartz	3.1+	3.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
12	58	30	0.2- 3.3	12	16	21	21	20	10	0

NJ 71 NW 4 **7154 1772** **Overtown, Kemnay** **Block B**

Surface level +85m
Water struck at +83.2m
250 and 200mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 1.3m
Waste 0.1m
Mineral I 0.9m
Waste 10.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	a 'Clayey' pebbly sand Gravel: fine, subangular to rounded granite and quartz Sand: fine to coarse, angular to subrounded quartz	1.3	1.6
Fluvioglacial sand and gravel	Clay, sand, silty, laminated, grey-brown	0.1	1.7
	b 'Clayey' sandy gravel Gravel: fine and coarse, angular to subangular metamorphic rocks Sand: fine to coarse, angular to subangular quartz Fines: clay, silty and peaty, laminated	0.9	2.6
Glaciolacustrine deposits	Clay, silty and increasingly sandy with depth; pebbly at base	7.4	10.0
Till	Clay, silty, sandy, stony, brown; pebbles of granite and metamorphic rocks	3.0+	13.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	10	82	8	0.3- 1.6	10	28	27	27	8	0	0
b	12	63	25	1.7- 2.6	12	22	25	16	16	9	0
a&b	11	74	15	Mean	11	26	25	23	11	4	0

NJ 71 NW 5	**7122 1552**	**North of Nether Coulie, Kemnay**	**Block B**

Surface level +89m
Water not struck
250mm percussion and shell
October 1984

Waste	5.0m
Bedrock	0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy and stony, brown to grey-brown; pebbles and cobbles of igneous and metamorphic rocks and 'clayey' sand from 1.8 to 2.3m	4.7	5.0
Dalradian	Mica schist, grey, weathered	0.8+	5.8

NJ 71 NW 6 **7152 1502** **South of Nether Coulie, Kemnay** **Block B**

Surface level +76m
Water struck at +74.1m
250 and 200mm percussion and shell
September 1984

Overburden 0.1m
Mineral I 2.3m
Waste 0.5m
Mineral I 1.6m
Waste 9.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Alluvium	a Sandy gravel Gravel: fine and coarse, subangular to subrounded granite and schist with gneiss and quartz Sand: medium and coarse, subangular to subrounded quartz and rock fragments	2.3	2.4
?Till	Clay, sandy, stony; pebbles and cobbles of granite and schist	0.5	2.9
Glacial sand and gravel	b Gravel Gravel: coarse with fine and cobble, subrounded granite and schists Sand: fine to coarse, subangular to subrounded quartz and rock fragments	1.6	4.5
Glaciolacustrine deposits	Silt, sandy in places, micaceous, laminated, grey to grey-brown	7.8	12.3
Till	Clay, sandy, stony, brown to reddish brown; pebbles of granite, schist and quartz	2.1+	14.4
	Borehole abandoned due to rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
a	9	57	34	0.1– 1.1	10	8	20	13	23	26	0
				1.1– 2.4	8	10	36	24	9	13	0
				Mean	9	9	29	19	15	19	0
b	3	27	70	2.9– 4.5	3	5	10	12	16	43	11
a&b	6	44	50	Mean	6	7	21	16	15	30	5

NJ 71 NW 7 **7258 1972** **Burn Hurrie, Kemnay** **Block A**

Water not struck
Pit
September 1984

Overburden 1.4m
Mineral II 2.1m
Waste 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty and sandy, yellowish brown; pebbles and boulders of granite	1.2	1.4
	'Clayey' sandy gravel Gravel: fine and coarse, subrounded to well rounded granite and schist with some psammite and quartzite Sand: fine to coarse, subangular to subrounded Fines: silty, yellowish brown	2.1	3.5
	Clay, sandy and silty, grey and orange mottled	0.1+	3.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
17	62	21	1.4- 2.6	16	18	23	19	9	15	0
			2.6- 3.5	19	23	21	18	10	9	0
			Mean	17	20	23	19	9	12	0

NJ 71 NW 8 **7230 1954** **South of Burn Hurvie, Kemnay** **Block A**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 3.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Pebbly sand, sandy and 'clayey' in part Gravel: fine and coarse, subrounded to rounded granite and metamorphic rocks Sand: fine to coarse, subangular to subrounded quartz	3.7+	3.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
8	79	13	0.1– 0.9	8	11	32	29	11	9	0
			0.9– 1.6	6	20	57	15	2	0	0
			1.6– 3.8	8	17	36	25	10	4	0
			Mean	8	16	39	24	9	4	0

NJ 71 NW 9 **7253 1840** **Holylind, Kemnay** **Block A**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 4.2m
Waste 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel Gravel: fine to cobble, subrounded to well rounded granite, diorite with some schist Sand: medium and coarse, angular to subrounded quartz, feldspar and rock fragments	4.2	4.3
Till	Clay, silty and sandy with boulders and pebbles of igneous and metamorphic rocks	1.2+	5.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
4	40	56	0.1- 3.0	4	7	13	22	15	15	24
			3.0- 4.3	3	5	14	20	12	24	22
			Mean	4	6	13	21	14	18	24

NJ 71 NW 10 **7281 1715** **Broom Haugh, Kemnay** **Block B**

Surface level +83m
Water struck at +81.5m
250mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 1.3m
Waste 2.0m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse with cobble, subangular to subrounded granite with schist and quartz Sand: fine to coarse, subangular quartz and rock fragments	1.3	1.5
Till	Clay, sandy, stony, brown; pebbles of schist and granite	2.0	3.5
Caledonian	Granite, grey	0.2+	3.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	58	31	0.2- 1.5	11	14	26	18	12	12	7

NJ 71 NW 11 | 7202 1701 | **Netherton, Kemnay** | **Block B**

Water not struck
Pit
September 1984

Overburden 0.2m
Mineral II 2.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	'Clayey' pebbly sand Gravel: fine and coarse, subangular to well rounded diorite, granite and schist Sand: fine to coarse, angular to subangular quartz Fines: silty clay, yellowish brown	2.8 +	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
18	62	20	0.2- 3.0	18	24	21	17	11	8	1

NJ 71 NW 12 **7236 1636** **Boatleys, Kemnay** **Block B**

Surface level +78m
Water struck at +75.5m
250 and 200mm percussion and shell
September 1984

Overburden 0.4m
Mineral I 0.8m
Waste 0.5m
Mineral I 1.5m
Waste 3.1m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	a 'Very clayey' sand Sand: fine, subangular to subrounded quartz Fines: silt, brown; laminated below 0.9m	0.8	1.2
	Silt, sandy in parts, laminated, brown	0.5	1.7
	b 'Very clayey' pebbly sand Gravel: fine, subrounded granite and schist Sand: fine to coarse, subangular to subrounded quartz and rock fragments Fines: silty clay, brown	1.5	3.2
Till	Clay, sandy, stony, brown; pebbles and cobbles of granite and schist	3.1	6.3
Caledonian	Granite, grey	0.2+	6.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
a	31	68	1	0.4– 1.2	31	59	8	1	1	0	0
b	21	64	15	1.7– 3.2	21	27	22	15	13	2	0
a&b	24	66	10	Mean	24	39	17	10	9	1	0

NJ 71 NW 13 | **7240 1510** | **Miltown Croft, Kemnay** | **Block C**

Water not struck
Section and pit
September 1984

Mineral I 7.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial sand and gravel	Gravel Gravel: cobble and coarse with fine, angular to well rounded granite, gabbro, diorite, schist and quartzite Sand: coarse and medium, angular to subangular quartz and rock fragments	7.2+	7.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
0	28	72	0.0- 4.0	0	1	5	12	11	21	50
			4.0- 5.0	1	3	15	26	21	21	13
			5.0- 6.0	0	2	8	13	10	23	44
			6.0- 7.2	1	2	18	31	22	26	0
			Mean	0	2	9	17	14	22	36

NJ 71 NW 14 **7308 1541** **Home Farm, Kemnay** **Block C**

Surface level +88m
Water not struck
250 and 200mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 5.8m
Waste 0.6m
Mineral II 5.9m
Waste 0.8m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a Sandy gravel Gravel: cobble and coarse with fine, subrounded to well rounded granites, gabbro, schist with some quartzite and quartz Sand: coarse and medium angular to subangular quartz and feldspar	5.8	6.0
Till	Clay, sandy, stony, grey; pebbles of schist and granite	0.6	6.6
	b 'Clayey' sandy gravel Gravel: fine with coarse, angular to rounded igneous and metamorphic rocks Sand: fine to coarse, subangular to subrounded quartz Fines: silty clay, orange-browm	5.9	12.5
? Caledonian	'Clayey' pebbly sand, mainly angular coarse quartz and feldspathic sand; possibly weathered granite	0.8	13.3
Caledonian	Granite	0.3+	13.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	5	49	46	0.2- 1.5	2	3	25	15	11	13	31
				1.5- 3.0	0	3	18	18	13	17	31
				3.0- 4.0	7	9	24	18	12	12	18
				4.0- 6.0	9	13	33	15	10	12	8
				Mean	5	7	26	16	11	14	21
b	10	61	29	6.6- 7.8	10	15	31	20	7	17	0
				7.8-11.0	7	8	26	34	20	5	0
				11.0-12.5	16	4	16	24	21	7	12
				Mean	10	8	24	29	18	8	3
a&b	7	55	38	Mean	7	8	24	23	15	11	12

NJ 71 NW 15 **7359 1930** **Backhill, Kemnay** **Block A**

Surface level +66m
Water struck at +62.5m
250mm percussion and shell
October 1984

Overburden 2.5m
Mineral I 1.9m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, sandy, brown	1.5	1.8
Till	Clay, sandy, stony; pebbles and cobbles of granite, psammite and basic igneous rocks	0.7	2.5
Glacial sand and gravel	Pebbly sand Gravel: fine to cobble, subangular quartzite and granite Sand: medium and coarse, subangular quartz	1.9	4.4
Caledonian	Granite, coarse grained, grey	0.1+	4.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
3	75	22	2.5- 3.8	2	9	40	24	6	5	14
			3.8- 4.4	5	12	43	27	8	5	0
			Mean	3	10	40	25	7	5	10

NJ 71 NW 16 **7389 1764** **Loanend, Kemnay** **Block C**

Surface level +88m
Water struck at +81m
250 and 200mm percussion and shell
October 1984

Overburden 0.4m
Mineral I 6.3m
Waste 0.6m
Mineral I 8.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	a 'Very clayey' sandy gravel Gravel: fine and coarse, subangular to rounded granite with some basic igneous rocks Sand: fine to coarse, subangular to subrounded quartz Fines: silt	6.3	6.7
Till	Clay, sandy, cobbly	0.6	7.3
Glacial sand and gravel	b 'Clayey' pebbly sand Gravel: fine with coarse, angular granite, rounded schist and basic igneous rocks Sand: medium and coarse, angular to subangular quartz	4.7	12.0
	c Sandy gravel Gravel: fine and coarse, subrounded to rounded granite and schist Sand: medium and coarse, angular to subangular quartz and feldspar	3.3+	15.3
	Borehole abandoned due to running sand		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	33	41	26	0.4- 3.0	31	6	18	16	15	14	0
				3.0- 6.0	37	7	21	9	12	8	6
				6.0- 6.7	18	32	25	9	4	4	8
				Mean	33	9	20	12	12	10	4
b	11	74	15	7.3-10.0	14	9	29	31	11	6	0
				10.0-12.0	6	11	34	37	11	1	0
				Mean	11	10	31	33	11	4	0
c	4	62	34	12.0-13.0	6	6	23	31	15	10	9
				13.0-15.0	3	5	23	34	16	19	0
				15.0-15.3	9	6	27	41	14	3	0
				Mean	4	5	23	34	16	15	3
b&c	8	70	22	Mean	8	8	28	34	13	8	1
a-c	19	57	24	Mean	19	9	24	24	13	9	2

NJ 71 NE 2 **7861 1830** **Fullerton, Kintore** **Block F**

Surface level +48m
Water struck at +45.4m
250mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 4.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with cobble, subrounded to rounded granite and quartzite Sand: coarse and medium, angular to subrounded quartz and feldspar	4.7+	5.0

Borehole abandoned in rising sand and gravel

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
3	46	51	0.3- 1.3	9	5	20	16	19	31	0
			1.3- 2.6	1	2	15	32	19	18	13
			2.6- 5.0	2	4	18	26	22	22	6
			Mean	3	4	18	24	21	23	7

NJ 71 NE 3 **7863 1775** **Cairnhill, Kintore** **Block F**

Surface level c+61m
Water not struck
Section and pit
September 1984

Overburden 0.5m
Mineral I 5.2m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, subangular to well rounded granite with quartz, diorite, schist and quartzo-feldspathic rock Sand: medium and coarse, angular to subrounded quartz, feldspar and rock fragments	5.2	5.7
Till	Clay, sandy, silty, stony; pebbles and cobbles of granite	1.5+	7.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	65	34	0.5- 1.5	1	2	26	23	16	25	7
			1.5- 2.5	0	4	35	25	14	22	0
			2.5- 3.5	1	4	38	30	15	12	0
			3.5- 4.5	0	5	26	27	18	13	11
			4.5- 5.7	1	6	43	32	15	3	0
			Mean	1	4	33	28	16	15	3

NJ 71 NE 4	7788 1724	West of Black Hillock, Kintore	Block F

Water not struck
Section and pit
September 1984

Overburden 0.5m
Mineral I 7.0m
Waste 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sand and gravel, well bedded; no further data available	7.0	7.5
Till	Clay, sandy, stony, yellowish brown	2.0+	9.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
			0.5 - 7.5	No grading data available for this deposit						

NJ 71 NE 5 **7856 1591** **South of Springburn, Kintore** **Block F**

Surface level +57m
Water struck at +52.6m
250 and 200mm percussion and shell
September 1984

Overburden 0.4m
Mineral I 5.1m
Waste 5.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	'Clayey' pebbly sand, 'very clayey' sand to 1.4m Gravel: fine, subrounded granite Sand: fine to coarse, subangular to subrounded quartz, feldspar and rock fragments Fines: silt, dark brown	5.1	5.5
Till	Clay, sandy, stony; pebbles and cobbles of granite and schist	5.4+	10.9
	Borehole terminated due to rock obstruction		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
17	78	5	0.4- 1.4	29	12	42	14	2	1	0
			1.4- 2.4	14	29	33	19	4	1	0
			2.4- 3.4	17	11	44	21	6	1	0
			3.4- 4.4	8	34	44	12	2	0	0
			4.4- 5.5	15	9	39	32	5	0	0
			Mean	17	19	39	20	4	1	0

NJ 71 NE 6 **7920 1710** **Tavelty, Kintore** **Block F**

Surface level +46m
Water struck at +44.6m
250 and 200mm percussion and shell
October 1984

Overburden 1.4m
Mineral I 2.9m
Waste 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, yellowish brown	1.1	1.4
Fluvioglacial sand and gravel	Gravel Gravel: coarse with fine, subrounded to rounded granite and schist Sand: medium and coarse, subangular quartz, feldspar and rock fragments	2.9	4.3
Glaciolacustrine deposits	Clay, silty and sandy, grey-brown	1.5	5.8
Till	Clay, stony	1.5+	7.3
	Borehole terminated due to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	48	50	1.4- 2.4	3	8	23	24	19	23	0
			2.4- 3.4	1	4	14	16	26	35	4
			3.4- 4.3	1	10	30	17	12	30	0
			Mean	2	7	22	19	19	30	1

NJ 71 SW 1 **7037 1493** **North of Nether Mains, Kemnay** **Block B**

Surface level +80m
Water struck at +73.8m
250 and 200mm percussion and shell
September 1984

Overburden	0.2m
Mineral I	2.6m
Waste	3.4m
Mineral I	1.8m
Waste	5.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine, subrounded granite and schist Sand: fine to coarse, subangular to subrounded quartz	2.6	2.8
Till	Clay with cobbles	3.4	6.2
Glacial sand and gravel	b Gravel Gravel: coarse and fine Sand: fine to coarse, subrounded quartz	1.8	8.0
Till	Clay, silty, sandy, stony, brown	5.0+	13.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	11	53	36	0.2- 1.2	10	7	18	16	19	30	0
				1.2- 2.8	12	11	33	16	16	12	0
				Mean	11	9	28	16	17	19	0
b	8	42	50	6.2- 8.0	8	7	16	19	19	31	0
a&b	10	48	42	Mean	10	8	23	17	18	24	0

NJ 71 SW 2	7079 1438	Nether Mains, Kemnay	Block A

Water not struck
Pit
September 1984

Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty, sandy, stony; cobbles and boulders of granite and granodiorite	2.0+	2.2

NJ 71 SW 3	7009 1353	Nether Inver, Kemnay	Block C

Water not struck
Pit
September 1984

Overburden 0.4m
Mineral I 3.0m
Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	Pebbly sand, cobble gravel in part Gravel: fine, subangular granite Sand: medium and coarse, angular to subangular, quartz and feldspar	3.0	3.4
Caledonian	Granite, medium grained, well-jointed, brownish pink	1.2+	4.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
5	86	9	0.4– 3.4	5	7	42	37	8	1	0

NJ 71 SW 4 **7056 1198** **Schoolcroft, Cluny** **Block D**

Surface level +91m
Water struck at +90.7m
250mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 2.1m
Waste 4.2m
Bedrock 1.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	'Very clayey' pebbly sand Gravel: fine Sand: medium and coarse, subangular quartz Fines: silty clay, orange-brown	2.1	2.4
Till	Clay, sandy, stony, yellow to grey-brown; pebbles and cobbles of schist and granite	4.2	6.6
Caledonian	Granite, pink; weathered to 7.6m	1.7+	8.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
25	68	7	0.3- 2.4	25	7	35	26	5	2	0

NJ 71 SW 5 **7020 1086** **West of Gight, Sauchen** **Block D**

Surface level +96m
Water struck at +91.2m
250mm percussion and shell
October 1984

Overburden 1.2m
Mineral I 1.4m
Waste 4.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, sandy, stony, orange; cobbles of igneous rocks at base	1.0	1.2
Fluvioglacial sand and gravel	a 'Very clayey' sandy gravel Gravel: coarse and fine, subrounded quartzite, schist and some igneous rocks Sand: fine to coarse, angular to subangular quartz and rock fragments	1.4	2.6
Till	Clay, sandy, stony, yellow-brown	2.6	5.2
Glacial sand and gravel	b 'Very clayey' pebbly sand Gravel: fine and coarse, subrounded granite Sand: medium and coarse	0.5	5.7
Till	Clay, sandy, stony, brown; pebbles and cobbles of granite	1.0+	6.7
	Borehole terminated on rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	23	42	35	1.2- 2.6	23	4	20	18	13	17	5
b	21	71	8	5.2- 5.7	21	7	32	32	5	3	0
a&b	22	50	28	Mean	22	5	23	22	11	13	4

NJ 71 SW 6 **7152 1406** **South of Dalriach, Kemnay** **Block C**

Water struck at a depth of 5.0m
Pit
September 1984

Overburden 1.0m
Mineral I 4.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.0	1.0
Glacial sand and gravel	Gravel Gravel: fine, coarse and cobble, subangular to rounded granite, gabbro and schist with some quartzite and quartz Sand: coarse and medium, angular to subrounded quartz, feldspar and rock fragments	4.0+	5.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	45	53	1.0- 2.0	0	3	23	27	18	19	10
			2.0- 3.5	1	3	17	28	14	17	20
			3.5- 5.0	3	2	11	25	16	22	21
			Mean	2	3	16	26	16	19	18

NJ 71 SW 7 **7204 1431** **Craigearn, Kemnay** **Block C**

Water not struck
Pit
September 1984

Overburden 0.3m
Mineral I 1.8m
Waste 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: fine to cobble, subrounded to well rounded granite and diorite with some quartzite and schist Sand: medium and coarse, angular to subrounded quartz, feldspar and rock fragments	1.8	2.1
Till	Clay, sandy, silty, stony, olive grey; cobbles and pebbles of granite and diorite	0.9+	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1−4	+4−16	+16−64	+64 mm
2	48	50	0.3− 1.4	0	4	21	22	14	19	20
			1.4− 2.1	5	6	22	22	14	19	12
			Mean	2	5	21	22	14	19	17

NJ 71 SW 8 **7165 1330** **Backhill, Kemnay** **Block D**

Water not struck
Pit
September 1984

Waste 2.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy, stony, brown; pebbles and cobbles of granite and metamorphic rocks	2.6+	2.8

NJ 71 SW 9 **7238 1473** **North of Craigearn, Kemnay** **Block C**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 1.5m
Waste 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel Gravel: cobble with fine and coarse, subrounded to well rounded granite, schist and quartzo-feldspathic rocks Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments	1.5	1.6
Till	Clay, sandy, silty, stony, yellowish grey	0.8+	2.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
3	43	54	0.1- 1.6	3	5	20	18	9	15	30

NJ 71 SW 10 **7276 1387** **Tappies, Kemnay** **Block D**

Water not struck
Pit
September 1984

Overburden 0.2m
Mineral II 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Gravel, cobbles and boulders 1.5 - 2.0m Gravel: cobble with coarse and fine, angular to rounded granite, quartzite and basic igneous rocks Sand: fine to coarse, angular to subrounded quartz	1.8+	2.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	22	73	0.2- 2.0	5	5	9	8	9	18	46

NJ 71 SW 11 **7331 1452** **Wester Leschangie, Kemnay** **Block E**

Surface level +97m
Water struck at +93m
250 and 200mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 6.9m
Waste 7.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Sandy gravel Gravel: coarse and fine with cobble, subangular to subrounded granite with schist Sand: medium and coarse, subangular quartz and granite fragments	5.0	5.3
	b Sand, pebbly in part Gravel: fine, subangular to subrounded granite with schist Sand: mainly medium, subangular quartz	1.9	7.2
Glaciolacustrine deposits	c Silt, sandy, grey-brown; laminated in places	2.9	10.1
Till	Clay, sandy, stony, brownish grey; pebbles and cobbles of granite and schist	4.5+	14.6
	Borehole terminated on rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	5	70	25	0.3- 1.3	5	10	28	24	9	9	15
				1.3- 2.3	5	15	38	20	9	10	3
				2.3- 3.3	6	9	40	22	9	8	6
				3.3- 4.3	5	9	47	15	5	12	7
				4.3- 5.3	3	4	35	34	14	10	0
				Mean	5	9	38	23	9	10	6
b	8	88	4	5.3- 6.2	8	21	51	14	5	1	0
				6.2- 7.2	8	25	55	9	2	1	0
				Mean	8	23	54	11	3	1	0
c	49	51	0	7.2- 8.0	49	41	9	1	0	0	0
a&b	6	75	19	Mean	6	13	42	20	8	7	4
a-c	10	72	18	Mean	10	16	38	18	7	7	4

NJ 71 SE 1 **7776 1449** **Fordtown, Kintore** **Block F**

Surface level +69m
Water struck at +67.5m
250 and 200mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 3.6m
Waste 4.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse with fine and cobble, angular to subrounded granite, schist and quartz Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments	3.6	3.9
Till	Clay, sandy, gravelly, reddish brown; pebbles and cobbles of granite and metamorphic rocks	4.5+	8.4
	Borehole terminated due to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	48	47	0.3- 1.3	4	8	27	13	13	18	17
			1.3- 2.3	5	7	31	13	15	29	0
			2.3- 3.9	5	6	23	18	10	24	14
			Mean	5	7	26	15	12	24	11

NJ 71 SE 2	7856 1491	Gauchill, Kintore	Block F

Surface level +63m
Water struck at +61.1m
250 and 200mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 2.6m
Waste 3.4m
Mineral I 1.4m
Waste 0.6m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine and coarse, subrounded granite, schist with quartz Sand: medium and coarse, subangular to subrounded quartz, feldspar and granite fragments	2.6	2.8
Till	Clay, sandy, gravelly, brown; pebbles and cobbles of granite, schist and quartz	3.4	6.2
Glacial sand and gravel	b Pebbly sand Gravel: fine and coarse, subrounded granite and schist Sand: medium and coarse, subangular to subrounded quartz and granite fragments	1.4	7.6
	Clay, sandy, gravelly, yellowish brown; pebbles of granite	0.6	8.2
Caledonian	Granite	0.2+	8.4

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	69	30	0.2- 1.2	2	8	37	24	17	12	0
				1.2- 2.8	0	4	32	34	17	13	0
				Mean	1	6	33	30	17	13	0
b	6	72	22	6.2- 7.6	6	9	33	30	9	9	4
a&b	3	71	26	Mean	3	7	34	30	14	11	1

NJ 71 SE 3	7822 1323	South Womblehill, Kintore	Block E

Water struck at a depth of
3.0m
Pit
September 1984

Overburden 0.1m
Mineral I 2.9m
Waste 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel Gravel: fine to cobble, subrounded to well rounded granite, gabbro, schist, quartzo-feldspathic rock and quartzite Sand: coarse, angular to subangular quartz, feldspar and rock fragment	2.9	3.0
Till	Clay, sandy, silty, gravelly, grey; pebbles and cobbles of igneous and metamorphic rocks	2.0+	5.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	33	66	0.1- 3.0	1	2	7	24	20	15	31

NJ 71 SE 4 **7837 1294** **Aquherton, Kintore** **Block E**

Water struck at a depth of 2.0m
Pit
September 1984

Overburden 0.3m
Mineral I 1.0m
Waste 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, subrounded granite and some basic igneous rocks Sand: fine to coarse, angular to subangular quartz and feldspar	1.0	1.3
Till	Clay, sandy, stony, grey; cobbles of granite and granodiorite	1.0+	2.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
9	58	33	0.3- 1.3	9	15	28	15	11	17	5

NJ 71 SE 5 **7976 1493** **Nethermill, Kintore** **Block F**

Surface level +57m
Water struck at +53.6m
250mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 4.0m
Waste 1.1m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Sand, fine to coarse, subangular to subrounded quartz and angular to subangular granite fragments	4.0	4.3
Till	Clay, sandy, silty, yellow-brown; sparse granite cobbles	1.1	5.4
Caledonian	Granite, fine grained, grey	0.2+	5.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
8	88	4	0.3- 2.3	12	13	51	21	3	0	0
			2.3- 3.4	3	10	45	37	5	0	0
			3.4- 4.3	4	26	44	22	4	0	0
			Mean	8	15	47	26	4	0	0

NJ 71 SE 6 **7942 1273** **Greenmoss, Kintore** **Block E**

Water struck at a depth of 1.4m
Pit
September 1984

Overburden 0.3m
Mineral I 1.1m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse with cobble, subangular to subrounded granite, schist, diorite and quartz Sand: fine to coarse, subangular to subrounded quartz Fines: silty clay, brown	1.1	1.4
Till	Clay, sandy, stony, brownish grey; pebbles and cobbles of granite and metamorphic rocks	1.5+	2.9

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
15	48	37	0.3- 1.4	15	13	17	18	13	17	7

NJ 80 NW 1 | **8051 0553** | **Hatton, Skene** | **Block N**

Water not struck
Pit
October 1984

Overburden 0.2m
Mineral II 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	'Clayey' pebbly sand; boulders at base Gravel: fine with coarse, rounded to well rounded granite with quartzite and psammitic rocks Sand: fine to coarse, angular to subangular quartz and granite fragments Fines: silty clay, brown to orange-brown	1.8+	2.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
17	68	15	0.2- 1.2	14	22	33	18	10	3	0
			1.2- 2.0	20	15	25	22	10	8	0
			Mean	17	19	29	20	10	5	0

NJ 80 NW 2 | **8388 0615** | **East of Fiddie, Skene** | **Block I**

Water not struck
Pit
September 1984

Waste 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty, sandy, gravelly, yellow-brown; pebbles and cobbles of granite and gneiss, many well weathered	2.8+	3.0

NJ 80 NW 3 | **8402 0962** | **Rivehill, Skene** | **Block I**

Water not struck
Pit
September 1984

Waste 0.1m
Bedrock 1.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Caledonian	Granite, coarse grained, pink; rubbly to 1.0m, hard below	1.4+	1.5

NJ 80 NW 4 | **8479 0795** | **Borrowstone, Newhills** | **Block I**

Water struck at a depth of 1.3m
Pit
September 1984

Overburden 0.2m
Mineral II 1.1m
Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Sandy gravel Gravel: fine to cobble, subangular to rounded granite with quartzite and psammite Sand: fine to coarse, angular quartz and granite fragments	1.1	1.3
	Clay, sandy and silty, gravelly, grey; pebbles and cobbles of granite, quartzite and psammite	2.2+	3.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1−4	+4−16	+16−64	+64 mm
7	60	33	0.2− 1.3	7	18	25	17	12	9	12

NJ 80 NE 4 **8530 0657** **Westholme, Kingswells** **Block I**

Surface level +130m
Water struck at +121.3m
250 and 200mm percussion and shell
October 1984

Overburden 0.5m
Mineral I 3.0m
Waste 3.2m
Mineral I 3.8m
Waste 0.2m
Bedrock 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial sand and gravel	a Pebbly sand, gravelly at base Gravel: fine with coarse, angular to subrounded granite and schist with some quartz and dark igneous rocks Sand: fine to coarse, subangular to subrounded quartz and rock fragments	3.0	3.5
Till	Clay, sandy, silty, gravelly, brown	3.2	6.7
Glacial sand and gravel	b Sandy gravel, sandy at top Gravel: coarse and fine, subangular to subrounded granite and schist with dark igneous rocks Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments	3.8	10.5
Till	Clay, silty and pebbly, orange-brown; pebbles of weathered schist	0.2	10.7
Caledonian	Granite, very pale grey, highly weathered	1.6+	12.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	6	81	13	0.5- 3.0	5	20	50	16	8	1	0
				3.0- 3.5	10	12	24	23	20	11	0
				Mean	6	19	45	17	10	3	0
b	9	59	32	6.7- 8.0	14	9	28	38	7	4	0
				8.0- 9.0	3	8	15	19	21	25	9
				9.0-10.0	5	7	26	23	16	23	0
				10.0-10.5	13	6	22	26	16	17	0
				Mean	9	8	23	28	14	16	2
a&b	7	70	23	Mean	7	13	34	23	12	10	1

NJ 80 SW 2 | 8081 0455 | **Woodside, Skene** | **Block N**

Water not struck
Pit
October 1984

Overburden 0.2m
Mineral I 1.2m
Bedrock 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a 'Clayey' gravel Gravel: coarse with fine and cobble, subangular to well rounded granite, psammite and quartzite with some schist and fine grained dark igneous rock Sand: fine to coarse, angular to subangular quartz amd granite fragments	1.2	1.4
Caledonian	b 'Clayey' sandy gravel (weathered granite bedrock) Gravel: coarse and fine, angular granite Sand: fine to coarse, angular quartz and feldspar Fines: silty clay and mica flakes, pale brown	2.2+	3.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	10	36	54	0.2- 1.4	10	11	14	11	11	36	7
b	14	48	38	1.4- 3.6	14	16	21	11	9	29	0
a&b	13	44	43	Mean	13	14	19	11	10	31	2

NJ 80 SW 3 **8082 0104** **West Wardmill, Drumoak** **Block N**

Surface level +59m
Water encountered at +55.5m
250 and 200mm percussion and shell
October 1984

Waste 6.8m
Bedrock 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Very clayey' sandy gravel Gravel: fine and coarse, subrounded to rounded granite and schist Sand: fine to coarse, angular quartz and dark rock fragments Fines: silty clay, orange-brown	0.7	1.0
	Clay, silty, sandy, stony, yellowish brown; pebbles and cobbles of granite, schist and dark igneous rocks	5.8	6.8
Caledonian	Granite, medium grained, reddish; weathered at top	0.6+	7.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
22	54	24	0.3- 1.0	22	14	20	20	11	13	0

NJ 80 SW 4 **8152 0205** **Easter Auguston, Peterculter** **Block N**

Surface level +60m
Water struck at +58.1m
250mm percussion and shell
October 1984

Overburden 0.5m
Mineral I 2.8m
Waste 6.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial sand and gravel	Sandy gravel Gravel: fine and coarse, subangular to rounded granite Sand: medium and coarse, angular to subangular quartz and feldspar	2.8	3.3
Till	Clay, sandy, stony, grey-brown	6.4+	9.7
	Borehole terminated on rock obstruction		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
4	72	24	0.5- 1.5	1	4	36	43	12	4	0
			1.5- 2.5	4	7	32	31	11	15	0
			2.5- 3.3	7	10	33	18	14	6	12
			Mean	4	7	33	32	12	9	3

NJ 80 SW 5 **8296 0160** **West Craigton, Peterculter** **Block N**

Water struck at a depth of 4.8m
Section and pit
September 1984

Overburden 0.2m
Mineral I 2.8m
Mineral II 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a Gravel Gravel: fine and coarse with cobble, subangular to rounded granite and psammite with quartzite, felsite and diorite Sand: mainly coarse, angular to subangular quartz	2.8	3.0
Till	b 'Clayey' sandy gravel Gravel: fine and coarse with cobble, subangular to well rounded schist and psammite with granite Sand: fine to coarse, angular to subangular quartz, feldspar and rock fragments	3.0+	6.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	19	80	0.2- 3.0	1	1	5	13	33	31	16
b	18	45	37	3.0- 4.8	18	8	21	18	16	19	0
				4.8- 6.0	17	7	18	19	15	14	10
				Mean	18	8	19	18	16	17	4
a&b	10	33	57	Mean	10	4	13	16	23	24	10

NJ 80 SW 6 **8333 0008** **West of Burnside, Peterculter** **Block N**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 0.9m
Waste 4.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Sandy gravel Gravel: fine with coarse, subangular to subrounded granite with psammite, schist and some quartzite Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments	0.9	1.0
Till	Clay, sandy, stony, orange-brown; pebbles and cobbles of granite, psammite and schist and lens of sand and gravel between 5.1 and 5.5m	4.6+	5.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	58	41	0.1- 1.0	1	2	25	31	30	11	0

NJ 80 SW 7	**8466 0424**	**East of East Brotherfield, Peterculter**	**Block N**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 3.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel Gravel: fine to cobble, subangular to subrounded granite and gneiss with quartzite and psammite Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments	3.2+	3.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
8	36	56	0.1- 3.3	8	3	12	21	12	23	21

NJ 80 SW 8 | **8443 0417** | **South of East Brotherfield, Peterculter** | **Block N**

Water not struck
Pit
September 1984

Overburden 0.2m
Mineral I 1.0m
Waste 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	'Clayey' gravel Gravel: fine to cobble, subangular to subrounded granite and gneiss with some quartzite and psammite Sand: coarse and medium, angular to subangular quartz, feldspar and rock fragments Fines: silty, yellow-brown	1.0	1.2
Till	Clay, silty, sandy, stony; cobbles of granite and gneiss	1.3+	2.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
13	22	65	0.2- 1.2	13	2	9	11	11	22	32

NJ 80 SE 1 **8582 0082** **Camp Hill, Peterculter** **Block O**

Surface level +15m
Water struck at +12.3m
250 and 200mm percussion and shell
October 1984

Overburden 0.4m
Mineral I 10.9m
Waste 0.2m
Mineral I 2.8m
Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	a Pebbly sand, gravel to 0.8m Gravel: fine and coarse, subrounded to well rounded granite and schist with quartz Sand: mainly medium, subangular to subrounded quartz	1.3	1.7
	b Sandy gravel Gravel: fine and coarse, subangular to rounded granite, schist, psammite and quartz Sand: medium and coarse, angular to subrounded quartz, feldspar and rock fragments	9.6	11.3
	Clay with pebbles	0.2	11.5
	c Gravel Gravel: coarse with fine and cobble, subangular to well rounded granite, schist and psammite with some dark igneous rocks Sand: medium and coarse, subangular to subrounded quartz, feldspar and rock fragments	2.8	14.3
Caledonian	Granite, weathered	1.2+	15.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	78	21	0.4- 0.8	2	7	31	8	7	29	16
				0.8- 1.7	1	15	74	4	2	4	0
				Mean	1	13	60	5	4	12	5
b	1	57	42	1.7- 2.7	2	7	27	23	20	16	5
				2.7- 3.7	0	3	24	29	20	17	7
				3.7- 4.8	1	3	24	29	19	24	0
				4.8- 6.0	2	5	30	31	17	15	0
				6.0- 7.0	2	6	35	20	14	23	0
				7.0- 8.0	1	5	29	13	21	31	0
				8.0- 9.0	2	5	39	12	18	17	7
				9.0-10.0	1	2	30	21	22	24	0
				10.0-11.3	1	2	35	23	17	22	0
				Mean	1	4	30	23	19	21	2
c	2	42	56	11.5-12.5	1	6	19	18	12	22	22
				12.5-13.5	2	3	15	22	16	42	0
				13.5-14.3	4	3	18	23	19	33	0
				Mean	2	4	17	21	15	33	8
a-c	2	56	42	Mean	2	5	30	21	17	22	3

NJ 80 SE 2 **8606 0359** **West of Hilton, Peterculter** **Block N**

Water not struck
Pit
September 1984

Overburden 0.2m
Mineral II 1.8m
Waste 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	'Clayey' sandy gravel Gravel: fine and coarse, angular psammite with subrounded to well rounded boulders of quartzite and psammite Sand: fine to coarse, angular to subangular quartz, feldspar and rock fragments Fines: silty clay, yellow-brown	1.8	2.0
	Clay, sandy and silty with psammite rubble	0.2+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
12	63	25	0.2– 2.2	12	14	20	29	14	11	0

NJ 80 SE 3	8675 0297	Hillhead, Peterculter	Block N

Water not struck
Pit
September 1984

Waste 2.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty and sandy, stony, yellow-brown; pebbles and cobbles of granite and metamorphic rocks	2.5+	2.8

NJ 80 SE 4	8633 0148	Milltimber	Block O

Surface level +42m
Water not struck
250mm percussion and shell
October 1984

Overburden 0.4m
Mineral I 3.1m
Waste 5.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, subangular to well rounded granite, psammite, schist and quartzite Sand: fine to coarse, subangular to rounded quartz and feldspar	3.1	3.5
Till	Clay, silty, stony, yellowish brown; pebbles and cobbles of granite, felsite, schist and psammite	5.5+	9.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	63	32	0.4- 2.5	5	18	26	19	13	19	0
			2.5- 3.5	5	27	28	9	9	14	8
			Mean	5	21	26	16	12	17	3

NJ 80 SE 5 **8770 0168** **East of Beechwood, Bieldside** **Block O**

Surface level +43m
Water not struck
250mm percussion and shell
October 1984

Overburden 0.5m
Mineral I 1.4m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine and coarse, subangular to rounded granite, quartzite and psammite Sand: medium and coarse, subangular to subrounded quartz, feldspar and rock fragments	1.4	1.9
Caledonian	Diorite (?), dark, very hard	0.2+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
9	56	35	0.5- 1.9	9	3	24	29	18	13	4

NJ 80 SE 6   8785 0109   **Maidenfold, Maryculter**   **Block 0**

Water struck at a level of 5.7m
Section and Pit
October 1984

Mineral 5.9m
Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Fluvioglacial sand and gravel	a Gravel Gravel: fine to cobble, rounded to well rounded granite with psammite and quartzite; some felsite and subangular to subrounded pelitic rocks Sand: medium and coarse, angular to subangular quartz, granite and fine mica	3.0	3.0
	b 'Clayey' sandy gravel; clean at top, 'clayey' at base Gravel: fine and coarse, rounded to well rounded granite and quartzite with psammite and pelite Sand: fine to coarse, angular to subangular quartz and granite	2.9	5.9
Caledonian	Granite, coarse grained, well-jointed, pinkish	0.8+	6.7

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	41	58	0.0- 3.0	1	4	18	19	20	25	13
b	10	54	36	3.0- 4.5	2	8	25	26	21	13	5
				4.5- 5.9	18	16	19	14	11	22	0
				Mean	10	12	22	20	16	17	3
a&b	5	48	47	Mean	5	8	20	20	18	21	8

NJ 80 SE 7 8710 0084 **Kintewline, Maryculter** **Block P**

Surface level +45m
Water not struck
250mm percussion and shell
November 1984

Waste 5.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy and stony, brown; pebbles and cobbles of granite and schist	5.2+	5.5
	Borehole terminated on rock obstruction, possibly bedrock		

NJ 80 SE 8 8827 0170 **Newton Dee, Bieldside** **Block O**

Surface level +10m
Water struck at +8.2m
250 and 200mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 7.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel 'clayey' at top Gravel: coarse with fine and cobble, rounded to wellrounded granite and quartzite with some schist, psammite and dark igneous rocks Sand: medium and coarse, angular to subangular quartz and rock fragments	7.7+	8.0
	Borehole terminated at 8.0m, unable to pass rock obstruction		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	45	53	0.3- 1.3	5	6	34	8	9	38	0
			1.3- 1.8	12	3	12	27	21	22	3
			1.8- 2.8	1	1	24	12	20	38	4
			2.8- 3.8	1	1	16	17	15	35	15
			3.8- 4.8	1	1	27	22	20	25	4
			4.8- 5.8	1	1	20	18	23	37	0
			5.8- 6.8	1	3	34	21	18	18	5
			6.8- 8.0	1	3	29	24	24	13	6
			Mean	2	2	25	18	19	29	5

NJ 80 SE 9 **8845 0111** **Blairs College, Maryculter** **Block O**

Water struck at a depth of 5.5m
Section and pit
October 1984

Overburden 0.3m
Mineral I 4.7m
Waste 3.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, rounded to well-rounded granite with quartzite, psammite and some pelitic rocks Sand: medium and coarse, angular to subangular quartz and granite fragments	4.7	5.0
Glaciolacustrine deposits	Clay, sand, silty, laminated, grey- to orange-brown	1.7	6.7
Till	Clay, pebbly, grey to grey-brown; pebbles and cobbles of granite, psammite and dark igneous rock	1.5+	8.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	47	52	0.3- 1.3	1	3	20	27	18	31	0
			1.3- 2.0	1	3	22	18	18	24	14
			2.0- 5.0	No grading data available						
			Mean	1	3	21	23	18	28	6

NJ 81 NW 3 | **8004 1599** | **Hindland, Kintore** | **Block H**

Surface level +47m
Water struck at c+44.6m
250 and 200mm perucssion and shell
September 1984

Overburden 2.8m
Mineral I 2.1m
Waste 0.2m
Mineral I 3.8m
Waste 11.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt, sandy, dark brown with lenses of micaceous fine sand. A bed of silty fine sand below 2.4m	2.8	2.8
Fluvioglacial sand and gravel	a Sandy gravel Gravel: mainly fine, subrounded to well rounded, red and grey granite with some quartz and quartzite Sand: mainly coarse and medium, angular to subrounded, quartz and rock	2.1	4.9
Peat	Peat, silty dusky brown and silty clay greenish grey	0.2	5.1
Fluvioglacial sand and gravel	b Gravel Gravel: fine with coarse, subangular to well rounded, grey granite with some red granite, quartz and quartzite Sand: coarse with medium and fine, angular to subrounded, quartz and rock with some mica Fines: silt, laminated, yellowish grey	0.8	5.9
Glaciolacustrine deposits	c 'Very clayey' sand Sand: mainly fine, rounded quartz and mica Fines: silt and clay, laminated, yellowish brown	3.0	8.9
	Silt, sandy, micaceous, laminated, interbedded with fine quartz sand; yellowish brown. A bed of finely laminated silty clay at 18.5m	11.1+	20.0
	Borehole abandoned owing to slow progress		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	3	54	43	2.8- 3.8	5	11	20	25	37	2	0
				3.8- 4.9	2	8	19	26	38	7	0
				Mean	3	9	19	26	38	5	0
b	7	45	48	5.1- 5.9	7	10	14	21	32	16	0
c	22	78	0	5.9- 8.9	22	75	2	1	0	0	0
a&b	4	52	44	Mean	4	10	18	24	36	8	0
a-c	13	65	22	Mean	13	43	10	12	18	4	0

NJ 81 NW 4 **8089 1576** **South of Wester Fintray, Fintray** **Block H**

Surface level +54m
Water struck at c+44m
250 and 200mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 8.0m
Waste 12.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, brown	0.3	0.3
Glacial sand and gravel	a Sand, with sparse rounded granite pebbles to 3.3m Sand: mainly medium, subangular to subrounded, quartz and feldspar with some rock Fines: silt, disseminated, light brown	4.0	4.3
	b 'Clayey' sand Sand: mainly fine, subangular to subrounded, quartz with some feldspar, rock and mica Fines: silt and clay, light brown; in thin seams, especially towards the base	4.0	8.3
Glaciolacustrine deposits	c Silt, clayey, very sandy below 9.3m, laminated, light brown	1.7	10.0
	Silt, sandy, brownish grey, micaceous; partings of fine quartz sand	11.0+	21.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	2	95	3	0.3- 1.3	1	13	65	15	6	0	0
				1.3- 2.3	2	25	60	11	2	0	0
				2.3- 3.3	2	21	62	11	4	0	0
				3.3- 4.3	2	22	73	3	0	0	0
				Mean	2	20	65	10	3	0	0
b	15	85	0	4.3- 5.3	10	72	18	0	0	0	0
				5.3- 6.3	12	79	9	0	0	0	0
				6.3- 7.3	12	82	5	1	0	0	0
				7.3- 8.3	26	70	4	0	0	0	0
				Mean	15	76	9	**	0	0	0
c	55	45	0	8.3- 9.3	67	31	2	0	0	0	0
				9.3-10.0	36	61	3	0	0	0	0
				Mean	55	43	2	0	0	0	0
a&b	8	91	1	Mean	8	49	37	5	1	0	0
a-c	16	83	1	Mean	16	48	31	4	1	0	0

NJ 81 NW 5	**8182 1867**	**Peathill,** Kinmuck	**Block G**

Surface level +63m
Water struck at c+59m
250 and 200mm percussion and shell
October 1984

Waste 4.4m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Clayey' sand and sandy clay, dark brown, with granitic and quartzite clasts, up to boulder size; becoming grey, pebbly and stiff below 2.9m	3.7	4.0
Glacial sand and gravel	Sandy gravel Gravel: fine with coarse, granitic and basic igneous rocks Sand: mainly coarse rock and quartz	0.4	4.4
? Caledonian	Granite, badly weathered, coarse grained, grey	0.1+	4.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	59	39	4.0- 4.4	2	2	14	43	23	16	0

NJ 81 NW 6	**8254 1842**	**North of Burngrains,** Kinmuck	**Block G**

Water not struck
Pit
September 1984

Waste 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Sand, clayey, stiff, mainly decomposed schist, pale yellowish brown with angular clasts up to boulder size	1.9+	2.0
	Pit abandoned owing to rock obstruction, possibly on schist bedrock		

NJ 81 NW 7 | **8294 1767** | **West of Castlehungry, Fintray** | **Block H**

Water struck at 3.0m depth
Pit
September 1984

Overburden 0.5m
Mineral I 1.5m
Waste 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy and pebbly	0.5	0.5
Glacial sand and gravel	Gravel Gravel: coarse with some fine, cobbles at the base; subrounded to well rounded granite, schist, gneiss and some quartzite Sand: coarse and medium with some fine, angular to subrounded rock and quartz Fines: silt and clay, brown, disseminated	1.5	2.0
Till	Clay, sandy and silty, firm, olive to medium grey, clasts up to boulder size	1.0+	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
2	33	65	0.5– 2.0	2	5	12	16	17	38	10

NJ 81 NW 8 **8249 1662** **Newton of Fintray, Fintray** **Block H**

Water struck at c2.5m depth
Pit
September 1984

Overburden 0.1m
Mineral I 2.0m
Waste 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.1	0.1
Glaciolacustrine deposits	Sand; with horizontal lamination Sand: mainly fine, quartz and mica Fines: silt and clay, disseminated and as finely laminated partings and drapes; yellowish brown mottled with orange and grey	2.0	2.1
	Clay, silty, firm, finely laminated in part and interbedded with silty, fine, micaceous sand	1.6+	3.7
	Stiff clay at the base of the pit, probably resting on bedrock surface		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
4	96	0	0.1- 1.4	3	84	13	0	0	0	0
			1.4- 2.1	6	87	7	0	0	0	0
			Mean	4	85	11	0	0	0	0

NJ 81 NW 9 **8268 1606** **Milton of Fintray, Fintray** **Block H**

Surface level +45m	Overburden	1.8m
Water struck at c+43.5m	Mineral I	2.8m
250 and 200mm percussion and shell	Waste	12.4m+
September 1984		

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty clay, pale yellowish brown	0.2	0.2
Alluvium	Clay and silt, firm; mottled dark yellowish brown and moderate olive brown	1.3	1.5
Peat	Peat, fibrous organic matter, dusky brown	0.3	1.8
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine, angular to rounded, pink granite, quartz, feldspar and quartzite, some angular schist Sand: mainly coarse, angular to rounded, quartz, feldspar and rock Fines: silt, sandy, greenish black and humic, dark brown. Thin seams, especially from 1.8 to 2.9m	2.8	4.6
Glaciolacustrine deposits	Silt, sandy, micaceous, greyish olive green becoming brownish olive grey below 5.2m. Beds of laminated clayey silt from 5.5m and poorly laminated silty clay below 9.0m	12.4+	17.0
	Borehole abandoned owing to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	73	22	1.8- 2.9	9	2	9	61	19	0	0
			2.9- 3.9	1	2	12	61	24	0	0
			3.9- 4.6	3	5	15	54	23	0	0
			Mean	5	3	12	58	22	0	0

NJ 81 NW 10 **8333 1700** **Hattonfaulds, Fintray** **Block H**

Water not struck
Pit
September 1984

Overburden 0.1m
Mineral I 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel; fining downwards, poorly bedded below 1.1m Gravel: coarse and fine, with cobbles to 2.1m, subangular to well rounded, schist with pink granitic rock and some quartzite Sand: mainly coarse and medium, angular to subrounded, quartz with feldspar Fines: deposit loosely bound above 1.1m, silt and clay, yellowish brown	3.0+	3.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	44	54	0.1- 1.1	3	4	15	19	13	19	27
			1.1- 2.1	1	2	20	23	20	22	12
			2.1- 3.1	1	2	19	29	22	27	0
			Mean	2	3	18	23	18	23	13

NJ 81 NW 11 **8352 1639** **Mill of Fintray, Fintray** **Block H**

Water not struck	Overburden 0.2m
Pit and 250mm percussion shell	Mineral I 3.0m
September 1984	?Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	Gravel, boulders at the base Gravel: cobbles with coarse and fine, subangular to subrounded granite and psammite Sand: mainly medium, angular to subangular quartz and feldspar with some rock Fines: silt, disseminated	3.0	3.2
? Caledonian	? Granite	0.3+	3.5
	Borehole terminated owing to rock obstruction, probably bedrock		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	31	68	0.2- 1.4	0	2	19	9	11	20	39
			1.4- 3.2	1	3	16	12	10	24	34
			Mean	1	3	17	11	10	22	36

NJ 81 NW 12 **8453 1621** **Hatton of Fintray, Fintray** **Block H**

Surface level +54m
Water not struck
250mm percussion shell
September 1984

Overburden 0.4m
Mineral II 9.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Till	'Clayey' sandy gravel, compact, finer below 4.7m Gravel: fine and coarse, granite and psammite Sand: medium and coarse with some fine, quartz and rock Fines: silt and clay, disseminated, greyish brown, much being washed out.	9.6+	10.0

Borehole terminated owing to slow progress

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
16	64	20	0.4- 1.5	15	6	22	24	16	17	0
			1.5- 2.5	16	10	22	19	19	14	0
			2.5- 3.5	9	12	18	19	26	16	0
			3.5- 4.7	19	7	20	20	17	17	0
			4.7- 5.7	16	15	35	20	12	2	0
			5.7-10.0	16	17	37	24	5	1	0
			Mean	16	13	29	22	12	8	0

NJ 81 NE 1 **8558 1562** **North of Beidleston, Dyce** **Block H**

Surface level +44m
Water struck at c+41.8m
250 and 200mm percussion and shell
September 1984

Overburden 1.9m
Mineral I 3.9m
Waste 16.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, dark yellowish brown	0.1	0.1
Alluvium	Silt, sandy firm, moderate brown to moderate yellowish brown	1.8	1.9
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine, subangular granite, schist and vein quartz Sand: mainly coarse, angular to rounded quartz with pelite Fines: disseminated, moderate yellowish brown, becoming olive grey below 2.2m	3.9	5.8
Glaciolacustrine deposits	Silt, sandy to 8.9m becoming more clayey and finely laminated with depth, micaceous; light olive brown becoming light olive grey below 10.0m. A thin bed of silty sand at 6.0m	16.2+	22.0
	Borehold abandoned owing to slow progress (below potentially workable depth)		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
3	86	11	1.9- 4.0	2	6	40	41	11	0	0
			4.0- 5.8	4	4	45	36	11	0	0
			Mean	3	5	42	39	11	0	0

NJ 81 NE 2 **8649 1586** **Logie Farm, Fintray** **Block H**

Surface level +69
Water not struck
250mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 1.0m
Waste 2.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	'Clayey' pebbly sand Gravel: mainly coarse Sand: mainly fine and medium, subangular to subrounded quartz Fines: mainly silt, brownish orange	1.0	1.3
Till	Clay, sandy and silty, mottled olive grey and brownish orange; rounded schist pebbles to 1.6m, clasts up to boulder size of pelite, psammite and granite; beds of finely laminated brown silty clay below 1.6m	2.1+	3.4
	Borehole terminated owing to rock obstruction, possibly bedrock		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
12	76	12	0.3- 1.3	12	37	34	5	1	11	0

NJ 81 NE 3 **8728 1924** **Woodside, New Machar** **Block G**

Water struck at c1.8m depth
Pit
September 1984

Waste 2.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy, silty, gravelly, firm, mottled medium grey and orange becoming bluish grey, very sandy and poorly bedded below 1.3m. Angular and rounded clasts up to boulder size of pelite, psammite and granite	2.6+	2.8

NJ 81 NE 4 **8749 1663** **Causewayend, New Machar** **Block G**

Water not struck
Pit
September 1984

Waste 2.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Morainic drift	Clay, very sandy, stiff, pale brown, becoming silty sand, pale yellowish brown below 1.5m. Angular and rounded granitic clasts, up to large boulder size	2.2+	2.4
	Pit terminated owing to rock obstruction, possibly granitic bedrock		

NJ 81 NE 5 **8756 1529** **St. Fergus's Church, Dyce** **Block H**

Surface level +53m
Water not struck
Pit and 250mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 3.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, with large boulders, dark brown	0.3	0.3
Glacial sand and gravel	Gravel, very poorly sorted, virtually unstratified Gravel: mainly cobbles, boulders and coarse pebbles, well rounded to angular, grey granite, basic igneous rock and psammite Sand: mainly coarse with some medium, angular quartz with rock Fines: disseminated, brownish orange	3.2+	3.5
	Borehole and pit terminated owing to slow progress caused by large boulders retrived at bottom of pit		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	27	71	0.3- 3.5	2	2	10	15	15	28	28

NJ 81 NE 6 **8708 1529** **Liddell's Monument, Dyce** **Block H**

Water not struck
Section and pit
November 1984

Overburden 1.0m
Mineral I 15.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
? Till	Sand, clayey. Clasts up to boulder size. (Deposit absent locally)	0.7	1.0
Glacial sand and gravel	a Gravel, poorly bedded, boulders at the top Gravel: cobble, coarse and fine, subangular to subrounded, grey and pink granite, gneiss and psammite, with some quartzite, quartz, gabbro and schist Sand: mainly medium and coarse, angular to subangular quartz, feldspar and rock	10.0	11.0
	b 'Clayey' sand, cross-bedded above 15.0m Sand: mainly medium and fine, angular to subangular, quartz with feldspar and rock Fines: silt, thin seams of clayey silt, pale brown	5.2+	16.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	32	67	1.0- 8.0	1	3	16	14	11	15	40
				8.0-11.0	2	4	13	14	16	35	16
				Mean	1	3	15	14	13	21	33
b	10	89	1	11.0-15.0	10	29	54	6	1	0	0
				15.0-16.2	12	41	44	3	0	0	0
				Mean	10	32	52	5	1	0	0
a&b	4	52	44	Mean	4	13	28	11	8	14	22

NJ 81 NE 7 **8811 1958** **Gaucyhillock, New Machar** **Block G**

Surface level		Waste	2.5m
Water not struck		Bedrock	0.2m+
Pit			
September 1984			

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, very sandy, pebbly; mottled yellowish brown, medium grey and orange. Angular clasts of schist up to boulder size	2.3	2.5
Dalradian	Schistose semipelite, micaceous with quartz and feldspar segregations, highly weathered, black	0.2+	2.7

NJ 81 NE 8 **8938 1876** **Pinkie, New Machar** **Block G**

Water not struck		Waste	1.2m
Pit		Bedrock	1.6m+
September 1984			

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, sandy, and silty, pale yellowish brown. Angular clasts of schistose psammite up to boulder size	1.1	1.2
Dalradian	Schistose psammite, fissured and high weathered	1.6+	2.8

NJ 81 NE 9 **8924 1669** **Upper Tack, New Machar** **Block G**

Water not struck		Waste	1.4m
Pit		Bedrock	0.6m+
September 1984			

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, very sandy, angular, clasts of highly weathered schist; some well rounded clasts above 0.4m	1.3	1.4
Dalradian	Schist, fissured and highly weathered	0.6+	2.0

NJ 81 NE 10 | **8955 1607** | **Buckie, New Machar** | **Block G**

Surface level +66
Water not struck
250mm percussion and shell
October 1984

Waste 3.4m
Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.3	0.3
Till	Clay, sandy, light brown, pebbles of psammite and basic igneous rock. A bed of pebbly micaceous sand from 1.0 to 1.8m; cobbles of pink granite below 1.8m	3.1	3.4
Caledonian	Granite	1.0+	4.4

NJ 81 NE 11 | **8974 1576** | **North Waulkmill, New Machar** | **Block G**

Water not struck
Pit
September 1984

Waste 0.5m
Bedrock 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Sand, silty and clayey, pale yellowish brown. Clasts up to cobble size, mainly highly weathered schist	0.4	0.5
Dalradian	Schist, coarse grained, micaceous, with segregations of quartz and felspar and granitic veins; highly weathered	1.5+	2.0

NJ 81 SW 1 **8216 1168** **North East of Blackhill, Kinellar** **Block I**

Pit
Water struck at 2.8m depth
September 1984

Overburden 0.3m
Mineral I 1.2m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, humic	0.3	0.3
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, with cobbles; subangular to rubrounded granite, with some metamorphic rocks Sand: medium and coarse with some fine; subangular quartz with feldspar and some rock, ironstained from 0.3 to 1.3m Fines: silt and clay, disseminated, light brown	1.2	1.5
Till	Clay, sandy, stiff, bluish grey with clasts up to boulder size of granite, diorite and schist	1.5+	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1−4	+4−16	+16−64	+64 mm
6	56	38	0.3− 1.5	6	11	23	22	19	19	0

NJ 81 SW 2 **8280 1166** **Burnside Crofts, Newhills** **Block I**

Surface level +73m	Overburden 0.2m
Water struck at c+71.2m	Mineral I 1.0m
250 and 200mm percussion and shell	Waste 4.1m
October 1984	Bedrock 0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, humic, dark brown	0.2	0.2
Alluvium	Sand; dark brown, humic near the top Sand: mainly medium, with some fine and coarse, quartz and feldspar	1.0	1.2
? Till	Gravel, clayey and sandy, yellowish brown with pebbles of subrounded quartzite and grit; thin beds of grey sandy clay throughout	1.2	2.4
Till	Clay, stony, stiff, medium brown with rounded clasts of grit, quartzite and mica schist; becoming sandy with boulder size granitic clasts from 4.8 to 6.0m; clayey reddish brown, with soft weathered granitic clasts towards the base	4.1	6.5
Caledonian	Granodiorite, badly weathered	0.5+	7.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	93	2	0.2- 1.2	5	23	57	13	2	0	0

NJ 81 SW 3 **8282 1048** **Mill of Birsack, Skene** **Block I**

Water struck at 3.4m depth
Pit
September 1984

Waste 3.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, very sandy and silty, pale olive brown; angular and rounded clasts up to boulder size, from 0.2 to 1.3m and towards the base; granitic rocks and quartzite	3.2+	3.4

NJ 81 SW 4 **8364 1173** **Broombank, Newhills** **Block I**

Water not struck
Pit
September 1984

Overburden 1.4m
Mineral II 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, sandy, stiff, yellowish olive brown with granitic clasts up to boulder size	1.2	1.4
	'Clayey' pebbly sand; poorly bedded, with soft weathered granitic clasts towards the base Gravel: fine, angular granite Sand: coarse and medium, with some fine; angular quartz and feldspar Fines: disseminated, pale yellow	2.0+	3.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	81	8	1.4- 2.4	11	13	32	36	8	0	0
			2.4- 3.4	No grading data available						

NJ 81 SE 13 **8589 1496** **Guildhall, Dyce** **Block H**

Surface level +56m
Water struck at c+51.5m
250 and 200mm percussion and shell
September 1984

Overburden 0.2m
Mineral I 2.2m
Waste 4.8m
Bedrock? 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark yellowish brown	0.2	0.2
Glacial sand and gravel	Clayey' gravel, very poorly sorted, virtually unbedded, becoming finer and more silty with depth Gravel: mainly coarse, with some cobbles, boulders and some fine; rounded to subangular, pink and grey granite, with some pelite and psammite Sand: mainly medium, with some fine and coarse; subangular quartz and rock, with some mica and feldspar Fines: mainly silt, loosely binding deposit, moderate brown to moderate yellowish brown	2.2	2.4
Till	Clay, gravelly and sandy, yellowish brown. Clasts up to boulder size of granite and schist at the top	4.8	7.2
Dalradian	Quartzite, coarse grained, gritty	0.1+	7.3
	Borehole terminated owing to an obstruction, probably bedrock		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	42	47	0.2- 1.4	5	9	14	9	13	31	19
			1.4- 2.4	19	15	24	14	10	18	0
			Mean	11	12	19	11	12	25	10

NJ 81 SE 14 **8647 1106** **Chapel Croft, Newhills** **Block I**

Water not struck — Waste 2.3m+
Pit
September 1984

LOG

Geological classification	Lithology	Thickness m	Depth m
? Till	Clay and silty sand, gravelly, dark brown with clasts up to large boulder size of schist and granite	2.3+	2.3

NJ 81 SE 16 **8765 1102** **Mill of Craibstone, Newhills** **Block I**

Water not struck — Waste 3.2m+
Pit
September 1984

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, sandy, silty, stony, stiff, medium orange to yellowish brown; clasts up to boulder size of schist and gneiss; thin lenses of sand and gravel throughout	2.7+	3.2

NJ 81 SE 17 8842 1454 **Goval Villa, New Machar** **Block H**

Surface level +44m
Water struck at +33.8m
250 and 200mm percussion and shell
September 1984

Overburden	0.9m
Mineral I	8.2m
Waste	1.1m
Mineral I	1.8m
Waste	0.2m
Mineral I	7.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy and silty, rounded cobbles of granite below 0.4m	0.9	0.9
Glacial sand and gravel	a 'Clayey' sand, sparse angular pebbles Sand: mainly fine and medium, subangular to subrounded, quartz with some mica and rock Fines: disseminated	1.3	2.2
	b 'Clayey' sandy gravel Gravel: coarse and fine, with some cobbles, rounded to well rounded; red and grey granite, with some quartzite and vein quartz Sand: medium with coarse and fine, angular to subangular, quartz and rock Fines: Clay and silt, disseminated	2.9	5.1
	c Pebbly sand Gravel: mainly fine, rounded granite with some quartzite and quartz Sand: mainly medium, angular to subrounded, quartz with some rock and mica Fines: disseminated, pale brown	4.0	9.1
	d Silt, clayey and sandy, micaceous, laminated, pale greyish brown. Some manganese and iron staining from 9.5 to 9.7m	1.1	10.2
	e 'Clayey' sand, sparse pebbles Sand: mainly medium, angular to subangular, quartz with some mica	1.8	12.0
	Silt, laminated, pale brown; fine quartz sand partings	0.2	12.2
	f Sandy gravel, becoming less pebbly with depth Gravel: coarse and fine with some cobbles, rounded to well rounded, granite with some quartzite and quartz; some basic igneous rock type above 13.2m Sand: coarse and medium with fine, angular to subangular, quartz with some rock	7.9+	20.1

Borehole abandoned owing to an obstruction

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	10	88	2	0.9- 2.2	10	49	36	3	1	1	0
b	12	53	35	2.2- 3.2	15	10	26	16	13	15	5
				3.2- 4.2	11	10	19	13	12	18	17
				4.2- 5.1	10	9	36	23	15	7	0
				Mean	12	10	26	17	13	14	8
c	6	88	6	5.1- 6.1	1	7	60	27	5	0	0
				6.1- 6.9	2	10	50	28	7	3	0
				6.9- 9.1	10	31	43	10	3	3	0
				Mean	6	21	49	18	4	2	0
d	55	42	3	9.1-10.2	55	20	17	5	3	0	0
e	13	84	3	10.2-12.0	13	29	50	5	2	1	0
f	5	57	38	12.2-13.2	7	9	10	17	19	31	7
				13.2-14.5	5	13	9	12	19	30	12
				14.5-15.5	3	11	12	22	23	29	0
				15.5-16.5	3	11	15	27	29	15	0
				16.5-17.5	6	16	32	22	13	11	0
				17.5-18.5	3	11	32	30	10	7	7
				18.5-19.5	5	23	33	25	7	7	0
				19.5-20.1	4	17	37	34	6	2	0
				Mean	5	14	21	22	16	18	4
a-f	10	67	23	Mean	10	19	31	17	10	10	3

NJ 81 SE 18 **8959 1444** **Home Farm, New Machar** **Block J**

Surface level +42m
Water not struck
250mm percussion shell
September 1984

Waste 3.8m
Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
Till	Clay, sandy, brownish grey to moderate yellowish brown; pebbles and cobbles of deeply weathered schist and grey granite	3.6	3.8
Caledonian	Granite, medium grained, hard, light grey	1.0+	4.8

NJ 81 SE 19 **8991 1363** **Dovecot Wood, New Machar** **Block H**

Surface level +52m
Water not struck
250 and 200mm percussion and shell
October 1984

Overburden 0.2m
Mineral I 1.0m
Waste 2.0m
Mineral I 4.1m
Waste 0.2m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.2	0.2
Fluvioglacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine, angular to subrounded, schist and psammite with some quartz and brown (?Devonian) sandstone Sand: medium with coarse and some fine, angular to subrounded, quartz with some feldspar and rock Fines: clay and silt, disseminated, dark yellowish brown	1.0	1.2
Till	Clay, gritty and sandy, pale brown, becoming more sandy with depth; clasts up to cobble size of gneiss. A bed of yellowish brown pebbly sand from 2.4 to 2.7m	2.0	3.2
Glacial sand and gravel	b 'Clayey' sandy gravel, weakly clay bound below 5.3m Gravel: coarse with fine and cobbles, subrounded, granite, psammite and gneiss Sand: medium with coarse and fine, quartz mica and feldspar Fines: clay and silt, pale yellowish brown	4.1	7.3
? Till	Clay and sand, pebbly, medium brown; clasts of weathered gneiss	0.2	7.5
Dalradian	Gneiss deeply weathered	0.1+	7.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	11	61	28	0.2- 1.2	11	9	31	21	15	13	0
b	18	52	30	3.2- 4.2	15	21	28	16	7	8	5
				4.2- 5.2	18	11	32	21	9	9	0
				5.2- 6.3	16	3	14	17	10	13	27
				6.3- 7.3	25	5	22	17	12	19	0
				Mean	18	10	24	18	10	12	8
a&b	17	53	30	Mean	17	10	25	18	11	12	7

NJ 90 SW 6 | 9062 0220 | **Banchory-Devenick** | **Block 0**

Surface level +33m
Water not struck
250mm percussion and shell
November 1984

Overburden 0.5m
Mineral I 2.0m
Waste 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sandy gravel; mainly boulders and cobbles, no sample recovered	1.0	1.5
	'Clayey' pebbly sand Gravel: fine and coarse, angular to rounded granite and quartzite Sand: mainly medium, angular to subangular quartz and rock fragments Fines: silty clay, brown	1.0	2.5
Caledonian/Dalradian	Granite and schist, hard	1.3+	3.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	68	21	0.5- 1.5	No grading data available						
			1.5- 2.5	11	17	36	15	9	12	0

NJ 90 SW 7 9386 0059 **Charleston, Nigg** **Block P**

Water not struck
Pit
October 1984

Overburden 0.1m
Mineral I 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel Gravel: coarse and cobble with fine, rounded to well-rounded granite with some schist, psammite and basic igneous rocks Sand: fine to coarse, angular to subangular quartz and granite	3.0+	3.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
6	21	73	0.1- 3.1	6	5	7	9	13	28	32

NJ 90 SW 8 | **9438 0121** | **South Loirston, Nigg** | **Block P**

Water struck at a depth of 9.5m
Section and Pit
October 1984

Overburden 2.0m
Mineral I 8.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
? Till	Cobble gravel in greyish clay matrix	2.0	2.0
Glacial sand and gravel	a Sandy gravel, 'clayey' to 4.0m Gravel: fine and coarse with cobble, rounded to well-rounded granite and psammite with quartzite and angular to subangular pelitic rocks Sand: medium and coarse, angular to subangular quartz and granite fragments	6.5	8.5
	b 'Clayey' sand Sand: fine and medium, angular to subangular quartz Fines: clay grey-brown, with silt yellowish brown	1.7+	10.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	7	57	36	2.0- 4.0	16	5	18	16	18	27	0
				4.0- 5.0	1	2	29	25	13	19	11
				5.0- 6.5	1	9	60	17	9	4	0
				6.5- 7.5	No grading data available						
				7.5- 8.5	2	6	19	25	17	8	23
				Mean	7	6	31	20	14	16	6
b	10	90	0	8.5-10.2	10	55	34	1	0	0	0
a&b	7	64	29	Mean	7	16	32	16	11	13	5

NJ 91 NW 42 **9320 1531** **Newhill, Belhelvie** **Block J**

Surface level +79m
Water not struck
250mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 4.7m
Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark yellowish brown	0.3	0.3
Glacial sand and gravel	a Sandy gravel Gravel: fine to cobble, subangular to angular, granite with schist and psammite Sand: medium and coarse with some fine angular quartz Fines: silt, disseminated, light brown	1.3	1.6
	b Sand, sparse fine pebbles of quartz and pelite Sand: mainly medium, subangular quartz with some feldspar and mica Fines: silt, disseminated, light brown	1.0	2.6
	c Gravel Gravel: coarse with fine and cobble, rounded to angular, pink and grey granite, with some gabbro, pelite and quartz Sand: mainly coarse, angular, quartz and rock with some feldspar and mica Fines: disseminated, light brown	2.4	5.0
Till	Clay, very sandy and silty, compact, moderate brown. Clasts up to boulder size of grey granite, weathered and unweathered schist	2.2+	7.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	5	59	36	0.3- 1.6	5	7	28	24	13	11	12
b	3	94	3	1.6- 2.6	3	13	72	9	2	1	0
c	1	41	58	2.6- 3.6	2	2	16	25	15	28	12
				3.6- 5.0	1	2	12	25	18	23	19
				Mean	1	2	14	25	17	25	16
a-c	3	56	41	Mean	3	6	29	21	13	16	12

NJ 91 NW 43 **9379 1625** **Plodhill, Belhelvie** **Block K**

Surface level +77m
Water struck at c+73m
250mm and 200mm percussion and shell
September 1984

Overburden 0.3m
Mineral I 8.7m
Waste 5.4m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dusky brown	0.3	0.3
Glacial sand and gravel	a Pebbly sand Gravel: coarse and fine, subangular to subrounded, granite, metamorphic rocks and quartz with some brown (Devonian) sandstone Sand: mainly medium, angular to subrounded, quartz with some feldspar and rock Fines: disseminated, moderate yellowish brown	1.7	2.0
	b 'Clayey' sand, fining downwards Sand: fine with some medium, quartz and feldspar with some mica Fines: silt and clay, disseminated. Some thin seams of clayey silt at the base. Moderate yellowish brown	4.0	6.0
	c 'Very clayey' sand, finely laminated towards the base Sand: fine, rounded quartz and some mica Fines: silt and clay in finely laminated seams. Beds of reddish brown and grey clay at the base	3.0	9.0
Glaciolacustrine deposits	Silt and clay, interlaminated, becoming firm silty clay from 10.0 to 12.8m; greyish brown to moderate reddish brown	5.0	14.0
? Till	Clay, silty and sandy, dark yellowish brown: pebbles of black ultra basic igneous rock	0.4	14.4
Caledonian	Ultrabasic rock, hard, greenish black	0.1+	14.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	5	75	20	0.3- 1.3	6	4	48	23	9	10	0
				1.3- 2.0	3	4	44	27	11	11	0
				Mean	5	4	46	25	10	10	0
b	14	86	0	2.0- 3.0	5	54	39	2	0	0	0
				3.0- 4.0	14	57	27	2	0	0	0
				4.0- 5.0	24	68	8	0	0	0	0
				5.0- 6.0	14	75	10	1	0	0	0
				Mean	14	64	21	1	0	0	0
c	36	64	0	6.0- 7.0	31	65	4	0	0	0	0
				7.0- 8.0	39	59	2	0	0	0	0
				8.0- 9.0	37	60	3	0	0	0	0
				Mean	36	61	3	0	0	0	0
a-c	20	76	4	Mean	20	51	20	5	2	2	0

NJ 91 NW 44 **9429 1654** **Milton of Potterton, Belhelvie** **Block K**

Water struck at 3.5m depth
Pit
September 1984

Overburden 0.3m
Mineral I 1.7m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, black	0.3	0.3
Glacial sand and gravel	Sandy gravel, bedded Gravel: mainly coarse with some fine and some cobbles, rounded granite, schist and psammite Sand: mainly medium and coarse, angular to subangular quartz, feldspar and rock Fines: silt, disseminated. A few thin drapes of dark reddish brown silty clay	1.7	2.0
Till	Clay, sandy, silty, stiff, pale yellowish brown with clasts up to boulder size of psammite, pelite and fine grained basic igneous rock. Some lenses of clean sandy gravel, especially towards the base. Stiff bluish grey clay from 2.0 to 2.4m	1.5+	3.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
7	47	46	0.3- 2.0	7	6	23	18	10	29	7

NJ 91 NW 45 **9482 1659** **Home Farm, Belhelvie** **Block K**

Surface level +72m
Water not struck
250 and 200mm percussion and shell
September 1984

Overburden	2.3m
Mineral I	1.0m
Waste	2.0m
Mineral I	3.9m
Waste	0.4m
Mineral I	1.0m
Waste	3.4m
Bedrock	0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glaciolacustrine deposits	Clay and sand, reddish brown; rounded pebbles of schist, quartzite and granite	1.9	2.3
	a Sand, with sparse pebbles of quartzite and schist Sand: mainly fine, rounded to subangular quartz and mica Fines: silt and clay, disseminated, moderated reddish brown	1.0	3.3
	b Silt and clay, very sandy, interlaminated with fine quartz sand. Moderate brown to moderate reddish brown.	2.0	5.3
Glacial sand and gravel	c Pebbly sand Gravel: coarse and fine, rounded to angular schist, quartz, quartzite and basic igneous rocks, some psammite and granite Sand: medium and coarse with some fine, angular quartz with some rock Fines: silt and clay, loosely binding deposit below 7.0m; some silt seams to 8.0m. Dusky reddish brown	3.9	9.2
Glaciolacustrine deposits	Silt and waxy clay, interlaminated, some fining downwards varved couplets (10-20mm). Reddish brown and light olive brown	0.4	9.6
	d 'Very clayey' sand, interlaminated with waxy clay Sand: fine, well rounded quartz with some mica Fines: clay and silt, stiff, waxy, moderate reddish brown	1.0	10.6
	e Silt and sand; interlaminated, micaceous; red to light olive brown	1.9	12.5
Till	Clay and clayey sand, pebbly, light olive brown; abundant highly weathered schist pebbles	1.5	14.0
Caledonian	Gabbro, hard, ultrabasic rock, greenish black	0.6+	14.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	13	83	4	2.3- 3.3	13	59	20	4	2	2	0
b	55	45	0	3.3- 4.3	46	53	1	0	0	0	0
				4.3- 5.3	65	32	3	0	0	0	0
				Mean	55	43	2	0	0	0	0
c	6	76	18	5.3- 5.8	9	31	48	7	4	1	0
				5.8- 7.0	5	8	36	25	7	19	0
				7.0- 8.0	5	10	33	26	10	16	0
				8.0- 9.2	7	25	44	16	6	2	0
				Mean	6	17	39	20	7	11	0
d	27	73	0	9.6-10.6	27	70	3	0	0	0	0
e	40	60	0	10.6-11.6	40	51	9	0	0	0	0
				11.6-12.5	41	56	3	0	0	0	0
				Mean	40	54	6	0	0	0	0
a&c	8	77	15	Mean	8	25	35	17	6	9	0
a-e	26	67	7	Mean	26	39	20	8	3	4	0

NJ 91 NE 10	9588 1897	South Orrock, Belhelvie	Block K

Surface level +83m
Water not struck
250 and 200mm percussion and shell
September 1984

Overburden	0.2m
Mineral I	3.3m
Waste	1.7m
Mineral II	1.3m
Waste	2.9m
Bedrock	0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey and sandy, pale brown	0.2	0.2
?Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine, with some cobbles, subangular to rounded, red and pink granite, basic igneous rocks and pink quartzite; some schist and grey granite Sand: medium with coarse and fine, angular quartz and rock Fines: silt and clay, loosely binding the deposit; reddish brown becoming moderate yellowish brown with depth	3.3	3.5
Glaciolacustrine deposits	Clay, sandy, moderate reddish brown, interlaminated with clayey silt; thin stringers of vein quartz and red granite pebbles	0.5	4.0
	Silt, clayey, sandy, laminated, reddish to olive brown, abundant pebbles (?dropstones) of granite, quartz and schist	1.2	5.2
Flow-till	b 'Very clayey' pebbly sand, cleaner with depth Gravel: fine and coarse, rounded, red quartzite and schist with some granite Sand: medium and coarse with fine, angular, quartz and rock Fines: silt and clay binding deposit, olive brown to dark yellowish brown	1.3	6.5
Till	Clay, sandy, very compact, brown. Angular pebbles of schist, brown (Devonian) sandstone, vein quartz and granite	2.9	9.4
Caledonian	Basic rock, hard, greenish black, possibly metamorphosed	0.4+	9.8

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	19	49	32	0.2- 1.2	14	20	27	12	17	10	0
				1.2- 2.5	30	11	24	14	11	10	0
				2.5- 3.5	11	11	12	16	18	26	6
				Mean	19	14	21	14	15	15	2
b	28	53	19	5.2- 6.0	37	10	27	16	8	2	0
				6.0- 6.5	14	12	20	21	14	19	0
				Mean	28	11	24	18	10	9	0
a&b	22	50	28	Mean	22	13	22	15	14	13	1

NJ 91 NE 11 **9562 1762** **Hare Cairn, Belhelvie** **Block K**

Surface level +75m
Ground water conditions not recorded
250mm percussion and shell
October 1984

Overburden 2.9m
Mineral I 2.1m
Waste 3.7m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, humic, sandy, dark brown	0.3	0.3
? Till	Clay, sandy, mottled moderate brown and yellowish brown	1.4	1.7
Glaciolacustrine deposits	Silt, sandy, granitic cobbles at the base	1.2	2.9
	'Clayey' sand, sparse pebbles Sand: mainly medium and fine, subangular to subrounded, quartz with some mica Fines: clay and silt, finely laminated, reddish brown	2.1	5.0
Till	Clay, sandy, reddish brown; interbedded with clayey sand and gravel. Pebbles and cobbles of schist and granite above 8.1m; angular pebbles of quartz and basic igneous rock below 8.1m	3.7	8.7
? Caledonian	Ultrabasic rock, bluish black	0.3+	9.0
	Borehole abandoned due to rock obstruction probably bedrock		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
12	87	1	2.9- 4.0	7	21	60	11	1	0	0
			4.0- 5.0	18	42	35	4	1	0	0
			Mean	12	31	48	8	1	0	0

NJ 91 NE 12 **9540 1580** **Broom Hill, Belhelvie** **Block J**

Surface level
Water struck at 11.6m depth
Section and pit
November 1984

Overburden	0.3m
Mineral I	2.0m
Waste	0.2m
Mineral I	6.0m
Waste	0.9m
Mineral I	2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Sandy gravel Gravel: coarse and fine with some cobbles and boulders up to 200mm; rounded granite, gabbro, psammite, schist, quartzite and vein quartz Sand: mainly coarse and medium, angular to subrounded quartz with feldspar and rock Fines: disseminated, buff	2.0	2.3
	Clay, silty	0.2	2.5
	b Sand; sparse pebbles to 6.5m, climbing ripple cross-lamination and planar bedding below 6.5m Sand: medium and fine, angular to subrounded quartz Fines: silt and clay. Thin seams and clay drapes,especially towards the base; yellowish brown	6.0	8.5
Glaciolacustrine deposits	Clay, silty; interlaminated with very fine silty sand in horizontally laminated couplets (10-30mm); reddish brown to pale brown	0.9	9.4
	c 'Very clayey' sand, interbedded with olive and pale yellowish brown silt Sand: fine, rounded quartz and mica	2.2+	11.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	54	45	0.3- 2.3	1	3	25	26	17	20	8
b	3	96	1	2.5- 6.5	1	28	65	5	1	0	0
				6.5- 8.5	6	69	24	1	0	0	0
				Mean	3	42	50	4	1	0	0
c	38	62	0	9.4-11.6	38	61	1	0	0	0	0
a&b	2	86	12	Mean	2	32	45	9	5	5	2
a-c	10	80	10	Mean	10	38	35	7	4	4	2

NJ 91 NE 13 **9663 1960** **Orrock House, Belhelvie** **Block K**

Surface level +62m
Water struck at +51.5m
250 and 200mm percussion and shell
October 1984

Overburden	4.8m
Mineral I	1.3m
Waste	4.4m
Mineral I	2.6m
Bedrock	1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, reddish brown	0.3	0.3
Glaciolacustrine deposits	Silt and clay, reddish brown, with thin beds of fine angular gravel	2.1	2.4
	Clay, silty, interlaminated with sandy silt, yellowish brown to reddish brown	0.3	2.7
	Silt and clay, pebbly and sandy, yellowish brown. Clasts up to cobble size of granitic rock, metamorphic rocks and brown (?Devonian) sandstone	1.3	4.0
	Silt, sandy	0.2	4.2
	a Sandy silt and 'Very clayey' pebbly sand; pale brown, with pebbles of quartzite, schist and basic igneous rocks	0.2	4.4
	Silt, sandy, interbedded with stiff clay; reddish brown. Partings of fine quartz sand	0.4	4.8
	b 'Very clayey' sand Sand: medium and fine, rounded quartz and mica; some coarse angular rock Fines: silt and clay, disseminated to 5.5m with beds of hard waxy clay towards the base; moderate yellowish brown	1.3	6.1
? Flow-till	Silt, and clay, sandy, moderate to dark yellowish brown; thin partings of stiff clayey sandy gravel to 8.0m. Clasts up to boulder size towards the base.	4.4	10.5
Glacial sand and gravel	c Gravel Gravel: coarse and fine, large cobbles from 11.7m, angular to well rounded, schist with some vein quartz; some granite and basic igneous rocks to 12.5m	2.6	13.1
Dalradian	Schist, pelitic, micaceous, highly weathered, olive grey with ironstained fractures	0.2	13.3
	Schist, semipelitic, quartz and feldspar segregations; showing refolded cleavage	0.9+	14.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	41	42	17	4.2- 4.4	41	18	17	7	6	11	0
b	20	79	1	4.8- 5.5	8	27	60	4	1	0	0
				5.5- 6.1	35	37	24	3	1	0	0
				Mean	20	32	43	4	1	0	0
c	3	31	66	10.5-11.7	2	2	5	19	32	40	0
				11.7-12.5	4	2	8	20	26	23	17
				12.5-13.1	5	3	12	28	29	14	9
				Mean	3	2	8	21	30	29	7
b&c	9	46	45	Mean	9	12	19	15	21	19	5
a-c	11	46	43	Mean	11	12	19	15	19	19	5

NJ 91 NE 14 **9659 1531** **Blackdog Rifle Ranges, Belhelvie** **Block L**

Surface level +22m
Water struck at c+16.5m
250 and 200mm percussion and shell
October 1984

Mineral I 1.5m
Waste 13.8m
Bedrock 0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Blown Sand	Sand, with root fragments Sand: mainly fine, with some medium, well rounded quartz, 'soft', light brown to dark yellowish brown	1.5	1.5
	Silt, sandy, humic, laminated, dusky brown mottled with olive grey and dark orange brown	0.1	1.6
Glaciolacustrine deposits	Clay, waxy, firm, homogeneous to faintly laminated, moderate reddish brown. Vertical veins of greenish grey clay. Rounded fine pebbles (?dropstones) of weathered mica schist, basic igneous rocks, pale grey (?Jurassic) limestone and grey shale	3.9	5.5
	Silt, sandy, soft, light olive grey to olive brown, interlaminated with fine quartz sand	0.5	6.0
	Clay and silt, interlaminated, (?varved), firm, moderate reddish brown to moderate brown; partings of micaceous fine quartz sand, below 10.6m	7.6	13.6
Till	Clay, sandy, brownish grey. Subangular to rounded clasts, up to boulder size, of granite, basic igneous rocks and quartzite	1.7	15.3
Dalradian	Schist, with quartz segregations, dark grey	0.5+	15.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
4	96	0	0.0- 1.0	2	58	40	0	0	0	0
			1.0- 1.5	7	60	33	0	0	0	0
			Mean	4	58	38	0	0	0	0

NJ 91 NE 15 **9749 1768** **East of Little Eigie, Belhelvie** **Block L**

Water struck at 2.6m
Pit
September 1984

Overburden	0.2m
Mineral I	0.9m
Waste	1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
Blown sand	Sand, mainly medium with some fine, quartz, pale yellowish orange becoming grey towards the base	0.9	1.1
Post-Glacial beach and estuarine deposits	Peat, fibrous to amorphous organic matter, dark brown	0.2	1.3
	Sand and sandy silt, clayey in part, micaceous; medium grey becoming bluish grey with depth	1.7+	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm	
			0.2-1.1	No grading data available for this deposit							

NJ 91 SW 1 | **9091 1423** | **Badgers' Hill, New Machar** | **Block J**

Surface level +82m
Water not struck
Pit and 250mm percussion and shell
September 1984

Overburden 0.1m
Mineral I 2.9m
Waste 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Gravel, with large boulders from 0.9m, poorly bedded Gravel: cobble to fine, subangular to rounded, granite, psammite and gneiss, with some schist, quartzite, quartz and felsite Sand: mainly medium and coarse, angular to subangular quartz with feldspar, rock and some mica Fines: silt, disseminated, pale brown	2.9	3.0
? Till	Sand, gravelly and clayey, compact, pale yellowish brown. Clasts up to large boulder size	1.1+	4.1
	Borehole abandoned owing to drilling difficulties. Casing off line on large boulders		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	33	62	0.1- 0.9	12	16	22	13	13	24	0
			0.9- 1.5	1	4	13	15	12	24	31
			1.5- 3.0	2	3	11	11	11	18	44
			Mean	5	7	14	12	12	21	29

NJ 91 SW 2 **9105 1450** **Bishops' Manor, New Machar** **Block J**

Water not struck
Section and pit
November 1984

Overburden 1.1m
Mineral I 13.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Flow till	Clay, stony, sandy, poorly bedded, interstratified with clayey silt and pebbly clay	0.8	1.1
Glacial sand and gravel	a Gravel, with large scale trough cross bedding and thin seams of silty sand Gravel: coarse and fine, with some cobbles, subrounded to rounded, grey and pink granite, psammite and gabbro, with some gneiss, schistose grit, mica schist, vein quartz and quartzite Sand: coarse and medium, angular to subangular quartz with feldspar and rock Fines: silt and clay drapes	2.9	4.0
	b Sand, sparse fine pebbles, large-scale cross-bedding Sand: mainly medium and coarse, angular to subangular quartz with some feldspar and rock	4.0	8.0
	c 'Clayey' sand Sand: mainly fine, quartz Fines: silt, disseminated	2.0	10.0
	d Gravel, with a bed of large boulders from 13.0 to 13.3m Gravel: cobble with some coarse and fine, mainly rounded granite, psammite and gabbro, with some gneiss, schist, quartz and quartzite Sand: mainly medium and coarse, angular quartz with feldspar and rock	5.0+	15.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	42	57	1.1- 4.0	1	3	17	22	21	26	10
b	1	97	2	4.0- 8.0	1	12	54	31	2	0	0
c	17	83	0	8.0-10.0	17	74	9	0	0	0	0
d	3	45	52	10.0-15.0	3	4	21	20	10	11	31
a-d	4	65	31	Mean	4	16	28	21	9	9	13

NJ 91 SW 3 **9156 1481** **North Allans, New Machar** **Block J**

Surface level +98m
Water not struck
250mm percussion and shell
September 1984

Waste	3.5m
?Bedrock	2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly and sandy	0.2	0.2
Till	Clay, sandy and stony, stiff, pale yellowish brown. Clasts up to boulder size of granite and quartzite	3.3	3.5
?Dalradian	Hard grey rock (no sample recovery)	2.2+	5.7
	Borehole abandoned owing to slow progress		

NJ 91 SW 4 **9187 1379** **Hillhead, Old Machar** **Block J**

Water not struck
Pit
November 1984

Waste	3.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, silty, sandy, firm to very stiff, orange brown becoming reddish brown below 1.8m, clasts up to boulder size of pelite, semipelite and granite	3.0+	3.2

NJ 91 SW 5 | 9102 1304 | **Lower Bodachra, Old Machar** | **Block J**

Water not struck
Pit
September 1984

Overburden 0.3m
Mineral II 2.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.3	0.3
Till	'Very clayey' pebbly sand; claybound Gravel: fine and coarse, angular to well rounded grey granite and gneiss, with some schist, quartzite and psammite Sand: mainly medium and fine, quartz and rock Fines: clay and silt, pale yellowish brown	2.9+	3.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
22	60	18	0.3- 3.2	22	22	24	14	10	8	0

NJ 91 SW 6	9275 1493	Leuchlands Croft, Old Machar	Block J

Water not struck
Section and pit
November 1984

Overburden 0.3m
Mineral I 6.0m
Waste 1.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Sandy gravel, with boulders at the top and base Gravel: fine and coarse, with some large cobbles; mainly rounded grey and pink granite, psammite and gabbro, with some gneiss, schist, quartz and quartzite Sand: mainly coarse and medium, angular to subangular, quartz with feldspar and rock Fines: clay and silt, sparse clay drapes from 2.0 to 3.5m; disseminated yellowish orange and brown clay and silt to 1.0m	6.0	6.3
Glaciolacustrine deposits	Clay, silty, olive brown, interlaminated with silt and fine sand	0.3	6.6
Till	Clay, silty, sandy and gravelly, stiff, yellowish olive brown. Clasts up to boulder size	1.1+	7.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
1	59	40	0.3– 1.0	2	2	8	11	11	27	39
			1.0– 2.0	1	6	52	30	8	3	0
			2.0– 3.5	1	2	15	25	16	18	23
			3.5– 5.5	1	2	29	39	21	8	0
			5.5– 6.3	No grading data available						
			Mean	1	3	27	29	16	12	12

NJ 91 SW 7 **9300 1420** **Annfield, Old Machar** **Block J**

Water not struck
Section and pit
November 1984

Overburden 1.0m
Mineral I 15.3m
Waste 0.2m
Bedrock 0.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Flow-till	Clay, sandy and gravelly, stiff, reddish brown, crude horizontal bedding. Clasts mainly cobbles and boulders	0.7	1.0
Glacial sand and gravel	a Gravel, fining upwards, large scale trough cross-bedding Gravel: cobble to fine, with some large boulders, subangular to subrounded granite, gabbro, quartzite and quartz, with some schist and gneiss Sand: coarse and medium, angular to subangular quartz, with feldspar and rock Fines: yellowish brown	3.0	4.0
	b Pebbly sand, cross-bedded Gravel: fine and coarse, subangular to subrounded, granite, gabbro, quartzite and quartz, with some schist and gneiss Sand: mainly medium, angular quartz with feldspar and some rock	3.0	7.0
	c 'Very clayey' sand, finely laminated Sand: mainly fine, quartz Fines: silt, with fine horizontal laminations, pale brown. Some clay drapes	0.7	7.7
	d Sandy gravel, clayey towards the base Gravel: coarse and fine with some cobble; boulders from 13.8 to 14.8m, subangular to subrounded granite, gabbro, quartzite and quartz with some schist and gneiss Sand: mainly coarse and medium, angular quartz, with some feldspar and rock Fines: silt and clay, pale brown	8.6	16.3
Till	Clay, sandy, stiff, reddish brown, with quartzite rubble	0.2	16.5
Dalradian	Orthoquartzite, medium to coarse grained, recrystalised, very hard, flaggy, pale grey streaked with reddish brown	0.7+	17.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	27	72	1.0- 4.0	1	2	12	13	14	23	35
b	7	74	19	4.0- 7.0	7	8	45	21	10	9	0
c	28	72	0	7.0- 7.7	28	56	15	1	0	0	0
d	3	50	47	7.7-10.7	1	1	12	26	19	28	13
				10.7-12.7	2	6	36	25	17	14	0
				12.7-14.8	2	5	18	14	16	24	21
				14.8-16.3	12	10	25	28	17	8	0
				Mean	3	5	21	24	17	20	10
a-d	5	50	45	Mean	5	7	23	20	15	18	12

NJ 91 SW 8 **9217 1398** **North East of Hillhead, Old Machar** **Block J**

Surface level +88m
Water not struck
250mm percussion and shell
September 1984

Overburden 0.3m
Mineral II 5.1m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy and pebbly, dark brown	0.3	0.3
Till	'Clayey' pebbly sand Gravel: coarse and fine, rounded granite with some quartz and quartzite Sand: mainly medium and coarse, angular to subangular quartz and granite	5.1	5.4
Caledonian	Granite, pink medium grained, highly weathered	0.2+	5.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
17	70	13	0.3- 5.4	17	14	30	26	6	7	0

NJ 91 SW 9 **9314 1449** **East of Corby Loch, Old Machar** **Block J**

Surface level +98m
Water not struck
250mm percussion and shell
September 1984

Waste 3.6m
Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, dark brown	0.2	0.2
Glacial sand and gravel	Gravel, sandy, brownish orange; rounded clasts, up to cobble size, of granite, quartzite and quartz	0.5	0.7
Till	Clay, sandy, stony, pale brown. Clasts up to cobble size of granite, gneiss, quartzite and weathered schist	2.9	3.6
Dalradian	Schist, semipelitic, micaceous, knotted, some quartz segregations, greyish green weathering orange brown	0.4+	4.0

NJ 91 SW 10 **9363 1348** **East of Leuchlands, Old Machar** **Block J**

Surface level +72m
Water struck at c+66.8m
250mm percussion and shell
September 1984

Overburden	0.3m
Mineral I	2.8m
Waste	3.5m
Bedrock	0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy and silty, brown	0.3	0.3
Glacial sand and gravel	'Clayey' gravel, cobbly at the base Gravel: fine and coarse, rounded to subangular, granite with some quartzite, quartz, gneiss and weathered schist Sand: coarse, medium and fine, angular to subangular quartz, with some rock Fines: silty clay, brown	2.8	3.1
Till	Clay, sandy and pebbly, compact, greyish brown. Clasts up to cobble size of granite, quartzite, quartz, schist and gneiss	3.5	6.6
Dalradian	Schist, micaceous, highly weathered, well jointed; greenish yellow, with brownish-red haematite veins	0.5+	7.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
11	41	48	0.3- 1.3	12	12	13	18	23	22	0
			1.3- 2.3	9	10	10	16	26	29	0
			2.3- 3.1	12	12	12	21	22	12	9
			Mean	11	11	12	18	23	22	3

NJ 91 SW 11 **9300 1335** **West of Leuchlands, Old Machar** **Block J**

Water not struck
Section and pit
November 1984

Overburden	0.3m
Mineral I	3.0m
Waste	1.0m
Mineral I	1.5m
Waste	0.5m
Mineral I	2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Gravel, with trough cross-bedding Gravel: cobble to fine, some large boulders, subangular to rounded, psammite, pink and grey granite, with gneiss, schistose grit, quartzite, quartz, pelitic schist and gabbro Sand: mainly coarse, angular to subangular, quartz with feldspar and rock Fines: silt and clay, disseminated orange-brown	2.0	2.3
	b'Clayey' sand, with ripple-drift cross-lamination Sand: mainly fine, quartz Fines: silt and clay, pale yellowish brown Discrete plannar laminated seams and clay drapes on beds of cross-laminated sand	1.0	3.3
	Silt, sandy and clayey, planar-lamination, pale yellowish brown	1.0	4.3
	c 'Clayey' sand, with planar and ripple-drift lamination Sand: mainly fine, quartz with some mica Fines: silt and clay. Some seams (50 to 100mm)	1.5	5.8
	Silt and sand, micaceous, pale brown; interbedded with silty clay	0.5	6.3
	d 'Very clayey' sand Sand: mainly fine, quartz Fines: silt and clay in seams (up to 200mm), pale yellowish brown	2.2+	8.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	3	36	61	0.3- 2.3	3	2	12	22	18	15	28
b	20	80	0	2.3- 3.3	20	51	28	1	0	0	0
c	19	81	0	4.3- 5.8	19	65	15	1	0	0	0
d	24	76	0	6.3- 8.5	24	56	20	0	0	0	0
a&b	9	50	41	Mean	9	18	17	15	12	10	19
a-d	16	67	17	Mean	16	42	18	7	5	4	8

NJ 91 SW 12 | 9375 1260 | **Dubford, Old Machar** | **Block J**

Water not struck
Section and pit
November 1984

Overburden 2.3m
Mineral I 6.3m
Waste 1.4m
Bedrock 0.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Silt, sand and clay, pebbly, poorly bedded; mottled grey and reddish brown below 1.3m. Clasts up to boulder size	2.0	2.3
Glacial sand and gravel	a Sandy gravel, with trough cross-bedding Gravel: cobble to fine, with some boulders, subangular to well rounded, granite, gabbro, psammite, quartzite and vein quartz Sand: coarse and medium, subangular to subrounded quartz, with feldspar and rock	1.5	3.8
	b Sand, fining downwards Sand: mainly medium with some fine, subangular to subrounded quartz, with feldspar and rock Fines: silt, in thin seam, pale brown	2.5	6.3
	c Sand, with sparse pebbles, clayey to 7.5m Sand: mainly fine Fines: silt, in thin seams, pale yellowish brown	2.3	8.6
Till	Clay, sandy, stiff, passing laterally into silty clay, pale brown; angular clasts of quartzite	1.4	10.0
Dalradian	Orthoquartzite, recrystalised, medium to coarse grained, very hard, pale grey with thin purple veins	0.7+	10.7

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	1	65	34	2.3- 3.8	1	0	28	37	5	10	19
b	6	94	0	3.8- 6.3	6	16	77	1	0	0	0
c	9	89	2	6.3- 7.5	15	50	22	12	1	0	0
				7.5- 8.6	3	71	17	5	1	3	0
				Mean	9	60	0	9	1	1	0
a-c	6	84	10	Mean	6	28	44	12	2	3	5

NJ 91 SW 13 **9410 1444** **Cranfield, Old Machar** **Block J**

Surface level +70m
Ground water conditions not recorded
250mm percussion and shell
September 1984

Waste	2.4m
Bedrock	1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
Till	Clay, sandy and stony, firm, moderate reddish brown to moderate brown. Pebbles of weathered schist and granite; a large cobble of weathered schist at 2.1m	2.2	2.4
Dalradian	Semipelite, schistose, micaceous, with quartz veins, dark grey weathering reddish brown	1.9+	4.3

NJ 91 SW 14 **9451 1376** **Newton of Mundurno, Old Machar** **Block J**

Surface level +54m
Water not struck
250mm percussion and shell
September 1984

Overburden	0.2m
Mineral I	1.1m
Waste	4.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
Glacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse with some fine, subangular to well rounded, granite, psammite and quartz Sand: medium with coarse and fine, subangular to subrounded quartz and angular granite Fines: silty clay in thin beds, reddish brown	1.1	1.3
Glaciolacustrine deposits	Clay, silty, laminated, reddish brown to pale brown; partings of fine quartz sand	0.3	1.6
Till	Clay, stony, greyish brown. Clasts up to cobble size of granite, psammite and quartz. A large boulder of weathered schist from 2.1 to 3.4m	1.8	3.4
Glaciolacustrine deposits	Clay, poorly laminated, reddish brown	1.7	5.1
?Till	Gravel and sand; angular fragments of quartz, schist and quartzite, with reddish brown silt and clay.	0.2+	5.3
	Borehole abandoned owing to slow progress. Obstruction caused by large boulder or bedrock		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
29	39	32	0.2- 1.3	29	10	17	12	12	20	0

NJ 91 SE 1 **9538 1486** **Middlefield, Belhelvie** **Block J**

Surface level +45
Water struck at +40.6m
250mm percussion and shell
September 1984

Overburden 2.0m
Mineral I 1.0m
Waste 3.8m
Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, humic, dusky yellowish brown	0.3	0.3
Till	Clay, sandy and pebbly, interbedded with finely laminated sandy silt, reddish brown. Pebbles of red and grey granitic rock, quartz, schist and basic igneous rock	0.8	1.1
Glaciolacustrine deposits	a Silt, sandy, laminated, micaceous, moderate brown	0.9	2.0
	b 'Clayey' sand Sand: mainly fine, rounded quartz and mica Fines: silt and clay, finely laminated discrete seams, moderate brown	1.0	3.0
	c Silt, very sandy, with partings of laminated brown clay	1.2	4.2
	Clay, waxy, stiff, laminated in part; thin beds of sand from 4.2 to 4.6m; moderate reddish brown to reddish brown	2.6	6.8
Caledonian	Peridotite, hard ultrabasic rock, greenish black	1.2+	8.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	52	48	0	1.1- 2.0	52	45	3	0	0	0	0
b	13	87	0	2.0- 3.0	13	83	4	0	0	0	0
c	44	56	0	3.0- 4.2	44	53	2	1	0	0	0
a-c	36	64	0	Mean	36	61	3	trace	0	0	0

NJ 91 SE 2 **9550 1320** **Tarbuthill Farm, Old Machar** **Block J**

Surface level +32m
Water not struck
250mm percussion and shell
September 1984

Overburden 0.4m
Mineral I 1.9m
Waste 3.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, humic, sandy, dark brown	0.4	0.4
Glacial sand and gravel	'Clayey' pebbly sand; cleaner with depth Gravel: coarse and fine, some cobbles, angular to subrounded, red and grey granite, schist and some basic igneous rocks Sand: mainly medium and coarse, angular to rounded quartz with some feldspar and rock Fines: silt and clay, disseminated, yellowish brown	1.9	2.3
Till	Clay, sandy, very stiff, dark yellowish brown. Abundant clasts upto cobble size of schist, pink, red and grey granite, psammite and basic igneous rocks	3.8+	6.1
	Borehole abandoned owing to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
12	64	24	0.4- 1.1	21	12	19	18	11	12	7
			1.1- 2.3	7	12	37	23	10	11	0
			Mean	12	12	31	21	10	11	3

NJ 92 SE 1 **9751 2114** **Cothill, Belhelvie** **Block G**

Surface level +47m
Water struck at +42.3m
250mm percussion and shell
October 1984

Waste 5.0m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, brownish red, becoming mottled with dark grey below 1.5m, sparse boulders of schist and scattered pebbles	4.7	5.0
Dalradian	Schist, semipelitic	0.1+	5.1

NJ 92 SE 2 **9872 2217** **Drums, Foveran** **Block K**

Surface level +24m
Water struck at +23.6m
250mm percussion and shell
November 1984

Overburden 4.4m
Mineral I 1.4m
Waste 2.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, brown	0.4	0.4
Till	Clay, pebbly, becoming sandy and gritty below 0.9m, reddish brown. Clasts up to cobble size of quartzite and sandstone	3.2	3.6
Glaciolacustrine deposits	Silt, sandy, brown, interbedded with fine sand	0.8	4.4
Glacial sand and gravel	Sandy gravel, fining downwards Gravel: cobble to fine, subangular metamorphic rocks and psammite Sand: mainly medium, angular quartz, rock and mica Fines: clay and silt, disseminated, greyish brown	1.4	5.8
Till	Clay, silty, firm, dark yellowish brown to brownish grey. Clasts up to boulder size of schist, granitic, fine-grained basic igneous and metamorphic rocks. A bed of sandy gravel from 6.8 to 7.1m	2.9+	8.7
	Borehole abandoned owing to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
8	65	27	4.4– 5.2	5	8	25	18	9	16	19
			5.2– 5.8	12	19	52	13	3	1	0
			Mean	8	13	36	16	6	10	11

NJ 92 SE 3	9818 2144	**Hatterseat, Belhelvie**	**Block K**

Surface level +40m
Water struck at +38.1m
Pit and 250mm percussion and shell
November 1984

Overburden 0.1m
Mineral I 7.1m
Waste 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel (Esker)	Sandy gravel Gravel: cobble to fine, subangular to rounded quartzite, quartz and psammate with some granite, pelite and sandstone Sand: mainly coarse and medium, angular to subangular quartz and quartzite	7.1	7.2
Dalradian	Semipelite, weathered, grey	0.4+	7.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
2	53	45	0.1- 2.0	1	4	20	24	7	8	36
			2.0- 4.0	2	5	24	32	13	6	18
			4.0- 5.0	2	4	19	32	18	17	8
			5.0- 6.0	1	2	15	36	25	21	0
			6.0- 7.2	2	2	12	33	26	25	0
			Mean	2	4	19	30	16	13	16

NJ 92 SE 4	9884 2088	**Coast Guard Lookout, Belhelvie**	**Block L**

Water struck at 1.1m depth
Pit
September 1984

Waste 2.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Blown Sand	Sand, mainly fine and medium, 'soft' pale yellowish brown	0.7	0.8
Post-Glacial beach and estuarine deposits	Very silty sand, fine to medium, quartz; micaceous, medium grey below 1.9m. Disseminated organic matter above 1.0m; amorphous peat from 1.0 to 1.1m; sand and gravel towards the base	2.1+	2.9

NJ 92 SE 5 | 9876 2076 | **Menie Links, Belhelvie** | **Block L**

Surface level +7.0m
Water struck at c+6.3m
250 and 200mm percussion and shell
November 1984

Overburden	0.3m
Mineral I	1.3m
Waste	0.6m
Mineral I	3.8m
Waste	2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Made Ground	Soil with cobbles of quartzite and granite	0.3	0.3
Blown Sand	a Sand with sparse pebbles and cobbles Sand: mainly medium with some fine, angular to subrounded quartz Fines: disseminated, yellowish orange above 0.7m, yellowish brown below	1.3	1.6
Peat	Peat, sandy and silty, dark brown, compact	0.6	2.2
Post-Glacial beach and estuarine deposits	b Pebbly sand, clayey towards the top Gravel: mainly fine, subangular to rounded, quartzite, quartz and psammite Sand: fine and medium with coarse, angular to subangular quartz Fines: silt, laminated, greyish green to 3.2m, reddish brown and greyish brown below	3.8	6.0
Till	Clay, stony, compact, grey-brown. Small pebbles of psammite, quartzite, quartz and red and yellow-brown sandstone; angular pebbles of psammite and dark green basic rock below 7.6m	2.0+	8.0

Borehole abandoned owing to slow progress

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	2	89	9	0.3- 1.6	2	36	52	1	0	9	0
b	7	85	8	2.2- 3.2	12	56	20	7	2	3	0
				3.2- 4.2	6	26	37	24	5	2	0
				4.2- 5.2	4	19	32	30	13	2	0
				5.2- 6.0	7	35	35	19	4	0	0
				Mean	7	34	31	20	6	2	0
a&b	6	85	9	Mean	6	34	36	15	5	4	0

NJ 92 SE 6 | **9866 2074** | **Menie Links, Belhelvie** | **Block L**

Water struck at c3.0 depth
Pit
September 1984

Overburden	0.1m
Mineral I	1.1m
Waste	2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Blown Sand	Sand, mainly medium, quartz, pale yellowish brown	1.1	1.2
Post-Glacial beach and estuarine deposits	Very silty sand, fine quartz and disseminated organic matter, dark grey to black	0.6	1.8
	Silt, clayey and sandy, firm, micaceaus, humic patches; bluish grey to black. A bed of sand and gravel towards the base	1.4	3.2
Till	Clay, very silty and sandy, stiff, scattered pebbles; mottled medium grey and orange	0.2+	3.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand				Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4		+4-16	+16-64	+64 mm
			0.1-1.2	No grading data available for this deposit							

NJ 92 SE 7 **9906 2356** **Pitscaff Croft, Foveran** **Block K**

Surface level +32m
Water struck, level not recorded
250mm percussion and shell
November 1984

Overburden 5.8m
Mineral I 9.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, brown	0.2	0.2
Till	Clay, pebbly, yellowish brown above 1.2m; reddish brown from 1.2 to 4.7m, interbedded with subangular quartz sand. Rounded pebbles of quartz, quartzite and weathered pelite	4.5	4.7
Glaciolacustrine deposits	Clay, silty, reddish brown, finely laminated with partings of brown silt and fine quartz sand; some thin beds of fine sand	1.1	5.8
Glacial sand and gravel (Esker)	Sandy gravel Gravel: fine with some coarse, sparse cobbles, subangular to rounded psammite, grey schist, red granite, vein quartz, gritty quartzite and some gneiss Sand: coarse and medium, angular to subangular rock and quartz Fines: disseminated, buff	9.4+	15.2
	Borehole terminated owing to obstruction. Large boulders at bottom of borehole		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
1	78	21	5.8- 6.8	2	2	23	54	15	4	0
			6.8- 7.8	2	2	25	40	18	13	0
			7.8- 8.8	1	2	38	40	8	11	0
			8.8-10.0	1	4	45	39	7	4	0
			10.0-11.0	1	6	61	23	8	1	0
			11.0-12.0	2	3	22	27	23	13	10
			12.0-13.0	1	4	39	48	7	1	0
			13.0-14.0	1	2	32	43	12	10	0
			14.0-15.2	1	4	23	42	13	17	0
			Mean	1	3	34	41	12	8	1

NJ 92 SE 8 **9898 2352** **Pitscaff Croft, Foveran** **Block K**

Water not struck
Pit
September 1984

Overburden 1.3m
Mineral I 1.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Made ground		0.4	0.4
Till	Clay, silty, stiff, reddish brown. Pebbles mainly of schist	0.9	1.3
Glacial sand and gravel (Esker)	Gravel Gravel: coarse with some fine and cobbles; rounded schist with some red and grey granite, quartzite, vein quartz and psammite Sand: mainly coarse with some medium, angular to subrounded, quartz with feldspar and some rock Fines: silt and clay; disseminated, orange brown	1.7+	3.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
5	32	63	1.3- 3.0	5	3	12	17	21	38	4

NJ 92 SE 9 | **9915 2105** | **Menie Links, Belhelvie** | **Block L**

Water struck at c0.7m depth
Pit
September 1984

Mineral I 2.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Post-Glacial beach and estuarine deposits	Pebbly sand; a bed of coarse gravel from 0.6 to 1.1m Gravel: fine and coarse, rounded to well rounded schist and psammite with some granite, quartzite and vein quartz Sand: mainly fine, rounded quartz with some mica Fines: silt, disseminated; reddish brown to pink towards the base	2.5+	2.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
4	81	15	0.0- 0.6	1	50	48	0	1	0	0
			0.6- 1.1	0	3	24	3	17	53	0
			1.1- 2.5	6	93	1	0	0	0	0
			Mean	4	63	17	1	4	11	0

NO 89 NW 1 | 8044 9917 | **Moss-side, Drumoak** | Block 0

Surface level +35m
Water struck at +32m
250mm percussion and shell
October 1984

Overburden 0.4m
Mineral I 4.9m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	'Clayey' pebbly sand Gravel: fine with coarse, subangular to subrounded granite, quartzite, schist and psammite Sand: coarse and medium, subangular to rounded quartz and feldspar	4.9	5.3
Caledonian	Granite, reddish, weathered	0.3+	5.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
18	69	13	0.4- 1.4	12	4	37	21	15	11	0
			1.4- 2.5	25	4	23	38	9	1	0
			2.5- 3.0	26	4	21	40	8	1	0
			3.0- 4.0	23	4	23	40	8	2	0
			4.0- 5.3	8	4	20	58	9	1	0
			Mean	18	4	25	40	10	3	0

NO 89 NW 2 | 8088 9838 | **Old Manse Wood, Drumoak** | **Block O**

Surface level +31m
Water struck at c+26m
250mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 10.0m
Waste 9.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine and coarse, subangular to subrounded, granite, schist and psammite Sand: coarse and medium, angular to subrounded quartz	8.2	8.5
	b 'Very clayey' sand Sand: fine and medium, subangular to subrounded quartz, feldspar and rock fragments Fines: silty clay, yellowish brown	1.8	10.3
Glaciolacustrine deposits	Silt, sandy in parts, laminated, yellowish brown	7.9	18.2
Fluvioglacial sand and gravel	c Pebbly sand Gravel: fine and coarse, subangular to rounded granite, schist and psammite Sand: fine and medium, subangular to subrounded quartz, feldspar and rock fragments	2.0+	20.2
	Borehole terminated on rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	4	54	42	0.3- 0.9	2	1	26	36	13	17	5
				0.9- 2.0	6	13	49	15	10	7	0
				2.0- 3.0	6	7	18	39	16	14	0
				3.0- 4.4	8	5	27	6	10	38	6
				4.4- 5.6	2	7	18	25	18	15	15
				5.6- 6.6	2	3	14	25	29	27	0
				6.6- 7.5	4	5	19	24	27	18	3
				7.5- 8.5	2	11	27	22	17	14	7
				Mean	4	7	25	22	17	20	5
b	30	69	1	8.5-10.3	30	32	29	8	1	0	0
c	5	76	19	18.2-19.0	6	32	38	11	6	7	0
				19.0-20.2	4	24	36	13	9	14	0
				Mean	5	27	37	12	8	11	0
a&b	9	57	34	Mean	9	11	26	20	14	16	4
a-c	8	61	31	Mean	8	14	28	19	13	15	3

NO 89 NW 3 | 8005 9767 | **Kincluny, Durris** | **Block O**

Surface level +44m
Water struck at +36m
250 and 200mm percussion and shell
October 1984

Overburden 0.3m
Mineral I 19.4m
Waste 2.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Sandy gravel, gravel at top, 'clayey' at base Gravel: fine and coarse with cobble, rounded granite with angular psammite and schist and some felsite and dark basic igneous rocks Sand: medium and coarse, angular quartz, feldspar and rock fragments	3.0	3.3
	b 'Clayey' sand, 'very clayey' at base, medium and fine, angular to subangular quartz, feldspar and lithic fragments	4.7	8.0
	c Pebbly sand Gravel: fine with coarse, angular granite, schist and felsite Sand: fine to coarse, angular to subangular quartz, feldspar and rock fragments	3.0	11.0
	d Sandy Gravel Gravel: coarse and medium, angular to subrounded granite, schist and quartz with some dark igneous rocks Sand: medium and coarse, angular to subrounded quartz, feldspar and rock fragments	8.7	19.7
Till	Clay, silty, stony, yellowish brown	2.3+	22.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	7	48	45	0.3- 1.0	2	1	10	14	16	38	19
				1.0- 2.5	5	8	21	25	24	17	0
				2.5- 3.3	14	10	23	27	18	8	0
				Mean	7	7	19	22	21	20	4
b	12	87	1	3.3- 4.3	7	10	58	21	3	1	0
				4.3- 5.3	2	13	72	11	2	0	0
				5.3- 6.3	8	41	46	5	0	0	0
				6.3- 7.0	7	20	62	10	1	0	0
				7.0- 8.0	36	44	19	0	0	1	0
				Mean	12	26	52	9	1	0	0
c	5	81	14	8.0- 8.5	13	19	34	25	9	0	0
				8.5- 9.5	2	22	46	20	10	0	0
				9.5-11.0	4	22	38	19	8	9	0
				Mean	5	22	39	20	9	5	0
d	2	69	29	11.0-12.0	1	5	25	22	17	30	0
				12.0-13.0	1	9	35	22	14	12	7
				13.0-14.0	3	16	38	20	13	10	0
				14.0-15.0	1	11	29	21	16	22	0
				15.0-17.0	4	10	39	28	10	9	0
				17.0-18.0	2	9	43	20	9	17	0
				18.0-19.0	1	10	39	17	15	18	0
				19.0-19.7	2	10	44	18	9	11	6
				Mean	2	10	37	22	13	15	1
a-d	6	71	23	Mean	6	15	37	19	11	11	1

NO 89 NW 4 **8194 9970** **Coalford, Drumoak** **Block N**

Water not struck
Pit
September 1984

Waste 1.2m
Bedrock 0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy and silty, stony, yellowish brown; cobbles and boulders of granite	0.9	1.2
Dalradian	Gneiss, coarse grained, hard, pink	0.5+	1.7

NO 89 NW 5 **8181 9836** **Tilbouries Lodge, Durris** **Block O**

Surface level +38m
Water struck at +32.6m
250 and 200mm percussion and shell
November 1984

Overburden 0.3m
Mineral I 5.0m
Waste 2.6m
Mineral I 1.9m
Waste 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine with coarse, subangular to rounded granite with schist, quartzite and psammite Sand: mainly medium, angular to subrounded quartz, feldspar and rock fragments	1.9	2.2
	b Pebbly sand Gravel: fine, subangular to rounded granite with quartzite, schist, psammite and quartz Sand: fine to coarse, subangular to subrounded quartz, feldspar and rock fragments	2.1	4.3
	c 'Very clayey' sand Sand: fine, subangular to subrounded quartz Fines: silt, laminated, yellowish-brown	1.0	5.3
Glaciolacustrine deposits	d Silt, sandy at top, laminated, reddish brown	2.6	7.9
Glacial sand and gravel	e Sandy gravel Gravel: fine and coarse with cobble, subangular to rounded granite, schist and quartzite Sand: fine to coarse, angular to subrounded quartz, feldspar and lithic fragments	1.9	9.8
Till	Clay, sandy, stony, grey-brown	0.3+	10.1
	Borehole terminated due to slow progress		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	2	73	25	0.3- 1.2	3	19	41	16	13	8	0
				1.2- 2.2	2	7	35	29	16	11	0
				Mean	2	13	37	23	15	10	0
b	8	86	6	2.2- 3.2	2	6	49	34	9	0	0
				3.2- 4.3	13	34	35	15	3	0	0
				Mean	8	21	41	24	6	0	0
c	28	72	0	4.3- 5.3	28	68	4	0	0	0	0
d	43	57	0	5.3- 6.2	43	53	3	1	0	0	0
e	4	59	37	7.9- 9.8	4	14	27	18	14	8	15
a-c+e	8	73	9	Mean	8	24	31	18	10	5	4

NO 89 NW 6 **8471 9993** **Templar's Park, Maryculter** **Block O**

Surface level +23m
Water struck at +20.7m
250 and 200mm percussion and shell
November 1984

Overburden 0.6m
Mineral I 4.7m
Waste 3.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
	Silt, sandy, brown	0.3	0.6
Fluvioglacial sand and gravel	a 'Clayey' sand Sand: fine and medium, subangular to subrounded quartz Fines: silty, pale brown	3.0	3.6
	b Sandy gravel Gravel: fine and coarse, subangular to well rounded granite with schist, quartzite and felsite Sand: medium and coarse, angular to subangular quartz and lithic fragments	1.7	5.3
Till	Clay, sandy, stony, greyish brown	1.2	6.5
Glacial sand and gravel	c Sandy gravel Gravel: fine and coarse, angular to subrounded granite and schist with quartzite and felsite Sand: medium and coarse, angular to subangular quartz, feldspar and rock fragments	0.8	7.3
Till	Clay, sandy, stony, grey; pebbles and cobbles of granite and schist	1.7+	9.0
	Borehole terminated due to slow progress		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64	+64 mm
a	12	86	2	0.6- 1.6	7	44	34	12	3	0	0
				1.6- 3.6	14	44	32	8	2	0	0
				Mean	12	44	33	9	2	0	0
b	2	66	32	3.6- 4.6	2	11	33	29	14	11	0
				4.6- 5.3	3	9	23	22	17	23	3
				Mean	2	10	30	26	15	16	1
c	6	51	43	6.5- 7.3	6	10	17	24	22	21	0
a&b	8	79	13	Mean	8	33	31	15	7	6	0
a-c	8	75	17	Mean	8	29	29	17	9	8	0

NO 89 SE 1 | 8810 9086 | **Cantlayhills, Muchalls** | **Block P**

Water not struck
Section and Pit
October 1984

Overburden 0.2m
Mineral 7.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.2	0.2
Glacial sand and gravel	a Sandy gravel Gravel: fine and coarse with cobbles, subangular to subrounded granite and quartzite with some weathered psammite and schist Sand: fine to coarse, angular quartz and granite	3.8	4.0
	b Gravel Gravel: fine to cobble, rounded to well rounded granite with psammite, schist and some quartz Sand: mainly medium and coarse, angular to subangular quartz and granite	1.6	5.6
	c Pebbly sand Gravel: fine and coarse, subrounded to rounded granite and psammite Sand: mainly fine and medium, angular to subangular quartz Fines: silty clay, reddish brown	1.7+	7.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	6	62	32	0.2- 2.0	8	10	41	14	14	13	0
				2.0- 4.0	4	14	29	17	17	11	8
				Mean	6	12	34	16	16	12	4
b	3	32	65	4.0- 5.6	3	4	12	16	18	24	23
c	9	75	16	5.6- 7.3	9	40	26	9	9	7	0
a-c	6	59	35	Mean	6	17	28	14	15	13	7

NO 89 SE 2 **8779 9065** **Hillocks, Muchalls** **Block P**

Overburden 0.1m
Mineral 3.2m+

Water not struck
Pit
October 1984

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.1	0.1
Glacial sand and gravel	Gravel Gravel: fine to cobble, rounded to well rounded granite, quartzite and psammite with some schist Sand: medium and coarse, angular to subangular quartz and granite	3.2+	3.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
3	32	65	0.1- 1.0	3	5	12	19	21	40	0
			1.0- 2.0	2	4	11	19	22	25	17
			2.0- 3.3	3	3	10	14	20	31	19
			Mean	3	4	11	17	21	31	13

NO 99 NW 1 | **9364 9930** | **Mains of Cairnrobin, Findon** | **Block P**

Water struck at a depth of 6.3m
Section and pit
October 1984

Overburden 1.0m
Mineral I 5.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	Cobble gravel in silty matrix; boulders and cobbles of granite, pelite and psammite	0.9	1.0
	a 'Very clayey' sandy gravel Gravel: fine and coarse, subrounded to well rounded granite with subangular to rounded, pelitic and psammitic rocks Sand: fine and medium, angular to subangular quartz Fines: silty clay, yellow-brown	2.0	3.0
	b Sandy gravel Gravel: fine and coarse with cobble, rounded to well rounded granite with quartzite and some pelitic, psammitic and basic igneous rocks Sand: fine to coarse, angular to subangular quartz and granite fragments	3.9+	6.9

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	25	50	25	1.0- 2.0	28	18	16	8	11	19	0
				2.0- 3.0	24	22	27	8	7	12	0
				Mean	25	20	22	8	9	16	0
b	8	55	37	3.0- 4.5	No grading data available						
				4.5- 5.5	6	14	24	21	14	16	5
				5.5- 6.9	10	17	18	17	18	12	8
				Mean	8	16	20	19	16	14	7
a&b	14	54	32	Mean	14	17	22	15	14	14	4

The following reports relate particularly to bulk mineral resources

Reports of the Institute of Geological Sciences

Assessment of British Sand and Gravel Resources

1 The sand and gravel resources of the country south-east of Norwich, Norfolk: Resource sheet TG 20.
E. F. P. Nickless.
Report 71/20 ISBN 0 11 880216 X £1.15

2 The sand and gravel resources of the country around Witham, Essex: Resource sheet TL 81. H. J. E. Haggard.
Report 72/6 ISBN 0 11 880588 6 £1.20

3 The sand and gravel resources of the country south and west of Woodbridge, Suffolk: Resource sheet TM 24.
R. Allender and S. E.Hollyer.
Report 72/9 ISBN 0 11 880596 7 £1.70

4 The sand and gravel resources of the country around Maldon, Essex: Resource sheet TL 80. J. D. Ambrose
Report 73/1 ISBN 0 11 880600 9 £1.20

5 The sand and gravel resources of the country around Hethersett, Norfolk: Resource sheet TG 10.
E. F. P. Nickless.
Report 73/4 ISBN 0 11 880606 8 £1.60

6 The sand and gravel resources of the country around Terling, Essex: Resource sheet TL 71. C. H. Eaton.
Report 73/5 ISBN 0 11 880608 4 £1.20

7 The sand and gravel resources of the country around Layer Breton and Tolleshunt D'Arcy, Essex: Resource sheet TL 91 and part 90. J. D. Ambrose.
Report 73/8 ISBN 0 11 880614 9 £1.30

8 The sand and gravel resources of the country around Shotley and Felixstowe, Suffolk: Resource sheet TM 23.
R. Allender and S. E. Hollyer.
Report 73/13 ISBN 0 11 880625 4 £1.60

9 The sand and gravel resources of the country around Attlebridge, Norfolk: Resource sheet TG 11.
E. F. P. Nickless.
Report 73/15 ISBN 0 11 880658 0 £1.85

10 The sand and gravel resources of the country west of Colchester, Essex: Resource sheet TL 92. J. D. Ambrose.
Report 74/6 ISBN 0 11 880671 8 £1.45

11 The sand and gravel resources of the country around Tattingstone, Suffolk: Resource sheet TM 13. S. E. Hollyer.
Report 74/9 ISBN 0 11 880675 0 £1.95

12 The sand and gravel resources of the country around Gerrards Cross, Buckinghamshire: Resource sheet SU 99, TQ 08, 09. H. C. Squirrell.
Report 74/14 ISBN 0 11 880710 2 £2.20

Mineral Assessment Reports (Institute of Geological Sciences)

13 The sand and gravel resources of the country east of Chelmsford, Essex: Resource sheet TL 70. M. R. Clarke.
ISBN 0 11 880744 7 £3.50

14 The sand and gravel resources of the country east of Colchester, Essex: Resource sheet TM 02. J. D. Ambrose.
ISBN 0 11 880745 5 £3.25

15 The sand and gravel resources of the country around Newton on Trent, Lincolnshire: Resource sheet SK 87.
D. Price.
ISBN 0 11 880746 3 £3.00

16 The sand and gravel resources of the country around Braintree, Essex: Resource sheet TL 72. M. R. Clarke.
ISBN 0 11 880747 1 £3.50

17 The sand and gravel resources of the country around Besthorpe, Nottinghamshire: Resource sheet SK 86 and part 76. J. R. Gozzard.
ISBN 0 11 880748 X £3.00

18 The sand and gravel resources of the Thames Valley, the country around Cricklade, Wiltshire: Resource sheet SU 09, 19 and parts SP 00, 10. P R. Robson.
ISBN 0 11 880749 8 £3.00

19 The sand and gravel resources of the country south of Gainsborough, Lincolnshire: Resource sheet SK 88 and part 78. J .H. Lovell.
ISBN 0 11 880750 1 £2.50

20 The sand and gravel resources of the country east of Newark upon Trent, Nottinghamshire: Resource sheet SK 85.
J. R. Gozzard.
ISBN 0 11 880751 X £2.75

21 The sand and gravel resources of the Thames and Kennet Valleys, the country around Pangbourne, Berkshire: Resource sheet SU 67. H. C. Squirrell.
ISBN 0 11 880752 8 £3.25

22 The sand and gravel resources of the country north-west of Scunthorpe, Humberside: Resource sheet SE 81.
J. W. C. James.
ISBN 0 11 880753 6 £3.00

23 The sand and gravel resources of the Thames Valley, the country between Lechlade and Standlake: Resource sheet SP 30 and parts SP 20, SU 29, 39. P. Robson.
ISBN 0 11 881252 1 £7.25

24 The sand and gravel resources of the country around Aldermaston, Berkshire: Resource sheet SU 56, 66.
H. C. Squirrell.
ISBN 0 11 881253 X £5.00

25 The celestite resources of the area north-east of Bristol: Resource sheet ST 68 and parts 59, 69, 79, 58, 68, 78, 77.
E. F. P. Nickless, S. J. Booth and P. N. Mosley.
ISBN 0 11 881262 9 £5.00

26 The limestone and dolomite resources of the country around Monyash, Derbyshire: Resource sheet SK 16.
F. C. Cox and D. McC. Bridge.
ISBN 0 11 881263 7 £7.00

27 The sand and gravel resources of the country west and south of Lincoln, Lincolnshire: Resource sheets SK 95 and part 96, and SK 97 and part 96. I. Jackson.
ISBN 0 11 884003 7 £6.00

28 The sand and gravel resources of the country around Eynsham, Oxfordshire: Resource sheet SP 40 and part 41.
W. J. R. Harries.
ISBN 0 11 884012 6 £3.00

29 The sand and gravel resources of the country south-west of Scunthorpe, Humberside: Resource sheet SE 80.
J. H. Lovell.
ISBN 0 11 884013 4 £3.50

30 Procedure for the assessment of limestone resources.
F. C. Cox, D. McC. Bridge and J. H. Hull.
ISBN 0 11 884030 4 £1.25

31 The sand and gravel resources of the country west of Newark upon Trent, Nottinghamshire: Resource sheet SK 75.
D. Price and P. J. Rogers.
ISBN 0 11 884031 2 £3.50

32 The sand and gravel resources of the country around Sonning and Henley, Berkshire, Oxfordshire and Buckinghamshire: Resource sheet SU 77, 78.
H. C. Squirrell.
ISBN 0 11 884032 0 £5.25

33 The sand and gravel resources of the country north of Gainsborough, Lincolnshire: Resource sheet SK 89.
J. R. Gozzard and D. Price.
ISBN 0 11 884033 9 £4.50

34 The sand and gravel resources of the Dengie Peninsula, Essex: Resource sheet TL 90 and parts 80, TM 00, TQ 89, 99, TR 09. M. B. Simmons.
ISBN 0 11 884081 9 £5.00

35 The sand and gravel resources of the country around Darvel, Strathclyde: Resource sheet comprising parts of NS 53, 54, 63, 64. E. F. P. Nickless, A. M. Aitken and A. A. McMillan.
ISBN 0 11 884082 7 £7.00

36 The sand and gravel resources of the country around Southend-on-Sea, Essex: Resource sheets comprising parts of TQ 88, 89, 98, 99, TR 08, 09; and TQ 78, 79 and parts of 88, 89. S. E. Hollyer and M. B. Simmons.
ISBN 0 11 884083 5 £7.50

37 The sand and gravel resources of the country around Bawtry, South Yorkshire: Resource sheet SK 69.
A. R. Clayton.
ISBN 0 11 884053 3 £5.75

38 The sand and gravel resources of the country around Abingdon, Oxfordshire: Resource sheet SU 49, 59, SP 40, 50.
C. E. Corser.
ISBN 0 11 884084 5 £5.50

39 The sand and gravel resources of the Blackwater Valley (Aldershot) area: Resource sheet SU 85, 86 and parts 84, 94, 95, 96. M. R. Clarke, A. J. Dixon and M. Kubala.
ISBN 0 11 884085 1 £7.00

40 The sand and gravel resources of the country west of Darlington, County Durham: Resource sheet NZ 11, 21.
A. Smith.
ISBN 0 11 884086 X £5.00

41 The sand and gravel resources of the country around Garmouth, Grampian Region: Resource sheet NJ 36.
A. M. Aitken, J. W. Merritt and A. J. Shaw.
ISBN 0 11 884090 8 £8.75

42 The sand and gravel resources of the country around Maidenhead and Marlow: Resource sheet SU 88 and parts 87, 97, 98. P. N. Dunkley.
ISBN 0 11 884091 6 £5.00

43 The sand and gravel resources of the country around Misterton, Nottinghamshire: Resource sheet SK 79.
D. Thomas and D. Price.
ISBN 0 11 884092 4 £5.25

44 The sand and gravel resources of the country around Sedgefield, Durham: Resource sheet NZ 32. M. D. A. Samuel.
ISBN 0 11 884093 2 £5.75

45 The sand and gravel resources of the country around Brampton, Cumbria: Resource sheet NY 55, part 56. I. Jackson.
ISBN 0 11 884094 0 £6.75

46 The sand and gravel resources of the country north of Harlow, Essex: Resource sheet TL 41. P. M. Hopson.
ISBN 0 11 884107 6 £9.50

47 The limestone and dolomite resources of the country around Wirksworth, Derbyshire: Resource sheet SK 25 and part 35. F. C. Cox and D. J. Harrison.
ISBN 0 11 884108 4 £15.00

48 The sand and gravel resources of the Loddon Valley area: Resource sheet SU 75, 76, and parts 64, 65, 66, 74.
M. R. Clarke, E. J. Raynor and R. A. Sobey.
ISBN 0 11 884109 2 £8.75

49 The sand and gravel resources of the country around Lanark, Strathclyde Region: Resource sheet NS 94 and part 84. J. L. Laxton and E. F. P. Nickless.
ISBN 0 11 884110 6 £11.00

50 The sand and gravel resources of the country around Fordingbridge, Hampshire: Resource sheet SU 11 and parts 00, 01, 10, 20, 21. M. Kubala.
ISBN 0 11 884111 4 £7.75

51 The sand and gravel resources of the country north of Bournemouth, Dorset: Resource sheet SU 00, 10, 20, SZ 09, 19, 29. M. R. Clarke.
ISBN 0 11 884112 2 £9.75

52 The sand and gravel resources of the country between Hatfield Heath and Great Waltham, Essex: Resource sheet TL 51, 61. R. J. Marks.
ISBN 0 11 884113 0 £8.00

53 The sand and gravel resources of the country around Cottenham, Cambridgeshire: Resource sheet TL 46, 47.
A. J. Dixon.
ISBN 0 11 884114 9 £9.25

54 The sand and gravel resources of the country around Huntingdon and St Ives, Cambridgeshire: Resource sheets comprising parts of TL 16, 17, 26, 27; and TL 26, 27, 36, 37.
R. W. Gatliff.
ISBN 0 11 884115 7 £8.75

55 The sand and gravel resources of the country around Ipswich, Suffolk: Resource sheet TM 14. R. Allender and S. E. Hollyer.
ISBN 0 11 884116 5 £10.00

56 Procedure for the assessment of the conglomerate resources of the Sherwood Sandstone Group. D. P. Piper and P. J. Rogers.
ISBN 0 11 884143 2 £1.25

57 The conglomerate resources of the Sherwood Sandstone Group of the country around Cheadle, Staffordshire: Resource sheet SK 04. P. J. Rogers, D. P. Piper and T. J. Charsley.
ISBN 0 11 884144 0 £7.75

58 The sand and gravel resources of the country west of Peterhead, Grampian Region: Resource sheet NK 04 and parts NK 05, 14, 15, NJ 94, 95. A. A. McMillan and A. M. Aitken.
ISBN 0 11 884145 9 £12.00

59 The sand and gravel resources of the country around Newbury, Berkshire: Resource sheet SU 46, 47 and parts 36, 37, 47. J. R. Gozzard.
ISBN 0 11 884146 7 £11.50

60 The sand and gravel resources of the country south-west of Peterborough, in Cambridgeshire and east Northamptonshire: Resource sheets TL 09, 19 and SP 98, TL 08.
A. M. Harrisson.
ISBN 0 11 884147 5 £15.50

61 The sand and gravel resources of the country north of Wrexham, Clwyd: Resource sheet SJ 35 and part 25.
P. N. Dunkley.
ISBN 0 11 884148 3 £11.75

62 The sand and gravel resources of the country around Dolphinton, Strathclyde Region, and West Linton, Borders Region: Resource sheet NT 04, 14 and parts 05 15.
A. A. McMillan, J. L. Laxton and A. J. Shaw.
ISBN 0 11 884149 1 £8.00

63 The sand and gravel resources of the valley of the Douglas Water, Strathclyde Region: Resource sheet NS 83 and parts 82, 92, 93. A. J. Shaw and E. F. P. Nickless.
ISBN 0 11 884150 5 £11.50

64 The sand and gravel resources of the country between Wallingford and Goring, Oxfordshire: Resource sheet SU 68 and part 58. C. E. Corser.
ISBN 0 11 884151 3 £11.50

65 The sand and gravel resources of the country around Hexham, Northumberland: Resource sheet NY 86, 96.
J. H. Lovell.
ISBN 0 11 884152 1 £7.50

66 The sand and gravel resources of the country west of Chelmsford, Essex: Resource sheet TL 60. P. M. Hopson.
ISBN 0 11 884153 X £8.50

67 The sand and gravel resources of the country around Hatfield and Cheshunt, Hertfordshire: Resource sheet TL 20, 30 and parts TQ 29, 39. J. R. Gozzard.
ISBN 0 11 884167 X £10.00

68 The sand and gravel resources of the country north-east of Halstead, Essex: Resource sheet TL 83. R. J. Marks and J. W. Merritt.
ISBN 0 11 884168 8 £13.25

69 The sand and gravel resources of the country around Welwyn Garden City, Hertfordshire: Resource sheet TL 11, 21.
J. R. Gozzard.
ISBN 0 11 884169 6 £10.50

70 The sand and gravel resources of the country east of Harrogate, North Yorkshire: Resource sheet SE 35.
D. L. Dundas.
ISBN 0 11 884170 7 £15.50

71 The sand and gravel resources of the country around Hemel Hempstead, St Albans and Watford: Resource sheet TL 00, 10, and parts TQ 09, 19.
W. J. R. Harries, S. E. Hollyer and P. M. Hopson.
ISBN 0 11 884171 8 £12.00

72 The sand and gravel resources of the country around Bury St Edmunds, Suffolk: Resource sheet TL 86.
M. P. Hawkins.
ISBN 0 11 884172 6 £10.50

73 The sand and gravel resources of the country between Ely and Cambridge, Cambridgeshire: Resource sheet TL 56, 57. A. R. Clayton.
ISBN 0 11 884173 4 £9.50

74 The sand and gravel resources of the country around Blaydon, Tyne and Wear: Resource sheet NZ 06, 16.
J. R. A. Giles.
ISBN 0 11 884174 2 £10.50

75 The sand and gravel resources of the country around Stokesley, North Yorkshire: Resource sheet NZ 40, 50, and parts 41, 51. R. G. Crofts.
ISBN 0 11 884175 0 £11.50

76 The sand and gravel resources of the country around Ellon, Grampian Region: Resource sheets NJ 93 with parts 82, 83, 92, and NK 03 with parts 02, 13. J. W. Merritt.
ISBN 0 11 884176 9 £15.00

77 The limestone and dolomite resources of the country around Buxton, Derbyshire: Resource sheet SK 07 and parts 06, 08. D. J. Harrison.
ISBN 0 11 884177 7 £13.50

78 The sand and gravel resources of the country west of Boroughbridge, North Yorkshire: Resource sheet SE 36.
D. A. Abraham.
ISBN 0 11 884178 5 £12.75

79 The limestone and dolomite resources of the country around Bakewell, Derbyshire: Resource sheet SK 26 and part 27. D. McC. Bridge and J. R. Gozzard.
ISBN 0 11 884179 3 £10.50

80 The sand and gravel resources of the country between Stamford, Lincolnshire, and Peterborough, Cambridgeshire: Resource sheet TF 00, 10. S. J. Booth.
ISBN 0 11 884180 7 £14.50

81 The sand and gravel resources of the country around Dorchester and Watlington, Oxfordshire: Resource sheet SU 69 and part 59. C. E. Corser.
ISBN 0 11 884204 8 £14.25

82 The sand and gravel resources of the country around Sible Hedingham, Essex: Resource sheet TL 73.
R. J. Marks and D. W. Murray.
ISBN 0 11 884205 6 £10.75

83 The sand and gravel resources of the country around Hollesley, Suffolk: Resource sheet TM 34.
S. E. Hollyer and R. Allender.
ISBN 0 11 884206 4 £13.25

84 The sand and gravel resources of the country around Kirk Hammerton, North Yorkshire: Resource sheet SE 45.
J. R. A. Giles.
ISBN 0 11 884207 2 £10.00

85 The sand and gravel resources of the country around Nayland, Suffolk: Resource sheet TL 93. P. M. Hopson.
ISBN 0 11 884208 0 £11.25

86 The sand and gravel resources of the country around Wem, Shropshire: Resource sheet SJ 42, 52.
B. Cannell and W. J. R. Harries.
ISBN 0 11 884209 9 £15.50

87 The sand and gravel resources of the country around Ranskill and East Retford, Nottinghamshire: Resource sheet SK 68 and part 78. D. Thomas.
ISBN 0 11 884210 2 £8.50

88 The sand and gravel resources of the country around Tholthorpe, North Yorkshire: Resource sheet SE 46.
R. Stanczyszyn.
ISBN 0 11 884211 0 £13.00

[illegible] The sand and gravel resources of the country around Newport-on-Tay, Fife Region: Resource sheet NO 42 and parts 32, 52. J. L. La[illegible]n and D. L. Ross.
ISBN 0 11 887413 6 £12.75

90 The sand and gravel resources of the country around Shrewsbury, Shropshire: Resource sheet SJ 41, 51.
B. Cannell.
ISBN 0 11 884213 7 £17.00

91 The conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire: Resource sheet SJ 94. D. Piper.
ISBN 0 11 884214 5 £7.00

92 The sand and gravel resources of the country around Armthorpe, South Yorkshire: Resource sheet SE 60. D. Price and D. P. Best.
ISBN 0 11 884215 3 £10.00

93 The sand and gravel resources of the country around Whittlesey, Cambridgeshire: Resource sheet TF 20, TL 29.
S. J. Booth.
ISBN 0 11 884216 1 £12.50

94 The sand and gravel resources of the country north and west of Woodhall Spa, Lincolnshire: Resource sheet TF 16 and part 17. I. Jackson.
ISBN 0 11 884217 X £14.75

95 The sand and gravel resources of the country around Biggar, Strathclyde Region: Resource sheet NS 93, NT 03, and parts NS 92, NT 02. A. J. Shaw and J. W. Merritt.
ISBN 0 11 887414 4 £15.00

96 The sand and gravel resources of the country around Potter Hanworth and Reepham, Lincolnshire: Resource sheet TF 06, 07. R. G. Crofts.
ISBN 0 11 884219 6 £9.75

97 The sand and gravel resources of the country around Clare, Suffolk: Resource sheet TL 74. R. Marks.
ISBN 0 11 884297 8 £10.00

98 The limestone and dolomite resources of the country around Tideswell, Derbyshire: Resource sheet SK 17 and parts 18, 27. R. W. Gatliff.
ISBN 0 11 884298 6 £14.50

99 The sand and gravel resources of the country north and west of Billingham, Cleveland: Resource sheet NZ 42 and part 52. J. W. C. James.
ISBN 0 11 884299 4 £10.50

100 The sand and gravel resources of the country around Billinghay, Lincolnshire: Resource sheet TF 15 and part 05.
J. B. L. Wild.
ISBN 0 11 884300 1 £13.75

101 The sand and gravel resources of the country around Glenrothes, Fife Region: Resource sheet NO 20 and parts 21, 30, 31. A. M. Aitken and D. L. Ross.
ISBN 0 11 887415 2 £15.00

102 The sand and gravel resources of the country around Coggeshall, Essex: Resource sheet TL 82. S. J. Booth and J. W. Merritt.
ISBN 0 11 887416 0 £16.00

103 The sand and gravel resources of the country between Dorchester and Wareham, Dorset: Resource sheets comprising parts of SY 68, 69, 78, 79, 88, 89, 98, 99.
S. J. Mathers.
ISBN 0 11 884303 6 £17.00

104 The sand and gravel resources of the country around Stansted Mountfitchet, Essex: Resource sheet TL 52.
P. M. Hopson.
ISBN 0 11 884304 4 £11.75

105 The sand and gravel resources of the Welshampton area, Shropshire and Clwyd: Resource sheet SJ 43. Institute of Geological Sciences.
ISBN 0 11 884305 2 £12.00

106 The sand and gravel resources of the country south of Wrexham, Clwyd: Resource sheet SJ 34 and part 24. D. F. Ball.
ISBN 0 11 884306 0 £11.00

107 The sand and gravel resources of the country between Rugby and Northampton, Warwickshire and Northamptonshire: Resource sheet SP 66 and parts 56, 57, 65, 67, 75 and 76. M. R. Clarke and E. R. Moczarski.
ISBN 0 11 884307 9 £20.00

108 The sand and gravel resources of the country south of Horncastle, Lincolnshire: Resource sheet TF 26. G. Power and J. B. L. Wild.
ISBN 0 11 884308 7 £9.75

109 The sand and gravel resources of the country around Great Dunmow, Essex: Resource sheet TL 62. C. W. Thomas.
ISBN 0 11 884309 5 £12.75

110 The sand and gravel resources of the country north of Newmarket, Cambridgeshire and Suffolk: Resource sheet TL 67 and part 66. C. E. Corser.
ISBN 0 11 884310 9 £14.50

111 The sand and gravel resources of the country east and south-east of Darlington, Durham: Resource sheet NZ 30, 31. J. R. Gozzard and D. Price.
ISBN 0 11 884311 7 £14.25

112 The sand and gravel resources of the country around Hertford, Hertfordshire: Resource sheet TL 31. P. M. Hopson and M. D. A. Samuel.
ISBN 0 11 884312 5 £11.75

113 The sand and gravel resources of the country around Mold, Clwyd: Resource sheet SJ 26 and part 16. D. F. Ball and K. A. McL. Adlam.
ISBN 0 11 884313 3 £12.00

114 The sand and gravel resources of the country around Kettering and Wellingborough, in parts of Northamptonshire, Cambridgeshire and Bedfordshire: Resource sheets SP 97 and parts SP 87, TL 07; and SP 86, 96. A. M. Harrisson.
ISBN 0 11 884314 1 £18.00

115 The sand and gravel resources of the country east of Solihull, Warwickshire: Resource sheet comprising parts of SP 17, 18, 27, 28. B. Cannell.
ISBN 0 11 884315 X £10.75

116 The limestone resources of the Craven Lowlands: Resource sheet comprising parts of 1:50000 geological sheets 59, 69, 61, 67, 68 and 69. D. J. Harrison.
ISBN 0 11 884316 8 £15.00

117 The sand and gravel resources of the country around Redgrave, Suffolk: Resource sheet TM 07 and part 08. C. A. Auton.
ISBN 0 11 884317 6 £15.00

118 The sand and gravel resources of the country around Sudbury, Suffolk: Resource sheet TL 84. P. M. Hopson.
ISBN 0 11 884318 4 £12.50

119 The sand and gravel resources of the country around Bedale, North Yorkshire: Resource sheet SE 28. J. R. A. Giles.
ISBN 0 11 884319 2 £11.75

120 The sand and gravel resources of the country around Catterick, North Yorkshire: Resource sheet SE 29. J. H. Lovell.
ISBN 0 11 884320 6 £10.75

121 The sand and gravel resources of the country around Callander and Dunblane, Central Region: Resource sheet NN 60, 70. J. W. Merritt and J. L. Laxton.
ISBN 0 11 887417 9 £15.00

122 The sand and gravel resources of the country around Lymington and Beaulieu, Hampshire: Resource sheet comprising parts of SU 20, 30, 40, and SZ 29, 39, 49. S. J. Mathers.
ISBN 0 11 884322 2 £17.00

123 The sand and gravel resources of the country between Mildenhall and Barrow, Suffolk: Resource sheet TL 76, 77, and part 87. A. R. Clayton.
ISBN 0 11 884323 0 £15.50

124 The sand and gravel resources of the country around Chatteris, Cambridgeshire: Resource sheet TL 38 and part 37. J. R. Gozzard.
ISBN 0 11 884324 9 £12.50

125 The sand and gravel resources of the country between Coventry and Rugby, Warwickshire: Resource sheet SP 47 and part 37.
ISBN 0 11 884325 7 £12.75

126 The limestone and dolomite resources of the country around Settle and Malham, North Yorkshire: Resource sheet comprising parts of 1:50000 geological sheets 50 and 60. D. W. Murray.
ISBN 0 11 884326 5 £9.75

127 The sand and gravel resources of the country around Woolpit, Suffolk: Resource sheet TL 96. M. R. Clarke.
ISBN 0 11 884327 3 £13.00

128 The sand and gravel resources of the country around Coningsby, Lincolnshire: Resource sheet TF 25. I. Jackson and M. D. Issaias.
ISBN 0 11 884328 1 £11.75

129 The limestone and dolomite resources of the country north and west of Ashbourne, Derbyshire: Resource sheet SK 15 and parts 04, 05, 14. D. McC. Bridge and D. S. Kneebone
ISBN 0 11 884329 X £15.25

130 The sand and gravel resources of the country between Bourne and Crowland, Lincolnshire: Resource sheet TF 11 and parts 01, 21. S. J. Booth.
ISBN 0 11 884430 X £20.00

131 The sand and gravel resources of the country west of Stirling, Central Region: Resource sheet NS 69, 79. J. L. Laxton and D. L. Ross
ISBN 0 11 887421 7 £14.50

132 The sand and gravel resources of Strathallan, Tayside Region: Resource sheet comprising parts of NN 80, 81, 90, 91. A. M. Aitken and A. J. Shaw.
ISBN 0 11 887422 5 £15.50

133 The sand and gravel resources of the country north-east of Thaxted, Essex: Resource sheet TL 63. R. J. Marks.
ISBN 0 11 884433 4 £11.50

134 The sand and gravel resources of the country around Prees, Shropshire: Resource sheet SJ 53. J. W. C. James.
ISBN 0 11 884434 2 £16.00

135 The sand and gravel resources of the country around West Tanfield, North Yorkshire: Resource sheet SE 27. G. E. Strong and J. R. A. Giles.
ISBN 0 11 884435 0 £10.75

136 The sand and gravel resources of the country around Whitchurch and Malpas, Clwyd, Cheshire and Shropshire: Resource sheet SJ 44, 54. I. Jackson, D. J. Lowe, A. N. Morigi and S. J. Mathers.
ISBN 0 11 884436 9 £16.00

137 The sand and gravel resources of the country around Diss, Norfolk: Resource sheet TM 17 and part 18. C. J. Wilcox and R. Stanczyszyn.
ISBN 0 11 884437 7 £15.00

138 The sand and gravel resources of the country around Chichester and north of Bognor Regis, Sussex: Resource sheet SU 80, 90. J. H. Lovell and P. H. A. Nancarrow.
ISBN 0 11 884438 5 £16.00

139 The sand and gravel resources of the country around Kinross, Tayside Region: Resource sheet NO 00, 10, and parts NT 09, 19. J. W. Merritt and D. L. Ross.
ISBN 0 11 887423 3 £17.50

Mineral Assessment Reports (British Geological Survey)

140 The sand and gravel resources of the country around Dalkeith and Temple, Lothian Region: Resource sheets NT 25 and 26, and NT 35 and 36. A. M. Aitken, J. H. Lovell, A. J. Shaw and C. W. Thomas.
ISBN 0 11 887526 4 £20.00

141 The hard-rock resources of the country around Caerphilly, South Wales: Resource sheet comprising parts of 1:50000 geological sheets 249 and 263. K. A. McL. Adlam, D. J. Harrison and J. B. L. Wild.
ISBN 0 11 884441 5 £11.50

142 The sand and gravel resources of the country around Henley-in-Arden, Warwickshire: Resource sheet SP16 and parts 15, 17, 25, 26, 27. B. Cannell and R. G. Crofts.
ISBN 0 11 884442 3 £25.00

143 The sand and gravel resources of the country north-east of Ripon, North Yorkshire: Resource sheet SE 37 and part 47. A. N. Morigi and J. W. C. James.
ISBN 0 11 884443 1 £16.50

144 Limestones of the Peak: a guide to the limestone and dolomite resources of the Peak District of Derbyshire and Staffordshire: Resource sheet comprising parts of 1:50000 geological sheets 99, 111, 112, 124 and 125.
D. J. Harrisson and K. A. McL. Adlam.
ISBN 0 11 884444 X £5.00

Open-File Mineral Assessment Reports (British Geological Survey)

145 The sand and gravel resources of the country around Harleston and Bungay, Norfolk and Suffolk. Description of 1:25,000 resource sheets; including parts of TM 27, 28, 38 and 39.
C.A.Auton, A.N. Morigi and D. Price.

Reports of the Institute of Geological Sciences

Other Reports

69/9 Sand and gravel resources of the Inner Moray Firth. A. L. Harris and J. D. Peacock.
ISBN 0 11 880106 0 35p

70/4 Sands and gravels of the southern counties of Scotland. G. A. Goodlet.
ISBN 0 11 880105 8 90p

72/8 The use and resources of moulding sand in Northern Ireland. R. A. Old.
ISBN 0 11 881594 0 30p

73/9 The superficial deposits of the Firth of Clyde and its sea lochs. C. E. Deegan, R. Kirby, I. Rae and R. Floyd.
ISBN 0 11 880617 3 95p

77/1 Sources of aggregate in Northern Ireland (2nd edition). I. B. Cameron.
ISBN 0 11 881279 3 70p

77/2 Sand and gravel resources of the Grampian Region. J. D. Peacock and others
ISBN 0 11 881282 3 80p

77/5 Sand and gravel resources of the Fife Region. M. A. E. Browne.
ISBN 0 11 884004 5 60p

77/6 Sand and gravel resources of the Tayside Region. I. B. Paterson.
ISBN 0 11 884008 8 £1.40

77/8 Sand and gravel resources of the Strathclyde Region. I. B. Cameron and others.
ISBN 0 11 884028 2 £2.50

77/9 Sand and gravel resources of the Central Region, Scotland. M. A. E. Browne.
ISBN 0 11 884016 9 £1.35

77/19 Sand and gravel resources of the Borders Region, Scotland. A. D. McAdam.
ISBN 0 11 884025 8 £1.00

77/22 Sand and gravel resources of the Dumfries and Galloway Region. I. B. Cameron.
ISBN 0 11 884021 5 £1.20

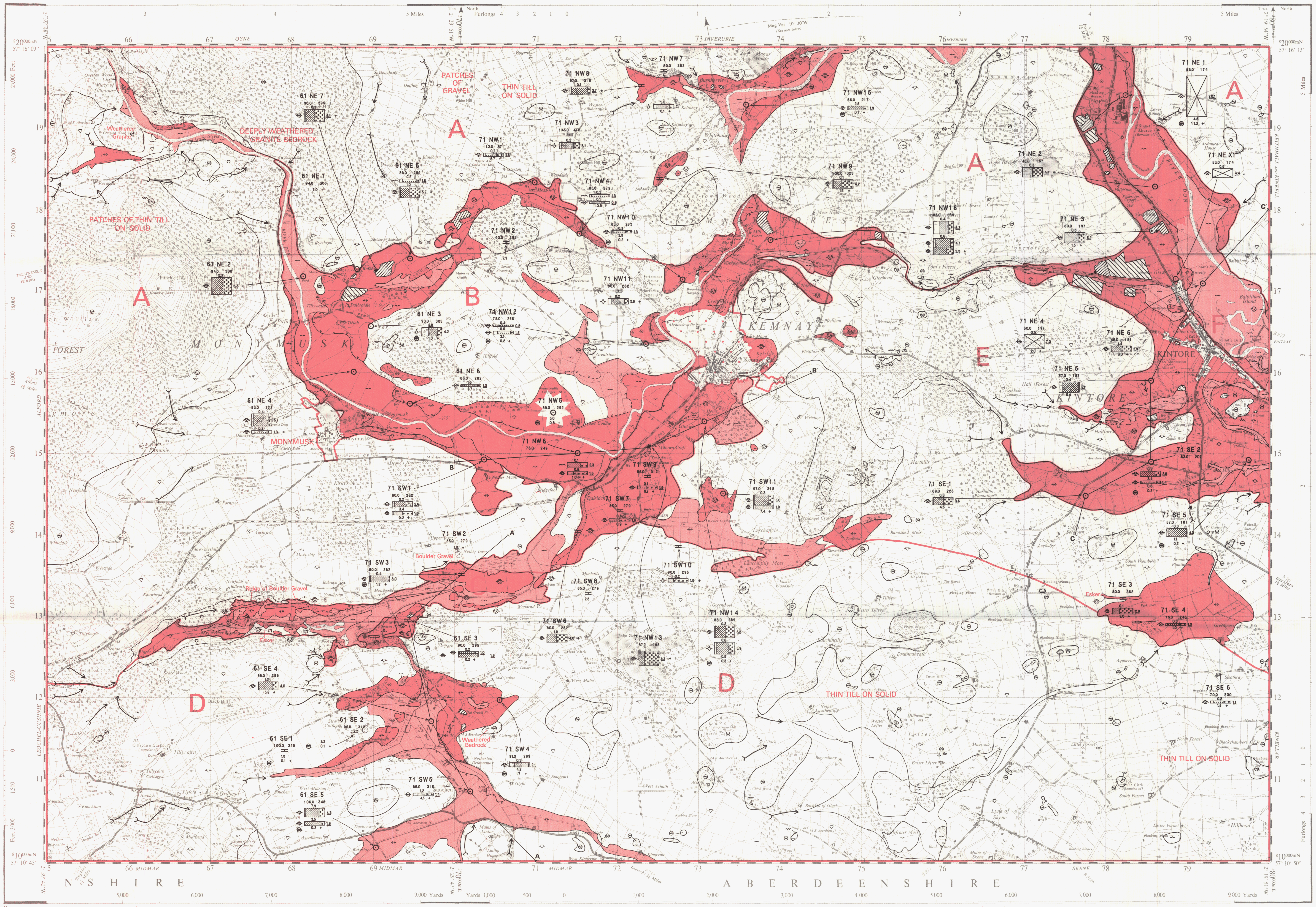
78/1 Sand and gravels of the Lothian Region of Scotland. A. D. McAdam.
ISBN 0 11 884042 8 £1.00

78/8 Sand and gravel resources of the Highland Region. W. Mykura, D. L. Ross and F. May.
ISBN 0 11 884050 9 £3.00

BRITISH GEOLOGICAL SURVEY (SCOTLAND)

THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 1, KEMNAY)

SHEET NJ71 and NJ61NE & SE



Original geological survey on the six-inch scale by H. Skae, D. R. Irvine, J. S. Grant Wilson and L. W. Hinxman in 1886.
Partial resurvey by C. G. Smith, D. L. Ross, J. W. Merritt, C. A. Auton and R. G. Crofts, 1984-85.
J. D. Peacock and D. J. Fettes, Managers' Programme A1.

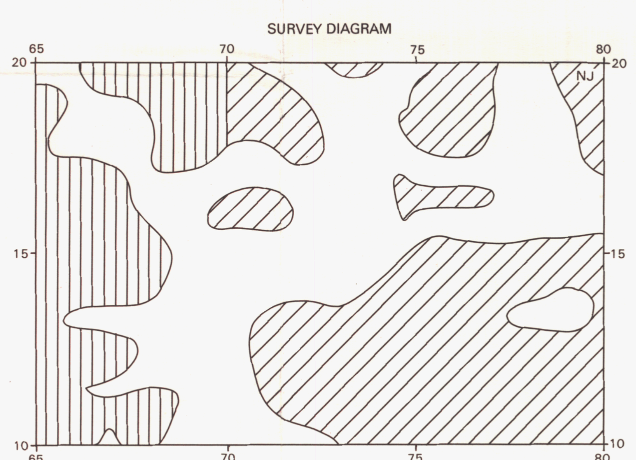
Sand and gravel survey by C. A. Auton, R. G. Crofts, J. Hudson, A. Grout, J. W. Merritt, D. L. Ross and C. W. Thomas in 1984-85.
J. D. Peacock and D. J. Fettes, Managers' Programme A1.

The 1:25 000 sand and gravel resource sheet published 1986
G. I. Lumsden, D.Sc., F.R.S.E., Director, British Geological Survey.

Borehole Graphics drawn by computer using programs written by J.L. McInnes, N.E.R.C. Computer Services, Edinburgh.

This Map and the accompanying report were commissioned and financed by the Department of the Environment, with support from Grampian Regional Council, Aberdeen and Gordon District Councils and local industry.

SURVEY DIAGRAM



Original survey by H. Skae, D. R. Irvine, J. S. Grant Wilson and L. W. Hinxman, 1886

Reconnaissance resurvey by C.G. Smith, 1985

Detailed resurvey for sand and gravel assessment by C.G. Smith, D. L.Ross, J.W. Merritt C. A. Auton and R. G. Crofts, 1984-85

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

Produced for the British Geological Survey by Baynefield Carto-Graphics (Edinburgh) Limited
Printed by John Bartholomew & Son Ltd, Edinburgh 1986

LOCATION OF RESOURCE SHEET 1 (KEMNAY)

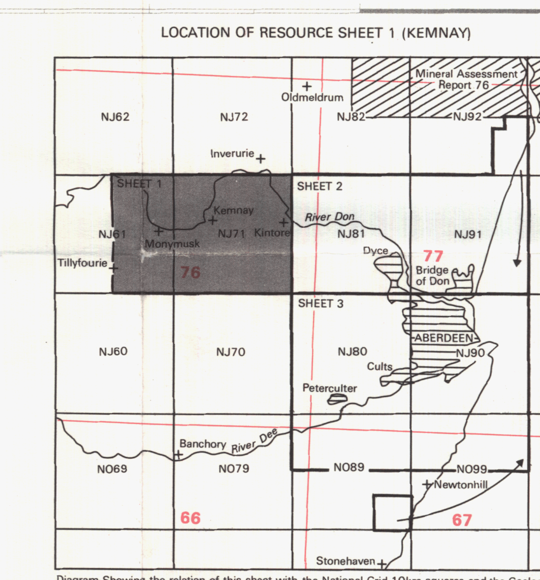


Diagram showing the relation of this sheet with the National Grid 10km squares and the Geological Sheets.

The floodplain of the River Don between Monymusk and Kemnay is floored by sandy alluvium, which generally overlies sandy till. A buried channel, some 10 to 15m below the floodplain is cut into brown clayey till and is filled with grey laminated sandy silt. Between Pitfichie [678 166] and Nether Mains [704 147], the valley is flanked by narrow kame terraces underlain by fluvioglacial sand and gravel. Outwash gravel also underlies a broad, kettled terrace at a height of up to 12m above floodplain level, to the southeast of the River Don, below its confluence with Ton Burn.

The Kemnay Esker is a steep-sided, sinuous ridge of cobble-gravel up to 13m high. It trends north-eastwards from near Woodend [711 132] to Home Farm [733 155], where it stands above the adjacent outwash terrace. The esker also extends to the north of Kemnay, and finally merges with the moundy deposits of glacial outwash to the south and east of Mill Farm [736 178].

The floodplain of the River Don near Kintore is underlain by a thin spread of fluvioglacial sand and gravel (braided-river gravels) resting locally on glaciolacustrine deposits overlying till. The gravels thicken upstream and occupy a buried channel beneath the course of the present river. Fluvioglacial sand and gravel underlies a prominent ice-marginal (kame) terrace on the southwestern flank of the valley of the River Don. It also occurs beneath higher terraces, associated with the Bridgealehouse, Torry and Tuach burns where they meet the main valley.

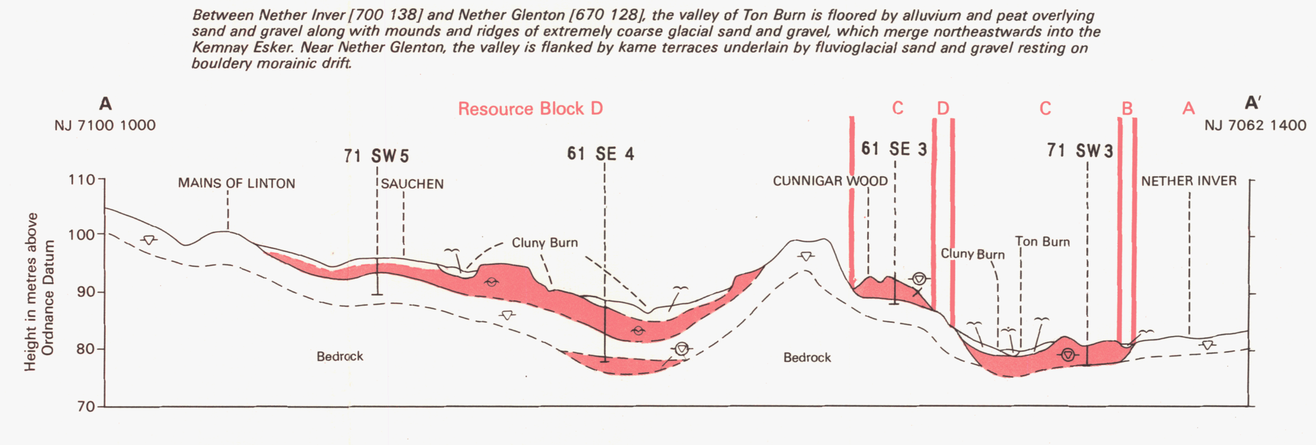
Coarse glacial sand and gravel forms ridges and mounds on the southern side of the valley of Torry Burn. It was probably deposited as eskers and fan-deltas when the ice-sheet which occupied the valley, retreated.

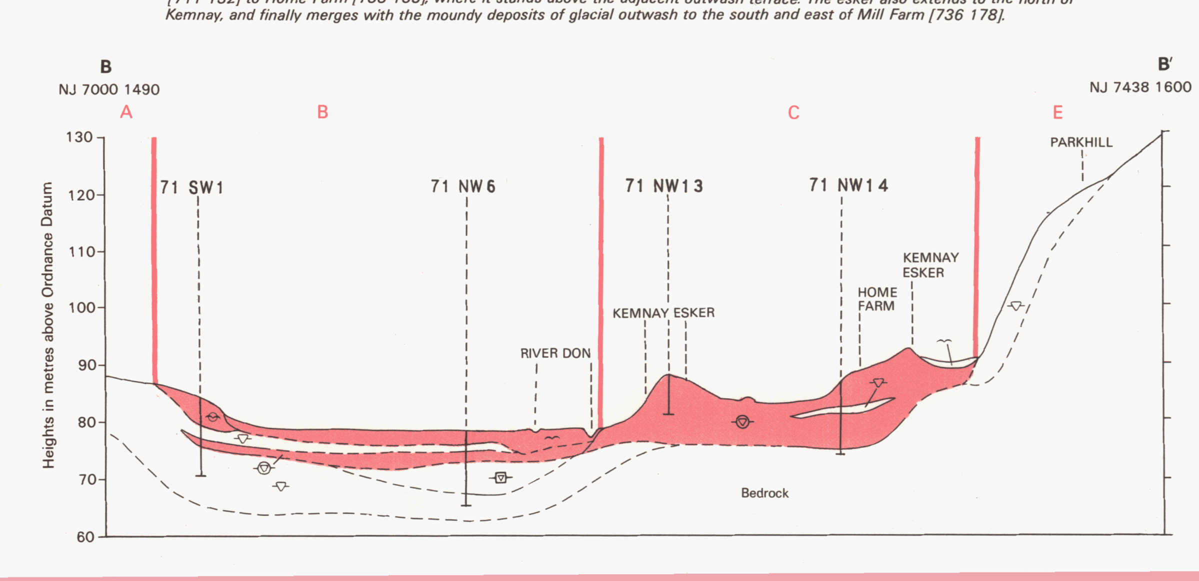
GENERALISED HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

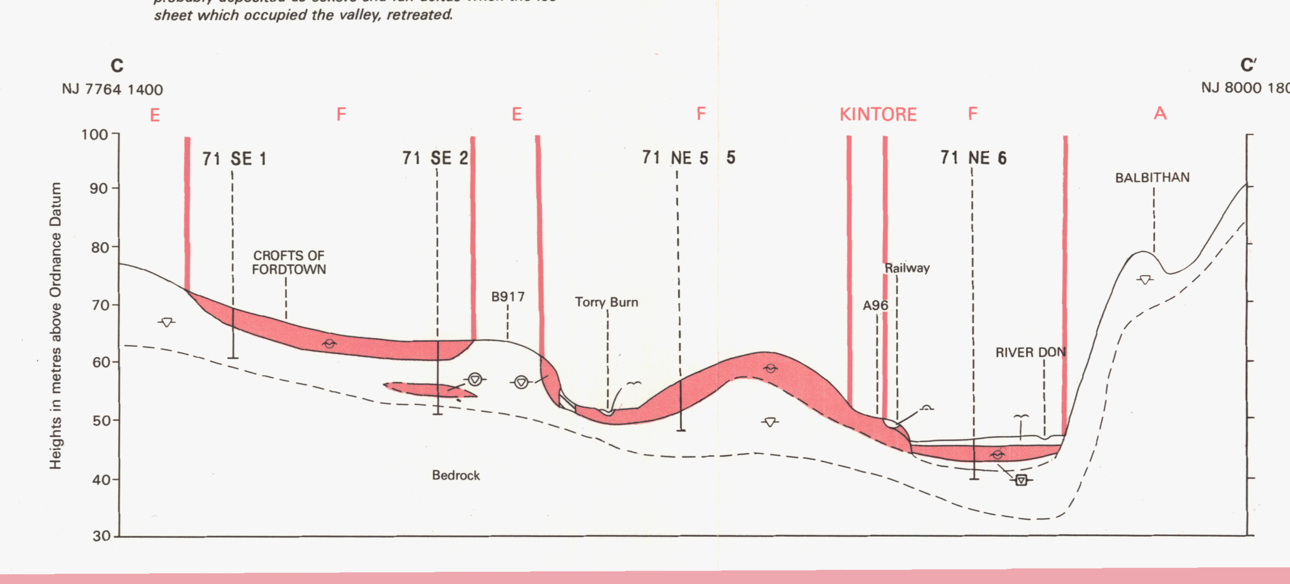
HORIZONTAL SCALE 1:25 000
VERTICAL EXAGGERATION 25×

Cluny Burn and Ton Burn are the principal tributaries of the River Don between Sauchen and Monymusk. The floodplain alluvium of Cluny Burn, which forms an alluvial cone at the junction of the two tributary valleys, is flanked by low kame terraces underlain by fluvioglacial sand and gravel. The terrace deposits rest on brown sandy till, which locally overlies glacial sand and gravel filling a channel cut in bedrock.

Between Nether Inver [700 138] and Nether Glenton [670 128], the valley of Ton Burn is floored by alluvium and peat overlying sand and gravel along with mounds and ridges of extremely coarse glacial sand and gravel, which merge northeastwards into the Kemnay Esker. Near Nether Glenton, the valley is flanked by kame terraces underlain by fluvioglacial sand and gravel resting on bouldery morainic drift.







THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 1, KEMNAY)

146 (SHEET 1)

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Made ground -waste and/or natural earth materials deposited on the original ground surface MG-3

Made ground -waste and/or natural earth materials deposited in open-cast workings in bedrock MG-8

DRIFT

Recent and Pleistocene

Peat P-1

Alluvium -silt, clay, sand and gravel A-51

Alluvial cone -fan composed of alluvium AC-2

Fluvioglacial sand and gravel -mainly coarse gravel with medium and coarse sand, moderately to poorly sorted FL-35

Glacial sand and gravel -deposits vary from poorly sorted coarse gravel with coarse and medium sand to well sorted, silty fine sand GS-55

Glaciolacustrine deposits (not mapped at surface) -fine sand, micaceous silt and clay, often interbedded with clayey till, sometimes laminated, typically olive-brown and olive-grey G-8

Till -typically a pebbly silty clay, mainly grey-brown, sandy and with sand and gravel lenses. Widespread basal till, stiff, grey stony TL-25

Flow-till and debris flow deposits -poorly sorted sand and gravel in a matrix of silty sandy clay (Mineral II) FT-2

Morainic drift -mainly cobble gravel and clay, very poorly sorted in a matrix of clayey sand and silt MD-5

SOLID

Bedrock, at or near surface -Bedrock mainly comprises metamorphic rocks of the Grampian Caledonides, typically gneiss, migmatite, mica-schist, quartzite and psammite
Several Caledonian plutonic masses which include granite, gabbro and norite are present within the area: the basic igneous rocks commonly contain partially assimilated metasediments. There are a number of felsite and quartz-dolerite dykes.

SAND AND GRAVEL WORKINGS

Made ground -waste and/or natural earth materials deposited either on the original ground surface or in man-made workings MG-3

Worked ground-boundaries as at December 1985 WG-9

BOUNDARY LINES

Geological boundary

Geological boundary coincident with back feature to a terrace

Line marking back feature to a terrace

Form line identifying a major mound or ridge of sand and gravel

Inferred boundary between categories of deposit

Resource block boundary

Glacial drainage channel, arrow shows direction of water flow

BOREHOLE AND OTHER DATA SITE LOCATIONS

British Geological Survey (BGS) borehole

Other borehole

Recorded exposure

BGS shallow pit

BGS BOREHOLES

Registration Number → 91 NE 10
Borehole Site
83.0 272 ← Surface level in metres and feet above O D (Newlyn)
Geological Classification
Grading Diagram
0.2 ← Overburden
3.3 ← Mineral I (sand and gravel)
1.7 ← Waste
1.3 ← Mineral II (flow-till)
2.9 ← Waste
0.4 + ← Bedrock

Thicknesses in metres

Note:

(i) Figures underlined denote thicknesses used in the assessment of resources
(ii) The + sign indicates that the base of the deposit was not reached
(iii) The Geological Classification is given only for mineral and bedrock
(iv) When grading data are not sufficiently detailed or are absent the grading diagram is shown without ornament
(v) The surface level of each assessment borehole has been measured, using a surveying aneroid barometer and is accurate to + or −1 metre

Registration Number

Each BGS borehole is identified by a registration number, e.g. **92 SE 5**
The first numbers and letters refer to the quarter sheet and the final figures to the BGS serial numbers for that quarter. The unique designation for borehole **92 SE 5**, is **NJ 92 SE 5**

Grading Diagrams

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

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

The height of the diagram is proportional to the mineral thickness

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

OTHER BOREHOLES

Site investigation boreholes and wells providing ancillary assessment data are located on the map where space permits. These boreholes are either registered in the same series as BGS boreholes, e.g. **80 SW 1**, or are identified by serial numbers prefixed by the letter **X**, and indexed by the numbers and letters of the relevant standard quarter sheet, e.g. **81 NW X1**

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for BGS boreholes but they are located by an asterisk thus ✱. The exposures are registered in the same series as the boreholes, for example, **91 SW 7**

SHALLOW PITS

Where space permits the locations of shallow pits providing ancillary assessment data are shown by a distinctive symbol, thus ⌶. Each pit is identified by serial registration numbers e.g. **61 SE 2.** The surface level for each pit has been extrapolated from the contours on the 1:25 000 and 1:10 000 scale topographic maps.

CATEGORIES OF DEPOSITS

Exposed, potentially workable sand and gravel CAT-E7

Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden CAT-C4

Sand and gravel not assessed (usually in built-up areas) CAT-N1

Sand and gravel absent or not potentially workable CAT-A4

RESOURCE BLOCKS

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

KEY TO SECTIONS

Potentially workable sand and gravel, continous or almost continuous deposits, exposed or beneath overburden

Bedrock and waste, including overburden, are uncoloured

Geological boundary (broken line denotes uncertainty)

Inferred boundary limiting the extent of potentially workable material

Otherwise symbols and abbreviations as map legend

Detailed records may be consulted on application to the Manager, Programme A1, British Geological Survey (Scotland), Murchison House, West Mains Road, Edinburgh EH9 3LA.

The British Geological Survey welcomes any revisions or additional geological information known to the user.

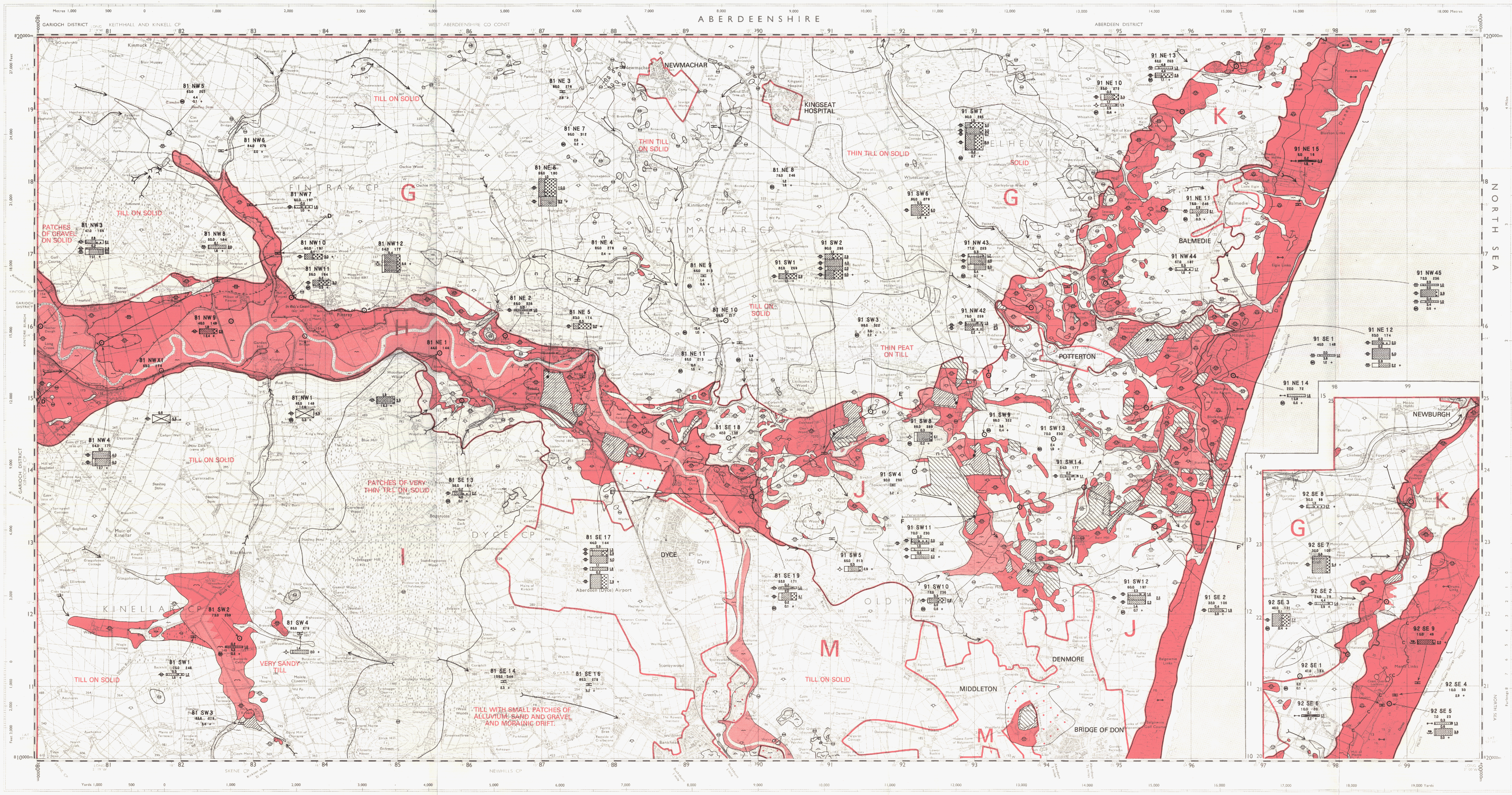
BRITISH GEOLOGICAL SURVEY (SCOTLAND)

THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 2, DYCE)

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

Second Series

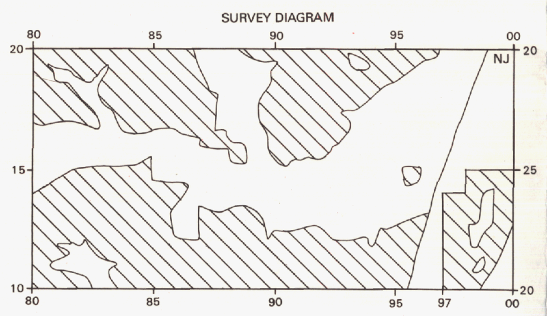
SHEET NJ 81/91 and part of NJ 92 SE



SHEET NJ 81/91 and part of NJ 92 SE

Original geological survey on the six-inch scale by D. R. Irvine, 1885.
Drift geology resurveyed at a scale of 1:10,000 by F. McLean and W. Murdoch, 1969-74.
Partial resurvey by C. A. Auton and R. G. Crofts in 1984-85.
J. D. Peacock, Manager, Programme A1
Sand and gravel survey by C. A. Auton, R. G. Crofts, J. Hudson, A. Grout, J. W. Merritt, D. L. Ross and C. W. Thomas in 1984-85.
J. D. Peacock and D. J. Fettes, Managers, Programme A1.
The 1:25,000 sand and gravel resource sheet published 1986.
G. I. Lumsden B.Sc., F.R.S.E., Director, British Geological Survey.

SURVEY DIAGRAM



Resurvey by F. McLean and W. Murdoch, Aberdeen University, 1969-74

Detailed resurvey for sand and gravel assessment by C. A. Auton, J.W. Merritt and R. G. Crofts, 1984-85

INDEX TO ADJOINING SHEETS

NJ 62/72	NJ 82/92	NK 02
NJ 61/71	NJ 81/91	
NJ 60/70	NJ 80/90	

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

Produced for the British Geological Survey by Baynefield Carto-Graphics (Edinburgh) Limited
Printed by John Bartholomew & Son Ltd, Edinburgh 1986

Borehole Graphics drawn by computer using programs written by J.L. McInnes, NERC Computer Services, Edinburgh.

This Map and the accompanying report were commissioned and financed by the Department of the Environment, with support from Grampian Regional Council, Aberdeen and Gordon District Councils and local industry.

LOCATION OF RESOURCE SHEET 2 (DYCE)

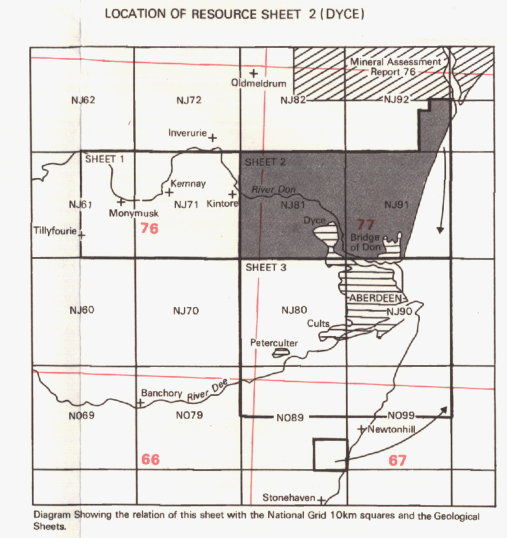
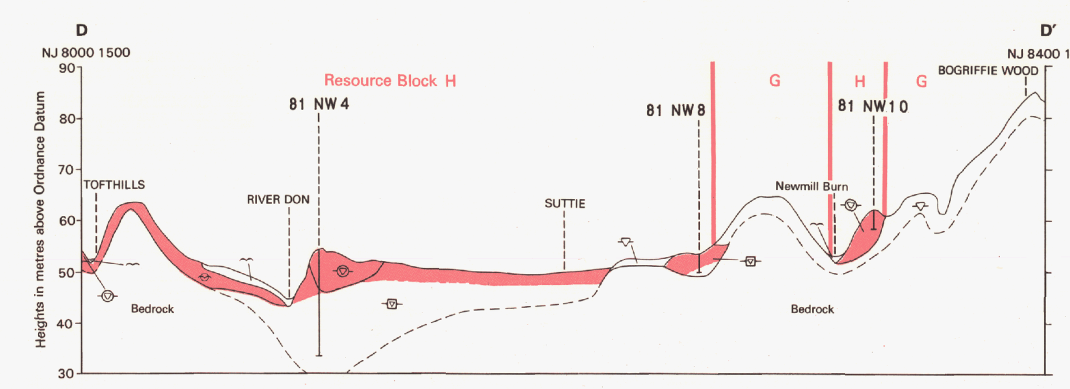


Diagram Showing the relation of this sheet with the National Grid 10km squares and the Geological Sheets.

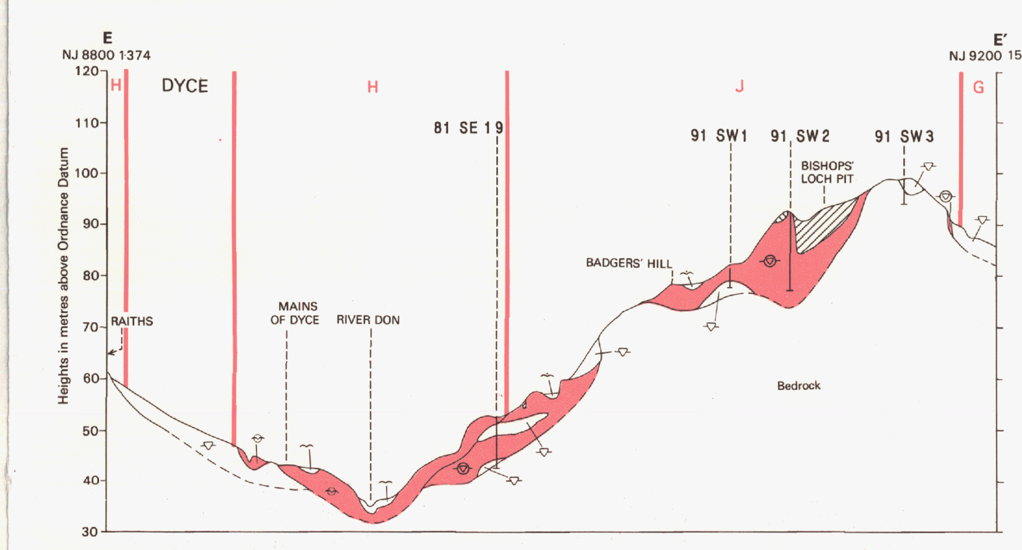
GENERALISED HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

HORIZONTAL SCALE 1:25 000
VERTICAL EXAGGERATION 25×

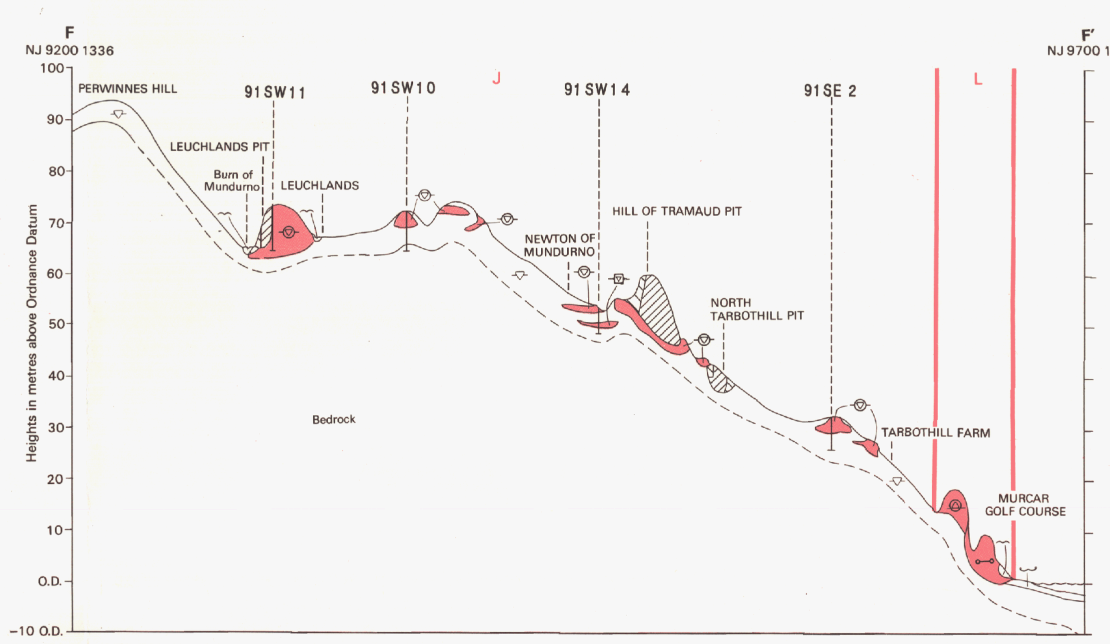
The valley of the River Don, west of Goval House [878 153], is floored by sand, silt and clay deposited in a pro-glacial lake which occupied the valley for a while during the decay of the last ice-sheet. The lake was ponded between glacier ice in the main valley upstream of Fintray and a barrier of glacial deposits in the vicinity of Liddell's Monument [869 152]. The moundy deposits of glacial sand and gravel in the valley were formed mainly as fan-deltas and eskers at the ice-margin as it retreated westwards. These deposits typically fine downwards from gravels to finely laminated silt and clay. Fluvioglacial sand and gravel (braided river gravels) underlie the floodplain alluvium and some higher terraces.



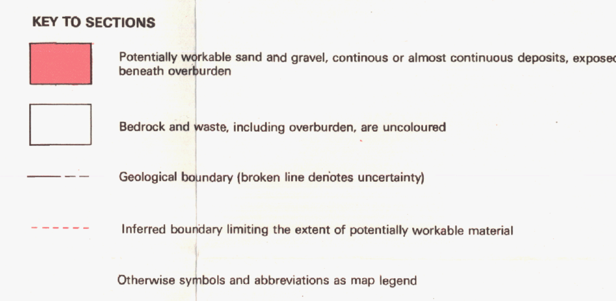
Fluvioglacial sand and gravel (braided river gravels) underlie the floodplain alluvium of the River Don and several ice-marginal (kame) terraces, which flank the river and rise approximately 10 m above the level of the floodplain. The kame-terraces and higher-level spreads of glacial sand and gravel between Dyce and Corby Loch were all formed during the decay of the last ice-sheet, before the River Don had taken its present, more southerly route to the sea. The moundy deposits formed in a similar fashion to those described upstream (section D—D′).



East of Corby Loch, the inter-relationship between the drift deposits is very complicated. Apart from lodgement tills laid down directly from ice, the glacial deposits accumulated in and around ice-marginal lakes which were ponded between land-based ice and an ice- sheet occupying the northern North Sea Basin. The latter impinged on the coast locally. The glacial material includes sand and gravel, clay-rich glaciolacustrine deposits, flow-till and debris flow deposits. Those derived from the North Sea ice are typcially a vivid red- brown colour. Isolated mounds and ridges of glacial sand and gravel, which have been extensively worked, were formed as eskers, sub-aqueous esker-deltas or fan-deltas; the sediments typically fine-downwards from coarse gravels to laminated silt and clay. Blown sand conceals the glacial deposits along the coast.



KEY TO SECTIONS



THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 2.)

146 (SHEET 2)

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Made ground -waste and/or natural earth materials deposited on the original ground surface MG-3

Made ground -waste and/or natural earth materials deposited in open-cast workings in bedrock MG-8

DRIFT

Recent and Pleistocene

Peat P-1

Alluvium -silt, clay, sand and gravel A-51

Lacustrine Alluvium -mainly humic silt and clay LA-13

Alluvial cone -fan composed of alluvium AC-2

Blown sand - clean, mainly medium sand BS-16

Older blown sand overlying glacial sand and gravel -clean medium and fine sand over moderately sorted fine to coarse gravel OB-1

Present day beach and estuarine deposits -mainly well sorted, medium sand or silt and clay PB-4

Fluvioglacial sand and gravel -mainly coarse gravel with medium and coarse sand, moderately to poorly sorted FL-35

Glacial sand and gravel -deposits vary from poorly sorted coarse gravel with coarse and medium sand to well sorted, silty fine sand GS-55

Glaciolacustrine deposits -fine sand, micaceous silt and clay, often interbedded with clayey till, sometimes laminated, typically olive-brown and olive-grey inland, vivid red-brown near coast G-9

Till -typically a pebbly silty clay, mainly grey-brown, sandy and with sand and gravel lenses. Widespread basal, stiff, grey stony till inland, vivid red-brown near coast TL-26

Flow-till and debris flow deposits - poorly sorted sand and gravel in a matrix of silty sandy clay (Mineral) FT-2

Morainic drift -mainly cobble gravel and clay, very poorly sorted in a matrix of clayey sand and silt MD-5

SOLID

Bedrock, at or near surface -Bedrock mainly comprises metamorphic rocks of the Grampian Caledonides typically gneiss, migmatite, mica-shist, quartzite and psammite
Several Caledonian plutonic masses which include granite, gabbro and norite are present within the area: the basic igneous rocks commonly contain partially assimilated metasediments.
There are a number of felsite and quartz-dolerite dykes.

SAND AND GRAVEL WORKINGS (including some brickclay workings)

Made ground -waste and/or natural earth materials deposited either on the original ground surface or in man-made workings MG-3

Worked ground-boundaries as at December 1985 WG-9

BOUNDARY LINES

Geological boundary

Geological boundary coincident with back feature to a terrace

Line marking back feature to a terrace

Form line identifying a major mound or ridge of sand and gravel

Geological boundary marking the position of former coastline

Inferred boundary between categories of deposit

Resource block boundary

Glacial drainage channel, arrow shows direction of water flow

BOREHOLE AND OTHER DATA SITE LOCATIONS

British Geological (BGS) Survey borehole

Other borehole

Recorded exposure

BGS shallow pit

BGS BOREHOLES

Registration Number → 91 NE 10
Borehole Site
83.0 272 ← Surface level in metres and feet above O D (Newlyn)
Geological Classification
Grading Diagram
0.2 Overburden
3.3 Mineral I (sand and gravel)
1.7 Waste
1.3 Mineral II (flow-till)
2.9 Waste
0.4 + Bedrock

Thicknesses in metres

Note:

(i) Figures underlined denote thicknesses used in the assessment of resources
(ii) The + sign indicates that the base of the deposit was not reached
(iii) The Geological Classification is given only for mineral and bedrock
(iv) When grading data are not sufficiently detailed or are absent the grading diagram is shown without ornament
(v) The surface level of each assessment borehole has been measured, using a surveying aneroid barometer and is accurate to + or −1 metre

Registration Number

Each BGS borehole is identified by a registration number, e.g. **92 SE 5**
The first numbers and letters refer to the quarter sheet and the final figures to the BGS serial numbers for that quarter. The unique designation for borehole **92 SE 5**, is **NJ 92 SE 5**

Grading Diagrams

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

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

The height of the diagram is proportional to the mineral thickness

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

OTHER BOREHOLES

Site investigation boreholes and wells providing ancillary assessment data are located on the map where space permits. These boreholes are either registered in the same series as BGS boreholes, e.g. **80 SW 1**, or are identified by serial numbers prefixed by the letter **X**, and indexed by the numbers and letters of the relevant standard quarter sheet, e.g. **81 NW X1**

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for BGS boreholes but they are located by an asterisk thus ✱. The exposures are registered in the same series as the boreholes, for example, **91 SW 7**

SHALLOW PITS

Where space permits the locations of shallow pits providing ancillary assessment data are shown by a distinctive symbol, thus ⌶. Each pit is identified by serial registration numbers e.g. **61 SE 2**. The surface level for each pit has been extrapolated from the contours on the 1:25 000 and 1:10 000 scale topographic maps.

CATEGORIES OF DEPOSITS

Exposed, potentially workable sand and gravel CAT-E7

Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden CAT-C4

Sand and gravel not assessed (usually in built-up areas) CAT-N1

Sand and gravel absent or not potentially workable CAT-A4

RESOURCE BLOCKS

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

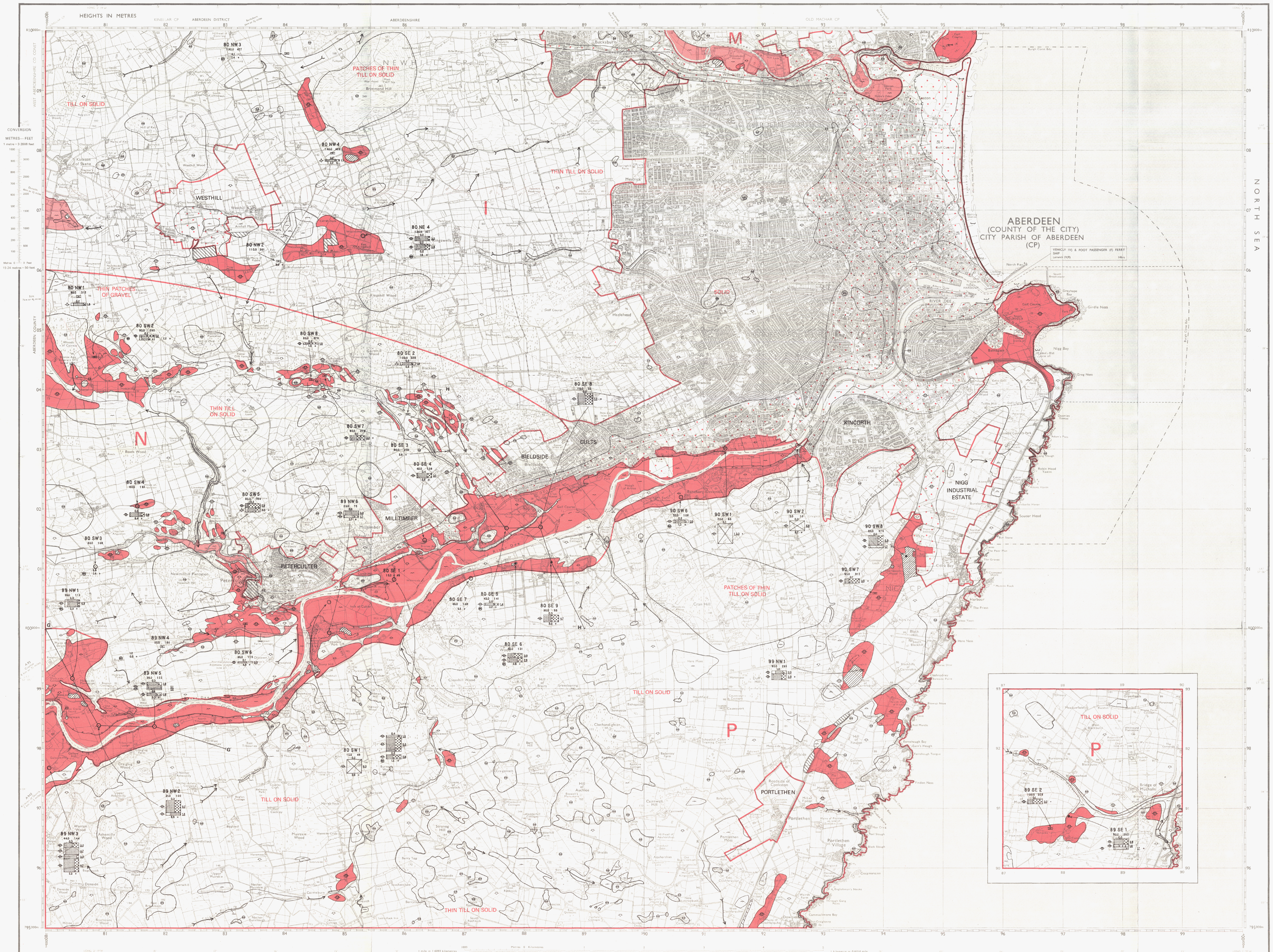
Detailed records may be consulted on application to the Manager, Programme A1, British Geological Survey (Scotland), Murchison House, West Mains Road, Edinburgh EH9 3LA.

The British Geological Survey welcomes any revisions or additional geological information known to the user.

BRITISH GEOLOGICAL SURVEY (SCOTLAND)

THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 3, PETERCULTER)

Scale 1:25 000 — Outline Edition Pathfinder Series — ORDNANCE SURVEY — SHEET NJ80/90 and PARTS OF NO89 & 99



SHEET NJ 80/90

THE SAND AND GRAVEL RESOURCES OF THE ABERDEEN AREA, GRAMPIAN REGION (RESOURCE SHEET 3, PETERCULTER)

146 (SHEET 3)

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Made ground -waste and/or natural earth materials deposited on the original ground surface MG-3

Made ground -waste and/or natural earth materials deposited in open-cast workings in bedrock MG-8

Landslip L-1

DRIFT

Recent and Pleistocene

Peat P-1

Alluvium -silt, clay, sand and gravel A-51

Lacustrine alluvium -mainly humic silt and clay LA-13

Blown sand - clean, mainly medium sand BS-16

Present day beach and estuarine deposits -mainly well sorted, medium sand or silt and clay PB-4

Post-Glacial beach and estuarine deposits -silt and clay, medium to coarse sand with some gravel PO-3

Fluvioglacial sand and gravel -mainly coarse gravel with medium and coarse sand, moderately to poorly sorted FL-35

Glacial sand and gravel -deposits vary from poorly sorted coarse gravel with coarse and medium sand to well sorted, silty fine sand GS-55

Glaciolacustrine deposits -fine sand, micaceous silt and clay, often interbedded with clayey till, sometimes laminated, typically vivid red-brown near coast G-9

Till -typically a vivid red-brown pebbly silty clay towards the coast whereas inland, mainly grey-brown, sandy and with sand and gravel lenses. Widespread basal till, stiff, grey stony till TL-26

Flow-till and debris flow deposits -poorly sorted sand and gravel in a matrix of silty sandy clay (Mineral II) FT-2

SOLID

Bedrock, at or near surface -Bedrock mainly comprises metamorphic rocks of the Grampian Caledonides, typically gneiss, migmatite, mica-shist, quartzite and psammite
Several Caledonian plutonic masses which include granite, gabbro and norite are present within the area: the basic igneous rocks commonly contain partially assimilated metasediments.
There are a number of felsite and quartz-dolerite dykes.

SAND AND GRAVEL WORKINGS

Made ground -waste and/or natural earth materials deposited either on the original ground surface or in man-made workings MG-3

Worked ground -boundaries as at November 1984 WG-9

BOUNDARY LINES

Geological boundary

Geological boundary coincedent with back feature to a terrace

Line marking back feature to a terrace

Form line identifying a major mound or ridge of sand and gravel

Geological boundary marking the position of former coastline

Inferred boundary between categories of deposit

Resource block boundary

Glacial drainage channel, arrow shows direction of water flow

BOREHOLE AND OTHER DATA SITE LOCATIONS

British Geological (BGS) Survey borehole

Other borehole

Recorded exposure

BGS shallow pit

BGS BOREHOLES

Registration Number → 91 NE 10
83.0 272 ← Surface level in metres and feet above O D (Newlyn)
Borehole Site
Geological Classification; Grading Diagram
0.2 Overburden
3.3 Mineral I (sand and gravel)
1.7 Waste
1.3 Mineral II (flow-till)
2.9 Waste
0.4 + Bedrock

Thicknesses in metres

Note:

(i) Figures underlined denote thicknesses used in the assessment of resources
(ii) The + sign indicates that the base of the deposit was not reached
(iii) The Geological Classification is given only for mineral and bedrock
(iv) When grading data are not sufficiently detailed or are absent the grading diagram is shown without ornament
(v) The surface level of each assessment borehole has been measured, using a surveying aneroid barometer and is accurate to + or −1 metre

Registration Number

Each BGS borehole is identified by a registration number, e.g. **92 SE 5**
The first numbers and letters refer to the quarter sheet and the final figures to the BGS serial numbers for that quarter. The unique designation for borehole **92 SE 5,** is **NJ 92 SE 5**

Grading Diagrams

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

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

The height of the diagram is proportional to the mineral thickness

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

OTHER BOREHOLES

Site investigation boreholes and wells providing ancillary assessment data are located on the map where space permits. These boreholes are either registered in the same series as BGS boreholes, e.g. **80 SW 1**, or are identified by serial numbers prefixed by the letter **X**, and indexed by the numbers and letters of the relevant standard quarter sheet, e.g. **81 NW X1**

EXPOSURE RECORDS

Information from the inspection of exposures is shown in the same way as for BGS boreholes but they are located by an asterisk thus✱. The exposures are registered in the same series as the boreholes, for example, **91 SW 7**

SHALLOW PITS

Where space permits the locations of shallow pits providing ancillary assessment data are shown by a distinctive symbol, thus ⌶. Each pit is identified by serial registration numbers e.g. **61 SE 2.** The surface level for each pit has been extrapolated from the contours on the 1:25 000 and 1:10 000 scale topographic maps.

CATEGORIES OF DEPOSITS

Exposed, potentially workable sand and gravel CAT-E7

Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden CAT-C4

Sand and gravel not assessed (in built-up areas) CAT-N1

Sand and gravel absent or not potentially workable CAT-A4

RESOURCE BLOCKS

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

KEY TO SECTIONS

Potentially workable sand and gravel, continous or almost continuous deposits, exposed or beneath overburden

Bedrock and waste, including overburden, are uncoloured

Geological boundary (broken line denotes uncertainty)

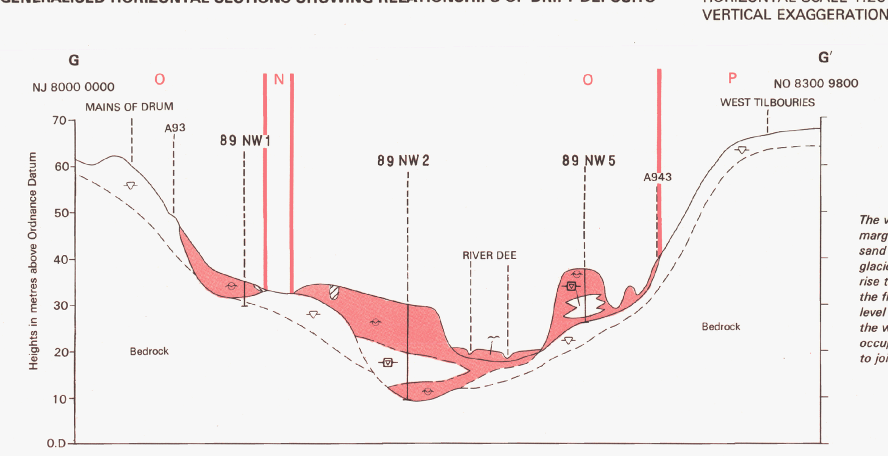
Otherwise symbols and abbreviations as map legend

*Original geological survey on the six-inch scale by D. R. Irvine in 1884 (south-eastern part); J. S. Grant Wilson and D. R. Irvine in 1885 (north eastern part); H. Skae, D. A. Irvine, J. S. Grant Wilson and L. W. Hinxman in 1886 (north western part) and D. R. Irvine and G. Barrow in 1897, (south western part).
Drift geology resurveyed in part, at a scale of 1:10,000 by F. McLean and W. Murdoch, 1969-74.
Partial resurvey by R. G. Crofts, R. J. O. Hamblin and C. A. Auton 1984-85.
J. D. Peacock, Manager, Programme A1
Sand and gravel survey by C. A. Auton, R. G. Crofts, J. Hudson, A. Grout, J. W. Merritt, D. L. Ross and C. W. Thomas in 1984-85
J. D. Peacock and D. J. Fettes, Managers, Programme A1.
The 1:25,000 sand and gravel resource sheet published 1986.
G. I. Lumsden, B.Sc., F.R.S.E., Director, British Geological Survey.*

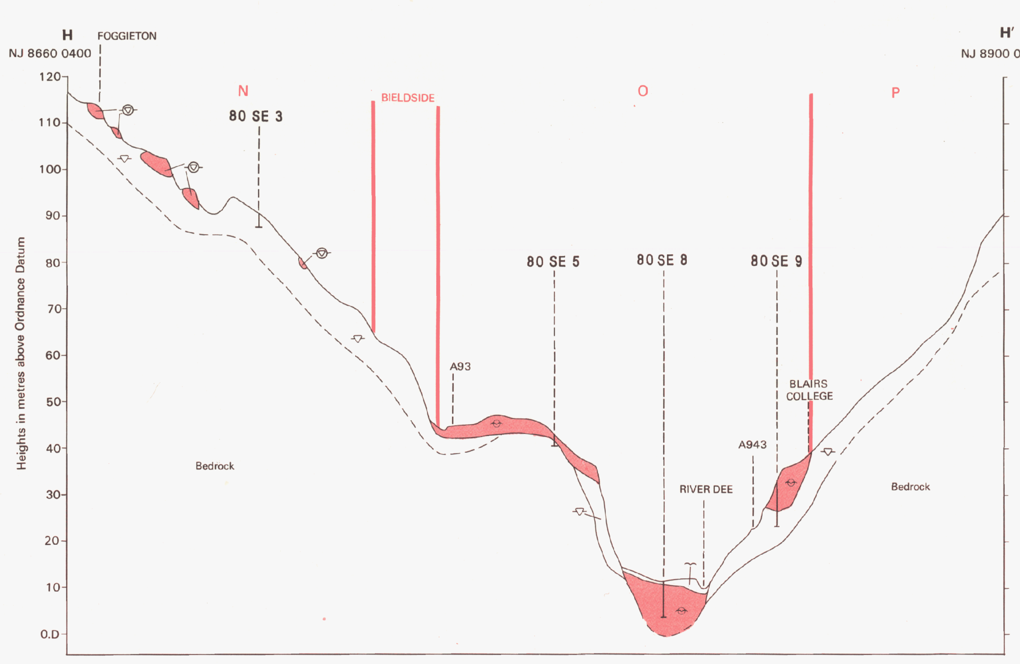
Data quoted for an individual borehole refer strictly to that site; reliable conclusions cannot be drawn about the thickness and grading elsewhere in the deposit, particularly in material as variable as sand and gravel. However, estimates of the volume and mean grading of the mineral as a whole in each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

GENERALISED HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

HORIZONTAL SCALE 1:25 000
VERTICAL EXAGGERATION 25×

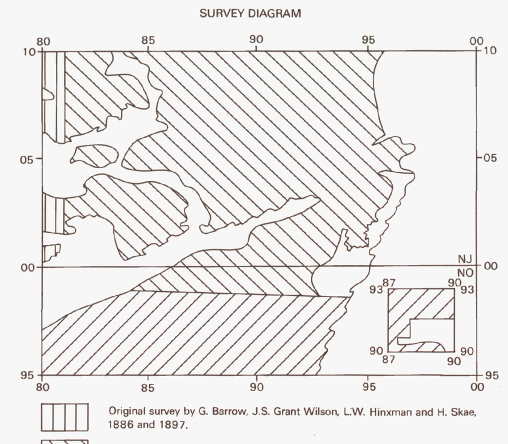


The valley of the River Dee is flanked by ice-marginal (kame) terraces underlain by fluvioglacial sand and gravel, incorporating lenses of glaciolacustrine laminated silt. The terrace deposits rise to between 10 and 20 m above the level of the floodplain. East of Mains of Drum, a higher-level spread of fluvioglacial sand and gravel lies at the western end of a glacial drainage channel (now occupied by Temple Burn) which trends eastwards to join the main valley south of Peterculter.



*The floodplain of the River Dee is underlain by fluvioglacial sand and gravel filling a buried channel some 250m to the north of the present river. The valley is flanked by ice-marginal (kame) terraces, which rise to between 20 and 30m above the floodplain. On the northern side of the valley, the main terrace is up to 1km wide and is kettled. The terraces are underlain by fluvioglacial sand and gravel, resting on benches cut into grey-brown till or bedrock. The terrace deposits on the northern side of the valley are both thicker and more extensive than on the southern side.
Isolated mounds and ridges up to 10 m high, composed of glacial sand and gravel, floor the broad valley which meets the valley of the River Dee between Milltimber and Bieldside. The deposits were laid down by glacial meltwaters which took an easterly route along the valleys now occupied by the Leuchar and Ord (Silver) burns.*

SURVEY DIAGRAM



Original survey by G. Barrow, J.S. Grant Wilson, L.W. Hinxman and H. Skae, 1886 and 1897.

Resurvey by F. McLean and W. Murdoch, Aberdeen University, 1969-74.

Reconnaissance resurvey by R.G. Crofts and R.J.O. Hamblin 1984.

Detailed resurvey for sand and gravel assessment by C.A. Auton and R.G. Crofts, 1984-85.

This Map and the accompanying report were commissioned and financed by the Department of the Environment, with support from Grampian Regional Council, Aberdeen and Gordon District Councils and local industry.

LOCATION OF RESOURCE SHEET 3 (PETERCULTER)

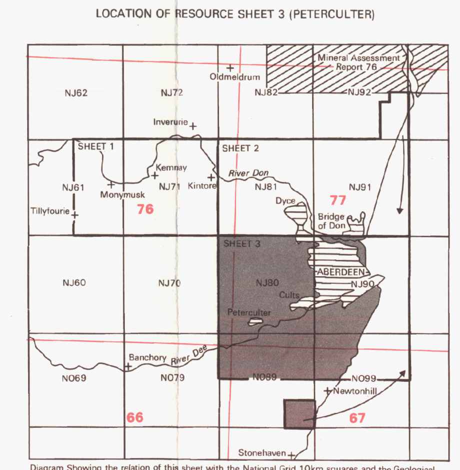


Diagram Showing the relation of this sheet with the National Grid 10km squares and the Geological Sheets.

Borehole Graphics drawn by computer using programs written by J.L. McInnes, NERC Computer Services, Edinburgh.

*Produced for the British Geological Survey by Baynefield Carto-Graphics (Edinburgh) Limited
Printed by John Bartholomew & Son Ltd, Edinburgh 1986*

Detailed records may be consulted on application to the Manager, Programme A1, British Geological Survey (Scotland), Murchison House, West Mains Road, Edinburgh EH9 3LA.

The British Geological Survey welcomes any revisions or additional geological information known to the user.