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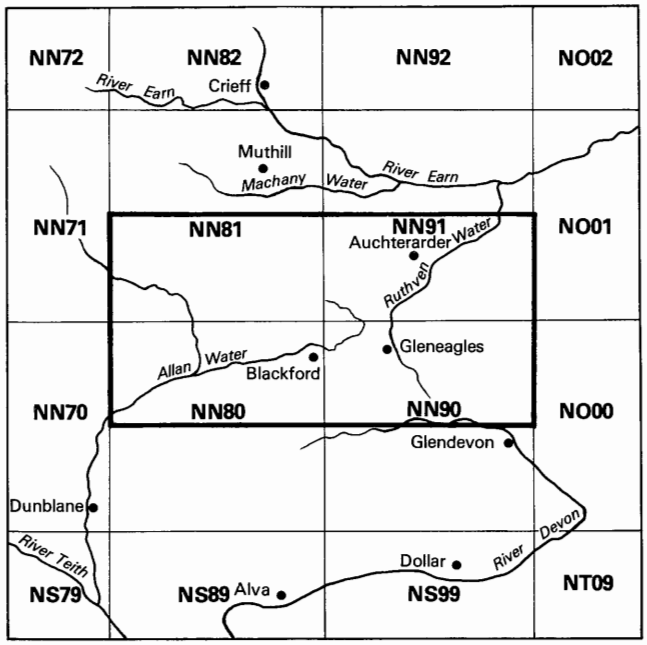

The sand and gravel resources of Strathallan, Tayside Region

Description of parts of 1:25 000 sheets NN 80, 81, 90 and 91

A. M. Aitken and A. J. Shaw

Contributor
M. Armstrong

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The first twelve reports on the assessment of British sand and gravel resources appeared in the Report series of the Institute of Geological Sciences as a subseries. Report 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

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

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The asterisk on the cover indicates that parts of sheets adjacent to the one cited are described in this report.

PREFACE

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

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding most urgent attention, initially in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. In 1968, following a short feasibility study initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys which have been extended progressively through central and northern England. Work in Scotland, which began in 1975 in the Darvel area of Strathclyde Region, is being financed by the Department of the Environment, acting through the Scottish Development Department and is being undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report describes the resources of sand and gravel of 200 km^2 of country in Strathallan, lying mostly in Tayside Region, and shown on the accompanying resource map. The survey was conducted by A. M. Aitken and A. J. Shaw under the supervision of E. F. P. Nickless, Officer-in-Charge of the sub-unit in Edinburgh. The work is based principally on the revision geological survey at a scale of six-inches to one-mile of Sheet 39 undertaken between 1950 and 1961 by M. Armstrong, I. H. Forsyth and E. H. Francis of the North Lowlands Unit, but incorporating the results of partial revision mapping undertaken by M. Armstrong in 1981.

The section of the report on the geology of the area was prepared by M. Armstrong.

J D Burnell, ISO, FRICS (Land Agent), has been responsible for negotiating access to land for drilling; the ready cooperation of land owners, tenants and sand and gravel operators is gratefully acknowledged.

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Director

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SUMMARY

The geological maps of the Institute of Geological Sciences, fifty-five boreholes and twenty-five shallow pits sunk for the Industrial Minerals Assessment Unit, together with pre-existing borehole information and data from one working pit, form the basis of the assessment of sand and gravel resources in Strathallan, Tayside Region.

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

The 1:25000 map is divided into five resource blocks, four of which are assessed statistically and contain between 3.4 and 10.6km^2 of potentially workable sand and gravel. For the fifth resource block inferred assessments are offered for 7.0km^2 of mineral. 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 accompanying resource map.

Bibliographic reference

Aitken, A. M. and Shaw, A. J. 1983. The sand and gravel resources of Strathallan, Tayside Region. Description of parts of 1:25000 sheets NN 80, 81, 90 and 91. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 132.

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Note

National Grid references are given in square brackets. In this publication all lie within the 100-km square NN.

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 $\frac{1}{16}$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 which 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.

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

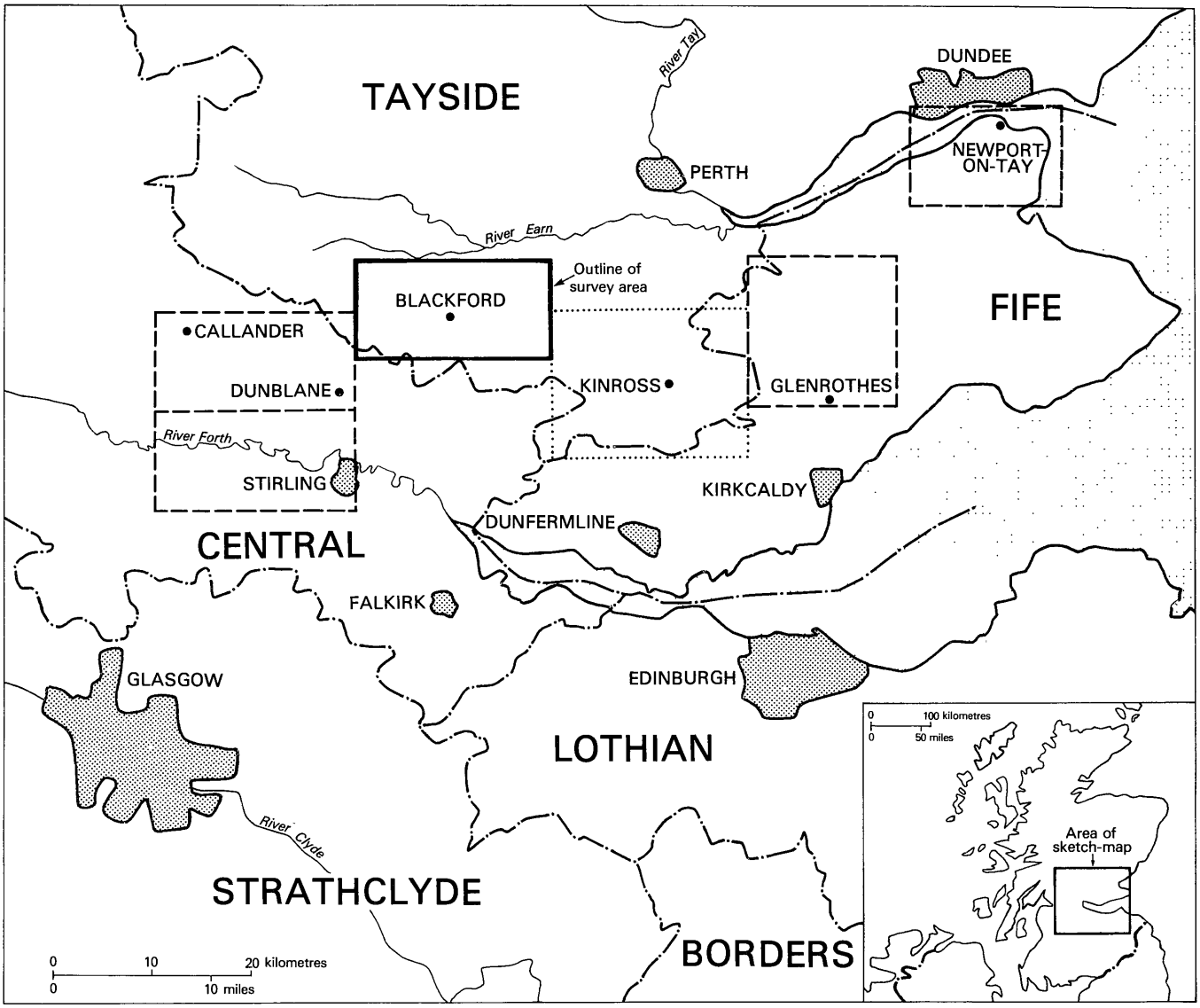

Figure 1 Sketch-map showing the location of the resource sheet and its relationship with areas previously assessed (dashed outline) and an area for which a report is in preparation (dotted line)

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

DESCRIPTION OF THE RESOURCE SHEET

GENERAL

The resource sheet area covers 200km^2 of country in and around Strathallan and the valley of the Ruthven Water of which 39.1km^2 or about 20 per cent are judged to be mineral bearing. The area lies predominantly in Tayside Region and includes the villages of Auchterarder, Blackford and Braco (Figures 1 and 2). The strategic importance of the valleys in terms of communications has been appreciated since Roman times; they carry the A9 trunk road and the main rail route north from Glasgow. By road Blackford, which lies roughly in the centre of the survey area is approximately 31km from Perth, 24km from Stirling, 66km from Glasgow and 84km from Edinburgh (Figure 1). The lower-lying ground is devoted to mixed agriculture with some forestry and in the upland areas sheep farming is the mainstay along with game-husbandry. The area also contains the internationally renowned Gleneagles golf courses [913 109] which follow the contours of a fine suite of glaciofluvial landforms.

Previous literature on the sand and gravel resources of the area includes a brief account of the deposits by Anderson (1946) who suggested that they lay rather far from the centres of population to be of economic importance at that time. More recently, published and unpublished information on the resources in Tayside Region were summarised by Paterson (1977) and those in Central Region were described by Browne (1977). Assessment surveys have been conducted in the adjacent Callander and Kinross areas: the results of the former are published in Mineral Assessment Report 121

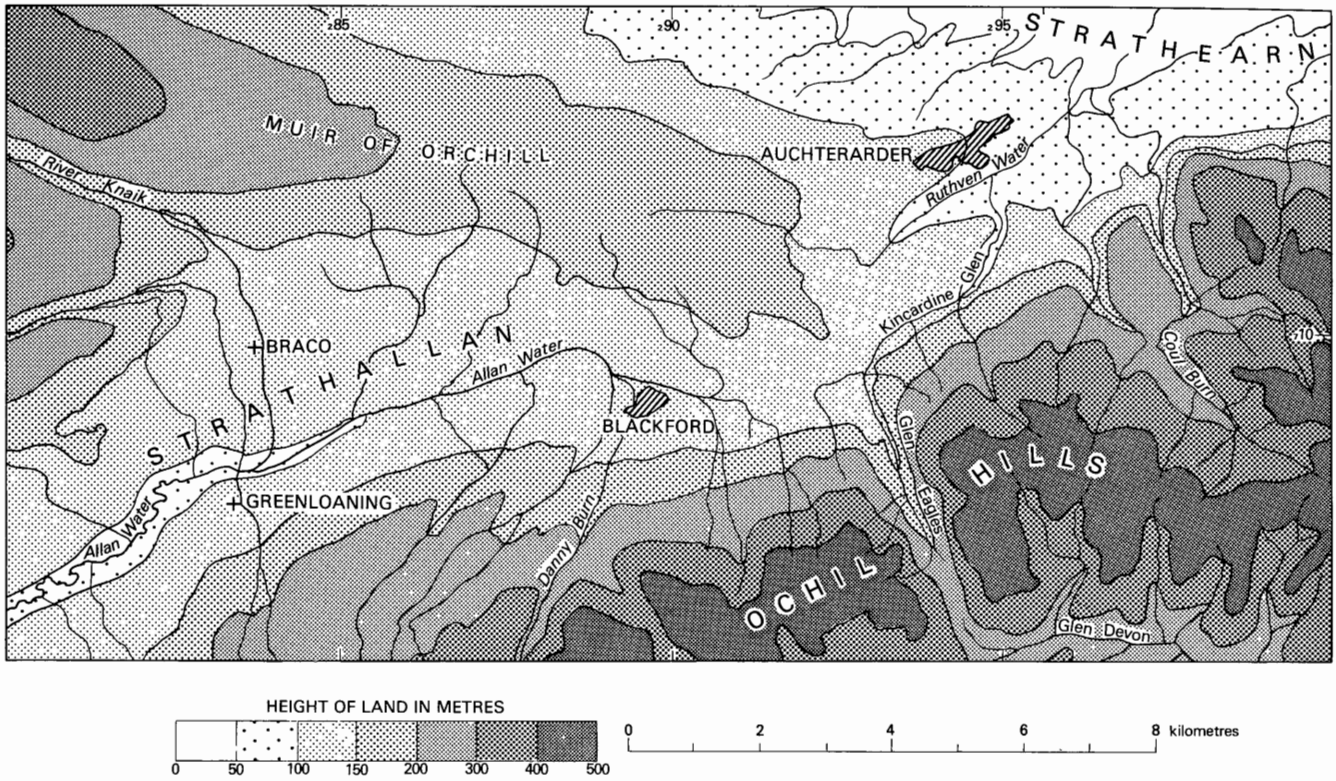

Figure 2 Sketch-map showing physiography

(Merritt and Laxton, 1982) and those of the latter are *in press*. Currently, sand and gravel extraction is limited to the working of a small mound near Coul [968 125], commenced during 1981.

TOPOGRAPHY

The major physiographic features within the resource sheet area (shown in Figure 2) are largely controlled by rock-type. Strathallan is dominated to the south by the volcanic rocks forming the Ochil Hills which reach a maximum height in the area of 502m above Ordnance Datum at Wether Hill [923 059]. Much of the remainder of the area is underlain by sandstone which has led to the development of a moderately subdued, rolling topography.

The westerly-flowing Allan Water, occupying the prominent through valley of Strathallan, is a misfit stream which formerly constituted part of the River Earn catchment (Forsyth, 1970), having reversed its direction of flow as a result of glacial erosion. The lowest point on the present Earn-Allan watershed near Muiralehouse [917 091] is 126m above Ordnance Datum. From its source north of Blackford the Allan Water flows south-east, then west, to be joined near Blacklands [834 077] by the River Knaik. The Ruthven Water, with its source in Glen Eagles, now follows a deeply incised channel known as Kincardine Glen [945 105] (Plate 1), which originated during the last glaciation, before joining the pre-glacial valley at Auchterarder.

GEOLOGY

The area lies mainly within the Alloa (39E) and Stirling (39W) sheets of the 1:50000 Geological Map of Scotland, a narrow strip along the northern margin being included in the Crieff (47) One-inch Sheet. The original geological survey at a scale of six-inches to one-mile by R. L. Jack and J. S. G. Wilson between 1874 and 1884 was followed by the publication of One-inch Sheet 39 in 1901. No sheet explanation was published, although the Devonian rocks were described by Jack and Etheridge (1877). A revision survey was under-

Table 1 Geological classification of deposits

DRIFT (Quaternary)	
Flandrian (post-Glacial)	Alluvium (undifferentiated)
	Peat (of various ages)
Late-Devensian (late-Glacial)	Late-Glacial alluvium
	Late-Glacial raised estuarine deposits
	Glaciolacustrine deposits
	Glacial sand and gravel (of various ages)
	Till
SOLID	
Permo-Carboniferous	Quartz-dolerite dykes
Lower Devonian	Teith Formation - sandstone
	Cromlix Formation - mainly mudstone
	Dunblane Formation - sandstone
	Buttergask Formation - sandstone and siltstone
	Sheriffmuir Formation - sandstone
	Ochil Volcanic Formation - mainly andesitic and basaltic lava with interbedded volcanic conglomerate and tuff

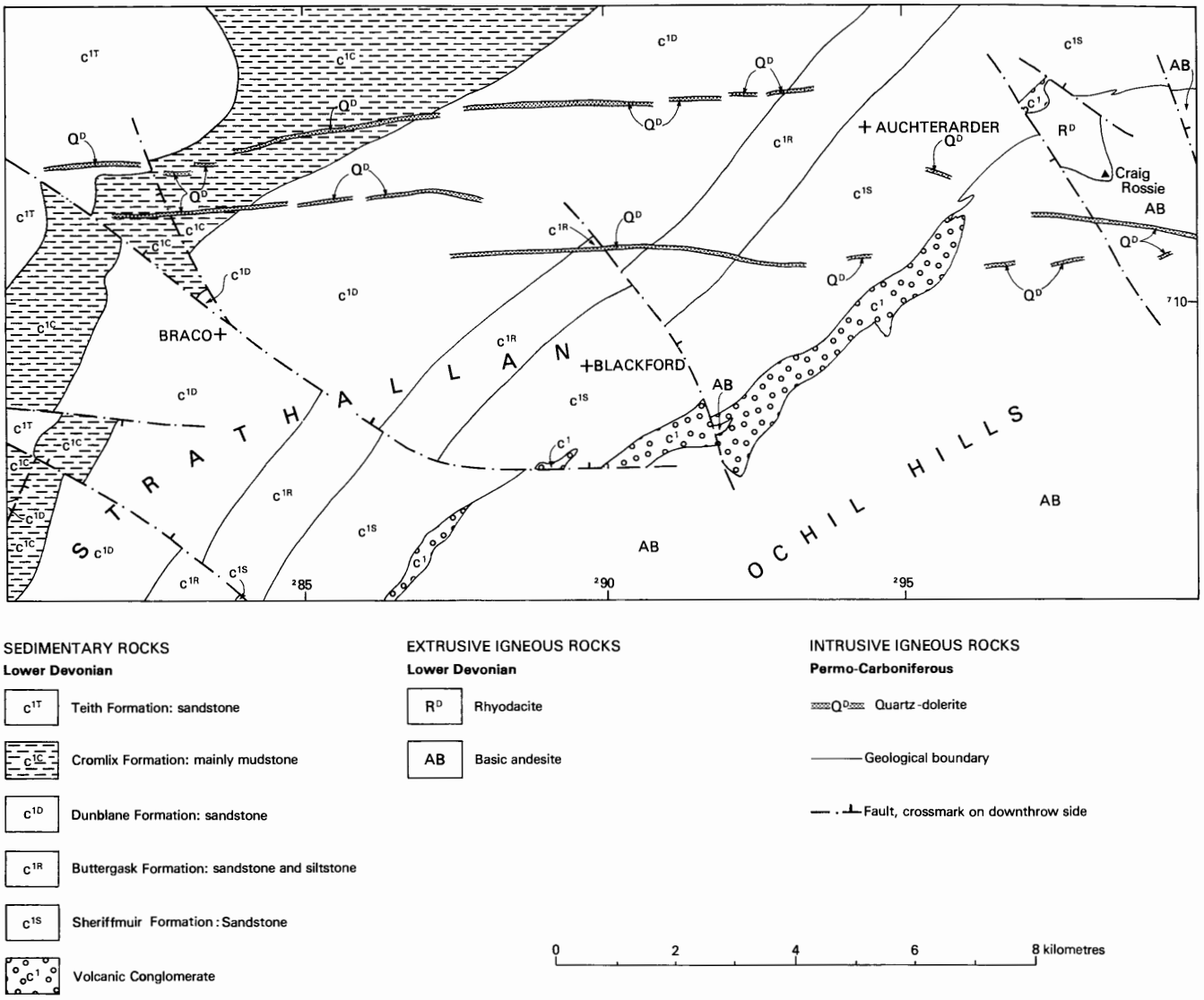

Figure 3 Sketch-map showing the solid geology

taken by M. Armstrong, I. H. Forsyth and E. H. Francis between 1958 and 1961, the results being incorporated in Solid and Drift versions of Sheet 39, published in 1969, accompanied by a descriptive memoir (Francis and others, 1970). The currently available metric equivalents of this sheet were published in 1974 without further revision. A partial survey of the drift, with particular attention to the sand and gravel deposits, was undertaken by M. Armstrong during 1981 and the results are presented on the resource map accompanying this report.

The geological sequence is shown in Table 1, where the deposits are listed, as far as possible, in order of increasing age. The solid rocks are undifferentiated on the resource map accompanying the report, but their distribution is shown in a sketch-map (Figure 3), which is a provisional reinterpretation incorporating recent borehole data.

Solid

The Lower Devonian sequence, commonly referred to as the Lower Old Red Sandstone, comprises sediments of mainly fluvial origin overlying a thick succession of volcanic rocks, and was laid down in a subsiding basin lying parallel to the Highland Boundary Fault. The volcanic rocks crop out in the Ochil Hills and are mainly andesitic and basaltic lavas but some flows are more acidic in composition, notably the rhyodacite of Craig Rossie [985 122] east of Auchterarder. Interleaved with the lavas are beds of andesitic and basaltic tuff and agglomerate which although largely of pyroclastic origin also include much detritus eroded from earlier lava flows. Volcanic conglomerates commonly occur at the top of the Ochil Volcanic Formation.

The overlying sedimentary sequence, comprising over 2000m of sandstone, siltstone and mudstone, was constructed of detritus eroded from Dalradian rocks which formed a mountainous tract north of the Highland Boundary Fault during Lower Devonian times.

During the Middle Devonian, the Lower Devonian strata were folded, the principal structure formed being the Strathmore Syncline. The Lower Devonian strata within the assessment area lie on the south-east limb of the syncline and dip north-westwards. Towards the end of the Carboniferous period quartz-dolerite dyke-echelons trending generally east-west were intruded into the Lower Devonian rocks.

Drift

Within the resource sheet area, as in the whole of Central Scotland, the effects of early Quaternary glaciations cannot be distinguished because of the erosive nature of each ice-advance. The glacial deposits are probably all of late-Devensian age

Plate 3 Strathallan : view westwards from above Milton of Panholes [891 096]
Flat-topped kames bordering the north (right) side of the alluvial plain of the Allan Water demonstrate a consistent upper surface. On the southern side a lower late-Glacial terrace is visible to the right of the curve in the railway line and corresponds with the height of the track. Deaf Knowe, a remnant mound of glacial sand and gravel, lies isolated in the floodplain adjacent to the Allan Water, which forms a broad sweep, between the two hay-fields. (D 419)

Plate 4 Glaciofluvial topography near Kirkton [898 100]
A prominent kettled kame-terrace, at a height of approximately 140m above Ordnance Datum occupies the foreground and middle distance. Its top corresponds with the line of low trees to the right of the farmhouse. The skyline coincides with a series of eskers, now forming part of the Gleneagles golf courses. (D 417)

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and no interglacial deposits have been identified. The Highland source of the ice is indicated by the wide distribution of erratics derived from rocks which crop out in the vicinity of the Highland Boundary Fault zone. The most characteristic erratics are of Dalradian schistose grit and Lower Devonian conglomerate. A south-easterly movement of the ice-sheet is clearly indicated by the transport of erratics composed of rhyodacite from Craig Rossie on to high ground south-east of the outcrop of this distinctive rock (Armstrong in Francis and others, 1971). At low levels within the ice-sheet, however, major lines of flow were probably in part along the valleys. On low ground north-east of Auchterarder, the the general trend of drumlins indicates that the ice moved east-north-eastwards.

Except on the high ground of the Ochil Hills the solid rocks of the area are generally overlain by till. Although far-travelled boulders of resistant rock-types are found in the deposits, the matrix usually reflects the nature of the underlying bedrock. On sandstone the till is generally sandy with a reddish brown or purplish brown colour; that resting on mudstone of the Cromlix Formation is charged with fragments of that rock and is dark purplish brown in colour. On the Ochil Hills the till is commonly pale grey, sandy in places, and contains much lava debris.

With the amelioration of the climate and the break-up of the late-Devensian ice-sheet the high ground of the Ochil Hills began to emerge from the ice-cover. As deglaciation continued the ice was confined to progressively lower levels. In Strathallan the ice surface descended generally towards the east and glacial meltwaters were constrained to flow in this direction away from the thicker ice which impeded southward drainage in the lower part of the strath. At an early stage in the deglaciation meltwaters are thought to have flowed northwards from Glen Devon into the ice at the head of Glen Eagles where moundy deposits of glacial sand and gravel now occur. This is suggested by the height of a gravel spread in lower Glen Quey, near Glendevon Village [992 045] (just south of the resource sheet area), which coincides with, and was probably controlled by, the level of the Glen Eagles-Glen Devon watershed, north-west of Glenhead [951 053].

On the north side of the Ochil Hills patchy deposits of glacial sand and gravel occur east of Auchterarder. But the principal development is in Strathallan where the earliest post-till deposits appear to be a system of eskers which were deposited subglacially along the northern slopes of the strath and through the ground occupied by the Gleneagles golf courses (Plate 2), to terminate near the mouth of Glen Eagles in a single gravel ridge. Thereafter the Strathallan meltwaters descended to lower levels in the ice as evidenced by numerous, probably submarginal, meltwater channels cut in successively lower and more westerly positions. Some of the earlier of these channels appear to cut the pre-existing esker system east of Muir of Orchill [860 125]. Much of the glacial sand and gravel now present within Strathallan probably originated as a product of the erosion of these channels through till or older gravel deposits. The ultimate escape of meltwater from Strathallan was through the Kincardine Glen Spillway (Plate 1) into Strathearn, by way of the Ruthven Water. In its initiation the spillway was probably cut through the gravels of the esker at the foot of Glen Eagles and was thereafter incised more slowly into till and rock.

The Kincardine Glen Spillway controlled water levels within the ice occupying Strathallan and therefore influenced the levels to which sand and gravel accumulated within the ice on the floor of the strath. Thus the fall westward in the elevations attained by flat-topped kames in upper Strathallan is interpreted as an indication of progressive downcutting of the outlet. These features (Plate 3), reaching levels in excess of the height of the present watershed at the head of Strathallan (126m above Ordnance Datum) persist westwards to the general neighbourhood of Braco, and it is clear that the influence of the Kincardine Glen Spillway on the deposition of sediments in association with the Strathallan ice was felt at least as far west as this.

The disintegration of the ice mass in lower Strathallan eventually permitted southward drainage into the valley of the River Forth. The Kincardine Glen Spillway was now abandoned and water levels within the complex of dead ice and sediment occupying upper Strathallan were probably controlled at this stage by an outlet to the south over a gravel ridge which lay across Strathallan immediately north of Kinbuck [792 051], one kilometre to the south-west of the resource sheet area. A large temporary lake impounded north of the Kinbuck ridge extended into Upper Strathallan and thick deposits of glaciolacustrine clay, proved in pipeline trenches and in boreholes south of Braco, were laid down. The lake was eventually eliminated as a consequence of infilling by sediment and by downcutting of the outlet. The lacustrine clay is generally overlain by alluvial sand and gravel of late-Glacial age which is thickest in the ground between Braco and Greenloaning [833 073] and probably originated from the valley of the River Knaik.

Meltwaters emerging from the Kincardine Glen Spillway deposited sand and gravel, which forms extensive alluvial terraces of late-Glacial age in the valley of the Ruthven Water east of Auchterarder. The terraces relate to late-Glacial high sea levels in Strathearn, where raised estuarine deposits including marine clay were laid down while the land was isostatically depresssed.

Alluvium and peat accumulated throughout the post-Glacial period and these deposits occupy numerous poorly-drained depressions and kettle holes formed by the melt-out of dead ice. Along the Allan Water and the lower course of the River Knaik post-Glacial alluvium conceals lacustrine clay and alluvium of late-Glacial age. Extensive peat deposits occur west of Corry Our [833 139], in the north-west part of the resource sheet area, and also on lower ground at Shelforkie Moss [861 093], west of Carsebreck [866 094]. Peat intercalations occur in the alluvium near Blackford and at the foot of Glen Eagles.

PARTICLE-SIZE DISTRIBUTION AND PETROGRAPHY OF THE MINERAL DEPOSITS

Detailed mean grading data (particle size distributions) of the various potentially workable sand and gravel deposits proved in boreholes and pits have been used to calculate the mean grading characteristics for the resource within each geological deposit. The data are presented in Table 2 and represented graphically in Figures 4 to 7 which show cumulative mean grading curves with envelopes within which the cumulative mean grading of the mineral proved at individual sample points lie. The bar graphs illustrate frequency distribution, the length of each bar representing the percentage by weight of material passing the sieve of the indicated aperture and retained upon the next finest sieve.

Table 2 Mean grading of potentially workable deposits

Deposit	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 +1-4mm	Fine gravel +4-16mm	Coarse gravel +16-64mm	Cobbles and boulders +64mm
Alluvium and late-Glacial alluvium	9	21	21	12	15	18	4
Late-Glacial raised estuarine deposits	10	34	49	4	2	1	0
Glaciolacustrine deposits	23	73	4	0	0	0	0
Glacial sand and gravel	10	28	25	10	12	12	3
Till	13	18	17	10	15	21	6

Petrographical analyses (pebble-counts) were conducted on seven samples of pebbles in the size range +10-14mm which were also subjected to the mechanical and physical tests described below. To obtain sufficient aggregate of the specified size for a full range of tests, grouping of gravel within a borehole was undertaken in two cases though in one material from a nearby excavation was added; in four cases gravel from two adjacent boreholes which penetrated similar deposits were combined and a stockpile at a working pit provided another sample: details are presented in Table 3. Samples 1, 2, 3, 4, and 7 are thought to typify the glacial sand and gravel deposits in the Strathallan resource sheet area. The first two are from the thickly developed, extensive, moundy deposits in the valley of the Allan Water, 4 is from the thinner sediments higher up the northern valley side, 3 represents the terraced deposits in the valley of the River Knaik and 7 is derived from an isolated mound to the south-east of Auchterarder. Samples 5 and 6 are thought to be representative of the gravel in the deposits beneath the floodplain of the Allan Water. The former is derived from the alluvium, the latter is a combination of alluvial and glacial deposits grouped because both deposits if worked commercially would be exploited simultaneously.

Table 3 Source and classification of aggregate test samples

Composite sample number	Resource block	Geological classification of deposit	Boreholes from which samples were taken	Depth range (m)	Number of bulk samples
1	A	Glacial sand and gravel	80 NW 14	1.0-7.0	6
				13.1-15.3	2
				18.6-21.0	2
			80 NE 2	0.3-1.8	1
				4.8-17.8	13
2	A	Glacial sand and gravel	90 NW 3	0.2-19.6	19
3*	E_1	Glacial sand and gravel	81 SW 3	0.3-4.5	5
4	B	Glacial sand and gravel	81 SE 7	0.3-8.3	7
			81 SE 8	0.7-4.1	3
5	C	Alluvium	80 NW 11	0.7-6.4	6
			80 NW 12	0.8-3.7	2
6	C	Glacial sand and gravel	80 NE 6	2.5-8.2	6
		Alluvium	80 NE 8	2.3-3.8	1
7§	E_3	Glacial sand and gravel	Coul sand and gravel pit	-	-

* Includes material collected from an excavation close to the borehole site; however as the gravel lithology changes with depth the additional material creates a bias towards the composition of the upper part of the borehole

§ Material collected from stockpile

Table 4 Pebble counts of composite samples 1 to 7 (10 to 14mm size fraction)

Composite sample number		1	2	3	4	5	6	7
Resource block		A	A	E_1	B	C	C	E_2
BS Petrological Group	Rock-type							
Basalt (2)*	Andesite and basalt	7.0	7.1	3.8	6.0	8.4	7.2	15.0
	Dolerite	0.8	1.9	1.0	1.3	1.0	0.8	0.5
	Epidiorite	-	-	-	-	-	0.3	-
	Total	**7.8**	**9.0**	**4.8**	**7.3**	**9.4**	**8.3**	**15.6**
Gabbro (4)	Gabbro	0.2	-	-	-	-	0.8	-
	Diorite and microdiorite	0.2	1.2	0.5	0.5	1.2	1.7	1.1
	Basic gneiss	-	-	-	-	-	0.3	-
	Total	**0.4**	**1.2**	**0.5**	**0.5**	**1.2**	**2.8**	**1.1**
Granite (5)	Undivided	-	0.7	0.2	0.3	-	-	-
Gritstone (6)	Sandstone	19.1	25.7	27.9	19.4	18.8	12.6	13.7
	Grit and conglomerate	7.8	10.6	14.9	9.8	18.5	9.4	20.1
	Tuff	0.2	0.7	0.2	-	-	1.7	0.5
	Total	**27.1**	**37.0**	**43.0**	**29.2**	**37.3**	**23.7**	**34.3**
Hornfels (7)	Undivided	-	-	-	-	-	-	0.3
Limestone (8)	Limestone and dolomite	0.2	-	-	-	-	1.7	-
Porphyry (9)	Porphyry	3.3	0.9	4.7	6.0	4.2	13.9	6.6
	Rhyolite	0.5	1.9	1.0	0.5	3.7	1.2	2.4
	Felsite	0.5	0.9	0.2	1.5	0.5	0.8	1.6
	Total	**4.3**	**3.7**	**5.9**	**8.0**	**8.4**	**15.9**	**10.6**
Quartzite (10)	Quartzitic sandstone	30.8	16.3	6.9	8.0	4.5	16.4	7.4
	Quartzite, psammite and schistose grit	15.8	22.4	12.3	17.8	16.8	18.1	15.9
	Vein-quartz	6.8	7.8	7.3	11.1	9.6	10.7	9.0
	Total	**53.4**	**46.5**	**26.5**	**36.9**	**30.9**	**45.2**	**32.3**
Schist (11)	Undivided	**1.3**	**0.2**	**2.1**	-	**2.7**	**1.2**	**0.3**
Others	Siltstone and mudstone	**5.5**	**1.7**	**17.0**	**17.8**	**10.1**	**1.2**	**5.5**
Number of pebbles	counted	399	424	423	398	405	403	378

Results are given in frequency per cent. Calculations of weight per cent showed a close correlation. For origin of samples see Table 3

* The numbers in parenthesis correspond with those used in BS 812:1975. Petrological groups 1 and 3 are not represented here

Visual examination suggests that the pebbles in the specified size range are representative of the gravel fraction as a whole. Moreover, little variation in composition between different size ranges has been noted from pebble-counts undertaken on gravels from other resource sheet areas.

The pebble-count analyses are presented in Table 4 as percentages by number of clasts. The classification scheme used is based upon the petrological groups (trade groups) as defined in BS 812.1:1975 but modified to accommodate the deleterious argillaceous sediments. Also vein-quartz is included in the quartzite group on grounds of chemical composition and hardness. As these rock-types are not normally quarried they are not embraced by the standard.

The samples examined are composed mainly of rocks assigned to the quartzite and gritstone trade groups. The former are all durable and comprise quartzitic sandstones derived from the Lower Devonian and quartzose metasediments with vein-quartz, assignable to rock-types found north of the Highland Boundary Fault. The latter include moderately to poorly indurated, locally derived, fine- to medium-grained sandstones and well indurated, quartzitic grit and conglomerate transported from the Highland border, and all of Lower Devonian age. Pebbles in the basalt trade group include mainly durable clasts of andesite and basalt, probably largely derived from Lower Devonian conglomerates, and pebbles of dolerite, probably from Permo-Carboniferous intrusions. This group is most abundant in sample 7, from deposits close to the Ochil Hills. Pebbles assigned to the porphyry group are almost as plentiful, but are mostly of secondary origin, being derived largely from Lower Devonian conglomerates. In most samples clasts of mica schist and pelite, both of Highland origin, with intrusive diorite form minor components, and gabbro, basic gneiss, granite, limestone and

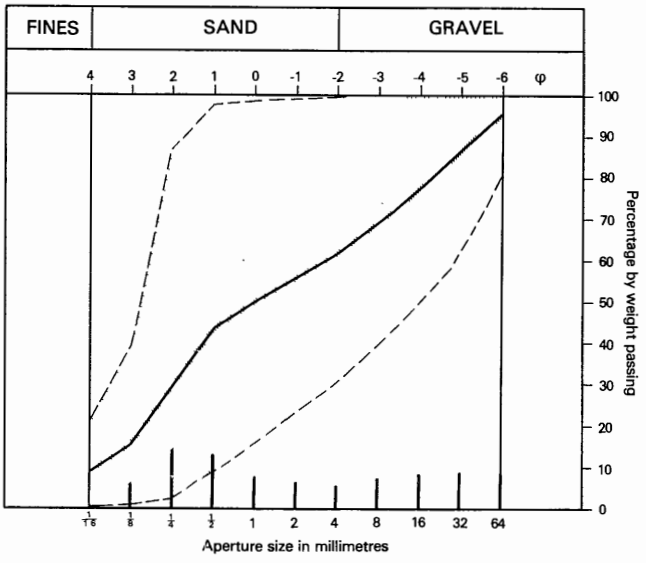

Figure 4 Grading characteristics of resources in the alluvium: the continuous line is the cumulative mean; the broken lines define the envelope containing the cumulative mean grading for each separately identified mineral deposit; the frequency distribution of the mean grading (0.063 to 64mm) is represented by the bar graph

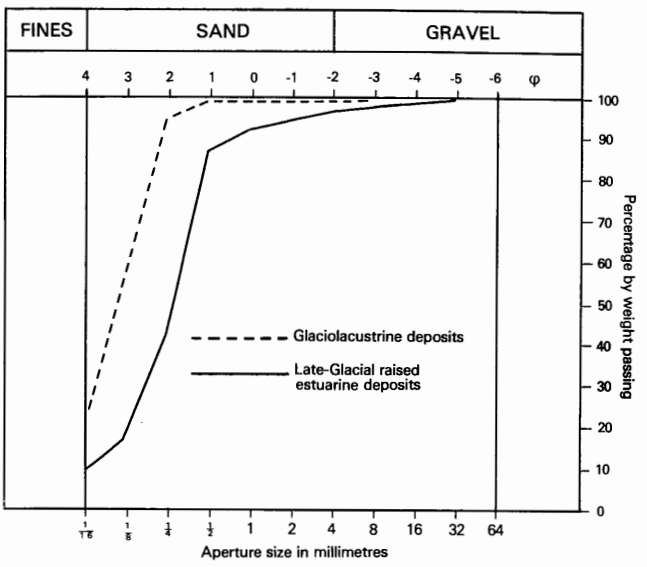

Figure 5 Grading characteristics of resources in the late-Glacial raised estuarine deposits and the glaciolacustrine deposits

hornfels occur sporadically. Locally-derived siltstone and mudstone, usually reddish brown or grey, which are not assigned to any British Standard group, are found in all samples, the frequency ranging from 1.2 to 17.8 per cent.

Alluvium and late-Glacial alluvium The mean grading of the alluvium and late-Glacial alluvium in Strathallan is fines 9 per cent, sand 57 per cent, gravel 34 per cent (sandy gravel); that in the valley of the Ruthven Water is fines 8 per cent, sand 45 per cent, gravel 47 per cent (gravel). As the deposits in both valleys are similar in grading they may be considered together and a mean for the alluvium and late-Glacial alluvium as a whole is given in Table 2. The deposits are generally well sorted, the mean grading curve in Figure 4 displaying unimodality and peaking in the fine to medium sand fraction. However, the grading of the alluvium shows extreme variability, as outlined by the width of the envelope about the mean grading curve, reflecting the effect of the hydraulic conditions on the sediments which range from over-bank deposits comprising fine sand, silt and clay to river channel gravels. Of the alluvium and late-Glacial alluvium penetrated in boreholes, 14 per cent proved non-mineral and 46 per cent graded as gravel.

The overall mean grading of the alluvium and late-Glacial alluvium is fines 9 per cent, sand 54 per cent and gravel 37 per cent (sandy gravel). The fines comprise silt with clay which is disseminated and in seams. The sand fraction, which consists of fine, medium and coarse grades, is angular to rounded, is composed of quartz with rock fragments, some feldspar and mica and is generally reddish brown, yellowish brown or greyish brown in colour. The angular to well rounded gravel comprises coarse and fine fractions with some cobbles and is composed of a variety of rock-types including sandstone, conglomerate, mudstone, andesite, porphyry, psammite, pelite, quartzite, and vein-quartz. Pebble counts on samples 5 and 6 (Table 4) suggest that within the alluvial gravel there is a possible increase in sandstone, grit, conglomerate and siltstone with a concomitant decrease in porphyry and quartzitic sandstone westwards along the valley of the Allan Water.

Late-Glacial raised estuarine deposits The potentially workable late-Glacial raised estuarine deposits near Aberuthven were investigated by only two IMAU sample points: consequently the grading curve in Figure 5 is shown without an envelope. The sediments are well sorted, the mean grading showing distinct unimodality and peaking in the medium sand grade. Grading as 'clayey' sand (fines 10 per cent, sand 87 per cent, gravel 3 per cent) the deposit exhibits a fining-downwards sequence in borehole 91 SE 7. The gravel fraction, fine with coarse, is subrounded to well rounded and predominantly composed of sandstone, conglomerate, andesite, rhyodacite, schist, quartzite and vein-quartz. The sand, which is medium with fine and rarely coarse grades, is angular to rounded and composed of quartz with feldspar and rock fragments. Silt, disseminated and in seams, constitutes the fines fraction; and the overall colour of the deposit is moderate brown.

Head Head mainly occurs as thin cappings to glacial sand and gravel and till. Generally it is poorly sorted and is composed of silt and clay with sand and some pebbles. Only in boreholes 81 SE 9 and 90 NW 5 did the deposit prove to be mineral, grading as 'very clayey' sand in the former and 'very clayey' gravel in the latter where it overlay glacial meltwater deposits and was buried beneath alluvium. Details are presented in the borehole logs (Appendix E). It is not practical to give mean grading data for the deposits as a whole owing to their diversity. Head does not constitute a significant aggregate resource.

Glacial sand and gravel Rapidly changing hydraulic conditions characterise a glacial meltwater system and account for the compositional variability of the glacial sand and gravel as

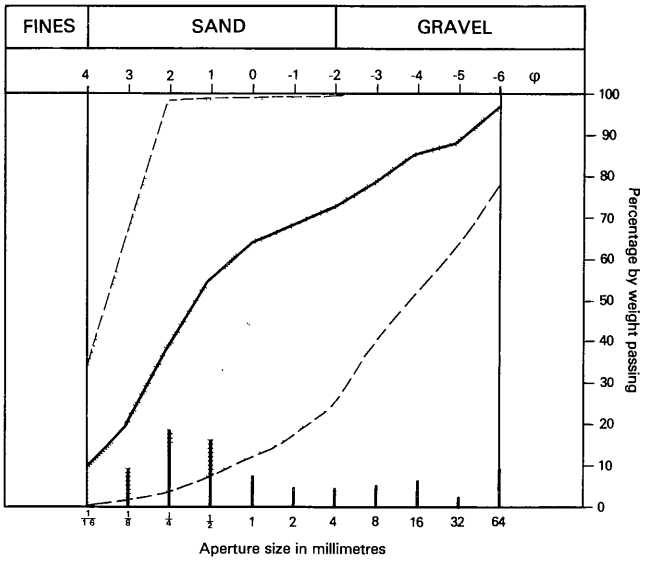

Figure 6 Grading characteristics of resources in the glacial sand and gravel (for explanation see Figure 4)

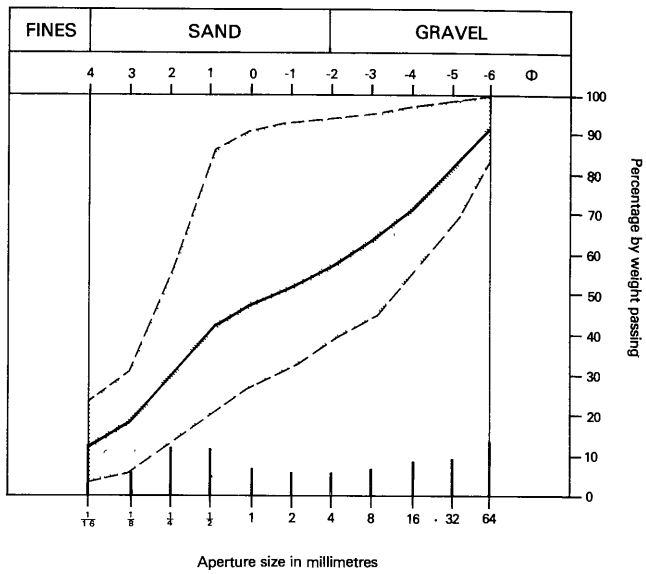

Figure 7 Grading characteristics of resources in the till (for explanation see Figure 4).

illustrated by the wide envelope about the mean grading curve in Figure 6. The sediments range from clay, silt and fine sand - deposited in quiet waters - to coarse gravels laid down in high energy environments. Eleven of the twelve IMAU mineral categories (Appendix C) were proved. Seven per cent of the deposits penetrated are judged to be non-mineral. The mineral has a mean grading of fines 10 per cent, sand 63 per cent and gravel 27 per cent ('clayey' sandy gravel).

The glacial sand and gravel comprises coarse and fine gravel with some cobbles which are angular to well rounded and are mainly composed of sandstone, conglomerate, mudstone, andesite, rhyolite, porphyry, schistose grit, pelite, quartzite and vein-quartz. The sand fraction is fine to medium with coarse grades and is composed of angular to rounded clasts of quartz and rock fragments with feldspar and mica. Fines are composed of silt and clay which occur disseminated and in seams. The overall colour of the deposit varies from shades of brown to reddish, yellowish and greyish brown.

The mean grading curve (Figure 6) for the glacial sand and gravel indicates a weak bimodality with peaks in the fine sand and fine gravel fractions. Well sorted sequences were penetrated over much of the survey area, particularly in the deposits mantling the northern side of the valley of the Allan Water. Fining-downward sequences from gravelly and pebbly surface deposits to silty sand proved to be common, as for example in boreholes 80 NW 8, 80 NE 7 and 90 NW 4. Poorly sorted, clay-bound sediments were revealed at a number of sample points on the valley side south of the Allan Water.

Glaciolacustrine deposits These deposits are generally composed of laminated silts and clays with some fine sand seams, and only 13 per cent of the sediments penetrated during the survey are judged potentially workable. In the borehole 80 NW 12 only the lower 5.7m of a glaciolacustrine deposit 12m thick was mineral, grading as 'very clayey' sand. In comparison, in borehole 80 NW 9 'clayey' sand became finer with depth and overlay laminated silt and clay which also showed reduction of grain size with depth. Owing to the paucity of data an envelope is not presented in Figure 5. The deposits are very well sorted, the mean grading curve (Figure 5) exhibits a strong unimodality peaking in the fine sand fraction, and they grade as 'very clayey' sand (fines 23 per cent, sand 77 per cent). The sand is almost entirely of fine grade and composed of subangular to subrounded clasts of quartz with feldspar, mica and rock fragments. Fines comprise mainly laminated silt seams.

Till A mantle of till drapes the bedrock over much of the area and is commonly buried beneath glacial meltwater and alluvial sediments in the valleys. Some 42 per cent of the total thickness drilled proved to be potentially workable in that the fines content was less than 40 per cent. In 13 per cent of the thickness drilled, the fines content was less than 10 per cent, and in 22 per cent the fines content exceeded 10 but was less than 20 per cent. However, the deposits were often sampled below the water-table and owing to a washing action caused by the drilling technique which tends to remove silt and clay particles, the fines contents have probably been artificially depressed in some cases. The deposit is poorly sorted, as reflected by the shape of the mean grading curve in Figure 7, and has a mean grading of fines 13 per cent, sand 45 per cent and gravel 42 per cent ('clayey' sandy gravel). Gravel is coarse and fine in grade with cobbles; it is mainly angular in shape but ranges to well rounded. The lithology of the erratics generally reflects the underlying rock-types which commonly give the deposit a reddish brown to greyish red colour, being mainly composed of Lower Devonian sediments with some andesite, rhyolite, psammite, quartzite, and vein-quartz. The sand fraction, which is fine to coarse, is angular to rounded and composed of quartz and comminuted rock fragments with feldspar. Fines comprise clay with silt.

MECHANICAL AND PHYSICAL PROPERTIES OF THE AGGREGATE

Tests to determine flakiness index, aggregate impact value (AIV), aggregate crushing value (ACV), 10% fines value, relative density and water absorption were undertaken in accordance with British Standard 812:1975 on the seven samples of

Table 5 Results of mechanical and physical tests (BS 812:1975)

Sample	1	2	3	4	5	6	7
Flakiness index	8	10	16	8	13	9	9
AIV*	24	23	25	26	26	24	23
AIVR	43	43	38	38	36	37	47
ACV	16	16	18	17	18	18	15
ACVR	47	48	40	48	45	47	49
10% fines value (kN)	230	250	210	240	220	200	250
Relative density (oven-dried basis)	2.47	2.49	2.35	2.38	2.40	2.46	2.42
Relative density (saturated and surface-dried basis)	2.54	2.56	2.46	2.48	2.49	2.53	2.51
Apparent relative density	2.66	2.67	2.64	2.64	2.65	2.65	2.64
Water absorption (%)	3.0	2.7	4.7	4.2	3.9	2.9	3.4
Inferred shrinkage§	0.090	0.084	0.126	0.114	0.108	0.088	0.099

* Test results on untreated material. For explanation, see text

§ Based on Edwards, 1970. For explanation, see text

10- to 14-mm sized gravel listed in Table 3. The results are presented in Table 5.

AIV, ACV and 10% fines value judge the strength of an aggregate: the first value gives a measure of resistance to sudden impact whereas the last two gauge resistance to a slowly applied compressive load. ACV and 10% fines values differ in that the former appraises the compaction produced by applying a gradually increasing load attaining 400kN after ten minutes: the latter measures the load which, when applied over ten minutes, produces 10 per cent by weight of comminuted material passing a 2.36-mm sieve. The potential use of an aggregate, particularly as a roadstone, may be subject to its resistance to the types of loading exemplified in these three tests. Although the AIV and ACV provide some indication of the strength of intergranular bonding, a misleading impression of aggregate performance may be gained as the tests assess only the amount of cataclastic material passing a 2.36-mm sieve yet may ignore extensive break-up of an aggregate. Consequently, values of aggregate impact value residue (AIVR) and aggregate crushing value residue (ACVR), as defined by Ramsay (1965) and Dhir and others (1971), were determined from measurements of the amounts of material exceeding 10mm that remained after testing. It is arguably more important, in assessing the potential of an aggregate, for clasts to survive loading relatively intact thus yielding high values of AIVR and ACVR rather than to be fragmented yet not finely pulverised which would yield favourable results for AIV and ACV but low AIVR and ACVR values.

The behaviour of crushed rock aggregates in response to mechanical testing has been studied exhaustively, for example Ramsay (1965), Dhir and others (1971), Ramsay and others (1973, 1974), allowing predictions about mechanical properties to be made which with caution may be extended to natural aggregates. The resistance of an aggregate to impact and compressive load is a function of petrography, shape and degree of weathering, the last two characteristics being in turn related to petrography, distance of transportation and conditions of deposition. The flakiness index is a judgement of clast shape and measures the shortest and median axes, a pebble being described as flaky if it has a thickness (smallest dimension) of less than 0.6 of its nominal size. The flakiness of an aggregate can affect its potential use particularly in the manufacture of concrete: a preferred orientation due to the alignment of flaky clasts may create planes of weakness. Moreover, a high sphericity aggregate is desirable if the material is to be pumped successfully.

The results for AIV, ACV, 10% fines, AIVR and ACVR generally show a similar trend. All samples show differing relative strengths and prove more susceptible to comminution upon impact than by compression. However, the AIV apparatus was mounted on a concrete block 450mm thick as indicated in BS 812:1975, though Ramsay, Dhir and Spence (1973) have suggested that bases composed of less resilient material will yield lower test results which show closer correlation with aggregate crushing values. Test results for AIV range from 23 to 26 and are high compared with the average of 19 for worked gravels cited in Edwards (1970). The ACVs which range from 15 to 18, are close to the cited average of 17. Similarly the AIVR values range from 36 to 47 (mean 40) whereas the ACVR results vary between 40 and 49 and have an average of 46. In general the 10% fines value

shows an inverse correlation with ACV suggesting that a similar control applies.

Ramsay (1965) and Dhir and others (1971) demonstrated an inverse relationship between flakiness index and the strength of an aggregate. Their findings are supported by some of the test results: sample 3 proved flakier and more susceptible to loading than the other tested material, sample 7 proving least susceptible to pressure and having a low flakiness index. However, petrography and the degree of weathering probably play equally important roles in governing the strength of the aggregates tested. The variation in the ratio of durable pebbles, which are mainly assigned to the basalt, porphyry and quartzite petrological groups, to the locally-derived, moderately or poorly indurated sandstones and mudstones of Lower Devonian age is important. Samples 1, 2 and 7, the strongest of those tested, contained 65, 60 and 59 per cent respectively of pebbles belonging to the three durable groups; the moderately strong sample 4 contained 52 per cent; samples 3 and 5 contained only 36 and 48 per cent respectively and proved to be weaker than the aforementioned samples. Although sample 6 proved to be equally weak it comprised only 25 per cent gritstone and argillaceous sediment pebbles and 69 per cent basalt, porphyry and quartzite; the lower strength is probably due to a higher degree of weathering of the clasts.

In natural sections and workings, the deleterious components of the gravels, the mudstones and poorly cemented sandstones, tend to break down on exposure to the weather. During preparation of material for relative density and water absorption tests, gravel from the samples was thoroughly soaked, washed and dried and this resulted in many of the mudstone and some sandstone pebbles disaggregating and being lost from the 10- to 14-mm test fraction. AIV determinations subsequently carried out on such material gave values substantially lower than those from tests on untreated samples. After treatment, for example, sample 3, which had the highest gritstone and argillaceous sediments content, the AIV result improved from 25 to 20 and the AIVR improved from 38 to 48. Insufficient material prevented ACV and 10% fines tests from being undertaken on the treated samples, but similar improvements in results might be expected had the tests been performed. Beneficiation of the aggregate in the area, especially that with a high mudstone content, could probably be instigated by processing, soaking and exposure to the weather.

Although the gravels of the resource sheet area are relatively strong judged in terms of the aggregate crushing values and 10% fines values, the suitability of an aggregate for use in concrete manufacture is affected by other factors, including water absorption and drying shrinkage.

The water absorption value of an aggregate is a measure of the absorption of distilled water after 24 hours of immersion, expressed as a percentage of the oven-dry weight. The importance of this measure is illustrated by the broad linear relationship between water absorption and drying shrinkage, both of the aggregate itself and of any concrete prepared from it (Edwards, 1970). *Moisture movement*, which includes drying shrinkage and wetting expansion, is a prime factor in determining the stress-carrying ability of concrete and its susceptibility to weathering (Building Research Station, 1968). The water absorption values given in Table 5, which range from 2.7 to 4.7 per cent (average 3.5 per cent), are high compared with the average of 1.48 per cent and the range of 0.09 to 2.77 per cent quoted for Scottish gravels (Edwards, 1970) and are generally higher than the values determined for gravels from the nearby Callander (Merritt and Laxton, 1982) and Stirling (Laxton and Ross, 1983) resource sheet areas. Such differences probably result from the abundance, within the gravels of the Strathallan area, of friable and porous pebbles composed of rock-types assigned to the gritstone petrological group and others category (argillaceous sediments) (Table 4). Variations in the abundance of these two lithological groupings in the gravels across the resource sheet area may account for the differing water absorption values listed in Table 5. Sample 3 with the highest value (4.7 per cent) includes 60 per cent gritstone and mudstone, whereas sample 6 with a value of 2.9 per cent contains only 25 per cent. The other samples show the same general relationship except for sample 2 which has the lowest recorded water absorption value (2.7 per cent) and yet 39 per cent of its constituent pebbles comprise gritstone and argillaceous sediments. However, examination of the sandstone pebbles in this sample shows them to be well cemented and durable.

Inferred shrinkage values may be extrapolated from the graph plotting water absorption against concrete drying shrinkage, presented by Edwards (1970). They range from 0.084 per cent for sample 2 to 0.126 per cent for sample 3. Gravels which yield concrete drying shrinkage values greater than 0.085 per cent lie in the category defined by the Building Research Station Digest 35 (1968) that requires the greatest care to be exercised when they are used in concrete manufacture. However, it must be emphasised that such inferred shrinkage values should be interpreted cautiously. For definitive values laboratory testing of concrete blocks made from the aggregates should be undertaken.

The relative density of the samples is quoted on both oven-dried and saturated, surface-dried bases. In addition, their apparent relative densities have been calculated. Like the water absorption values, the determined values reflect the abundance of gritstone and argillaceous pebbles which generally have a lower density than the other rock-types represented in the gravels.

In conclusion, the mechanical and physical properties of the aggregate are likely to be improved by using processing involving soaking and exposure to the weather to reduce the amount of friable constituents.

THE MAP

The sand and gravel resource map is folded into the pocket at the end of this report. The base map is the Ordnance Survey 1:25000 Outline Edition which together with the contours is printed in grey: the geological lines and symbols are in black. Mineral assessment information, including areas of potentially workable sand and gravel, resource notes and block boundaries, is presented in shades of red.

Geological data The geological boundary lines are taken from the geological maps of the area, which were surveyed on the scale of 1:10560. The boundaries are the best interpretation of information available at the time of the survey. However, it is inevitable, particularly with variable superficial deposits, that locally 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 map.

Mineral resource information The map is divided into resource blocks (see Appendix A), within which the extent of mineral-bearing ground is shown in 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 it 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.

A further category which is shown on the resource map in the lightest tone of red, is recognised where mineral is considered discontinuous. The recognition of categories is subjective, depending on the proportion of boreholes which did not find potentially workable sand and gravel, and the distribution of these barren boreholes within a block. The mineral is described as *almost continuous* if it is present in 75 per cent or more of the boreholes in a resource block, and as *discontinuous* if present in more than 25 per cent but less than 75 per cent of the boreholes in a resource block.

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 patches too small to be assessed, but which may nevertheless be potentially workable, are 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 than 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 ASSESSMENT

The resource sheet area is divided into five blocks for assessment. The positioning of the block boundaries is a compromise to meet the aims of the survey: on the one hand to provide sufficient sample points on which to base an assessment and on the other to group together deposits of broadly similar origin, thickness, grade and composition; geological boundaries have usually facilitated such divisions.

Mineral resources are mainly confined to Strathallan with some potentially workable material in the valley of the Ruthven Water. Blocks A to D, which encompass the spreads of potentially workable sand and gravel deposits in Strathallan, conform readily with the above criteria, except that the location of the boundary between blocks A and B is arbitrary, owing to the gradational nature of the transition: borehole information suggested the initial position of the line, aerial photographs being used for subsequent refinement. Block C includes all the valley floor deposits west of the Strathallan watershed. Block D comprises the valley side deposits on the south side of Strathallan, west of Blackford. Block E, incorporating the remainder of the sheet is split into five sub-blocks for convenience of description, using the same criteria adopted for constructing the block boundaries. Sub-block E_1 includes the glacial meltwater deposits west of Braco. The mineral resources in the valley of the Ruthven Water are included in sub-blocks E_2, E_3 and E_4. Sub-block E_2 encompasses the potentially workable material in Glen Eagles, E_3 the mounds and eskers composed of glacial sand and gravel south-east of Auchterarder and E_4 the alluvium, late-Glacial alluvium and raised estuarine deposits north-east of Auchterarder. Sub-block E_5 is mainly upland where mineral is rare, comprising glacial meltwater deposits in the form of eskers and kames. Till is probably potentially workable across much of the area, as judged by the arbitrary criteria adopted for the survey, but because the lithology is variable and the distribution of mineral is not accurately known, the resource is normally excluded from the assessment.

The statistical procedure adopted for the volumetric assessment of the mineral resources is outlined in Appendix B. Statistical assessments are offered for blocks A, B, C and D, but the potentially workable deposits of block E are too patchy and diverse to assess in such a manner. Consequently, inferred assessments are offered for the lithologically similar deposits in each of the sub-blocks (except sub-block E_5) based upon sample point data and consideration of the geology and three-dimensional shape. For example, eskers have been assumed to approximate the form of triangular prisms, the volumes of which have been calculated by simple arithmetic. Likewise mounds were often considered as hemispheres and terrace features as trapezoid prisms. However, the computed volumes must be interpreted cautiously. For example, the procedure tends to underestimate volume because no account has been taken of material that may lie below the general ground level, unless there is evidence to the contrary.

RESULTS

The mineral resources of the resource sheet area are discussed in the block descriptions. Data used in the assessment calculations together with the results are given in Tables 8 to 12: a summary of these data is presented in Tables 6 and 7. Some conclusions are offered, following the block descriptions, regarding the resources most likely to command attention in the future.

Accuracy of results For the four resource blocks assessed statistically, the accuracy of the results at the symmetrical 95 per cent probability level ranges from 16 to 43 per cent (that is, it is probable that nineteen times out of twenty the true volumes present lie within these limits). However, the real values are more likely to be nearer the median than the limits. Moreover, it is probable that in each block roughly the same percentage limits would apply for 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 of part of a block, it can be expected that more than ten sample points would be required, even if the area is quite small.

However, it must again be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be

Table 6 The sand and gravel resources: summary of statistical assessments

Resource block and mineral-bearing deposits	Area		Mean thickness		Volume of sand and gravel			Yield of sand and gravel	Mean grading percentage		
	Block km^2	Mineral km^2	Over-burden m	Mineral m	$m^3 x10^6$	Limits at the 95% probability level ±%	±$m^3 x10^6$	m^3 per hectare	Fines $-\frac{1}{16}$mm	Sand $+\frac{1}{16}$ -4 mm	Gravel +4 mm
A Glacial sand and gravel, glacio-lacustrine deposits and till	11.0	10.6	0.4	18.6	198	16	32	186000	10	68	22
B* Glacial sand and gravel	9.5	8.8	0.4	4.2	37	37	14	42000	12	42	46
C* Alluvium and glacial sand and gravel	9.4	9.3	1.8	4.0	37	43	16	40000	9	57	34
D* Glacial sand and gravel	6.1	3.4§	0.4	3.0	10	38	4	30000	17	57	26
Totals	36.0	32.1	-	-	282	-	-	-	-	-	-

* Excluding potentially workable till

§ This figure is two-thirds of the mapped area of glacial sand and gravel (for explanation see block description)

Table 7 The sand and gravel resources: summary of inferred assessments

Sub-block	Deposit	Area of mineral km^2	Mean thickness Over-burden m	Mean thickness Mineral m	Inferred volume of sand and gravel $m^3 x10^6$	Mean grading percentage Fines $-\frac{1}{4}$ mm	Sand $+\frac{1}{16}$ -4 mm	Gravel +4 mm
E_1	Glacial sand and gravel	3.3	0.3	5.6	18.4	11	57	32
E_2	Alluvium, head and glacial sand and gravel	1.3	0.2	3.8	5.0	16	61	23
E_3	Glacial sand and gravel	0.7	0.5	4.5	3.2	9	47	44
E_4	Post-Glacial and late-Glacial alluvium	1.0	0.3	4.0	4.1	5	39	56
E_4	Late-Glacial raised estuarine deposits	0.7	0.3	4.1	2.7	10	66	24
Totals	-	7.0	-	-	33.4	-	-	-

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

NOTES ON THE RESOURCE BLOCKS

Block A

The block is bounded to the south and to the west by the alluvium of the Allan water and of the River Knaik respectively, except near Muiralehouse [917 091] where the boundary follows the valley floor. The eastern limit coincides with the mapped extent of continuously exposed sand and gravel in the vicinity of Gleneagles Station [929 105]. To the north the block boundary has been drawn to delimit the extent of thickly developed and in the main, well-washed deposits of glacial sand and gravel from thinner and less clean material.

The ground surface is generally highly irregular (Section D-D_1) and reaches a maximum elevation of 185m above Ordnance Datum on the Gleneagles golf courses at White Muir [911 108]. However, below elevations of 140m above Ordnance Datum many flat-topped kames can be recognised (Section C-C_1). These deposits formed as spreads of outwash abutting ice which partially occupied the valley. The subsequent disappearance of this ice accounts for the highly irregular topography now found between the terrace remnants.

Glacial sand and gravel is exposed at the surface over much of the block, the principal exceptions being Shelforkie Moss [861 093] and the man-made lochs of Carsebreck [869 095], Upper Rhynd [863 101] and Lower Rhynd [857 096]. Boreholes suggest that locally the geology is more complicated than indicated on the resource map. Boreholes 80 NW 14 and 80 NE 2 proved 6.1m and 3.0m respectively of silt and clay within 9.2m of the surface, and the abundance of rushes on parts of the hillside between borehole 80 NW 14 and Gannochan [852 096] almost certainly locates the out-crop of these argillaceous seams.

Boreholes 91 SW 3 and 91 SW 4 proved the subcrop of the till about 150m and 145m respectively above Ordnance Datum. As the valley containing the headwaters of the Allan Water which separates these sites falls below 150m above Ordnance Datum, till is likely to be encountered in the valley floor or at minimal depth beneath it (Section D-D_1).

Small patches of thin peat or alluvium considered to be generally non-mineral, overlie the sand and gravel in many of the hollows and small valleys which abound in this block. On the basis of thirteen boreholes the mean thickness of mineral in block A is 18.6m (Table 8), significantly greater than in any other resource block in the resource sheet area. Boreholes 80 NE 13 and 90 NW 1 proved mineral to the maximum depth of drilling. Boreholes 80 NE 2, 80 NE 7, 80 NE 12, 90 NW 3 and 90 NW 4 were all terminated for

Table 8 Block A: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							
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	Descriptive category (see the diagram in Appendix C)
GLACIAL SAND AND GRAVEL, GLACIOLACUSTRINE DEPOSITS AND TILL											
80 NW 14	15.6*	0.3	6.1	13	31	23	13	13	7	-	CPS
80 NE 2	19.2+§	0.3	3.0	6	21	25	13	15	14	6	SG
80 NE 5	17.6	0.4	6.5	10	35	26	9	8	9	3	CPS
80 NE 7	23.1+	0.4	-	5	43	38	6	6	2	-	PS
80 NE 12	13.1+	0.5	-	5	15	28	14	18	17	3	SG
80 NE 13	24.7+	0.3	-	9	40	36	5	5	5	trace	PS
81 SE 6	20.2	0.4	-	11	49	27	5	5	3	-	CPS
90 NW 1	24.7+	0.5	-	11	32	26	7	10	12	2	CSG
90 NW 3	19.4+	0.2	-	8	15	21	10	18	21	7	SG
90 NW 4	23.9+	0.3	-	15	39	26	5	7	7	1	CPS
91 SW 3	13.5	0.2	-	14	22	20	8	14	18	4	CSG
91 SW 4	16.4	0.5	-	12	27	25	9	13	14	trace	CSG
91 SW 6	10.8	0.3	-	7	28	50	7	5	2	1	PS
Mean	18.6	0.4	-	10	32	28	8	10	10	2	CPS

* Including 1.0m of potentially workable glaciolacustrine deposits
§ Including 4.7m of potentially workable till, the base of which was not reached

Statistical assessment of glacial sand and gravel, glaciolacustrine deposits and till	
Area of exposed mineral	9.80km^2
Area of continuous or almost continuous spreads of mineral beneath overburden	0.84km^2
Total area of mineral	10.64km^2
Mean thickness of overburden	0.4m
Mean thickness of mineral	18.6m
Estimated volume of mineral	**198 million m^3** ±16% or 32 million m^3
Estimated yield of sand and gravel per hectare	**186 thousand m^3** ±16% or 30 thousand m^3

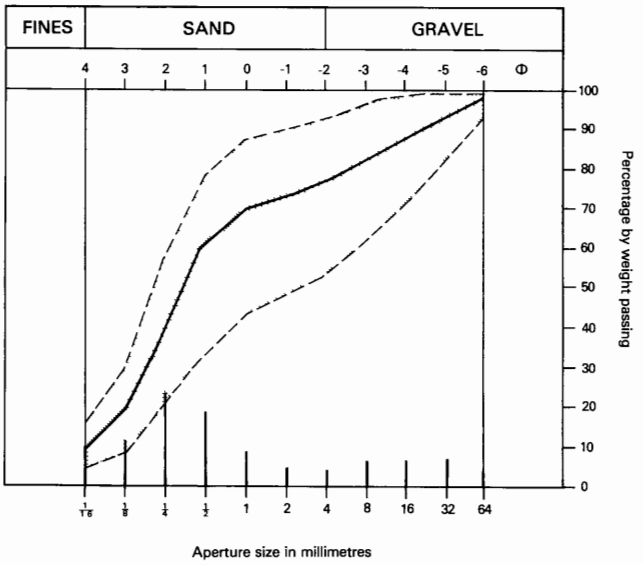

Figure 8 Grading characteristics of resources in the glacial sand and gravel, glaciolacustrine deposits and till of block A; the continuous line is the cumulative weighted mean; the broken lines define the envelope containing the cumulative mean grading of mineral proved in individual sample points; the frequency distribution of the weighted mean grading (0.063 to 64mm) is represented by the bar graph

technical reasons while still in potentially workable material, although at the first-mentioned site the basal mineral deposit was till, the sole occurrence in this block. No borehole in block A reached bedrock. Boreholes 80 NE 5, 81 SE 6, 91 SW 3, 91 SW 4 and 91 SW 6 were all terminated in till.

The mean thickness of overburden, based on data from thirteen boreholes, is 0.4m, but none was sited on peat or non-mineral alluvium which are believed to exceed 1.0m in thickness where mapped, especially on Shelforkie Moss.

The mean grading of the mineral is fines 10 per cent, sand 68 per cent and gravel 22 per cent ('clayey' pebbly sand) (Table 8 and Figure 8). In general the boreholes demonstrate coarsening-upward sequences, but this is by no means universal, the situation being complicated in some instances by the occurrence of more than one sedimentary cycle, for example in boreholes 80 NE 5 and 81 SE 6.

The glacial sand and gravel deposits are chiefly well sorted and graded, except in an area east of Woodside [903 101] where the upper 12.5m and 9.3m of mineral in boreholes 90 NW 1 and 91 SW 3 respectively, comprised ill-sorted, in part till-like deposits of 'clayey' sandy gravel which passed down abruptly into 'clean' well sorted material. Borehole 80 NE 2 proved 4.7m of potentially workable till but with depth the deposit became increasingly difficult to drill owing to its degree of consolidation, and the grading results are in some doubt because fines were unavoidably lost in the course of sampling.

The distribution of gravelly deposits in block A is somewhat erratic and trends are not obvious, apart from those previously mentioned.

Sand and gravel was formerly worked in small pits near Willow Bog at [848 988] and [846 100], at [866 099], near Milton of Panholes [891 096], near Comelyburn at [902 093], and at [903 096].

Water-table levels based solely on borehole information demonstrate areas of broad similarity. Between Willow Bog [844 101] and Westerton [875 102] boreholes proved groundwater levels between 106m and 109m above Ordnance Datum. From Burnbank [869 105] to Cecilmount [901 099], the water level was found to be between 115m and 117m above Ordnance Datum. Between Comelyburn [906 096] and Millhill [930 098] the water level ranged from 122m to 130m above Ordnance Datum, but was 110m near Gleneagles Station. Boreholes 91 SW 3 and 91 SW 4 did not reach the permanent water-table.

The estimated yield of all potentially workable material is 186000m^3 per hectare, equivalent to 198 million m^3 ± 16 per cent for the block as a whole.

Block B

The northern limit of this block coincides with the mapped extent of almost continuously exposed glacial sand and gravel north of the Allan Water and east of the River Knaik, except in the neighbourhood of Over Ardoch [837 115] where an inferred boundary has been drawn. To the south, block B abuts against block A along an arbitrary demarcation line which separates generally poorly sorted sand and gravel deposits of variable thickness from thickly developed and mainly well-washed sand and gravel to the south.

The geomorphology contrasts with block A in that flat-topped kame terraces and dead-ice features are less spectacularly developed. However, the undulating surface, rising northwards, is traversed by several sets of deeply dissecting drainage channels, for example near West Moor [895 109] and at White Muir. These are probably somewhat younger than the episode of glacial meltwater activity which created a series of prominent south-easterly-trending eskers between Muir of Orchill [860 125] and Easterton [884 112]. The Rhynd Burn forms a broad marshy depression in contrast to the valley of the Orchill Burn which is deeply incised. The hollows and stream valleys usually contain deposits of peat and silty alluvium.

The principal mineral deposit is glacial sand and gravel which crops out over most of the block. Unlike the position in block A, the underlying till and bedrock here are commonly exposed in stream sections and in glacial drainage channels. In two areas where glacial sand and gravel has been mapped at surface, it is considered that the mean thickness of the deposit is less than 1m and consequently is non-mineral. The larger occurrence is in the vicinity of Over Ardoch where evidence from a gas pipeline trench and pit 81 SW 5 indicates that the cover of sand and gravel is thin and patchy; accordingly an inferred boundary delimits this area. The second, near Orchill [868 118] and traversed by the same pipeline trench, comprises three separate patches which are depicted on the resource map in the same manner.

The alluvium of the Rhynd and Orchill Burns and that filling hollows in the glacial sand and gravel is likely to be too 'clayey' to be mineral. Borehole evidence indicates that the base of the glacial sand and gravel forms a very irregular surface, and for this reason it is difficult to predict definitively the occurrence of mineral beneath peat and alluvium. Areas reckoned to be barren are shown uncoloured on the accompanying resource map.

Much of the till is probably potentially workable in that the fines content is likely to be less that 40 per cent owing to the arenaceous nature of the majority of the local bedrock, although mudstone and siltstone of the Cromlix

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

Sample point	Recorded thickness			Mean grading percentage							
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	Descriptive category (see the diagram in Appendix C)
GLACIAL SAND AND GRAVEL											
81 SW 2	2.3	0.7	-	9	8	10	11	17	24	21	G
81 SW 4	5.6	0.3	-	15	13	12	12	20	23	5	CG
81 SE 2	3.7	0.3	-	8	10	13	15	20	19	15	G
81 SE 3	5.3	0.1	-	15	15	17	11	17	17	8	CSG
81 SE 4	2.1	0.3	-	6	7	14	14	21	31	7	G
81 SE 5	5.8	0.2	-	12	15	22	11	15	18	7	CSG
81 SE 7	8.0	0.3	-	10	12	18	15	20	20	5	CG
81 SE 8	3.4	0.7	-	11	18	17	10	17	22	5	CSG
81 SE 13	1.7+	0.4	-	3	20	25	10	17	25	0	SG
91 SW 2	6.7	0.3	-	20	18	13	11	18	18	2	VCSG
91 SW 5	1.4	0.3	-	9	8	12	13	23	26	9	G
Mean	4.2	0.4	-	12	14	16	12	18	21	7	CG
TILL											
81 SW 2	3.2	-	-	21	16	16	13	15	12	7	VCSG
81 SE 4	5.6	-	-	17	15	13	11	15	24	5	CG
81 SE 5	5.2	-	-	21	35	35	3	3	3	0	VCPS
81 SE 7	1.4+	-	-	14	21	34	9	9	4	9	CSG
81 SE 8	8.4+	-	-	8	14	13	15	20	25	5	G
81 SE 9	15.3	-	-	11	11	16	13	18	25	6	CG
Mean	6.5	-	-	14	16	18	12	15	20	5	CSG

Statistical assessment of glacial sand and gravel

Area of exposed mineral	8.55km^2
Area of continuous or almost continuous spreads of mineral beneath overburden	0.28km^2
Total area of mineral	8.83km^2
Mean thickness of overburden	0.4m
Mean thickness of mineral	4.2m
Estimated volume of mineral	**37 million m^3** ± 37% or 14 million m^3
Estimated yield of sand gravel per hectare	**42 thousand m^3** ± 37% or 16 thousand m^3

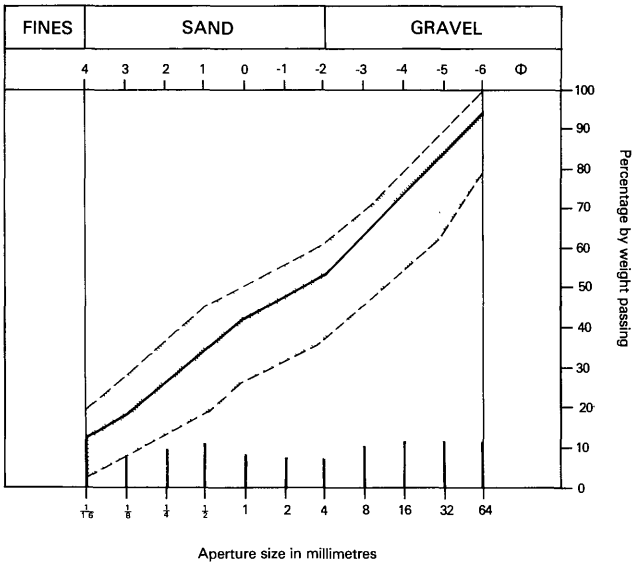

Figure 9 Grading characteristics of resources in the glacial sand and gravel of block B (for explanation see Figure 8)

Formation crop out near the north-west margin of the block and undoubtedly influence the composition of the till, for example in borehole 81 SW 4. Owing to the variability in thickness and composition of the till and uncertainty concerning the distribution of the mineral, no statistical assessment of this material is offered.

Based on eleven assessment boreholes and one pit, the mean thickness of glacial sand and gravel is 4.2m (Table 9). If potentially workable till were included, the mean thickness would increase to 7.2m (Table 9). Boreholes 81 SW 2, 81 SW 4, 81 SE 3, 81 SE 5, 81 SE 9, 91 SW 5 and pit 81 SW 5 proved the full succession to bedrock. Borehole 91 SW 2 and pit 81 SE 13 were probably close to bedrock when terminated, whereas boreholes 81 SE 2, 81 SE 4, 81 SE 7 and 81 SE 8 were stopped in till. The mean thickness of overburden is 0.4m.

The mean grading of glacial sand and gravel in block B is fines 12 per cent, sand 42 per cent and gravel 46 per cent ('clayey' gravel) (Table 9 and Figure 9), a noticably higher gravel content than in block A. For the till which was estimated visually to be mineral and thus was sampled and graded, the corresponding figures are fines 14 per

cent, sand 46 per cent and gravel 40 per cent ('clayey' sandy gravel) (Table 9), that is, not unexpectedly, broadly similar to the glacial sand and gravel which is commonly ill-sorted and is till-like in places. A shallow pit (81 SE 11) was sunk in the flank of one of the eskers which lies north and east of Orchill and gave a bulk sample with a gravel content of 66 per cent, much higher than the block average, and a fines content of 1 per cent, well below the norm.

There are no active or former workings in block B large enough to merit description. The permanent water-table was penetrated in several boreholes; 81 SE 4 at 119m, 81 SE 8 at 130m, 81 SE 9 at 138m and 91 SW 5 at 139m above Ordnance Datum, these levels being in accordance with the general easterly rise in the water-table described for block A. Boreholes 81 SW 2 and 81 SE 2 were dry. The remainder struck water-tables believed to be perched.

The estimated yield of all potentially workable glacial sand and gravel in block B is 42000m^3 per hectare, equivalent to 37 million m^3 ± 37 per cent for the block as a whole.

Block C

Block C comprises the alluvial flood plains of the Allan Water west of the Strathearn-Strathallan watershed at Muiralehouse to the boundary of the resource sheet and of the River Knaik from Braco [837 097] southwards. The boundary coincides with the mapped extent of alluvium, and higher alluvial terraces of late-Glacial age, but the contiguous deposits in several small tributary stream valleys are arbitrarily excluded. Four small glacial sand and gravel mounds which protrude through the alluvium, for example Deaf Knowe [882 097] (Plate 3), are also included. The block boundary is drawn across Shelforkie Moss in a position believed to correspond with the limit of alluvium beneath the peat.

The ground surface for the most part is flat and low-lying with a consequent preponderance of marshland, although higher terraces are found on the left bank of the River Knaik, north of Boreland [884 091], and in the extreme south-west of the resource sheet. The Allan Water falls approximately 30m in 13km; by contrast the River Knaik falls 15m in only 2km, and the sediments of the latter have the form of an alluvial fan, mostly laid down in late-Glacial times.

The major resource in block C is found in the alluvium, late-Glacial alluvium, and sand and gravel considered to be of glacial meltwater origin, which underlies the alluvium and late-Glacial alluvium in boreholes 80 NW 3, 80 NE 6, 80 NE 10 and 90 NW 2 and amounts to 46 per cent of the assessed mineral thickness. Three metres of till in the last-mentioned borehole also proved to be potentially workable, but the deposit is not assessed.

Glaciolacustrine deposits comprising silt, clay and fine sand, underlie the alluvium over much of block C and indicate the former presence of a large lake or lakes towards the end of the last glaciation (Section A-A$_1$ and B-B$_1$). Most boreholes between 80 NW 6 and 80 NE 8 proved the lacustrine sediments and in three (80 NW 6, 80 NW

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

Sample point	Recorded thickness			Mean grading percentage							
Borehole	Total mineral m	Depth of burial m	Intervening waste m	Fines −1/16 mm	Fine sand +1/16 −1/4 mm	Medium sand +1/4 −1 mm	Coarse sand +1 −4 mm	Fine gravel +4 −16 mm	Coarse gravel +16 −64 mm	Cobbles and boulders +64 mm	Descriptive category (see the diagram in Appendix C)
ALLUVIUM, LATE-GLACIAL ALLUVIUM, AND GLACIAL SAND AND GRAVEL											
80 NW 3	1.5	3.0	-	18	17	9	11	14	14	17	CG
80 NW 6	1.5	1.8	-	8	26	17	6	16	25	2	SG
80 NW 9	5.6*	0.7	-	14	38	40	6	2	0	0	CS
80 NW 11	5.7	0.7	-	7	11	13	15	20	27	7	G
80 NW 12	2.9§	0.8	-	5	8	11	11	16	30	19	G
80 NW 15	1.6	0.2	-	7	11	11	11	15	31	14	G
80 NE 3	4.3	0.2	-	12	41	29	12	6	0	0	CPS
80 NE 6	5.7	2.5	-	6	16	23	19	24	12	0	SG
80 NE 8	1.5	2.3	-	5	10	12	13	33	21	6	G
80 NE 10	9.1	5.8	-	9	31	14	8	14	21	3	SG
90 NW 2	5.1Ø	1.6	0.8	7	30	30	10	16	6	1	SG
Mean	4.0	1.8	-	9	25	21	11	15	15	4	SG

* Excluding 2.6m of potentially workable glaciolacustrine deposits
§ Excluding 5.7m of potentially workable glaciolacustrine deposits
Ø Excluding 3.0m of potentially workable till

Statistical assessment of alluvium, late-Glacial alluvium and glacial sand and gravel

Area of exposed mineral	4.94km^2
Area of continuous or almost continuous spreads of mineral beneath overburden	4.38km^2
Total area of mineral	9.32km^2
Mean thickness of overburden	1.8m
Mean thickness of mineral	4.0m
Estimated volume of mineral	**37 million m^3** ± 43% or 16 million m^3
Estimated yield of sand and gravel per hectare	**40 thousand m^3** ± 43% or 17 thousand m^3

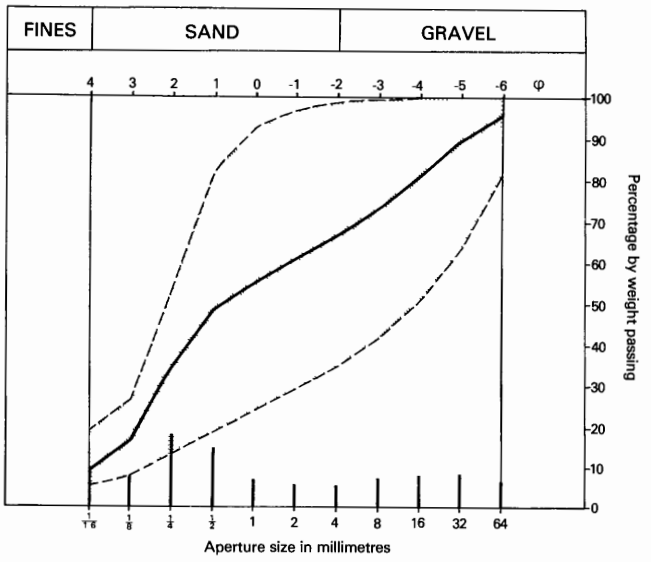

Figure 10 Grading characteristics of resources in the alluvium and glacial sand and gravel of block C (for explanation see Figure 8)

9 and 80 NW 11) the deposits were not bottomed. Part of this sequence proved to be mineral locally.

There is no evidence to indicate that potentially workable material is not present everywhere in the block; however, in view of the alluvial nature of much of the deposits and the marked variation in thickness which ranges from 1.5 to 1.9m, mineral may be absent in places.

Although the mean thickness of overburden for the block as a whole is 1.8m, for five boreholes between Loig [816 074] and Rhynd [855 093] the mean thickness is 0.5m, and inferred boundaries have been drawn on the resource map to define an area of exposed potentially workable sand and gravel. For the remainder of the block the mean thickness of overburden is 2.8m. The overburden thickness shows an increase above the norm for the resource sheet mainly owing to the presence of silty overbank deposits, locally with peat beds, for example, north-west of Deaf Knowe and on the southern margin of Shelforkie Moss. Additionally several boreholes proved seams of organic remains within or below the alluvial sequence.

Using ten assessment boreholes, the mean thickness of all potentially workable material in block C is 4.7m. If glaciolacustrine deposits and till, which are unlikely to command commercial interest, are excluded, the mean thickness falls to 4.0m, and this figure has been used in the volumetric calculations (Table 10). Only borehole 90 NW 2 reached bedrock; boreholes 80 NW 6, 80 NW 9 and 80 NW 11 were stopped in glaciolacustrine deposits when the overburden ratio became excessive. The remaining boreholes were abandoned owing to rock obstruction or slow progress in till.

The mean grading of alluvium, late-glacial alluvium and glacial sand and gravel is fines 9 per cent, sand 57 per cent and gravel 34 per cent (sandy gravel) (Figure 10): for all potentially workable material the statistics are fines 11 per cent, sand 60 per cent and gravel 29 per cent ('clayey' sandy gravel). The main gravel-bearing area is that including boreholes 80 NW 11, 80 NW 12 and 80 NW 15, corresponding to the alluvial fan deposits of the River Knaik.

Apart from borehole 80 NW 3 which did not reach groundwater, the depth to water-table in block C ranged from 0.5m in borehole 90 NW 2 to 5m in borehole 80 NW 11: the mean for ten boreholes is 2.3m. From borehole 80 NE 3 eastwards, the average depth to water-table was 1.8m. In comparison from borehole 80 NW 15 westwards, the average groundwater level was 3.1m below the surface. These readings were obtained during the summer of 1981; in winter the levels would almost certainly be higher. Sand and gravel is not known to have been worked in this block.

The estimated yield of the alluvium, late-Glacial alluvium and glacial sand and gravel in block C is 40000m^3 per hectare, equivalent to 37 million m^3 ± 43 per cent for the block as a whole.

Block D

The block includes the fragmented spread of glacial sand and gravel which drapes the southern side of the valley of the Allan Water. Generally the block boundaries coincide with the mapped extent of the deposit.

The ground surface is irregular and traversed by a number of valleys carved by streams draining from the Ochil Hills. Commonly, the valley sides expose glacial meltwater deposits on till which in turn rests on bedrock. Usually the till is sandy, reflecting the arenaceous nature of the underlying bedrock, and the sand and gravel is often poorly sorted and grades as 'clayey' or 'very clayey'. Consequently, it can be difficult to delineate the two deposits in poorly exposed areas such as pastureland. Furthermore, the glacial sand and gravel appears to have been draped over a hummocky sub-glacial landscape formed principally of till on bedrock. Consequently the thickness of the deposit bears no simple relationship to landform or topography and may be thin or absent in areas which appear contiguous with proven sand and gravel deposits. For example, only 2.3m of 'clayey' pebbly sand overlying 1.2m of laminated silt on a stiff till were proved by borehole 80 NE 14 sited on a mound next to and approximately 7m above the floodplain of the Allan Water. Boreholes 80 NW 4, 80 NW 7 and 80 NW 10 proved to be sited on till. Ploughing at Glenbank [811 058] and to the north-east of Netherton [870 086] whilst the field survey was in progress revealed the outcrop of sand and gravel deposits to be patchy and less extensive than previously thought. As the deposits are not laterally

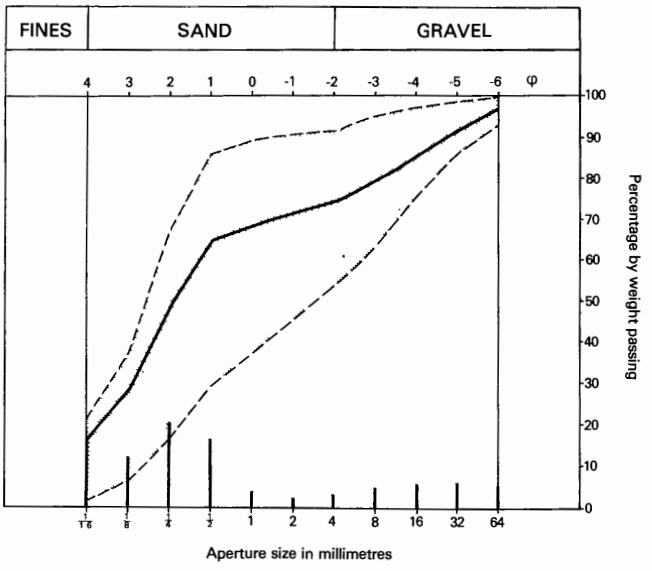

Figure 11 Grading characteristics of resources in the glacial sand and gravel of block D (for explanation see Figure 8)

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

Sample point	Recorded thickness			Mean grading percentage							
Borehole or pit	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	Descriptive category (see the diagram in Appendix C)
80 NW 7*	3.9	0.7	-	18	30	23	5	8	12	4	CSG
80 NW 10*	4.2	1.5	-	12	17	14	8	11	22	16	CG
80 NW 13	3.6	0.3	-	18	32	10	6	15	13	6	CSG
80 NW 16	2.8	0.6	1.0	17	27	25	8	10	9	4	CSG
80 NW 18	1.3	0.2	-	1	15	22	16	22	24	0	SG
80 NW 20§	1.6+	0.3	-	2	12	17	17	21	24	7	G
80 NE 4Ø	3.7	0.3	0.7	21	26	12	6	13	18	4	VCSG
80 NE 9	4.8	0.4	-	14	40	31	3	5	7	0	CPS
80 NE 11	2.3	0.4	-	18	28	10	9	14	14	7	CSG
80 NE 14	2.3	0.9	-	19	49	22	2	6	2	0	CPS
80 NE 16§	1.9+	0.4	-	4	28	13	9	16	22	8	SG
Mean	3.0	0.4	-	17	32	19	6	11	12	3	CSG

* Although borehole proved potentially workable till, data are not used in the assessment calculation
§ Not used in assessment calculation as the mineral deposit was not bottomed
Ø Overlying 3.5m+ of potentially workable till which is not included in the assessment calculation

Statistical assessment of the glacial sand and gravel

Area of discontinuous spreads of mineral exposed or beneath overburden	3.38km^2
Mean thickness of overburden	0.4m
Mean thickness of mineral	3.0m
Estimated volume of mineral	**10 million m^3** ± 38% or 4 million m^3
Estimated yield of sand and gravel per hectare	**30 thousand m^3** ± 38% or 11 thousand m^3

Note: The area of mineral bearing ground is taken as two-thirds of the area shown as discontinuous spreads of mineral

persistent, they are shown on the resource map as discontinuous. Sand and gravel is thought to be present over about two-thirds of the mineral-bearing ground marked on the map and for the purpose of the volume calculation this reduced area has been taken.

Potentially workable material is contained within the glacial sand and gravel deposits and the till. Till judged to be mineral was encountered in boreholes 80 NW 7, 80 NW 10 and 80 NE 4. Much of the till in the block probably contains less than 40 per cent fines but because of variability in thickness, grading and unknown lateral extent, assessment is not possible. The glacial sand and gravel proved in boreholes is less than 5m thick and poorly sorted (except in borehole 80 NE 9), many of the constituent pebbles being angular to subrounded in shape and composed of rock types derived locally from Lower Devonian strata. Borehole 80 NE 11, sited to the south of Boreland [884 091], is typical, proving 2.3m of such material overlying a thin till on bedrock. For the most part, the sediments were probably not transported very far by the glacial meltwaters. Near Longfold [879 086], borehole 80 NE 9 demonstrated a fining-downward sequence from 'clayey' pebbly sand to laminated sandy silt, the basal 2.3m of the deposit being judged non-mineral. Ploughing to the north of the boresite at a lower level revealed outcrops of laminated silt. Consequently, this non-mineral bearing area of glacial meltwater deposits has been delineated by an inferred boundary. In boreholes 80 NW 16 and 80 NE 4, thin deposits of ablation till, probably very localised in extent, are interbedded with the sand and gravel.

Water was encountered in several boreholes, the levels indicating the expected fall in height of the water-table westwards down the valley of the Allan Water. Sand and gravel deposits have not been worked commercially in the block.

A statistical assessment is offered for the glacial sand and gravel deposits. Based on six boreholes and one pit the deposits have a mean thickness of 3.0m and a mean grading of fines 17 per cent, sand 57 per cent and gravel 26 per cent ('clayey' sandy gravel). Overburden ranges in thickness from 0.2m in pit 80 NW 18 to 0.9m in borehole 80 NE 14 and for the block as a whole the mean thickness is 0.4m.

The estimated yield of potentially workable glacial sand and gravel is 30000m^3 per hectare, equivalent to 10 million m^3 ± 38 per cent for the block as a whole.

Block E

The block comprises all of the resource sheet area outwith blocks A, B, C and D, much of which is rolling upland mantled by till and with bedrock cropping out on the higher ground. Potentially workable sand and gravel deposits are scattered across the area of the block but they are too small, patchy and diverse to be assessed statistically. Inferred assessments are offered for four sub-blocks in which deposits have broadly similar geology. Till may be potentially workable over much of the ground but owing to the paucity of data no assessment is offered. Extensive use is made of ancilliary data for the calculation of mean thickness, mean grading and volume of sand

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

Sample point	Recorded thickness			Mean grading percentage							
Borehole or pit	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	Descriptive category (see the diagram in Appendix C)
SUB-BLOCK E_1 (GLACIAL SAND AND GRAVEL)											
80 NW 2	2.3	0.3	-	25	38	19	5	7	6	0	VCPS
80 NW 5	15.8	0.2	-	7	12	20	18	24	17	2	SG
80 NW 8	14.6	0.2	-	13	34	25	13	11	4	0	CPS
80 NW 17	1.1+	0.7	-	1	8	21	21	31	18	0	G
81 SW 1	2.0	0.3	-	9	13	11	17	23	21	6	G
81 SW 3	4.2	0.3	-	12	14	12	16	20	22	4	CG
Mean	5.6*	0.3	-	11	22	20	15	18	12	2	CSG
SUB-BLOCK E_2 (MINERAL RESOURCES EXCLUDING POTENTIALLY WORKABLE TILL)											
90 NW 5	5.3	0.3	2.2	16	22	12	7	14	27	2	CG
90 NW 6	4.8	0.1	-	18	64	15	2	1	trace	0	CS
Mean	3.8*	0.2	-	16	43	13	5	8	14	1	CSG
SUB-BLOCK E_3 (GLACIAL SAND AND GRAVEL)											
91 SE 5	2.5	1.4	-	13	15	17	12	17	20	6	CSG
91 SE 9	1.2	0.3	-	1	6	24	21	20	12	16	SG
Mean	4.5*	0.5	-	9	12	20	15	18	17	9	SG
SUB-BLOCK E_4 (POST-GLACIAL AND LATE-GLACIAL ALLUVIUM)											
91 SE 6	6.8	0.2	-	7	10	19	16	19	27	2	G
91 SE 11	1.3	0.3	-	trace	2	14	17	27	35	5	G
Mean	4.0*	0.3	-	5	10	17	12	20	33	3	G §
SUB-BLOCK E_4 (LATE-GLACIAL RAISED ESTUARINE DEPOSITS)											
91 SE 7	4.5	0.3	-	12	34	48	3	2	1	0	CS
Mean	4.1*	0.3	-	10	25	30	11	14	10	0	CSG §

* Mean thickness is an estimate based on sample point data and consideration of the form of the deposits

§ Mean grading calculated using data from site exploration report

Inferred assessment of the glacial sand and gravel of sub-block E_1

Area of exposed mineral	3.28km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral*	5.6m
Estimated volume of mineral	**18.4 million m^3**

Inferred assessemt pf the mineral resources (excluding potentially workable till) of sub-block E_2

Area of exposed mineral	1.32km^2
Mean thickness of overburden	0.2m
Mean thickness of mineral*	3.8m
Estimated volume of mineral	**5.0 million m^3**

Inferred assessment of the glacial sand and gravel of sub-block E_3

Area of exposed mineral	0.70km^2
Mean thickness of overburden	0.5m
Mean thickness of mineral*	4.5m
Estimated volume of mineral	**3.2 million m^3**

Inferred assessment of the post-Glacial and late-Glacial alluvium of sub-block E_4

Area of exposed mineral	1.02km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral*	4.0m
Estimated volume of mineral	**4.1 million m^3**

Inferred assessment of the late-Glacial raised estuarine deposits of sub-block E_4

Area of exposed mineral	0.67km^2
Mean thickness of overburden	0.3m
Mean thickness of mineral*	4.1m
Estimated volume of mineral	**2.7 million m^3**

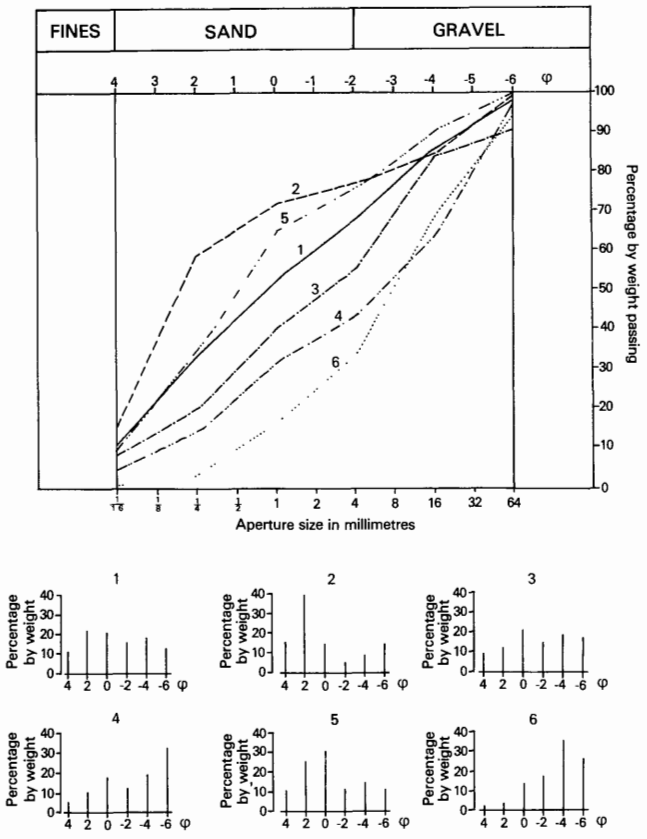

Figure 12 Grading characteristics of sand and gravel resources of block E

1 Glacial sand and gravel of sub-block E_1
2 Mineral resources (excluding potentially workable till) of sub-block E_2
3 Glacial sand and gravel of sub-block E_3
4 Post-Glacial and late-Glacial alluvium of sub-block E_4
5 Late-Glacial raised estuarine deposits of sub-block E_4
6 Glacial sand and gravel in the Lucas Wood area (sub-block E_5)

and gravel in sub-block E_4. The registration numbers of these sample points follow the same format as those sunk for IMAU except that the serial numbers are prefixed by the letter X, for example 91 SE X5. Details of mean thickness and estimated volume are given in Table 12 along with mean grading data which is also represented graphically in Figure 12.

Sub-block E_1 An almost continuous cover of glacial sand and gravel deposits drapes the valley sides between the Allan Water and the River Knaik west of Braco. West of Feddal House [822 089], pit 80 NW 19 proved till at the surface and the mapped sand and gravel deposits hereabouts are thought to have a mean thickness of less than 1m. The extent of mineral bearing ground is delineated by an inferred boundary. South-west of Gallowston Plantation [821 079] the glacial sand and gravel is believed to be generally thin and to have a patchy outcrop but at the level of detail adopted for this survey it is not possible to define the extent of barren ground. Examination of trenches dug for field drains suggests a similar situation exists near Nether Cambushinnie [809 067]. Borehole 80 NW 2 revealed poorly sorted sand and gravel 2.3m thick and grading as 'very clayey' pebbly sand. Such material is thought to be typical of this part of the sub-block; the sample of gravel recovered from below the water-table in pit 80 NW 17 has an artificially low fines content. Borehole 80 NW 1 for the well at Coupings [812 077] proved sand and gravel to a depth of 2.1m overlying till.

Most of the potentially workable material in the sub-block occurs in a dissected terrace feature which borders the floodplains of the River Knaik and the Allan Water south-westwards to Wester Feddal [821 085], although at Loig [816 074] borehole 80 NW 5 proved 15.8m of well sorted sand and gravel in a detached remnant of the terrace. North-east of Wester Feddal the terrace forms a prominent feature, over 20m in height, and borehole 80 NW 8 sited on it revealed 14.6m of glacial sand and gravel becoming finer with depth. It is assumed that these deposits thin towards the high ground and have a form approximating to a trapezoid prism. The terraces become more subdued northwards and the glacial meltwater deposits gradually thin. At Grinnan Hill [834 093], the height of the terrace top is reduced to about 15m above the level of the flood plain. Borehole 81 SW 3, to the south of Nether Braco [832 105], penetrated 4.2m of 'clayey' gravel; north of the farm, borehole 81 SW 1 proved only 2.0m of gravel overlying potentially workable till.

Upstream of Braco Castle [823 113], the outcrop of the glacial meltwater deposits terracing the southern valley side becomes less extensive than in the open valley to the south. These sediments have not been investigated by borehole or pit and may comprise sand and gravel, locally up to 10m thick, but generally they are thought to be thin and to have an estimated mean thickness of 2.5m. Alluvium hereabouts is considered not potentially workable.

Sub-block E_2 Glen Eagles is a north-north-westerly-trending, narrow, steep-sided glaciated trough extending from the Ochil Hills to Strathallan. Potentially workable material is contained within the glacial sand and gravel deposits which mantle the lower slopes of the glen and in the deposits occupying the valley floor downstream of Gleneagles House [930 087].

At the head of Glen Eagles scrapes show the moundy glacial meltwater deposits to be mainly sand. In addition, sand is known to have been worked from a mound to the south of St. Mungo's [937 074].

South of Gleneagles House glacial sand and gravel forms a terrace on the western valley side. Borehole 90 NW 6, sited on top of the feature, proved 4.8m of 'clayey' sand. In upper Glen Eagles the valley floor is generally narrow and covered by alluvium which is judged too thin to be potentially workable. Around Gleneagles House the alluvial plain widens. Borehole 90 NW 5 proved a sequence of potentially workable deposits to a depth of 11.1m before being terminated on an obstruction. The lowest 3.3m comprised mineral till but it has not been considered in the assessment. Water was encountered 3m below the surface.

West of Gleneagles Castle [929 092] there is an extensive, but probably thin, outcrop of the glacial meltwater deposits.

On the southern side of the valley of the Ruthven Water around Duchally Mill [933 097] and on the eastern side of the glen near East Mains Farm [933 088] there are ridges of glacial sand and gravel up to about 5m in height. These were not investigated by borehole or pit but scrapes show the sediments to be gravelly.

Sub-block E_3 To the south-east of Auchterarder glacial sand and gravel forms isolated mounds and eskers in which most of the mineral lies above the water-table. In the largest outcrop of the glacial meltwater deposits, which surrounds Thorn [960 120], borehole 91 SE 5 proved 2.5m of 'clayey' sandy gravel and pit 91 SE 9 revealed 1.2m of sandy gravel. Scrapes and excavations suggest that other deposits in the sub-block have a similar composition. The thicknesses demonstrated at Thorn, however, are believed to be lower than the mean for the area, as most deposits stand in excess of 5m above the surrounding land surface and are thought to contain mineral to at least that level. Sand and gravel is currently being won from a mound just to the south of Coul [968 125] which hearsay suggests contained about 500000 tonnes of material. The pit exposes well sorted, finely bedded sand and gravel to a maximum thickness of about 9m. Sandy till crops out in the base of the working. A string of eskers with an east-north-easterly trend contour the lower slope of Craig Rossie to the west of Rossie Farm [997 134]. The eskers are assymmetric in cross-section, the southern side being shorter than the northern. The esker named The Ship [987 131] has an undulating crest ranging in height above the surrounding land from about 14m at its westerly end to 7m in the east where a small excavation, intermittently worked for local use, exposes about 5.5m of glacial sand and gravel but not the base of the deposit. Poorly sorted gravel forms the core of the esker and is surrounded by well sorted and finely bedded sand and gravel. Glacial meltwater deposits were worked at [9594 1148] north-west of Pothill.

Sub-block E_4 Alluvial terraces at two levels above the present day floodplain occur in the valley of the Ruthven Water east of the Kincardine Glen. The underlying sediments were laid down by glacial meltwaters during late-Glacial times. The upper terrace was investigated to the south-west of Arns [974 141] by borehole 91 SE 6 and to the north-west of the farm by pit 91 SE X16. In the borehole 6.8m of gravel overlay till but in the pit the full thickness was not proved when digging was stopped at 2.6m depth. The lower terrace is altitudinally 1 to 2m lower than the upper, and is underlain by generally clean, well sorted gravel or sandy gravel which was penetrated to a depth of 4.0m by borehole 91 SE X7 though no sample point proved the full thickness of the deposits. The post-Glacial alluvium of the Ruthven Water largely comprises gravel. Sample points in the central part of the valley floor did not bottom the deposits but towards the edge, the sediments thin. For example, near Bankhead [952 124], borehole 91 SE X1 sited in a central position on the floodplain proved 4.7m of gravel but pit 91 SE X9 close to the valley side demonstrated only 1.0m of 'very clayey' sandy gravel overlying bedrock. The greatest thickness of sand and gravel was discovered by borehole 91 SE X4 in the mouth of the Dalry Burn: the base of the sediments was not proved when the borehole was stopped at a depth of 5.2m. Downstream of Shinafoot [965 136] the floodplain gradually widens. Pit 91 SE 11, near Westertown [977 144], proved 1.3m of gravel overlying late-Glacial raised estuarine deposits composed of sandy silty clay. The floodplain widens again on the west bank of the Ruthven Water near Damside Cottages [972 148] and may conceal thicker deposits of sand and gravel. Much of the potentially workable material in the alluvial deposits lies beneath the water-table.

An area of flat ground around Hall of Aberuthven [979 149] is underlain by late-Glacial raised estuarine deposits which are variable in composition. Pit 91 SE 10 penetrated 1.4m of sandy silt overlying 0.5m of clay which was not bottomed. About 200m to the north-west, borehole 91 SE X5 proved 2.8m of 'clayey' pebbly sand overlying till on bedrock and borehole 91 SE 6 penetrated 1.6m of 'very clayey' gravel overlying till. Just north of the assessment area, however, the deposits are thicker. Borehole 91 NE X1 proved sand and gravel, grading as 'clayey' pebbly sand and containing 1.1m of laminated silt and clay, to a depth of 9.6m and resting on till. Sandy gravel 8.9m thick was not bottomed by borehole 91 NE X2. A distinct terrace feature separates this flat from higher ground to the east, beneath which borehole 91 SE 7 proved 4.5m of 'clayey' sand lying above the water-table. Hearsay and evidence from scrapes indicates that the deposit in the field to the west of the boresite contains a higher gravel content but cultivation of the land prevented detailed investigation. The late-Glacial raised estuarine deposits north of Newbigging [957 146] were not examined in detail but the overlying soils were noted to be light and gravelly and it is probable that the deposits are potentially workable.

Sub-block E_5 Within the sub-block the scattered patches of glacial sand and gravel are too small to be assessed. Owing to the paucity of data and the limited extent of these deposits detailed descriptions and quantitative assessments are not possible, but brief notes are given for some of the larger outcrops. One of the largest deposits is located at the head of the valley of the Coul Burn, near Dun Muir [983 084]. Details of thickness are not known but scrapes show the sediments to be gravelly. A small terrace feature about 4m in height is present on the northern valley side of Lucas Burn near Lucas Wood [888 140]. Pit 81 SE 14, sited at the terrace top, proved gravel to a depth of 2.2m but did not bottom the deposit which probably contains potentially workable material to a depth equivalent to the height of the feature. The east-west-trending esker at Lairochs [868 150] was noted to be gravelly during the field survey.

Much of the alluvium covering the valley floor in Glen Devon is probably potentially workable but little detail of thickness or grading is known. Terrace features composed of late-Glacial and post-Glacial alluvium occur at three levels above the present day floodplain hereabouts. Scrapes show the sediments to be gravelly but little information about thickness is available.

CONCLUSIONS

The sand and gravel resources of the district have been described systematically and the results of the assessment summarised in Tables 6 and 7. It must be emphasised that the survey concerns the estimation of resources rather than reserves and that the assessment of the workability of deposits is judged solely in terms of the four arbitrary physical criteria stated in the introduction to this report. No account is taken of prevailing environmental or economic considerations: 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 against which the economic, social and environmental costs in developing, or constraints in preserving, the resources can be weighed.

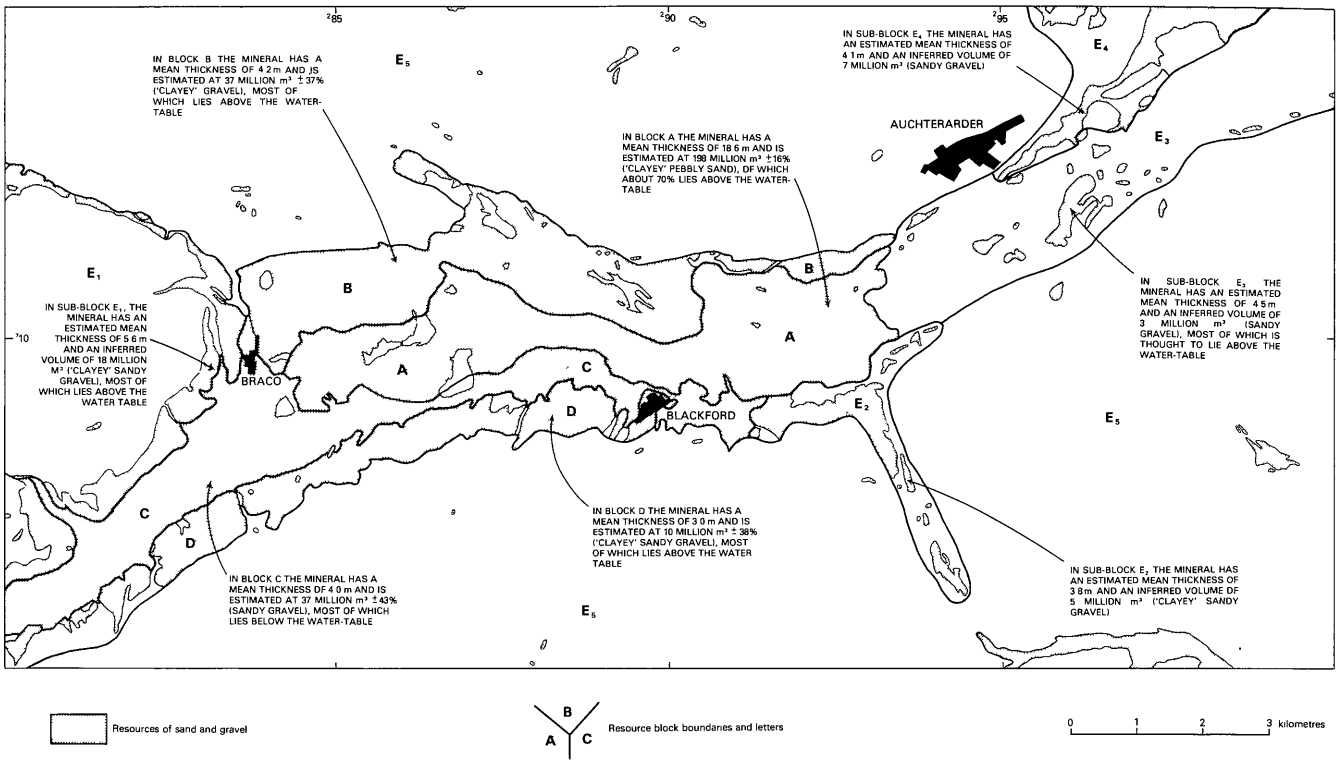

Figure 13 Sketch-map comparing the sand and gravel deposits in the resource blocks

Bearing in mind that much more detailed exploration and evaluation of the deposits will be required to establish the whereabouts of reserves, it is possible, nonetheless, to indicate, with some degree of certainty, those resources which may first command attention. The blocks have been delineated with the aim of grouping together, as far as possible, deposits of similar characteristics, the salient points of which are summarised below, block by block.

Block A has the largest mineral-bearing area: the estimated mean thickness of potentially workable material is 18.6m which exceeds by a factor greater than four the next highest figure for mean thickness, found in block B and excluding sub-block E_1. However, the attraction of the resource in block A is offset to an extent by a modest mean gravel content of 22 per cent.

Groundwater is an important aspect of the potential exploitation of sand and gravel, wet working being currently uncommon in Scotland. Although there has been shown to be a consistency in the groundwater levels in block A, the wide range of depths to water in boreholes is a result of the irregular topography. For the eleven boreholes which are considered to have proved the permanent water-table, the mean depth to water was 14.5m, or in other words, about 70 per cent of the mineral deposits might be capable of dry working.

In *block B* the mean thickness of glacial sand and gravel is 4.2m and the variability in deposit thickness is reflected by relatively high confidence limits of 37 per cent calculated for the volume. The comparable figure for block A is 16 per cent. Although some boreholes proved substantial thicknesses of potentially workable till, it is considered that the nature of the deposit is likely to preclude it from commercial consideration until such time as the more immediately attractive deposits have been discounted. However, it is noteworthy that the grading characteristics of the glacial sand and gravel in block B, as shown by Figure 9, demonstrate a poor degree of sorting, not unlike the size frequency distribution found in sandy tills.

The gravel content of the glacial sand and gravel in block B is 46 per cent. Pebble-count analyses of two composite samples from boreholes in the block gave mudstone and siltstone contents of about 17 per cent explaining the poor results for water absorption tests obtained from the same samples. The majority of the glacial sand and gravel could be capable of dry working.

Block C has a slightly larger mineral bearing area than block B but the mean thickness and mean gravel content (4.0m and 34 per cent respectively) are both lower. The mean fines content of 9 per cent is lower than in blocks A, B or D, but this variance probably results from more of the boreholes in this block than elsewhere being drilled wet, a technique which tends to give less representative sampling owing to unavoidable loss of fines.

Arguably the major physical factor affecting potential exploitation of deposits in block C is the high water-table. Excluding borehole 80 NW 3 which was sited on the margin of the alluvial plain and did not strike water, the mean depth to groundwater in ten boreholes was 2.4m: drilling took place during the summer when levels are likely to be lower than average.

In *block D* boreholes and field survey evidence indicate that the deposits are extremely variable in thickness and quality. Only part of the glacial sand and gravel crop is potentially workable and because the extent of barren to mineral-bearing ground cannot be determined on the available evidence, the deposit is shown as discontinuous on the resource map. In the volumetric calculation it is assumed that the actual mineral-bearing ground is two thirds of the mapped area and potentially workable till has been excluded.

The mean grading of glacial sand and gravel in the block shows the deposits to have 17 per cent fines, more than the material in blocks A, B or C, and to have a gravel content of 26 per cent.

Block E is divided into sub-blocks which are too small or have too few sample points for statistical assessments to be valid. The inferred volumes of mineral in the sub-blocks are of modest proportions, with the exception of sub-block E_1 in which the glacial sand and gravel deposits include similar lithologies and sequences to those found in blocks A and B. The means for thickness, gravel and fines content for the sub-block all lie between the mean values obtained for blocks A and B.

To date the sand and gravel industry is believed to have devoted limited attention to the mineral resources of upper Strathallan in comparison with, for example, the Teith Valley and lower Strathallan, but this has probably been a result of marketing influences, primarily transportation distance. With the inevitable eventual exhaustion of proximal supplies of sand and gravel, upper Strathallan is likely to demand more attention from the industry than hitherto.

To summarise, in blocks A, B and the eastern part of sub-block E_1, although the sand and gravel deposits possess differing physical characteristics, they are likely to prove equally attractive as a resource. Block C, sub-blocks E_2 and E_3 are less likely to command attention until such time as more immediately attractive deposits have been discounted. In block D, together with sub-blocks E_4 and E_5, the resource is considered to be of less interest than that elsewhere in the assesssed area.

LIST OF WORKINGS

In 1981 only one sand and gravel pit, listed below, was operational and that was newly opened. However it is known that interest has been shown in working sand and gravel elsewhere in the resource sheet area.

Sites of former working on a very small scale are common, especially within blocks A and B.

Site	*Grid Reference*	*Operator*	*Mode of Operation*	*Deposit Block worked*
Coul	968123	John MacGregor & Son, Aberuthven	Pit opened during 1981	Glacial sand and gravel E_3

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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 the Institute 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 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 about 200mm, 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.

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or at every 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 in the laboratories of the Industrial Minerals Assessment Unit.

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

Detailed records may be consulted at the appropriate offices of the Institute: the address is shown on page ii of this report, next to the preface.

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

1 A statistical assessment is made of an area of mineral greater than $2km^2$, 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. 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

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

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

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

and when n is greater than 20, as

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

Exceptionally in sub-block E_1, where the area of mineral is $3.3km^2$, an inferred assessment is made because an attempted statistical assessment resulted in confidence limits in excess of 100 per cent.

13 In some cases a resource block may include an area left uncoloured on the map, within which

Block calculation

Scale: 1:25000
Block: Fictitious

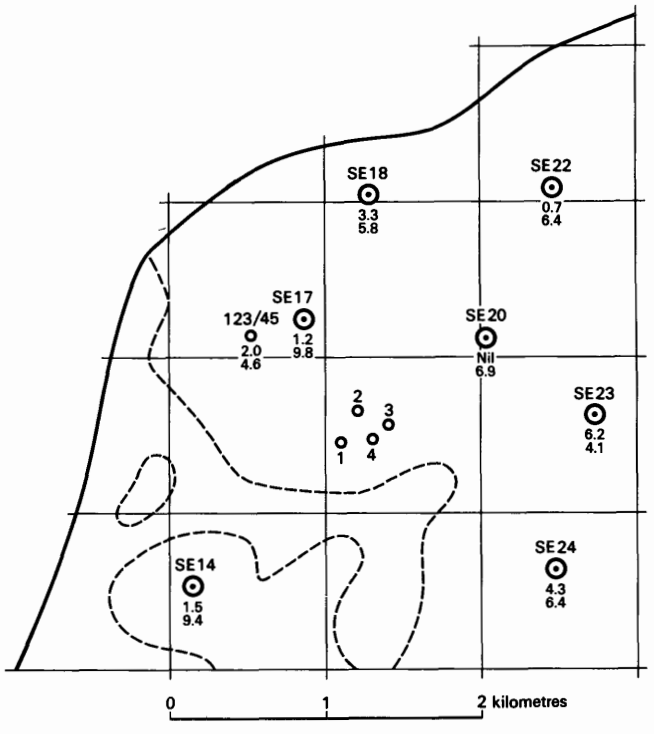
Area
Block: 11.08km^2
Mineral: 8.32km^2

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



SE24 ⊙ IMAU borehole

4.3 / 6.4 Overburden / Mineral] Thickness in metres

o Other boreholes

——— Boundary of resource block

– – – – – Boundary of sand and gravel deposit

Example of resource block assessment: map of a fictitious block

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	IMAU
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	Hydro-geology 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 (commer-cial)
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	$\lvert(\omega d_m - \overline{\omega d_m})\rvert$	$(\omega d_m - \overline{\omega d_m})^2$
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

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

$$= 1.05 \times (2.365/6.5)\sqrt{[15.82/(8\times7)]} \times 100$$

$$= 20.3$$

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

mineral (as defined) is interpreted to be generally absent. If there is reason to believe that some mineral may be present, an inferred assessment may be made.

14 No assessment is attempted for an isolated area of mineral less than 0.25km^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 64mm 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.

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

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; Wentworth, 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 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 qualitative 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-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 1377:1967). In this report the grading is tabulated on the borehole record sheets (Appendix E), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are

available for reference at the appropriate office of the Institute.

Each bulk sample is described, subjectively, by a geologist at the borehole site. 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, 'flint and quartz' indicates very approximate equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constituents are referred to as 'trace'.

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

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

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

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

Rounded: original faces 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.

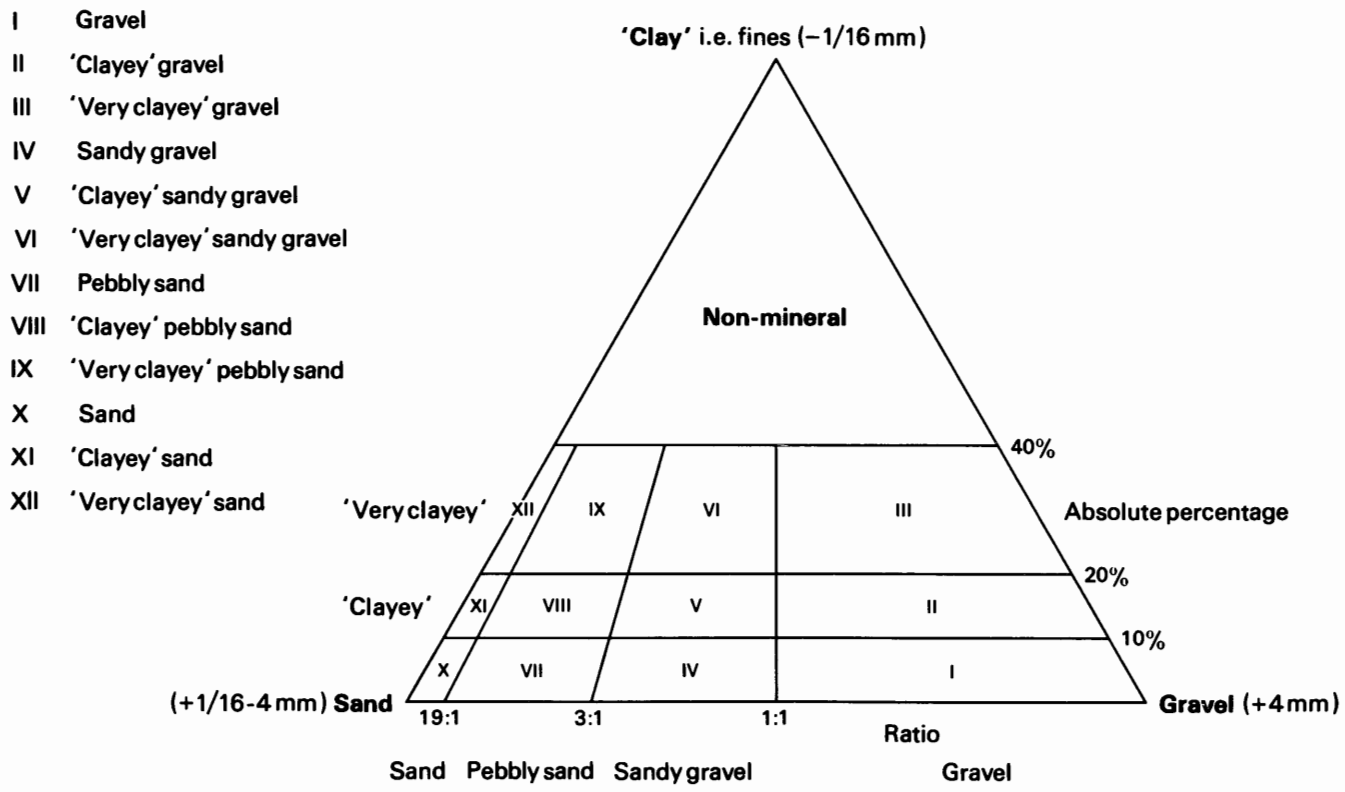


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D

EXPLANATION OF THE ASSESSMENT RECORD

Annotated example

NN 80 NW 2[1] **8091 0678**[2] **Nether Cambushinnie, Ardoch**[3] **Block E_1**

Altitude +111.57m (+366.0ft)[4]
Water struck (perched) at 110.1m[5]
250mm percussion[6]
June 1981

Overburden[7]	0.3m
Mineral	2.3m
Waste	1.8m
Mineral	2.0m
Waste	0.8m
Bedrock	0.6m+[9]

LOG

Geological classification	Lithology	Thickness[8] m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel[10]	a 'Very clayey' pebbly sand[11] Gravel: fine and coarse with rare cobbles, angular to rounded, sandstones, siltstone, grit, andesite, rhyolite, porphyry, psammite and vein-quartz Sand: fine with medium and some coarse, mainly subangular, quartz, rock fragments and feldspar, pale brown Fines: silt and clay, disseminated and in seams	2.3	2.6
Till	Clay, sandy, gravelly, firm, reddish brown	1.8	4.4
	b 'Clayey' pebbly sand Gravel: coarse, fine and cobbles, angular to subrounded, sandstone with schist and psammite Sand: medium and fine with some coarse, angular to subangular, quartz, rock fragments and feldspar, pale reddish brown Fines: silt and clay, disseminated	2.0	6.4
	Clay, pebbly, sandy, containing abundant soft sandstone fragments, reddish brown	0.8	7.2
Lower Devonian (Dunblane Formation)	Sandstone, medium grained, feldspathic, micaceous, thinly bedded, containing purple and pale green mudstone pebbles, pale brownish grey (5 YR 6/1)	0.6+	7.8

Grading

	Mean for Deposit[15] percentages			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	25	62	13	0.3- 1.8	30	40	20	4	5	1	0	
				1.8- 2.6	17	35	18	6	10	14	0	§[14]
				Mean	25	38	19	5	7	6	0	
b	11	69	20	4.4- 6.4	11	31	34	4	4	6	10	§
				6.4- 7.2	No grading data available							
				Mean	11	31	34	4	4	6	10	
a&b	17	67	16	Mean	17	35	28	4	5	6	5	

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

1 Registration Number
Each Industrial Minerals Assessment Unit (IMAU) borehole and shallow pit is identified by a registration number. This consists of two statements.
a The number of the 1:25000 sheet on which the datum point lies, for example NN 80.
b The quarter of the 1:25000 sheet on which the datum point lies and its number in a series for that quarter, for example NW 2.
Thus the full Registration Number is NN 80 NW 2. Usually this is abbreviated to 80 NW 2 in the text.

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

3 Location
The position of the sample point is generally referred to the nearest named locality on the 1:25000 base map, followed by the name of the parish. The resource block in which it lies is also stated.

4 Surface level (altitude)
The surface level at the sample point is given in metres above Ordnance Datum. Measurements were made in metres, approximate conversions to feet are given in brackets. Sites of boreholes and most pits were levelled from either spot heights or bench marks, the precision of the figure reflecting the nature of the point of origin. The surface levels of the remaining pit sites were estimated from contours on 1:10000 and 1:10560 sheets and are probably accurate to plus or minus two metres; such elevations are prefixed by the letter 'c'.

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

6 Method and date of sampling
Modified shell and auger rigs were used for the drilling of boreholes in this survey. The drilling method, the external diameter of the casing used, and the month and year of completion of the sampling are given. Where appropriate other methods of sampling are stated (for example, sampling by hand).

7 Overburden, mineral, waste and bedrock
Mineral is sand and gravel which, as part of a deposit falls within the arbitrary definition of potentially workable material (see p. 1). The summary of mineral thicknesses may include waste partings: the aggregated waste thickness is given in brackets and has been excluded in the assessment of resources. Consequently mineral thicknesses given in Tables 8 to 12 may not correspond precisely with the logs. Bedrock is the 'formation', 'country rock' or 'rockhead' below which potentially workable sand and gravel will not normally 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 deposit was not reached during drilling or sampling.

10 Geological classification
The geological classification is given wherever possible.

11 Lithological description
Where 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. Details of colour are based on the Rock-color Chart distributed by the Geological Society of America: the colour is followed by the relevant colour code.

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 retained on British Standard sieves whose aperture sizes are given in millimetres or fractions thereof.

14 Bailed samples
Fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures suggests that in boreholes the proportion of sand may be higher and the proportion of fines and coarse and cobble gravel (+16mm) may be lower. Samples obtained by the bailing technique (that is, from deposits below the water table) are indicated thus: §

15 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 thicknesses represented. The classification used is shown in the Table in Appendix C. Where two or more distinct mineral units form continuous sequences the mean gradings of these are also given under each unit. Trace amounts are indicated this: **. For multiple mineral units, each is designated by a letter, for example, a, b etc.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE AND SHALLOW PIT RECORDS

NN 80 NW 2 **8091 0678** **Nether Cambushinnie, Ardoch** **Block E_1**

Altitude +111.57m (+366.0ft)
Water struck (perched) at 110.1m
250mm percussion
June 1981

Overburden	0.3m
Mineral	2.3m
Waste	1.8m
Mineral	2.0m
Waste	0.8m
Bedrock	0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine and coarse with rare cobbles, angular to rounded, sandstones, siltstone, grit, andesite, rhyolite, porphyry, psammite and vein-quartz Sand: fine with medium and some coarse, mainly subangular, quartz, rock fragments and feldspar, pale brown Fines: silt and clay, disseminated and in seams	2.3	2.6
Till	Clay, sandy, gravelly, firm, reddish brown	1.8	4.4
	b 'Clayey' pebbly sand Gravel: coarse, fine and cobbles, angular to subrounded, sandstone with schist and psammite Sand: medium and fine with some coarse, angular to subangular, quartz, rock fragments and feldspar, pale reddish brown Fines: silt and clay, disseminated	2.0	6.4
	Clay, pebbly, sandy, containing abundant soft sandstone fragments, reddish brown	0.8	7.2
Lower Devonian (Dunblane Formation)	Sandstone, medium grained, feldspathic, micaceous, thinly bedded, containing purple and pale green mudstone pebbles, pale brownish grey (5 YR 6/1)	0.6+	7.8

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	25	62	13	0.3- 1.8	30	40	20	4	5	1	0	
				1.8- 2.6	17	35	18	6	10	14	0	§
				Mean	25	38	19	5	7	6	0	
b	11	69	20	4.4- 6.4	11	31	34	4	4	6	10	§
				6.4- 7.2	No grading data available							
				Mean	11	31	34	4	4	6	10	
a&b	17	67	16	Mean	17	35	28	4	5	6	5	

NN 80 NW 3 **8009 0626** **Mid Cambushinnie, Ardoch** **Block C**

Altitude +103m (+388ft)
Water not struck
200mm percussion
August 1981

Overburden 3.0m
Mineral 1.5m
Waste 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Head	Silt, containing some fine sand and rare pebbles, moderate brown	0.5	0.6
	Clay, sandy, gravelly, cohesive, reddish brown	1.6	2.2
Late-Glacial alluvium	Silt, sandy, laminated in part, containing some plant remains, moderate yellowish brown (10 YR 5/3) to dark reddish brown (10 R 3/4)	0.8	3.0
Glacial sand and gravel	'Clayey' gravel Gravel: coarse and fine and cobbles, subangular to well rounded, sandstone with grit, conglomerate, schist, andesite, dolerite, siltstone and vein-quartz Sand: fine, coarse and medium, angular to subangular, quartz and rock fragments, moderate brown (5 YR 3/4) Fines: silt and clay, disseminated	1.5	4.5
Till	Clay, gravelly, stiff, greyish red (10 R 4/2)	1.2+	5.7
	Borehole terminated owing to 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
18	37	45	3.0- 4.5	18	17	9	11	14	14	17

NN 80 NW 4 | **8020 0542** | **Naggyfauld, Dunblane and Lecropt** | **Block D**

Altitude +111.66m (+366.3ft)
Water struck at +109.5m and +108.2m
250mm percussion
August 1981

Lithology: Waste 5.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Silt, sandy, homogeneous, moderate yellowish brown (10 YR 5/4)	0.3	0.6
	Clay, silty, gravelly, sandy, ill-sorted, cohesive, dark reddish brown (10 R 3/4)	0.8	1.4
Till	Clay, gravelly, sandy, containing numerous angular fragments of weathered sandstone and mudstone, stiff, dusky red (5 R 3/4)	3.6+	5.0
	Borehole terminated owing to obstruction		

NN 80 NW 5 | **8157 0735** | **Loig, Ardoch** | **Block E_1**

Altitude +112.42m (+368.8ft)
Groundwater level +98.6m
Face sampling and percussion drilling (250mm and 200mm)
August 1981

Lithology: Overburden 0.2m; Mineral 17.8m; Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a Sandy gravel Gravel: fine and coarse with cobbles, sub-angular to well rounded, sandstone, grit, mudstone, conglomerate, andesite, dolerite, porphyry, rhyolite, schist and vein-quartz Sand: medium, coarse and fine, angular to sub-rounded, quartz with feldspar and rock fragments, pale reddish brown (10 R 5/4) to greyish brown (5 YR 3/2) Fines: silt, disseminated and in seams	15.8	16.0
Till	b Gravel Gravel: coarse and fine with cobbles, angular to well rounded, sandstone, siltstone, grit, conglomerate, andesite, porphyry, psammite and vein-quartz Sand: medium, coarse and fine, angular to subrounded, quartz and rock fragments with feldspar, pale reddish brown (10 R 5/4) Fines: silt and clay, disseminated	2.0	18.0
Lower Devonian (Dunblane Formation)	Sandstone, medium grained, feldspathic with some mica, containing rare mudstone and quartzite pebbles and thin seams of mudstone, reddish grey with greenish grey patches	0.4+	18.4

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	7	50	43	0.2- 1.6	4	13	26	16	19	15	7	
				1.6- 2.7	3	7	14	15	20	31	10	
				2.7- 3.7	7	26	28	17	15	7	0	
				3.7- 3.9	No grading data available							
				3.9- 4.9	6	14	23	18	20	8	11	
				4.9- 5.9	6	10	25	16	23	20	0	
				5.9- 6.9	6	11	23	21	21	18	0	
				6.9- 7.9	6	7	16	22	27	22	0	
				7.9- 8.9	6	6	13	15	29	31	0	
				8.9- 9.9	8	8	7	10	32	35	0	
				9.9-10.9	8	9	13	14	28	28	0	
				10.9-11.9	10	11	19	18	23	19	0	
				11.9-12.9	13	11	13	16	24	23	0	
				12.9-13.9	14	14	23	21	24	4	0	§
				13.9-14.7	7	23	42	15	12	1	0	§
				14.7-16.0	5	10	15	28	42	0	0	§
				Mean	7	12	20	18	24	17	2	
b	4	37	59	16.0-17.0	2	11	17	17	31	22	0	§
				17.0-18.0	5	8	11	8	26	42	0	§
				Mean	4	10	14	13	29	30	0	
a&b	7	48	45	Mean	7	12	19	17	24	19	2	

NN 80 NW 6 **8131 0625** **Woodside of Balhaldie, Ardoch** **Block C**

Altitude +97.03m (+318.3ft)
Groundwater level +94.0m
250mm and 200mm percussion
June 1981

Overburden 1.8m
Mineral 1.5m
Waste 16.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	1.0	1.0
Peat	Peat	0.8	1.8
Alluvium	Sandy gravel Gravel: coarse and fine with some cobbles, angular to rounded, sandstone, conglomerate, psammite and vein-quartz Sand: fine and medium with coarse, angular to rounded, quartz with rock fragments and feldspar, brownish grey (5 YR 4/1) Fines: silt and clay, disseminated	1.5	3.3
Glaciolacustrine deposits	Silt, clayey, laminated with fine sand and clay partings, pale brown (5 YR 5/2) and pale reddish brown (10 R 5/4)	16.7+	20.0
	Borehole terminated owing to excessive thickness of waste		

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	49	43	1.8- 2.8	9	30	20	7	17	17	0 §
			2.8- 3.3	6	16	12	5	15	41	5 §
			Mean	8	26	17	6	16	25	2

NN 80 NW 7 **8120 0580** **Glenbank, Ardoch** **Block D**

Altitude +116.37m (+381.8ft)
Water struck (perched) at +111.7m
250mm percussion
June 1981

Overburden	0.7m
Mineral	3.9m
Bedrock	0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Silt, sandy, containing fine sand and rare pebbles, medium to dark brown	0.4	0.7
Till	'Clayey' sandy gravel Gravel: coarse and fine with some cobbles, angular to well rounded, sandstone, mudstone, grit, andesite, dolerite, felsite, schistose grit and vein-quartz Sand: fine and medium with coarse, subrounded, quartz, greyish red (10 R 4/2) to dark reddish brown (10 R 3/4) Fines: silt and clay, disseminated	3.9	4.6
Lower Devonian (Dunblane Formation)	Sandstone, fine to medium grained, finely bedded, containing mudflakes, dark reddish brown (10 R 3/4)	0.2+	4.8

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
18	58	24	0.7- 1.8	11	28	23	7	11	11	9
			1.8- 3.3	17	26	19	4	8	22	4
			3.3- 4.6	25	37	27	4	5	2	0
			Mean	18	30	23	5	8	12	4

NN 80 NW 8 **8269 0877** **Glassick, Ardoch** **Block E_1**

Altitude +127.98m (+419.9ft)
Water struck at +111.7m
250mm and 200mm percussion
August 1981

Overburden	0.2m
Mineral	14.6m
Waste	1.5m
Bedrock	0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine with coarse, subangular to rounded, sandstones, conglomerate, siltstone, grit, andesite, gabbro, psammite, schist and vein-quartz Sand: medium, fine and coarse, angular to sub-rounded, quartz with rock fragments and feldspar, moderate brown (5 YR 3/4) Fines: silt and clay, disseminated and in seams	6.3	6.5
	b 'Clayey' pebbly sand Gravel: fine with some coarse, as above in shape and composition Sand: fine and medium with coarse, as above in shape and composition, pale brown (5 YR 5/2) Fines: silt, disseminated and in seams	6.2	12.7
	c 'Very clayey' sand Gravel: fine, mainly subangular, as above in composition Sand: fine with rare medium and coarse, sub-rounded to rounded, quartz, pale brown (5 YR 5/2) Fines: silt and clay, in laminated seams and disseminated	2.1	14.8
Till	Clay, sandy, gravelly, light brown	1.5	16.3
Lower Devonian (Dunblane Formation)	Sandstone, medium to coarse grained, feldspathic, containing siltstone pebbles, finely bedded	0.6+	16.9

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	10	67	23	0.2- 1.3	7	8	17	24	31	13	0
				1.3- 2.3	11	12	31	30	12	4	0
				2.3- 3.2	13	14	25	23	19	6	0
				3.2- 4.4	14	51	30	4	1	0	0
				4.4- 5.5	9	24	25	11	15	16	0
				5.5- 6.5	6	21	31	17	16	9	0
				Mean	10	23	26	18	15	8	0
b	11	77	12	6.5- 7.5	9	29	31	17	12	2	0
				7.5- 8.5	9	36	29	14	10	2	0
				8.5- 9.5	10	36	29	14	11	0	0
				9.5-10.7	9	31	30	12	14	4	0
				10.7-11.7	11	55	31	2	1	0	0
				11.7-12.7	18	32	22	14	13	1	0
				Mean	11	36	29	12	10	2	0
c	27	72	1	12.7-13.7	25	58	10	4	3	0	0
				13.7-14.8	29	68	3	0	0	0	0
				Mean	27	64	6	2	1	0	0
a&b	10	72	18	Mean	10	29	28	15	13	5	0
atoc	13	72	15	Mean	13	34	25	13	11	4	0

NN 80 NW 9 **8225 0771** **Gallowston Plantation, Ardoch** **Block C**

Altitude +99.62m (+326.8ft)
Water struck at +96.8m
200mm and 150mm percussion
August 1981

Overburden 0.7m
Mineral 8.2m
Waste 12.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, sandy, containing rare pebbles	0.3	0.7
	a 'Clayey' sand Gravel:fine, subangular to well rounded, sandstone, conglomerate, andesite, rhyolite, schist, psammite, quartzite and vein-quartz Sand: medium and fine with some coarse, angular to subrounded, quartz with rock fragments and feldspar, moderate brown (5 YR 3/4) Fines: silt, disseminated and in thin seams	5.6	6.3
Glaciolacustrine deposits	b 'Clayey' sand, fining downwards Sand: fine with rare medium, subangular to subrounded, quartz with feldspar, mica and rock fragments, moderate brown (5 YR 3/4) Fines: silt, in seams and disseminated	2.6	8.9
	Silt, clayey, sandy, fining downwards, laminated with fine sand seams to 13.0m and clay bands, moderate brown (5 YR 3/4), pale brown (5 YR 5/2), greyish red (10 R 4/2) and light olive grey (5 Y 5/2)	12.1+	21.0
	Borehole terminated owing to excessive thickness of waste		

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	84	2	0.7- 1.7	29	25	30	12	4	0	0	
				1.7- 4.6	9	23	58	8	2	0	0	§
				4.6- 6.3	15	72	13	0	0	0	0	§
				Mean	14	38	40	6	2	0	0	
b	18	82	0	6.3- 8.9	18	75	7	0	0	0	0	§
a&b	16	83	1	Mean	16	50	29	4	1	0	0	

NN 80 NW 10 **8232 0666** **Lower Quoigs, Ardoch** **Block D**

Altitude +107.54m (+352.8ft)
Water struck at +101.8m
250mm percussion
June 1981

Overburden 1.5m
Mineral 4.2m
Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.1	0.1
Head	Clay, sandy, gravelly, firm, pale reddish brown	1.4	1.5
Till	'Clayey' gravel Gravel: coarse with fine and cobbles, angular to well rounded, grit, sandstone, felsite, porphyry, andesite, rhyolite, psammite, schist, quartzite and vein-quartz Sand: fine and medium with coarse, angular to rounded, quartz, rock fragments and feldspar, moderate brown (5 YR 4/4) to greyish red (10 R 4/2) Fines: silt and clay, disseminated	4.2	5.7
Lower Devonian (Dunblane Formation)	Sandstone, medium grained, thinly bedded, containing mudflakes, greyish red (5 R 4/2) with some pale green reduction spots	0.4+	6.1

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
12	39	49	1.5- 2.5	7	12	11	9	16	26	19
			2.5- 3.5	15	19	15	7	9	18	17
			3.5- 4.5	16	20	15	8	9	23	9
			4.5- 5.7	No grading data available						
			Mean	12	17	14	8	11	22	16

NN 80 NW 11 **8344 0881** **Keirallan, Ardoch** **Block C**

Altitude +105m (+344ft)
Groundwater level +100m
250mm and 200mm percussion
June 1981

Overburden 0.7m
Mineral 5.7m
Waste 15.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Clay, silty, reddish brown	0.3	0.7
	a 'Very clayey' pebbly sand Gravel: fine and coarse, subangular to rounded, sandstone, conglomerate, porphyry and vein-quartz Sand: fine with medium and coarse, angular to rounded, quartz with rock fragments and feldspar, pale brown Fines: silt with clay, in seams and disseminated	1.0	1.7
	b Gravel Gravel: coarse and fine with cobbles, sub-angular to rounded, sandstone and conglomerate with porphyry, felsite, rhyolite, schist, pelite and vein-quartz Sand: coarse and medium with fine, angular to rounded, quartz with feldspar and rock fragments, pale grey-brown Fines: silt with clay, disseminated and in laminated seams	4.7	6.4
Glaciolacustrine deposits	Silt, clayey, fining downwards, laminated, pale brown (5 YR 5/2), light olive grey (5 Y 6/1), greyish red (10 R 4/2) and pale reddish brown (10 R 5/4)	15.0+	21.4
	Borehole terminated owing to excessive thickness of waste		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64	mm
a	23	60	17	0.7- 1.7	23	40	12	8	9	8	0	
b	3	34	63	1.7- 2.7	6	9	8	9	15	41	12	§
				2.7- 3.4	2	3	11	25	31	22	6	§
				3.4- 4.9	4	5	14	16	26	28	7	§
				4.9- 5.9	2	4	16	15	20	31	12	§
				5.9- 6.4	2	1	15	24	24	28	6	§
				Mean	3	5	13	16	23	31	9	
a&b	7	39	54	Mean	7	11	13	15	20	27	7	

NN 80 NW 12 **8341 0785** **Blacklands, Ardoch** **Block C**

Altitude +100.64m (+330.2ft)
Water struck at +98.1m
250mm and 200mm percussion
June 1981

Overburden	0.8m
Mineral	2.9m
Waste	6.3m
Mineral	5.7m
Waste	0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Silt	0.5	0.8
	a Gravel Gravel: coarse with fine and cobbles, mainly rounded to well rounded, sandstone, grit, conglomerate, andesite, dolerite, schist and vein-quartz Sand: coarse to fine, angular to subrounded, quartz and rock fragments, moderate brown (5 YR 3/4) to brownish grey (5 YR 4/1) Fines: silt, disseminated	2.9	3.7
Glaciolacustrine deposits	Clay, silty, laminated, greyish red (10 R 4/2)	6.3	10.0
	b 'Very clayey' sand Sand: fine with rare medium and traces of coarse, subrounded, quartz, moderate brown Fines: silt, in laminated seams, micaceous	5.7	15.7
	Clay, silty, laminated, containing rare pebbles, reddish brown	0.3	16.0
Till	Clay, sandy, gravelly, reddish brown	0.5+	16.5
	Borehole terminated for technical reasons		

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	30	65	0.8- 2.5	7	10	9	5	6	31	32	§
				2.5- 3.7	2	5	13	19	30	31	0	§
				Mean	5	8	11	11	16	30	19	
b	25	75	0	10.0-15.7	25	72	3	**	**	0	0	§
a&b	18	61	21	Mean	18	51	6	4	5	10	6	

NN 80 NW 13 **8300 0712** **Greenloaning, Ardoch** **Block D**

Altitude +121.40m (+398.3m)
Water struck (perched) at +117.5m
250mm percussion
August 1981

Overburden 0.3m
Mineral 3.6m
Waste 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse with some cobbles, subangular to well rounded, sandstone, andesite, dolerite, schist and vein-quartz Sand: fine with medium and coarse, angular to subangular, quartz with rock fragments and some feldspar, moderate brown Fines: silt and clay, disseminated	3.6	3.9
Till	Clay, gravelly, stiff, dark reddish brown (10 R 3/4)	0.6+	4.5
	Borehole terminated for technical reasons		

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	48	34	0.3- 1.3	22	27	10	8	18	15	0
			1.3- 2.9	18	35	11	5	14	11	6
			2.9- 3.9	15	33	8	5	13	15	11
			Mean	18	32	10	6	15	13	6

NN 80 NW 14 **8474 0987** **Willow Bog, Ardoch** **Block A**

Altitude +128.04m (+420.1ft)
Groundwater level +109.2m
250mm and 200mm percussion
August 1981

Overburden	0.3m
Mineral	6.7m
Waste	6.1m
Mineral	8.9m
Waste	3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Sandy gravel, including head to 1.0m Gravel: fine and coarse with rare cobbles, subangular to subrounded, sandstone, conglomerate, andesite, schistose grit and vein-quartz Sand: medium with coarse and fine, angular to rounded, quartz with rock fragments and feldspar, moderate brown (5 YR 3/4) to pale brown (5 YR 5/2) Fines: silt with clay, disseminated and in thin seams	6.7	7.0
	Silt, laminated with seams of silt and some thin clay partings, pale brown (5 YR 5/2)	6.1	13.1
	b 'Clayey' pebbly sand Gravel: fine with coarse, subangular to subrounded, grit, conglomerate, siltstone, andesite and vein quartz Sand: medium with coarse and fine, angular to subrounded, quartz and rock fragments with feldspar, pale brown (5 YR 5/2) Fines: silt with clay, mainly in seams	2.2	15.3
	c 'Very clayey' sand Gravel: traces of fine and coarse, shape and composition as above Sand: fine with some medium and traces of coarse, angular to subangular, quartz with rock fragments and feldspar, pale brown (5 YR 5/2) Fines: silt, in seams	3.3	18.6
	d Sandy gravel Gravel: fine with coarse, mainly subangular to subrounded, grit, conglomerate, sandstone, siltstone, schistose grit and vein-quartz Sand: coarse to fine, angular to subrounded, quartz with feldspar and rock fragments, moderate brown (5 YR 4/4) Fines: silt, disseminated and in seams	2.4	21.0
Glaciolacustrine deposits	e 'Very clayey' sand Sand: fine with some medium and traces of coarse, angular to subangular, quartz with feldspar, rock fragments and mica, pale brown (5 YR 5/2) Fines: silt, mainly in laminated seams	1.0	22.0
	Silt, laminated with sand seams and thin clay partings, containing rare pebbles	3.0+	25.0

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	9	63	28	0.3- 1.0	16	16	17	17	21	13	0	
				1.0- 2.2	4	6	44	26	17	3	0	
				2.2- 3.5	6	24	35	18	15	2	0	
				3.5- 4.5	5	19	39	17	16	4	0	
				4.5- 5.4	9	12	10	8	26	35	0	
				5.4- 6.5	10	16	20	17	21	16	0	
				6.5- 7.0	19	34	25	14	5	3	0	
				Mean	9	17	29	17	18	10	0	
b	13	71	16	13.1-14.3	8	13	37	24	14	4	0	
				14.3-15.3	18	21	34	13	10	4	0	
				Mean	13	17	35	19	12	4	0	
c	23	77	0	15.3-16.4	29	57	10	2	1	1	0	
				16.4-17.4	22	69	9	0	0	0	0	§
				17.4-18.6	19	72	8	1	0	0	0	§
				Mean	23	67	9	1	**	**	0	
d	10	60	30	18.6-19.8	9	18	13	15	30	15	0	§
				19.8-21.0	10	22	29	24	10	5	0	§
				Mean	10	20	20	20	20	10	0	
e	21	79	0	21.0-22.0	21	73	5	1	0	0	0	§
btoe	17	70	13	Mean	17	42	18	10	9	4	0	
atoe	13	67	20	Mean	13	31	23	13	13	7	0	

NN 80 NW 15 **8440 0872** **Ardoch House, Ardoch** **Block C**

Altitude +107.23m (+351.8ft)
Groundwater level +105.2m
250mm and 200mm percussion
June 1981

Overburden	0.2m
Mineral	1.6m
Waste	8.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Late-Glacial alluvium	Gravel Gravel: coarse with fine and cobbles, angular to well rounded, sandstone, grit, conglomerate, mudstone, andesite, dolerite, felsite, schist and vein-quartz Sand: coarse to fine, angular to subrounded, quartz and rock fragments with some feldspar, greyish red-brown Fines: silt and clay, disseminated	1.6	1.8
Glaciolacustrine deposits	Clay, silty, laminated, containing rare sand seams, dark reddish brown (10 R 3/4) and moderate reddish brown (10 R 4/6)	6.2	8.0
Till	Clay, sandy, gravelly, stiff, reddish brown	2.4+	10.4
	Borehole terminated owing to 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	
7	33	60	0.2- 1.2	8	15	14	11	13	23	16	§
			1.2- 1.8	6	5	7	11	19	41	11	§
			Mean	7	11	11	11	15	31	14	

NN 80 NW 16 **8444 0777** **Middleton of Rottearns, Ardoch** **Block D**

Altitude +120.47m (+395.2ft)
Water struck (perched) at 117.3m
250mm and 200mm percussion
August 1981

Overburden	0.6m
Mineral	1.1m
Waste	1.0m
Mineral	1.7m
Waste	2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Silt, pebbly, sandy, ill-sorted	0.3	0.6
Glacial sand and gravel	a 'Very clayey' sandy gravel, poorly sorted Gravel: fine and coarse with some cobbles, subangular to rounded, sandstone with andesite, dolerite, schist, psammite and vein-quartz Sand: fine with medium and coarse, angular to subangular, quartz and rock fragments, moderate brown (5 YR 3/4) Fines: silt and clay, disseminated	1.1	1.7
Flow till	Clay, gravelly, stiff, dark reddish brown (10 R 3/4)	1.0	2.7
Glacial sand and gravel	b 'Clayey' pebbly sand Gravel: coarse and fine and cobbles, angular to subrounded, sandstone with andesite, porphyry, psammite and vein-quartz Sand: medium and fine with some coarse, subangular to subrounded, quartz with feldspar and rock fragments, moderate brown (5 YR 3/4) Fines: silt, disseminated and in thin seams	1.7	4.4
Till	Clay, sandy, gravelly, stiff, dark reddish brown (10 R 3/4)	2.2+	6.6
	Borehole terminated owing 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	22	49	29	0.6- 1.7	22	24	13	12	16	13	0	
b	14	66	20	2.7- 3.7	14	29	33	6	9	3	6	
				3.7- 4.4	13	26	33	6	3	11	8	§
				Mean	14	28	32	6	7	6	7	
a&b	17	60	23	Mean	17	27	25	8	10	9	4	

NN 80 NW 17 **8051 0710** **Knoxfauld, Ardoch** **Block E_1**

Altitude c+129m (c+423ft)
Water struck at c+128m
Pit
April 1981

Overburden 0.7m
Mineral 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Clay, sandy, pebbly, firm, reddish brown	0.4	0.7
Glacial sand and gravel	Gravel Gravel: fine with coarse and some cobbles, mainly subrounded to well rounded, sandstone, conglomerate, andesite and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, quartz and rock fragments, reddish brown Fines: silt, disseminated	1.1+	1.8

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
1	50	49	0.7- 1.8	1	8	21	21	31	18	0 §

NN 80 NW 18 **8014 0510** **Kinbuck Muir, Dunblane and Lecropt** **Block D**

Altitude +129.92m (+426.3ft)
Water seepage at +128.32m
Pit
April 1981

Overburden 0.2m
Mineral 1.3m
Waste 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	Sandy gravel Gravel: coarse and fine with cobbles and boulders, mainly rounded to well rounded, sandstone with mudstone, grit, conglomerate, andesite, dolerite and vein-quartz Sand: coarse to fine, subangular to subrounded, quartz and rock fragments, reddish brown Fines: silt and clay, disseminated	1.3	1.5
Till	Clay, gravelly, stiff, reddish brown	0.8+	2.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	53	46	0.2- 1.5	1	15	22	16	22	24	0

NN 80 NW 19 **8194 0887** **Feddal House, Ardoch** **Block E_1**

Altitude c+139m (c+456ft)
Water not struck
Pit
April 1981

Waste 1.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, gravelly, sandy, containing numerous angular fragments of weathered sandstone, firm, reddish brown	1.2+	1.7

NN 80 NW 20 **8300 0704** **Greenloaning, Ardoch** **Block D**

Altitude +125.49m (411.7ft)
Water not struck
Pit
April 1981

Overburden 0.3m
Mineral 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, sandstone, grit, andesite, dolerite and vein-quartz Sand: coarse to fine, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated	1.6+	1.9

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
2	46	52	0.3- 1.9	2	12	17	17	21	24	7

NN 80 NE 2 **8560 0954** **Rhynd, Ardoch** **Block A**

Altitude +117m (+384ft)
Water struck at +106m
250mm and 200mm percussion
June 1981

Overburden	0.3m
Mineral	1.5m
Waste	3.0m
Mineral	17.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Sandy gravel Gravel: fine with coarse, mainly subrounded to well rounded, sandstone, andesite, dolerite, felsite, vein-quartz and schist Sand: fine to coarse, subangular to subrounded, quartz with rock fragments and feldspar, moderate reddish brown (10 R 4/6) Fines: silt, disseminated	1.5	1.8
	Silt, laminated with thin clay and fine sand partings, dusky red (5 R 3/4)	3.0	4.8
	b Sandy gravel Gravel: fine and coarse with some cobbles, mainly subrounded to well rounded, sandstone, andesite, dolerite, felsite, vein-quartz and schist Sand: fine and medium with coarse, subrounded, quartz with feldspar and rock fragments, moderate reddish brown (10 R 4/6) Fines: silt, disseminated	13.0	17.8
Till	c Gravel Gravel: coarse with fine and cobbles, subangular to well rounded, sandstone with mudstone, grit, conglomerate, quartzite, psammite, vein-quartz, rhyolite and porphyry Sand: medium with fine and coarse, subangular, quartz, rock fragments and feldspar, moderate reddish brown (10 R 4/6) Fines: clay and silt, much lost from samples owing to drilling action	4.7+	22.5
	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	
a	8	53	39	0.3- 1.8	8	19	19	15	25	14	0	
b	7	64	29	4.8- 5.8	6	18	44	14	13	5	0	
				5.8- 6.8	5	33	45	8	8	1	0	
				6.8- 7.8	12	50	32	2	3	1	0	
				7.8- 8.8	11	29	30	3	9	6	12	
				8.8- 9.8	9	17	26	10	15	23	0	
				9.8-10.8	7	10	18	13	24	18	10	
				10.8-11.8	4	15	26	39	12	4	0	§
				11.8-12.8	8	21	25	31	10	5	0	§
				12.8-13.8	10	13	13	19	15	22	8	§
				13.8-14.8	5	25	11	8	26	25	0	§
				14.8-15.8	5	25	17	13	13	10	17	§
				15.8-16.8	4	24	19	9	24	20	0	§
				16.8-17.8	8	38	26	9	13	6	0	§
				Mean	7	24	26	14	14	11	4	
c	3	45	52	17.8-18.8	3	14	16	9	8	36	14	§
				18.8-19.8	3	16	22	9	8	16	26	§
				19.8-20.8	2	8	23	23	27	17	0	§
				20.8-22.5	4	13	20	9	13	23	18	§
				Mean	3	13	20	12	14	23	15	
a&b	7	63	30	Mean	7	24	25	14	15	12	3	
atoc	6	59	35	Mean	6	21	25	13	15	14	6	

NN 80 NE 3 **8546 0872** **Rhynd, Ardoch** **Block C**

Altitude +102.49m (+336.3ft)
Groundwater level +101.6m
250mm and 200mm percussion
July 1981

Overburden	0.2m
Mineral	4.3m
Waste	8.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	a 'Very clayey' sand Sand: fine with some medium and traces of coarse, mainly angular, quartz with mica, feldspar and rock fragments, moderate yellowish brown (10 YR 5/4) Fines: silt, disseminated and in seams	2.0	2.2
	b Pebbly sand Gravel: fine with traces of coarse, angular to well rounded, sandstone, grit, andesite, porphyry, schistose grit and vein-quartz Sand: medium with coarse and fine, angular to rounded, quartz with rock fragments, mica and feldspar, brownish grey (5 YR 4/1) Fines: silt, disseminated and in seams	2.3	4.5
Glaciolacustrine deposits	Silt, laminated with reddish brown clay partings, micaceous, pale brown (5 YR 5/2)	1.5	6.0
Till	Clay, sandy, gravelly, stiff, pale reddish brown (10 R 5/4)	6.5+	12.5
	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	
a	22	78	0	0.2- 1.2	34	62	4	0	0	0	0	§
				1.2- 2.2	9	70	19	2	0	0	0	§
				Mean	22	65	12	1	0	0	0	
b	4	84	12	2.2- 3.4	4	23	42	16	15	0	0	§
				3.4- 4.5	4	10	48	29	9	0	0	§
				Mean	4	17	45	22	12	0	0	
a&b	12	82	6	Mean	12	41	29	12	6	0	0	

NN 80 NE 4 **8567 0840** **Blueton, Ardoch** **Block D**

Altitude +119.39m (+391.7ft)
Water struck (perched) at +112.8m
250mm percussion
August 1981

Overburden 0.3m
Mineral (inc. 0.7m waste) 7.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy with pebbles	0.3	0.3
Glacial sand and gravel	a 'Very clayey' sandy gravel, with illsorted stony clay, probably a flow till, from 1.7 to 2.4m Gravel: coarse and fine with cobbles, angular to subrounded, sandstones with conglomerate, andesite, vein-quartz, rhyodacite, porphyry, siltstone, rhyolite, gabbro, dolerite and schistose grit Sand: fine with medium and some coarse, angular to subangular, quartz with some feldspar and rock fragments, mainly pale brown (5 YR 5/2) to moderate brown (5 YR 3/4) Fines: disseminated silt and clay, dark reddish brown (10 R 3/4) from 1.7 to 2.4m	4.4	4.7
Till	b 'Very clayey' sandy gravel Gravel: coarse with fine and cobbles, angular to subangular, mainly sandstone, many with mudstone pebbles, also vein-quartz, andesite, cornstone, schistose grit and schist Sand: fine with medium and some coarse, angular to subangular, quartz with rock fragments, pale brown (5 YR 5/2) becoming moderate brown (5 YR 3/4) Fines: disseminated silt and clay, deposit 'claybound' and increasingly consolidated with depth	3.5+	8.2
	Borehole terminated owing to slow progress		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
a	21	44	35	0.3- 1.7	22	26	14	8	15	15	0
				1.7- 2.4	No grading data available						
				2.4- 3.7	20	29	12	5	10	16	8
				3.7- 4.7	21	21	9	6	14	23	6
				Mean	21	26	12	6	13	18	4
b	24	38	38	4.7- 5.7	24	24	12	5	9	18	8
				5.7- 6.7	29	32	11	3	5	20	0
				6.7- 7.7	19	15	8	5	12	31	10
				7.7- 8.2	No grading data available						
				Mean	24	24	10	4	9	23	6
a&b	22	42	36	Mean	22	26	11	5	11	20	5

NN 80 NE 5 **8654 0983** **Carsebreck, Ardoch** **Block A**

Altitude +114.8m (+377ft)
Groundwater level +107.8m
250mm, 200mm & 150mm
percussion
August 1981

Overburden	0.4m
Mineral	14.1m
Waste	6.5m
Mineral	3.5m
Waste	0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	a 'Clayey' pebbly sand Gravel: fine with coarse, subangular to subrounded, sandstone, conglomerate, siltstone, andesite, rhyolite, schistose grit, psammite and vein-quartz Sand: fine with medium and some coarse, angular to subrounded, quartz with feldspar and rock fragments, medium brown Fines: silt and clay, disseminated	4.9	5.3
	b Gravel Gravel: coarse with fine and cobbles, subangular to well rounded, sandstone with conglomerate, andesite, porphyry, schistose grit and vein-quartz Sand: medium and fine with coarse, angular to subrounded, quartz, rock fragments and feldspar, medium brown Fines: silt and clay, disseminated	4.0	9.3
	c 'Clayey' sand Gravel: rare coarse, subrounded to well rounded, sandstone Sand: fine with medium and rare coarse, subangular to subrounded, quartz, rock fragments and feldspar, medium brown Fines: silt and clay, disseminated	5.2	14.5
	Silt, containing some fine sand and clay with rare pebbles, medium brown	6.5	21.0
	d Sandy gravel Gravel: fine with coarse and rare cobbles, subangular to well rounded, sandstone, grit, conglomerate, psammite, quartzite, vein-quartz, schist, felsite and porphyry Sand: fine to coarse, angular to subrounded, quartz with rock fragments and feldspar, pale brown (5 YR 5/2) Fines: silt, disseminated	3.5	24.5
Till	Clay, sandy, gravelly, stiff, moderate reddish brown (10 R 4/6)	0.5+	25.0

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	16	77	7	0.4- 1.4	9	17	38	22	12	2	0	
				1.4- 2.4	17	23	25	24	9	2	0	
				2.4- 3.4	19	40	29	6	3	3	0	
				3.4- 4.4	19	64	15	2	0	0	0	
				4.4- 5.3	16	54	18	5	3	4	0	
				Mean	16	40	25	12	5	2	0	
b	7	44	49	5.3- 6.3	8	19	9	5	8	28	23	
				6.3- 7.3	8	14	14	8	13	43	0	
				7.3- 8.3	4	12	15	9	16	27	17	§
				8.3- 9.3	6	19	50	1	1	9	14	§
				Mean	7	16	22	6	10	25	14	
c	10	89	1	9.3-10.3	9	42	48	1	0	0	0	§
				10.3-11.3	10	61	25	1	0	3	0	§
				11.3-12.3	8	56	32	4	0	0	0	§
				12.3-13.3	11	60	27	2	0	0	0	§
				3.3-14.5	12	49	39	0	0	0	0	§
				Mean	10	53	34	2	0	1	0	
d	7	59	34	21.0-22.6	5	17	18	19	27	14	0	§
				22.6-24.5	8	24	19	19	20	10	0	§
				Mean	7	21	19	19	22	12	0	
a&b	12	62	26	Mean	12	29	24	9	7	13	6	
atoc	11	71	18	Mean	11	37	28	6	5	9	4	
atod	10	70	20	Mean	10	35	26	9	8	9	3	

NN 80 NE 6 **8655 0908** **Carsebreck, Ardoch** **Block C**

Altitude +103.49m (+339.5ft)
Groundwater level +102.3m
250mm and 200mm percussion
June 1981

Overburden 2.5m
Mineral 5.7m
Waste 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, silty, homogeneous, moderate reddish brown (10 R 4/6)	1.1	1.4
	Silt, clayey, sandy, coarsening downwards, greyish red (5 R 4/2)	0.6	2.0
Peat	Peat	0.5	2.5
Glacial sand and gravel	Sandy gravel Gravel: fine with coarse and rare cobbles, mainly subrounded to well rounded, sandstone, grit, conglomerate, andesite, porphyry, dolerite, schist and vein-quartz Sand: medium, coarse and fine, angular to subrounded, quartz with rock fragments and rare feldspar, very dusky red (10 R 2/2) Fines: silt, disseminated and in thin laminated seams	5.7	8.2
Till	Clay, sandy, gravelly, firm becoming hard below 8.8m, moderate reddish brown (10 R 4/4)	0.8+	9.0
	Borehole terminated for technical reasons		

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	58	36	2.5- 3.5	10	6	23	17	35	9	0	§
			3.5- 4.5	6	11	24	25	30	4	0	§
			4.5- 5.5	6	13	26	23	21	11	0	§
			5.5- 6.5	4	11	13	15	29	28	0	§
			6.5- 7.5	4	28	23	15	17	13	0	§
			7.5- 8.2	7	29	30	16	14	4	0	§
			Mean	6	16	23	19	24	12	0	

NN 80 NE 7 **8756 0981** **Westerton, Blackford** **Block A**

Altitude +132m (+433ft)
Water struck at +109m
250mm and 200mm percussion
June 1981

Overburden 0.4m
Mineral 23.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	a Pebbly sand Gravel: fine with some coarse, rounded to well rounded, sandstone, grit, conglomerate, andesite and vein-quartz Sand: medium and fine with coarse, subangular to rounded, quartz with rock fragments, reddish brown Fines: silt, disseminated	2.4	2.8
	b Pebbly sand Gravel: forming stringers, fine with coarse, subrounded to well rounded, as above in composition Sand: fine and medium with some coarse, as above in shape, composition and colour Fines: silt, disseminated and in seams	18.7	21.5
	c 'Clayey' sand Gravel: rare fine, rounded, sandstone Sand: fine with traces of medium, subrounded, quartz, reddish brown Fines: silt, disseminated and in laminated seams	2.0+	23.5
	Borehole terminated for technical reasons		

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	78	19	0.4- 1.4	2	21	37	17	19	4	0	
				1.4- 2.8	4	30	35	14	13	4	0	
				Mean	3	26	37	15	15	4	0	
b	3	90	7	2.8- 3.8	2	16	69	8	3	2	0	
				3.8- 4.8	2	22	72	4	0	0	0	
				4.8- 5.8	3	33	53	6	4	1	0	
				5.8- 7.0	2	28	62	4	3	1	0	
				7.0- 8.3	4	45	46	4	1	0	0	
				8.3- 9.4	2	35	58	4	1	0	0	
				9.4-10.4	2	60	37	1	0	0	0	
				10.4-11.4	4	58	38	0	0	0	0	
				11.4-12.9	3	40	49	4	4	0	0	
				12.9-13.9	2	12	25	30	27	4	0	
				13.9-14.4	2	19	29	24	24	2	0	
				14.4-15.7	6	61	31	1	1	0	0	
				15.7-16.7	8	61	30	1	0	0	0	
				16.7-17.7	4	64	28	2	2	0	0	
				17.7-18.7	2	34	26	14	15	9	0	
				18.7-19.4	2	22	22	17	19	18	0	
				19.4-20.4	5	55	38	1	1	0	0	
				20.4-21.5	4	70	25	0	1	0	0	
				Mean	3	42	42	6	5	2	0	
c	18	81	1	21.5-23.5	18	80	1	**	1	0	0	§
a&b	3	89	8	Mean	3	40	42	7	6	2	0	
atoc	5	87	8	Mean	5	43	38	6	6	2	0	

NN 80 NE 8 **8788 0923** **Longfold, Ardoch** **Block C**

Altitude +106.13m (+348.2ft)
Groundwater level +104.8m
250mm percussion
July 1981

Overburden 2.3m
Mineral 1.5m
Waste 8.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Alluvium	Silt, laminated with seams of peat and fine sand up to 50mm thick, containing rare pebbles from 1.8m, dark yellowish brown (10 YR 4/2)	1.9	2.3
	Gravel Gravel: fine and coarse with cobbles, subangular to rounded, sandstone, grit, schistose grit, schist, andesite and vein-quartz Sand: coarse to fine, angular to rounded, quartz with rock fragments and feldspar, moderate yellowish brown (10 YR 5/4) Fines: silt, disseminated and in seams up to 50mm thick	1.5	3.8
Glaciolacustrine deposits	Silt, laminated with partings of fine sand and containing pebbles and cobbles of sandstone, dolerite and porphyry from 9.8m	6.4	10.2
Till	Clay, silty, sandy, gravelly, firm, pale red (5 R 6/2) to greyish red (5 R 4/2)	1.9+	12.1
	Borehole terminated owing 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
5	35	60	2.3- 3.8	5	10	12	13	33	21	6 §

E

NN 80 NE 9 **8753 0894** **Longfold, Ardoch** **Block D**

Altitude +130.62m (+428.5ft)
Water struck at +123.4m
250mm percussion
July 1981

Overburden 0.4m
Mineral 4.8m
Waste 3.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	a 'Clayey' pebbly sand, fining downwards Gravel: coarse and fine with rare cobbles, angular to well rounded, sandstone with mudstone, andesite, felsite, dolerite, quartzite, psammite and vein-quartz Sand: medium and fine with some coarse, angular to subrounded, quartz with rock fragments and some feldspar, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated and in thin seams	3.2	3.6
	b 'Very clayey' sand Sand: fine with some medium and traces of coarse, subangular to subrounded, quartz with some rock fragments, feldspar and mica, moderate brown (5 YR 4/4) Fines: silt, mainly in seams up to 100mm thick, moderate yellowish brown (10 YR 5/4)	1.6	5.2
	Silt, sandy, laminated, micaceous, moderate brown (5 YR 4/4) with reddish brown partings	2.3	7.5
Till	Clay, gravelly, stiff, greyish red (10 R 4/2)	1.1+	8.6
	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
a	10	72	18	0.4- 1.5	11	21	22	6	15	25	0
				1.5- 2.5	8	32	47	3	5	5	0
				2.5- 3.6	10	36	48	3	3	0	0
				Mean	10	29	39	4	8	10	0
b	23	77	0	3.6- 4.6	21	63	16	0	0	0	0
				4.6- 5.2	26	63	11	0	0	0	0
				Mean	23	63	14	**	**	0	0
a&b	14	74	12	Mean	14	40	31	3	5	7	0

NN 80 NE 10 **8846 0942** **Boreland, Blackford** **Block C**

Altitude +114m (+374ft)
Groundwater level +109m
250mm and 200mm percussion
July 1981

Overburden 5.8m
Mineral 9.1m
Waste 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Late-Glacial alluvium	Silt, clayey, laminated, containing rare pebbles and sandy partings, moderate brown (5 YR 3/4)	5.5	5.8
Glacial sand and gravel	a 'Clayey' pebbly sand Gravel: coarse and fine, mainly subrounded to well rounded, sandstone, conglomerate, grit, andesite, dolerite, schistose grit and vein-quartz Sand: fine with some medium and traces of coarse, subangular to subrounded, quartz with feldspar and rock fragments, moderate brown Fines: silt, disseminated	2.7	8.5
	b Gravel Gravel: coarse with fine and some cobbles, subangular to well rounded, sandstone, conglomerate, siltstone, andesite, dolerite, schist and vein-quartz Sand: fine to coarse, angular to subrounded, quartz with rock fragments and feldspar, greyish brown Fines: silt and clay, disseminated	6.4	14.9
Till	Clay, sandy, gravelly, stiff, reddish brown	0.4+	15.3
	Borehole terminated owing 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	19	73	8	5.8- 7.2	16	67	7	1	3	6	0	§
				7.2- 8.5	23	61	8	1	3	4	0	§
				Mean	19	65	7	1	3	5	0	
b	4	45	51	8.5-10.9	8	24	8	7	18	29	6	§
				10.9-12.3	2	12	26	12	21	27	0	§
				12.3-13.5	2	13	25	13	19	28	0	§
				13.5-14.9	1	15	17	13	15	27	12	§
				Mean	4	17	17	11	18	28	5	
a&b	9	53	38	Mean	9	31	14	8	14	21	3	

NN 80 NE 11 **8852 0883** **Boreland, Blackford** **Block D**

Altitude +129m (+423ft)
Water not struck
250mm percussion
August 1981

Overburden	0.4m
Mineral	2.3m
Waste	0.6m
Bedrock	0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	'Clayey' sandy gravel, poorly sorted Gravel: coarse and fine with some cobbles, subangular to well rounded, sandstone with mudstone, grit, andesite, schist and vein-quartz Sand: fine with medium and coarse, angular to subangular, quartz with rock fragments, moderate brown (5 YR 3/4) Fines: silt and clay, disseminated	2.3	2.7
Till	Clay, gravelly, stiff, dusky red (5 R 3/4) to dark reddish brown (10 R 3/4)	0.6	3.3
Lower Devonian (Buttergask Formation)	Sandstone, fine grained, micaceous, finely bedded, greyish red (10 R 4/2)	0.2+	3.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
18	47	35	0.4- 1.7	15	27	11	9	17	21	0
			1.7- 2.7	21	31	9	8	10	5	16
			Mean	18	28	10	9	14	14	7

NN 80 NE 12 **8922 0977** **Milton of Panholes, Blackford** **Block A**

Altitude +117.75m (+386.3ft)
Groundwater level +115.3m
200mm and 150mm percussion
July 1981

Overburden 0.5m
Mineral 13.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine and coarse, with rare cobbles, subrounded to well rounded, sandstone, conglomerate, grit, siltstone, andesite, dolerite, porphyry, felsite, rhyolite, schistose grit and vein-quartz Sand: coarse to fine, angular to subangular, quartz and rock fragments, moderate brown Fines: silt and clay, disseminated	2.2	2.7
	b Sandy gravel Gravel: fine and coarse with cobbles, angular to rounded, as above in composition Sand: medium with fine and coarse, angular to rounded, quartz with rock fragments and feldspar, greyish brown Fines: silt and clay, disseminated	10.9+	13.6
	Borehole terminated owing to slow progreess		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	13	47	40	0.5- 1.7	13	13	16	15	20	23	0	
				1.7- 2.7	13	18	18	16	20	15	0	
				Mean	13	15	17	15	21	19	0	
b	3	58	39	2.7- 4.2	7	9	17	13	21	20	13	§
				4.2- 5.8	4	27	55	10	3	1	0	§
				5.8- 6.8	5	15	20	26	27	7	0	§
				6.8- 7.8	2	16	17	12	26	27	0	§
				7.8- 8.6	1	12	26	14	20	21	6	§
				8.6- 9.6	1	16	32	13	17	21	0	§
				9.6-10.6	1	10	25	19	22	23	0	§
				10.6-11.6	1	19	37	12	15	16	0	§
				11.6-12.6	2	19	29	10	15	25	0	§
				12.6-13.6	1	8	20	13	21	17	20	§
				Mean	3	16	28	14	18	17	4	
a&b	5	57	38	Mean	5	15	28	14	18	17	3	

NN 80 NE 13 **8991 0964** **Cecilmount, Blackford** **Block A**

Altitude +138m (+453ft)
Water struck at +117m
250mm and 200mm percussion
June 1981

Overburden 0.3m
Mineral 24.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles, subrounded to rounded, sandstone, conglomerate, mudstone, andesite, rhyolite, dolerite, porphyry, schist and vein-quartz Sand: medium, coarse and fine, angular to rounded, quartz with rock fragments and feldspar, greyish red (10 R 4/2) Fines: silt, disseminated	3.5	3.8
	b 'Very clayey' sand Gravel: traces of fine, cemented sand Sand: fine with some medium and traces of coarse, angular to subrounded, quartz, moderate brown (5 YR 4/4) Fines: silt, disseminated and in seams	6.2	10.0
	c Sand Gravel: fine with coarse, subangular to well rounded, sandstone, grit, conglomerate, siltstone, chert, dolerite, andesite, psammite, quartzite and vein-quartz Sand: medium and fine with some coarse, angular to rounded, quartz with feldspar and rock fragments, greyish red (10 R 4/2) to moderate reddish brown (10 R 4/6) Fines: silt, disseminated	15.2+	25.2

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	38	57	0.3- 1.3	5	7	11	11	17	38	11	
				1.3- 2.4	5	6	18	12	24	35	0	
				2.4- 3.8	6	8	26	12	23	25	0	
				Mean	5	7	19	12	22	32	3	
b	20	80	0	3.8- 5.0	28	61	9	1	1	0	0	
				5.0- 6.0	15	74	11	0	0	0	0	
				6.0- 8.0	18	65	17	0	0	0	0	
				8.0-10.0	19	57	24	0	0	0	0	
				Mean	20	64	16	**	**	0	0	
c	5	91	4	10.0-11.0	6	35	58	1	0	0	0	
				11.0-12.4	5	35	50	7	2	1	0	
				12.4-13.5	4	17	56	8	8	7	0	
				13.5-14.5	9	17	56	10	6	2	0	
				14.5-15.5	6	59	33	1	1	0	0	
				15.5-16.5	7	65	25	2	1	0	0	
				16.5-17.5	4	47	44	3	1	1	0	
				17.5-18.5	4	48	45	2	1	0	0	
				18.5-20.0	4	41	48	4	3	0	0	
				20.0-21.0	9	46	39	3	2	1	0	
				21.0-22.0	6	62	30	1	1	0	0	
				22.0-23.0	2	17	53	14	11	3	0	§
				23.0-25.0	2	20	67	8	3	0	0	§
				Mean	5	38	48	5	3	1	0	
atoc	9	81	10	Mean	9	40	36	5	5	5	**	

NN 80 NE 14 **8935 0887** **Mill of Ogilvie, Blackford** **Block D**

Altitude +130m (+427ft)
Groundwater level +124m
250mm percussion
August 1981

Overburden	0.9m
Mineral	2.3m
Waste	4.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
	Made ground	0.7	0.9
Glacial sand and gravel	'Clayey' pebbly sand Gravel: fine with coarse, subrounded to well rounded, sandstone, grit, andesite, dolerite, schist and vein-quartz Sand: fine with medium and rare coarse, angular to subangular, quartz with feldspar and rock fragments, moderate brown (5 YR 3/4) Fines: silt, disseminated and in laminated, micaceous seams	2.3	3.2
	Silt, laminated with thin partings of fine sand and clay, micaceous, moderate brown (5 YR 3/4 to 5 YR 4/4)	1.2	4.4
Till	Clay, sandy, gravelly, cohesive becoming stiff below 6.8m, dark reddish brown (10 R 3/4)	3.5+	7.9
	Borehole terminated for technical reasons		

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
19	73	8	0.9- 2.0	17	42	30	3	5	3	0
			2.0- 3.2	20	54	15	2	7	2	0
			Mean	19	49	22	2	6	2	0

NN 80 NE 15 **8551 0814** **Blueton, Ardoch** **Block D**

Altitude +129.44m (+424.7ft)
Water seepage at +127.9m
Pit
April 1981

Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Head	Silt, micaceous, homogeneous, orange-brown	0.4	0.8
Till	Clay, gravelly, sandy, stiff, medium grey-brown becoming reddish browm below 1.5m	1.4+	2.2

NN 80 NE 16 **8851 0883** **Boreland, Blackford** **Block D**

Altitude +129m (+423ft)
Water not struck
Pit
April 1981

Overburden 0.4m
Mineral 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	Sandy gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, sandstone, andesite, dolerite and vein-quartz Sand: fine with medium and coarse, subrounded, quartz and rock fragments, medium reddish brown Fines: silt and clay, disseminated	1.9+	2.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
4	50	46	0.4- 2.3	4	28	13	9	16	22	8

NN 81 SW 1 **8308 1075** **Nether Braco, Ardoch** **Block E_1**

Altitude +144.25m (+473.3ft)
Water struck at +139.4m
250mm percussion
August 1981

Overburden 0.3m
Mineral 6.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles, mainly subrounded, sandstone, conglomerate, siltstone, schistose grit, quartzite and vein-quartz Sand: coarse to fine, angular to subangular, quartz and rock fragments with feldspar, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated	2.0	2.3
Till	b 'Clayey' gravel Gravel: coarse and fine with cobbles, angular to rounded, sandstone, conglomerate and siltstone Sand: coarse to fine, angular to subangular, quartz and rock fragments with feldspar and some mica, greyish red (10 R 4/2) Fines: silt and clay, disseminated, deposit firm	4.1+	6.4
	Borehole terminated owing to 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	41	50	0.3- 1.3	10	14	12	19	27	18	0	
				1.3- 2.3	8	11	10	14	18	28	11	
				Mean	9	13	11	17	23	21	6	
b	11	39	50	2.3- 4.9	11	11	11	17	19	31	0	§
				4.9- 6.4	No grading data available							
				Mean	11	11	11	17	19	31	0	
a&b	10	39	51	Mean	10	11	11	17	20	29	2	

NN 81 SW 2 **8395 1044** **Roman Fort, Ardoch** **Block B**

Altitude +134.95m (+442.8ft)
Water not struck
250mm percussion
June 1981

Overburden 0.7m
Mineral 5.5m
Bedrock 0.2m+

LOG

Geological classification		Thickness m	Depth m
	Soil	0.7	0.7
Glacial sand and gravel	a Gravel Gravel: coarse and fine with numerous cobbles, mainly subrounded to rounded, grit, sandstone, conglomerate, mudstone, psammite, pelite, schist and vein-quartz Sand: coarse to fine, angular to subrounded, quartz, rock fragments and feldspar Fines: silt and clay, disseminated	2.3	3.0
Till	b 'Very clayey' sandy gravel Gravel: fine and coarse with some cobbles, angular to rounded, composition as above Sand: fine to coarse, angular to subrounded, quartz, rock fragments and feldspar moderate reddish brown Fines: silt and clay, disseminated, deposit firm	3.2	6.2
Lower Devonian (Dunblane Formation)	Sandstone, fine to medium grained, poorly sorted, thinly bedded	0.2+	6.4

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
a	9	29	62	0.7- 1.7	8	6	8	9	12	16	41
				1.7- 3.0	9	9	12	12	21	32	5
				Mean	9	8	10	11	17	24	21
b	21	45	34	3.0- 6.2	21	16	16	13	15	12	7
a&b	16	39	45	Mean	16	13	14	12	16	16	13

NN 81 SW 3 **8347 1006** **Ardoch Bridge, Ardoch** **Block E_1**

Altitude +133.00m (+436.4ft)
Water not struck
250mm percussion
August 1981

Overburden 0.3m
Mineral 4.2m
Waste 6.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	'Clayey' gravel Gravel: coarse and fine with cobbles, subangular to well rounded, sandstone with mudstone, grit, conglomerate, andesite, dolerite, psammite, schist and vein-quartz. Sandstone content decreasing with depth Sand: coarse to fine, mainly angular, quartz with rock fragments, moderate brown (5 YR 3/4) Fines: silt, disseminated	4.2	4.5
Till	Clay, sandy, gravelly, stiff, greyish red (5 R 4/2)	6.4+	10.9
	Borehole terminated owing to 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
12	42	46	0.3- 1.3	8	10	10	14	23	28	7
			1.3- 2.3	10	11	11	18	24	26	0
			2.3- 3.3	10	11	13	19	20	17	10
			3.3- 4.0	13	14	11	19	21	22	0
			4.0- 4.5	26	37	19	6	8	4	0
			Mean	12	14	12	16	20	22	4

NN 81 SW 4 **8426 1103** **Gunnocks, Ardoch** **Block B**

Altitude +138.70m (+455.1ft)
Groundwater level +135.9m
200mm percussion
August 1981

Overburden	0.3m
Mineral	5.6m
Waste	0.8m
Bedrock	0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	'Clayey' gravel Gravel: coarse and fine with cobbles, angular to well rounded, sandstone, grit, siltstone, conglomerate, andesite, dolerite, porphyry, rhyolite, psammite, schist and vein-quartz Sand: fine to coarse, angular to subangular, quartz and rock fragments, moderate brown Fines: silt and clay, disseminated	5.6	5.9
Till	Clay, gravelly, stiff, dark reddish brown (10 R 3/4)	0.8	6.7
Lower Devonian (Dunblane Formation)	Sandstone, fine grained, poorly sorted, dark reddish brown (10 R 3/4)	0.3+	7.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
15	37	48	0.3- 1.7	19	15	14	14	19	19	0	
			1.7- 3.2	10	13	11	12	23	17	14	
			3.2- 4.3	12	11	10	11	17	39	0	§
			4.3- 5.9	18	14	12	12	20	20	4	§
			Mean	15	13	12	12	20	23	5	

NN 81 SW 5 **8341 1136** **Mill of Ardoch, Ardoch** **Block E5**

Altitude +151.40m (+496.7ft)
Water not struck
Pit
April 1981

Waste	0.7m
Bedrock	0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, sandy, firm, reddish brown	0.4	0.7
Lower Devonian (Cromlix Mudstone)	Mudstone, micaceous, homogeneous, reddish brown	0.6+	1.3

NN 81 SW 6 **8428 1106** **Gunnocks, Ardoch** **Block B**

Altitude +137.73m (+451.9ft)
Water seepage at +136.0m
Pit
April 1981

Overburden 0.3m
Mineral 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, sandstone with mudstone, conglomerate, andesite and vein-quartz Sand: coarse with medium and fine, subangular to subrounded, quartz and rock fragments, medium reddish brown Fines: silt and clay, disseminated	1.9+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
**	24	76	0.3- 2.2	**	5	6	13	36	40	0

NN 81 SE 2 **8526 1124** **Dochlewan, Ardoch** **Block B**

Altitude +144.12m (+472.8ft)
Water not struck
250mm and 200mm percussion
August 1981

Overburden 0.3m
Mineral 3.7m
Waste 5.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: fine and coarse with cobbles, subangular to rounded, conglomerate with sandstone, siltstone, andesite, rhyolite, quartzite, psammite, schist and vein-quartz Sand: coarse to fine, angular to subrounded, quartz and rock fragments, moderate brown (5 YR 4/4 to 5 YR 3/4) Fines: silt and clay, disseminated	3.7	4.0
Till	Clay, sandy, gravelly, moderately stiff, greyish red (5 R 4/2) to 7.0m becoming moderate reddish brown (10 R 4/6)	5.4+	9.4
	Borehole terminated owing to slow progress		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
8	38	54	0.3- 1.3	5	6	11	13	19	21	25
			1.3- 2.3	9	11	15	15	22	13	15
			2.3- 3.3	10	13	16	17	19	19	6
			3.3- 4.0	8	10	10	13	21	24	14
			Mean	8	10	13	15	20	19	15

NN 81 SE 3 **8510 1058** **Broomhill, Ardoch** **Block B**

Altitude +123.39m (+404.8ft)
Water struck (perched) at +118.4m
200mm percussion
August 1981

Overburden 0.1m
Mineral 5.3m
Waste 2.1m
Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, sandstone, siltstone and conglomerate with andesite, rhyolite, porphyry, psammite, schist and vein-quartz Sand: medium, fine and coarse, subangular to subrounded, quartz, feldspar and rock fragments, moderate brown Fines: silt and clay, disseminated	5.3	5.4
Till	Clay, pebbly, sandy, firm, dark reddish brown (10 R 3/4)	2.1	7.5
Lower Devonian (?Dunblane Formation)	Sandstone, fine grained, feldspathic, dark reddish brown (10 R 3/4)	0.2+	7.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
15	43	42	0.1- 1.1	13	13	17	16	22	14	5
			1.1- 2.1	14	12	17	11	18	21	7
			2.1- 3.1	16	15	15	10	16	18	10
			3.1- 4.1	16	14	27	8	16	19	0
			4.1- 5.4	15	20	14	10	13	13	15
			Mean	15	15	17	11	17	17	8

NN 81 SE 4 **8560 1036** **Millhill, Ardoch** **Block B**

Altitude +123.4m (+405ft)
Groundwater level +118.8m
250mm percussion
June 1981

Overburden 0.3m
Mineral 7.7m
Waste 1.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a Gravel Gravel: coarse and fine with rare cobbles, mainly rounded to well rounded, sandstone and andesite with mudstone, grit, conglomerate, vein-quartz and rare schist Sand: coarse and medium with fine, subangular to subrounded, quartz and rock fragments, medium to dark reddish brown Fines: silt and clay, disseminated	2.1	2.4
Till	b 'Clayey' gravel Gravel: coarse with fine and some cobbles, angular to well rounded, sandstone, grit, conglomerate, andesite, dolerite, schist and vein-quartz Sand: fine to coarse, angular to subrounded, quartz and rock fragments, moderate reddish brown (10 R 4/6) Fines: clay, disseminated, deposit cohesive becoming firm with depth	5.6	8.0
	Clay, sandy, gravelly, stiff, moderate reddish brown (10 R 4/6)	1.4+	9.4
	Borehole terminated owing to 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	6	35	59	0.3- 1.3	7	8	17	17	24	27	0	
				1.3- 2.4	6	6	11	11	19	33	14	
				Mean	6	7	14	14	21	31	7	
b	17	39	44	2.4- 4.4	23	21	11	8	10	12	15	
				4.4- 8.0	14	11	14	12	18	31	0	§
				Mean	17	15	13	11	15	24	5	
a&b	14	36	50	Mean	14	12	13	11	17	27	6	

NN 81 SE 5 **8685 1125** **Orchill Mill, Ardoch** **Block B**

Altitude +143.2m (+470ft)
Water struck (perched) at +135.4m
250mm percussion
August 1981

Overburden 0.2m
Mineral 11.0m
Bedrock 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a 'Clayey' gravel Gravel: coarse and fine with cobbles, subangular to rounded, sandstone and siltstone with andesite, porphyry, dolerite, quartzite and vein-quartz Sand: medium, coarse and fine, mainly angular to subangular, quartz with rock fragments, feldspar and some mica, moderate brown (5 YR 3/4) Fines: silt and clay, disseminated	3.9	4.1
	b 'Clayey' pebbly sand Gravel: fine and coarse, subangular to rounded, sandstone, grit, andesite, schistose grit and vein-quartz Sand: medium and fine with some coarse, angular to subangular, quartz with rock fragments, feldspar and some mica, pale brown (5 YR 5/2) Fines: silt with clay, disseminated and in rare seams	1.9	6.0
Till	c 'Very clayey' pebbly sand Gravel: coarse and fine with rare cobbles, angular to rounded, sandstone with grit, conglomerate, andesite, felsite, quartzite, schistose grit, pelite and vein-quartz Sand: fine and medium with rare coarse, angular to subrounded, quartz with rock fragments and feldspar, greyish brown (5 YR 3/2) to dark reddish brown (10 R 3/4) Fines: silt and clay, disseminated	5.2	11.2
Lower Devonian (Dunblane Formation)	Sandstone, fine to medium grained, containing rare mudstone pebbles, dark reddish brown (10 R 3/4) with green reduction spots	0.9+	12.1

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	
a	10	42	48	0.2- 1.2	10	11	15	13	17	23	11	
				1.2- 2.2	10	11	24	15	20	20	0	
				2.2- 3.2	8	10	16	11	13	19	23	
				3.2- 4.1	11	11	15	11	19	28	5	
				Mean	10	11	18	13	17	21	10	
b	16	65	19	4.1- 5.1	17	22	32	8	13	8	0	
				5.1- 6.0	15	28	36	5	8	8	0	
				Mean	16	25	33	7	11	8	0	
c	21	73	6	6.0- 6.5	25	31	40	1	2	1	0	
				6.5- 7.1	9	12	25	15	17	22	0	
				7.1- 8.1	21	41	34	2	2	0	0	
				8.1-11.2	23	38	37	1	1	0	0	§
				Mean	21	35	35	3	3	3	0	
a&b	12	48	40	Mean	12	15	22	11	15	18	7	
atoc	16	60	24	Mean	16	25	28	7	9	11	4	

NN 81 SE 6 **8683 1052** **Burnbank, Ardoch** **Block A**

Altitude +126.4m (+415ft)
Groundwater level +116.0m
250mm and 200mm percussion
June 1981

Overburden 0.4m
Mineral 20.2m
Waste 2.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine and coarse with rare cobbles, subangular to well rounded, sandstones, grit, mudstone, conglomerate, andesite, rhyolite, dolerite, psammite, schist and vein-quartz Sand: medium, fine and coarse, angular to subrounded, quartz and rock fragments, moderate reddish brown Fines: silt, disseminated with thin seams	2.5	2.9
	b 'Clayey' sand Gravel: stringers of fine, rounded, sandstone, psammite, felsite, vein-quartz and cemented sand Sand: fine with some medium and traces of coarse, subrounded, quartz with rock fragments, reddish brown Fines: silt, disseminated and in seams	8.8	11.7
	c Pebbly sand Gravel: fine with some coarse, subrounded to rounded, sandstones, grit, conglomerate, andesite, rhyolite, felsite, psammite, pelite and vein-quartz Sand: fine and medium with coarse, mainly subangular, quartz with feldspar and rock fragments, dark reddish brown Fines: silt, disseminated	2.5	14.2
	d Sand Gravel: fine, as above in shape and composition Sand: medium and fine with rare coarse, angular to subangular, quartz with rock fragments and feldspar, greyish red (5 R 4/2) Fines: silt, disseminated	6.4	20.6
Till	Clay, sandy, gravelly, firm, reddish brown	2.4+	23.0
	Borehole terminated for technical reasons		

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	48	40	0.4- 1.4	5	8	33	14	24	16	0	
				1.4- 1.9	8	7	14	17	34	20	0	
				1.9- 2.9	22	27	12	8	12	19	0	
				Mean	12	15	21	12	22	18	0	
b	15	85	0	2.9- 3.9	13	71	16	0	0	0	0	
				3.9- 4.9	9	84	6	0	1	0	0	
				4.9- 5.9	13	81	6	0	0	0	0	
				5.9- 6.9	17	82	1	0	0	0	0	
				6.9- 8.7	20	80	0	0	0	0	0	
				8.7- 9.7	12	48	39	1	0	0	0	
				9.7-10.7	18	45	35	1	1	0	0	§
				10.7-11.7	11	71	18	0	0	0	0	§
				Mean	15	71	14	**	**	**	0	
c	7	73	20	11.7-13.0	8	27	21	22	20	2	0	§
				13.0-14.2	6	30	36	11	15	2	0	§
				Mean	7	28	28	17	18	2	0	
d	6	93	1	14.2-15.2	3	29	60	5	3	0	0	§
				15.2-16.0	4	19	60	13	4	0	0	§
				16.0-17.0	10	47	35	6	2	0	0	§
				17.0-17.2	10	57	30	2	1	0	0	§
				17.2-18.3	10	60	29	1	0	0	0	§
				18.3-19.3	5	41	54	0	0	0	0	§
				19.3-20.6	4	36	59	1	0	0	0	§
				Mean	6	40	49	4	1	**	0	
atod	11	81	8	Mean	11	49	27	5	5	3	0	

NN 81 SE 7 **8782 1073** **Harehill, Blackford** **Block B**

Altitude +143.0m (+469ft)
Water struck at +134.8m
250mm percussion
August 1981

Overburden 0.3m
Mineral 9.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, angular to well rounded, sandstone, grit, conglomerate, andesite, porphyry, quartzite, psammite, schist, vein-quartz and siltstone Sand: medium, coarse and fine, angular to subrounded, quartz and rock fragments with feldspar, greyish red (10 R 4/2) and dark yellowish brown (10 YR 4/2) Fines: silt and clay, disseminated	8.0	8.3
Till	b 'Clayey' sandy gravel Gravel: fine with coarse and cobbles, subangular to subrounded, sandstone and grit with schist and vein-quartz Sand: medium and fine with coarse, angular to subrounded, quartz and rock fragments with feldspar, moderate brown (5 YR 4/4) Fines: clay and silt, disseminated, deposit cohesive	1.4+	9.7
	Borehole terminated owing to obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	10	45	45	0.3- 1.3	5	7	18	12	21	29	8	
				1.3- 2.8	9	14	18	15	22	22	0	
				2.8- 3.8	12	11	15	17	20	25	0	
				3.8- 4.8	12	13	22	20	18	15	0	
				4.8- 5.8	12	9	17	18	20	11	13	
				5.8- 7.3	8	7	12	13	19	30	11	
				7.3- 8.3	12	26	29	10	17	6	0	§
				Mean	10	12	18	15	20	20	5	
b	14	64	22	8.3- 9.3	14	21	34	9	9	4	9	§
				9.3- 9.7	No grading data available							
				Mean	14	21	34	9	9	4	9	
a&b	10	49	41	Mean	10	13	22	14	18	18	5	

NN 81 SE 8 **8848 1042** **Mains of Panholes, Blackford** **Block B**

Altitude +136.7m (+448ft)
Water struck at +129.1m
250mm and 200mm percussion
July 1981

Overburden 0.7m
Mineral 11.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Silt, pebbly, sandy, firm	0.4	0.7
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, sandstone with grit, conglomerate, quartzite, psammite, vein-quartz, andesite and porphyry Sand: fine to coarse, angular to rounded, quartz with rock fragments, moderate reddish brown (10 R 4/6) Fines: silt and clay, disseminated and in seams	3.4	4.1
Till	b Gravel Gravel: coarse and fine with cobbles, subangular to well rounded, sandstone, grit, conglomerate, andesite, porphyry, dolerite, schist and vein-quartz Sand: coarse to fine, angular to subangular, quartz with rock fragments, greyish red (5 R 4/2) Fines: silt and clay, disseminated, deposit cohesive	8.4+	12.5
	Borehole terminated owing to slow progress		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	11	45	44	0.7- 1.8	16	30	23	9	13	9	0	
				1.8- 2.8	8	14	13	10	18	21	16	
				2.8- 4.1	8	11	16	11	19	35	0	
				Mean	11	18	17	10	17	22	5	
b	8	42	50	4.1- 5.2	15	29	17	9	14	16	0	
				5.2- 6.2	15	18	14	12	15	26	0	
				6.2- 7.2	10	14	11	9	12	20	24	
				7.2- 8.2	4	13	14	13	26	30	0	§
				8.2- 9.2	6	11	14	21	17	18	13	§
				9.2-10.2	7	11	9	17	19	32	5	§
				10.2-11.1	4	15	11	20	28	19	3	§
				11.1-12.5	4	6	14	19	28	29	0	§
				Mean	8	14	13	15	20	25	5	
a&b	9	43	48	Mean	9	15	14	14	19	24	5	

NN 81 SE 9 **8961 1025** **Kirkton, Blackford** **Block B**

Altitude +143m (+469 ft)
Groundwater level +138m
250mm and 200mm percussion
July 1981

Overburden 0.4m
Mineral 16.6m
Bedrock 0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Head	a 'Very clayey' sand Gravel: coarse with fine and rare cobbles, angular to subrounded, sandstone with conglomerate, andesite and vein-quartz Sand: fine with some medium and rare coarse, subrounded to rounded, quartz with rock fragments and feldspar, moderate brown (5 YR 4/4) Fines: silt, disseminated and in seams	1.3	1.7
Till	b 'Clayey' gravel Gravel: coarse and fine with cobbles, angular to rounded, sandstone, conglomerate, grit, mudstone, andesite, rhyolite, dolerite, schist, psammite, quartzite and vein-quartz Sand: coarse to fine, angular to subrounded, quartz with rock fragments, moderate reddish brown (10 R 4/6) to greyish red (10 R 4/2) Fines: silt and clay, disseminated	15.3	17.0
Lower Devonian (Buttergask Formation)	Sandstone, fine grained, micaceous, thinly bedded, brownish grey (5 YR 4/1)	0.5+	17.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	25	72	3	0.4- 1.4	25	58	12	2	1	2	0	
				1.4- 1.7	No grading data available							
				Mean	25	58	12	2	1	2	0	
b	11	40	49	1.7- 2.7	12	21	15	7	14	21	10	
				2.7- 3.7	15	11	16	13	18	27	0	
				3.7- 4.7	13	9	15	12	23	28	0	
				4.7- 5.7	15	8	16	12	20	29	0	
				5.7- 6.5	No grading data available							
				6.5- 7.5	10	6	14	13	21	28	8	
				7.5- 8.5	3	3	19	25	27	23	0	§
				8.5- 9.4	4	4	18	22	26	26	0	§
				9.4-10.4	18	16	15	8	11	26	6	§
				10.4-11.4	15	14	11	8	15	37	0	§
				11.4-12.5	8	9	10	12	18	22	21	§
				12.5-13.5	9	12	18	17	18	26	0	§
				13.5-14.5	14	17	27	9	8	14	11	§
				14.5-15.5	14	15	13	6	12	17	23	§
				15.5-16.5	7	11	18	15	19	30	0	§
				16.5-17.0	No grading data available							
				Mean	11	11	16	13	18	25	6	
a&b	12	43	45	Mean	12	15	16	12	17	23	5	

NN 81 SE 10 **8505 1130** **Dochlewan, Ardoch** **Block B**

Altitude +145.67m (+477.9ft)
Water not struck
Pit
April 1981

Overburden 0.3m
Mineral 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles and boulders, mainly well rounded, sandstone, conglomerate, mudstone, vein-quartz and schist Sand: coarse with medium and some fine, subangular to subrounded, quartz with rock fragments, medium brown Fines: clay and silt, disseminated	1.9+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
**	29	71	0.3- 2.0	**	3	10	16	28	40	3

NN 81 SE 11 **8629 1263** **Redford, Ardoch** **Block B**

Altitude c+189m (c+620ft)
Water not struck
Pit
April 1981

Overburden 0.2m
Mineral 1.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse with fine and some cobbles, mainly rounded to well rounded, sandstone, mudstone, conglomerate and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, quartz and rock fragments, reddish brown Fines: silt and clay, disseminated Pit abandoned owing to boulder obstruction	1.6+	1.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	33	66	0.2- 1.8	1	4	14	15	19	41	6

NN 81 SE 12 **8693 1083** **Seathaugh, Ardoch** **Block A**

Altitude c+130m (c+427ft)
Water not struck
Pit
April 1981

Overburden 0.7m
Mineral 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Head	Clay, sandy, pebbly below 0.5m, reddish brown becoming orange-brown below 0.5m	0.4	0.7
Glacial sand and gravel	Pebbly sand Gravel: fine with coarse, mainly well rounded, sandstone, mudstone, andesite and vein-quartz Sand: medium with fine and coarse, subangular to subrounded, quartz and rock fragments, reddish brown Fines: clay and silt, disseminated and in thin seams	1.2+	1.9

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	77	22	0.7- 1.9	1	23	36	18	17	5	0

NN 81 SE 13 **8841 1126** **Easterton, Ardoch** **Block B**

Altitude c+160m (c+525ft)
Water not struck
Pit
April 1981

Overburden 0.4m
Mineral 1.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Glacial sand and gravel	Sandy gravel Gravel: coarse with fine, rounded to well rounded, sandstone with andesite and vein-quartz Sand: medium and fine with coarse, subrounded, quartz with rock fragments, medium to dark brown Fines: silt, disseminated Numerous angular fragments of fine-grained sandstone in base of pit, possibly close to bedrock	1.7+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
3	55	42	0.4- 2.1	3	20	25	10	17	25	0

NN 81 SE 14 **8932 1417** **Lucas Wood, Muthill** **Block E5**

Altitude c+99m (c+325ft)
Water not struck
Pit
April 1981

Overburden 0.2m
Mineral 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	Gravel Gravel: fine and coarse with some cobbles, mainly subrounded to well rounded, sandstone, conglomerate, mudstone, andesite and vein-quartz Sand: coarse and medium with some fine, subangular, quartz and rock fragments, reddish brown Fines: silt, disseminated	2.0+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	34	65	0.2- 1.2	1	5	19	20	34	21	0
			1.2- 2.2	0	3	7	15	34	29	12
			Mean	1	4	13	17	34	25	6

NN 81 SE 15 **8913 1399** **Lucas Wood, Muthill** **Block E_5**

Altitude c+105m (c+344ft)
Water not struck
Pit
April 1981

Waste 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, gravelly, sandy, stiff, reddish brown	0.7+	1.0

NN 81 SE 16 **8953 1108** **West Moor, Blackford** **Block B**

Altitude +169m (+554ft)
Water seepage at +167.2m
Pit
April 1981

Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles and boulders, mainly rounded to well rounded, sandstone, mudstone, conglomerate, andesite and vein-quartz Sand: coarse to fine, subrounded, quartz and rock fragments, medium to dark brown Fines: silt and clay, disseminated	0.9	1.2
Till	Clay, gravelly, sandy, cohesive, reddish brown	1.0+	2.2

NN 81 SE 17 **8949 1072** **West Moor, Blackford** **Block B**

Altitude c+153m (c+502ft)
Water seepage at c+152.2m and c+151.1m
Pit
April 1981

Waste 2.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with some cobbles, mainly rounded to well rounded, sandstone, mudstone, conglomerate, andesite and vein-quartz Sand: coarse to fine, subangular to subrounded, quartz and rock fragments, orange-brown Fines: clay and silt, disseminated	0.6	0.8
Till	Clay, sandy with angular fragments of weathered sandstone, firm, reddish brown	1.5+	2.3

NN 90 NW 1 **9096 0980** **Comelyburn, Blackford** **Block A**

Altitude +145.8m (+478.4ft)
Groundwater level +128.3m
250mm and 200mm percussion
July 1981

Overburden 0.5m
Mineral 24.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Head	Clay, pebbly, sandy, reddish brown	0.4	0.5
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subangular to rounded, sandstone, grit, mudstone, conglomerate, andesite, dolerite, porphyry, psammite, schist, gneiss and vein-quartz Sand: medium with coarse and fine, angular to subrounded, quartz with rock fragments and some feldspar, moderate brown (5 YR 3/4) to pale brown (5 YR 5/2) Fines: silt and clay, disseminated and in seams	12.5	13.0
	b 'Clayey' sand Gravel: coarse and fine, subangular to subrounded, sandstone, grit, andesite, psammite, porphyry, vein-quartz and cemented sand Sand: fine and medium with coarse, angular to subrounded, quartz with feldspar, mica and rock fragments, pale brown (5 YR 5/2) to light brown (5 YR 6/4) Fines: silt, disseminated and in seams	12.2+	25.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	10	46	44	0.1- 1.6	6	8	14	15	22	22	13	
				1.6- 2.6	14	17	19	13	16	12	9	
				2.6- 3.8	16	17	18	10	15	24	0	
				3.8- 4.9	11	12	25	13	19	20	0	
				4.9- 5.9	16	29	21	8	12	14	0	
				5.9- 6.9	8	5	19	18	21	22	7	
				6.9- 7.4	7	8	11	14	30	24	6	
				7.4- 8.4	8	9	11	10	22	34	6	
				8.4- 9.3	8	12	17	10	28	25	0	
				9.3-10.3	5	6	39	16	19	15	0	
				10.3-11.3	11	9	27	12	19	22	0	
				11.3-12.5	11	12	33	16	16	12	0	
				12.5-13.0	9	11	23	9	15	27	6	
				Mean	10	12	21	13	19	21	4	
b	11	86	3	13.0-14.0	8	49	40	1	1	1	0	
				14.0-14.7	7	36	55	1	1	0	0	
				14.7-15.2	No grading data available							
				15.2-16.3	11	37	50	1	0	1	0	§
				16.3-17.5	9	57	30	1	0	3	0	§
				17.5-18.7	20	51	19	0	1	9	0	§
				18.7-19.7	13	82	5	0	0	0	0	§
				19.7-20.7	13	78	9	0	0	0	0	§
				20.7-21.7	8	62	27	0	0	3	0	§
				21.7-22.7	5	42	52	1	0	0	0	§
				22.7-23.7	11	35	44	2	3	5	0	§
				23.7-25.2	15	57	26	1	1	0	0	§
				Mean	11	54	31	1	1	2	0	
a&b	11	65	24	Mean	11	32	26	7	10	12	2	

NN 90 NW 2 **9054 0892** **Drumhead, Blackford** **Block C**

Altitude +119.68m (+392.65ft)
Groundwater level +119.2m
250mm percussion
July 1981

Overburden	1.6m
Mineral	1.7m
Waste	0.8m
Mineral	6.4m
Waste	1.5m
Bedrock	0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Silt, clayey, laminated, pale brown	0.5	0.8
Peat	Peat	0.8	1.6
Alluvium	a Sandy gravel Gravel: fine with some coarse, subangular to rounded, sandstone, grit, conglomerate, andesite, porphyry and vein-quartz Sand: medium and fine with coarse, subangular to subrounded, quartz with rock fragments, moderate brown (5 YR 4/4) Fines: silt, disseminated	1.7	3.3
	Silt, laminated with thin seams of fine sand, containing plant remains, brownish grey (5 YR 4/1)	0.3	3.6
	Silt, peaty, mottled, pale olive (10 Y 6/2) to greyish olive (10 Y 4/2)	0.3	3.9
	Clay, silty, reddish brown	0.2	4.1
Glacial sand and gravel	b Pebbly sand, coarsening downwards Gravel: fine and coarse with cobbles from 7.0m, subangular to well rounded, sandstone with grit, andesite, quartzite, schist and vein-quartz Sand: fine and medium with coarse, subangular to subrounded, quartz with rock fragments and feldspar, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated and in seams	3.4	7.5
Till	c Gravel Gravel: coarse and fine with cobbles, subangular to rounded, composition as above Sand: fine to coarse, angular to rounded, quartz with rock fragments and some feldspar, pale yellowish brown (10 YR 6/2) to moderate yellowish brown (10 YR 5/4) Fines: silt and clay, disseminated	3.0	10.5
	Clay, sandy, gravelly, firm, reddish brown	1.5	12.0
Lower Devonian (Sheriffmuir Formation)	Sandstone, fine grained, micaceous, thinly bedded, light brownish grey (5 YR 6/1)	0.4+	12.4

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	3	66	31	1.6- 3.3	3	27	28	11	28	3	0	§
b	9	72	19	4.1- 5.0	13	33	37	8	7	2	0	§
				5.0- 6.0	14	41	31	6	4	4	0	§
				6.0- 7.0	3	33	29	11	14	10	0	§
				7.0- 7.5	2	7	24	17	18	22	10	§
				Mean	9	31	31	10	10	8	1	
c	4	46	50	7.5- 8.5	4	20	14	10	23	29	0	§
				8.5- 9.5	4	18	14	8	13	22	21	§
				9.5-10.5	5	21	19	11	18	15	11	§
				Mean	4	20	16	10	18	21	11	
a&b	7	70	23	Mean	7	30	30	10	16	6	1	
atoc	6	60	34	Mean	6	25	25	10	17	12	5	

NN 90 NW 3 **9153 0939** **Drumfad, Blackford** **Block A**

Altitude +141.47m (+464.1ft)
Water struck at +123.07m
250mm and 200mm percussion
July 1981

Overburden 0.2m
Mineral 19.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles, subangular to well rounded, sandstone, andesite, grit, felsite, schistose grit, dolerite and vein-quartz Sand: medium with coarse and fine, angular to subrounded, quartz with rock fragments and feldspar, greyish red (5 R 4/2) to pale brown (5 YR 5/2) Fines: silt with clay, disseminated and in seams	15.0	15.2
	b Pebbly sand Gravel: fine with coarse, subrounded to well rounded, sandstone with schist and vein-quartz. Forms stringers Sand: fine and medium with some coarse, angular to subrounded, quartz with rock fragments and feldspar, moderate reddish brown (10 R 4/6) Fines: silt, disseminated and in moderate brown seams (5 YR 3/4)	2.1	17.3
	c Gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, sandstone, grit, andesite, dolerite and vein-quartz Sand: medium, fine and coarse, subangular to subrounded, quartz with rock fragments and some feldspar, moderate reddish brown (10 R 4/6) Fines: silt, disseminated	2.3+	19.6
	Borehole abandoned for technical reasons		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm	
a	8	41	51	0.2- 1.2	4	5	21	13	25	32	0	
				1.2- 2.2	6	7	22	24	29	12	0	
				2.2- 3.0	7	10	13	19	34	17	0	
				3.0- 4.2	12	18	37	8	8	4	13	
				4.2- 5.2	7	9	15	10	19	33	7	
				5.2- 6.1	5	6	11	8	17	42	11	
				6.1- 7.1	9	14	13	9	17	24	14	
				7.1- 8.0	14	26	19	6	13	22	0	
				8.0- 9.1	6	9	24	11	16	22	12	
				9.1-10.1	7	11	29	10	18	19	6	
				10.1-11.1	5	7	21	8	13	28	18	
				11.1-12.1	15	12	13	11	20	22	7	
				12.1-13.1	10	8	11	12	23	20	16	
				13.1-14.2	11	9	15	11	24	26	4	
				14.2-15.2	3	14	16	10	17	35	5	
				Mean	8	11	19	11	19	24	8	
b	9	85	6	15.2-16.2	9	51	34	3	2	1	0	
				16.2-17.3	8	37	39	7	7	2	0	
				Mean	9	44	36	5	4	2	0	
c	5	40	55	17.3-18.3	9	17	19	7	16	26	6	
				18.3-19.6	2	11	15	11	23	30	8	§
				Mean	5	14	17	9	20	28	7	
atoc	8	46	46	Mean	8	15	21	10	18	21	7	

NN 90 NW 4 **9256 0984** **Millhill, Blackford** **Block A**

Altitude +142.83m (+468.6ft)
Water struck at +121.8m
250mm and 200mm percussion
July 1981

Overburden 0.3m
Mineral 23.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subangular to well rounded, sandstone, grit and conglomerate with andesite, dolerite, felsite, schistose grit, psammite, pelite, vein-quartz, siltstone and porphyry Sand: medium, fine and coarse, angular to subrounded, quartz with rock fragments, greyish red (10 R 4/2) Fines: silt and clay, disseminated and in seams	8.9	9.2
	b 'Clayey' sand Gravel: rare fine with traces of coarse, mainly rounded to well rounded, composition as above Sand: fine and medium with traces of coarse, subangular to subrounded, quartz with rock fragments and feldspar, reddish brown Fines: silt, disseminated and in seams	5.2	14.4
	c 'Very clayey' sand Sand: fine with some medium and traces of coarse, subangular, quartz with rock fragments and mica, reddish brown Fines: silt, disseminated and in seams	4.0	18.4
	d 'Clayey' sand Gravel: rare, fine with coarse, subangular to subrounded, sandstone, grit, porphyry, schist and vein-quartz Sand: fine with medium and rare coarse, subangular, quartz with feldspar, mica and some rock fragments, reddish brown Fines: silt, disseminated	5.8+	24.2
	Borehole terminated for technical reasons		

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	52	37	0.3- 1.7	8	8	17	19	19	29	0	
				1.7- 2.8	12	36	27	6	12	7	0	
				2.8- 3.8	11	9	15	11	26	28	0	
				3.8- 4.8	12	12	18	11	17	25	5	
				4.8- 5.8	9	13	20	9	16	20	13	
				5.8- 6.9	11	16	24	9	21	19	0	
				6.9- 8.2	9	16	36	8	14	17	0	
				8.2- 9.2	16	29	35	5	8	7	0	
				Mean	11	17	25	10	16	19	2	
b	15	84	1	9.2-10.4	15	43	41	0	1	0	0	
				10.4-11.4	8	33	57	1	1	0	0	
				11.4-12.4	25	56	15	1	2	1	0	
				12.4-13.4	7	37	53	2	1	0	0	
				13.4-14.4	18	46	33	3	0	0	0	
				Mean	15	43	40	1	1	**	0	
c	33	67	0	14.4-15.4	32	56	11	1	0	0	0	
				15.4-17.4	36	53	11	0	0	0	0	§
				17.4-18.4	30	68	2	0	0	0	0	§
				Mean	33	58	9	**	**	0	0	
d	11	86	3	18.4-19.4	18	70	12	0	0	0	0	§
				19.4-21.3	13	63	21	2	1	0	0	§
				21.3-22.3	8	30	40	7	11	4	0	§
				22.3-24.2	7	49	40	3	1	0	0	§
				Mean	11	54	29	3	2	1	0	
atod	15	70	15	Mean	15	39	26	5	7	7	1	

NN 90 NW 5 **9288 0891** **The Kinnaker, Blackford** **Block E_2**

Altitude +127m (+417ft)
Groundwater level +124m
250mm percussion
July 1981

Overburden	0.3m
Mineral	2.8m
Waste	2.2m
Mineral	5.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	a 'Clayey' sandy gravel Gravel: coarse with fine, subangular to rounded, sandstone and andesite with conglomerate, rhyolite, porphyry, dolerite, quartzite and vein-quartz Sand: fine with medium and some coarse, angular to subangular, quartz with rock fragments and feldspar, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated and in thin seams	1.8	2.1
Head	b 'Very clayey' gravel Gravel: coarse with fine and cobbles, subrounded to rounded, conglomerate, sandstone, andesite, schistose grit and vein-quartz Sand: fine with medium and coarse, angular to subangular, quartz with rock fragments and feldspar, pale brown (5 YR 5/2) Fines: silt and clay, disseminated	1.0	3.1
Glacial sand and gravel	Silt, laminated with sand seams, containing rare pebbles	2.2	5.3
	c 'Clayey' gravel Gravel: coarse with fine and rare cobbles, subrounded to rounded, conglomerate, grit, sandstone, porphyry, andesite, vein-quartz and schistose grit Sand: fine with medium and coarse, angular to rounded, quartz with rock fragments, feldspar and mica, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated and in seams	2.5	7.8
Till	d Gravel Gravel: coarse with fine and cobbles, mainly angular, sandstone, conglomerate, brecciated lava, andesite, porphyry and vein-quartz Sand: fine with coarse and medium, angular to rounded, quartz with rock fragments, some feldspar and mica, moderate brown (5 YR 4/4) Fines: silt and clay, disseminated	3.3+	11.1
	Borehole terminated owing to 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	17	48	35	0.3- 1.4	20	33	20	7	7	13	0	§
				1.4- 2.1	11	15	9	7	19	39	0	§
				Mean	17	25	16	7	12	23	0	
b	20	40	40	2.1- 3.1	20	21	10	9	10	21	9	§
c	13	36	51	5.3- 7.0	15	22	6	4	19	34	0	§
				7.0- 7.8	10	15	17	11	15	32	0	§
				Mean	13	20	10	6	18	33	0	
d	9	32	59	7.8- 9.3	7	17	6	6	17	33	14	§
				9.3-10.8	10	14	8	12	15	32	9	§
				10.8-11.1	No grading data available							
				Mean	9	16	7	9	16	31	12	
a&b	18	46	36	Mean	18	24	14	8	11	22	3	
atoc	16	41	43	Mean	16	22	12	7	14	27	2	
atod	13	38	49	Mean	13	20	10	8	15	29	5	

NN 90 NW 6 **9299 0858** **Gleneagles House, Blackford** **Block E_2**

Altitude +146m (+479ft)
Water seepage at +141.1m
250mm percussion
August 1981

Overburden 0.1m
Mineral 4.8m
Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Glacial sand and gravel	'Clayey' sand Gravel: fine with traces of coarse, angular to subrounded, lava conglomerate with andesite and rare vein-quartz, sandstone and conglomerate Sand: fine with some medium and rare coarse, angular to subrounded, quartz with feldspar and rock fragments, moderate brown (5 YR 4/4) Fines: silt, disseminated and in thin seams	4.8	4.9
Lower Devonian	Volcanic conglomerate, angular fragments of andesitic lava in a sandy matrix, dark reddish brown	0.4+	5.3

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
18	81	1	0.1- 1.1	19	39	34	7	1	0	0
			1.1- 2.1	14	64	18	2	1	1	0
			2.1- 3.1	25	68	5	0	2	0	0
			3.1- 4.1	14	75	10	0	1	0	0
			4.1- 4.9	15	77	7	0	0	1	0
			Mean	18	64	15	2	1	**	0

NN 90 NW 7 **9191 0870** **Cauldhame Wood, Blackford** **Block E_5**

Altitude +140m (+459ft)
Water not struck
Pit
April 1981

Waste 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, gravelly, sandy in parts, stiff, reddish brown	1.6+	1.9

NN 90 NW 8 **9286 0889** **The Kinnaker, Blackford** **Block E_2**

Altitude +127m (+417ft)
Water struck at 124.8m
Pit
April 1981

Overburden 0.5m
Mineral 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Alluvium	'Very clayey' pebbly sand Gravel: coarse and fine, rounded to well rounded, sandstone, andesite and vein-quartz Sand: fine with medium and some coarse, quartz, reddish brown Fines: silt, disseminated and in seams	1.4	1.9
	Pebbly sand Gravel: coarse and fine, rounded to well rounded, sandstone, conglomerate, mudstone andesite and vein-quartz Sand: fine and medium with some coarse, subrounded, quartz and rock fragments, reddish brown Fines: silt, disseminated	0.4+	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
21	69	10	0.5- 1.9	21	40	24	5	5	5	0
			1.9- 2.3	No grading data available						
			Mean	21	40	24	5	5	5	0

NN 90 NW 9 **9298 0860** **Gleneagles House, Blackford** **Block E_2**

Altitude +145m (+476ft)
Water not struck
Pit
April 1981

Overburden 0.2m
Mineral 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	Sand Gravel: fine with traces of coarse and rare boulders, mainly rounded, sandstone, mudstone, andesite and vein-quartz Sand: medium and fine with some coarse, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated	2.0+	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
3	96	1	0.2- 2.2	3	46	46	4	1	**	0

NN 91 SW 2 **9027 1100** **White Muir, Blackford** **Block B**

Altitude +180.6m (+593ft)
Water struck (perched) at +175m
250mm percussion
July 1981

Overburden	0.3m
Mineral	6.7m
Waste	4.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly	0.3	0.3
Glacial sand and gravel	a 'Clayey' sandy gravel, tilloid from 1.7 to 2.1m and frequently below 2.5m Gravel: coarse and fine with cobbles and rare boulders, angular to well rounded, various sandstones, grit, andesite, vein-quartz, schistose grit, felsite, porphyry, schist, granodiorite and some siltstone Sand: fine, medium and coarse, angular to subrounded, quartz and rock fragments with feldspar, pale brown (5 YR 5/2) Fines: silt, mainly disseminated	4.2	4.5
	b 'Very clayey' sandy gravel, tilloid in part Gravel: coarse and fine, subangular to subrounded, composition as above Sand: fine with medium and coarse, angular to rounded, quartz with rock fragments and feldspar, pale brown (5 YR 5/2) Fines: disseminated silt and clay, and silt seams from 5.2 to 5.7m	1.7	6.2
	c 'Clayey' gravel Gravel: fine and coarse with rare cobbles, subangular to subrounded, sandstone, grit, conglomerate, andesite, schitose grit, porphyry and vein-quartz Sand: fine, medium and coarse, angular to subangular, quartz and rock fragments with feldspar and mica Fines: silt with clay, disseminated and as frequent seams, pale brown (5 YR 5/2) to greyish red (10 R 4/2)	0.8	7.0
	Silt, sandy, unlaminated, with seams containing rare grains of medium to coarse sand and rare fine gravel	0.5	7.5
Till	Clay, sandy, stony, silty, firm, reddish brown. From 9.2m clasts are mostly of sandstone and from 10.7m the sandstone is fine to medium grained, micaceous, with small siltstone pebbles, mottled yellowish grey-brown	3.8+	11.3
	Borehole terminated owing to rock obstruction, probably close to rockhead		

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	15	43	42	0.3– 1.4	12	16	16	10	19	20	7	
				1.4– 2.5	15	20	15	13	20	17	0	
				2.5– 3.5	20	17	14	13	17	19	0	
				3.5– 4.5	15	14	11	11	18	22	9	
				Mean	15	17	14	12	19	19	4	
b	33	43	24	4.5– 5.5	36	21	10	10	10	13	0	
				5.5– 6.2	28	26	10	11	14	11	0	§
				Mean	33	23	10	10	12	12	0	
c	14	36	50	6.2– 7.0	14	13	12	11	25	25	0	§
a&b	20	43	37	Mean	20	19	13	11	17	17	3	
atoc	20	42	38	Mean	20	18	13	11	18	18	2	

NN 91 SW 3 **9069 1027** **Woodside, Blackford** **Block A**

Altitude +167m (+548ft)
Water struck (perched) at +154m
250mm and 200mm percussion
July 1981

Overburden 0.2m
Mineral 13.5m
Waste 9.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	a 'Clayey' sandy gravel, frequently tilloid Gravel: coarse with fine and some cobbles, mainly subrounded to rounded, sandstone, grit, conglomerate, andesite, schistose grit, quartzite, vein-quartz, porphyry, rhyolite, felsite, psammite and siltstone Sand: fine with medium and some coarse, angular to subrounded, quartz with rock fragments, feldspar and some mica Fines: silt and clay, disseminated, also in seams up to 100mm thick, colour variable, mainly pale brown with reddish tinge (5 YR 5/2)	9.3	9.5
	b Sandy gravel Gravel: fine with coarse, subangular to subrounded, composition as above Sand: medium with fine and coarse, angular to subrounded, quartz with rock fragments and feldspar Fines: silt, disseminated and in seams, pale yellowish brown (10 YR 6/2)	3.2	12.7
	c 'Very clayey' sand Gravel: fine, subangular to subrounded, cemented sand and nodules, also quartzitic sandstone, porphyry, andesite, vein-quartz, schistose grit and psammite Sand: fine with medium, angular to subangular, mainly quartz Fines: silt with some clay, mainly in seams, increasing in thickness and frequency with depth, pale yellowish brown (10 YR 6/2)	1.0	13.7
	Silt, laminated, with sand and clay films and rare pebbles, pale red (10 R 6/2)	1.3	15.0
	Sand, fine, silty	0.9	15.9
	Silt and clay, laminated, with drop stones	0.8	16.7
Till	Silt, clayey, sandy, stony, firm, reddish brown; clasts include various sandstones, conglomerate, rhyolite, vein-quartz, quartzite and andesite. Colour is between greyish red (10 R 4/2) and pale brown (5 YR 5/2)	6.1+	22.8
	Borehole terminated owing to excessive waste		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64	mm
a	14	44	42	0.2- 1.2	15	22	19	7	17	20	0	
				1.2- 2.2	17	22	14	8	14	17	8	
				2.2- 3.2	14	16	17	12	14	21	6	
				3.2- 4.2	13	14	16	8	15	31	3	
				4.2- 5.5	10	11	15	10	18	36	0	
				5.5- 6.6	22	65	9	1	1	2	0	
				6.6- 7.7	10	9	14	10	18	23	16	
				7.7- 8.7	14	22	14	6	14	20	10	
				8.7- 9.5	12	11	13	9	22	29	4	
				Mean	14	21	15	8	15	22	5	
b	8	64	28	9.5-10.5	8	16	43	12	17	4	0	
				10.5-11.5	9	11	25	11	28	16	0	
				11.5-12.7	8	22	41	9	10	10	0	
				Mean	8	17	36	11	18	10	0	
c	35	63	2	12.7-13.7	35	49	14	0	2	0	0	§
a&b	13	49	38	Mean	13	20	20	9	15	19	4	
atoc	14	50	36	Mean	14	22	20	8	14	18	4	

NN 91 SW 4 **9172 1037** **Drumlochy, Blackford** **Block A**

Altitude +162m (+532ft)
Water struck (perched) at +145m
250mm and 200mm percussion
July 1981

Overburden 0.5m
Mineral (inc. 0.2m waste) 16.4m
Waste 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy loam, mid-brown	0.5	0.5
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: coarse and fine, subangular to rounded, sandstone with conglomerate, andesite, vein-quartz, grit, rhyolite, schistose grit, schist, dolerite and siltstone Sand: fine and medium with coarse, angular to subangular, quartz with some feldspar, rock fragments and rare mica Fines: disseminated silt, with clay at top, light brown (5 YR 5/6) then moderate brown (5 YR 4/4)	3.7	4.2
	b 'Clayey' pebbly sand, with 200mm clay seam at top Gravel: fine and coarse, mainly subangular to subrounded, composition as above Sand: fine and medium with coarse, angular to subangular, quartz with some rock fragments and feldspar Fines: silty clay seam at top and seams of silt associated with fine sand	6.2	10.4
	c Sandy gravel, with clay bound seams below 12.5m Gravel: coarse and fine with rare cobbles, mainly subangular to subrounded, composition as above Sand: medium with fine and coarse, angular to subrounded, quartz with rock fragments, feldspar and some mica Fines: mainly silt, disseminated and in seams up to 50mm thick, moderate brown (5 YR 3/4)	6.5	16.9
Till	Clay, sandy, stony, firm to stiff; clasts include sandstone, grit, conglomerate, andesite and schist; greyish red (10 R 4/2)	0.9+	17.8
	Borehole terminated for technical reasons		

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	62	26	0.5- 1.3	21	26	29	7	7	10	0
				1.3- 2.4	9	48	24	4	7	8	0
				2.4- 3.4	9	23	29	8	14	17	0
				3.4- 4.2	9	19	23	8	20	21	0
				Mean	12	29	26	7	12	14	0
b	16	73	11	4.2- 4.4	No grading data available						
				4.4- 5.3	19	30	19	5	8	19	0
				5.3- 6.3	16	38	34	8	3	1	0
				6.3- 7.3	21	42	24	7	6	0	0
				7.3- 8.3	14	33	32	9	7	5	0
				8.3- 9.3	13	41	31	7	4	4	0
				9.3-10.4	16	35	31	6	8	4	0
				Mean	16	37	29	7	6	5	0
c	9	49	42	10.4-11.5	13	23	19	10	17	18	0
				11.5-12.5	10	16	25	11	16	22	0
				12.5-13.5	8	13	20	14	21	24	0
				13.5-14.5	9	10	24	16	23	18	0
				14.5-15.4	7	12	21	11	19	24	6
				15.4-16.9	6	14	21	11	22	26	0
				Mean	9	15	22	12	20	21	1
atoc	12	61	27	Mean	12	27	25	9	13	14	**

NN 91 SW 5 **9208 1105** **Gleneagles Hotel, Blackford** **Block B**

Altitude +145.3m (+477ft)
Groundwater level +139m
250mm and 200mm percussion
July 1981

Overburden	0.3m
Mineral	1.4m
Waste	7.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly loam, dark brown	0.3	0.3
Glacial sand and gravel	Gravel, 'claybound' Gravel: coarse and fine with cobbles, subangular to rounded, mainly sandstones and grit with conglomerate, vein-quartz, porphyry, quartzitic sandstone and dolerite Sand: coarse and medium with fine, angular to rounded, quartz and rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 4/4)	1.4	1.7
Till	Clay, sandy, stony, silty, firm, reddish brown; clasts mainly of conglomerate, sandstone and vein-quartz, with schist, schistose grit, quartzite and andesite. From 3.5 to 8.0m clasts mainly comprise fine grained grey sandstone and chocolate brown siltstone. From 8.0m clasts entirely of fine grained, micaceous, thinly bedded, brownish grey sandstone	7.2+	8.9
	Borehole terminated owing to rock obstruction, probably rockhead		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
9	33	58	0.3- 1.7	9	8	12	13	23	26	9

NN 91 SW 6 **9275 1081** **Gleneagles Station, Blackford** **Block A**

Altitude +119m (+390ft)
Groundwater level +110m
250mm and 200mm percussion
July 1981

Overburden 0.3m
Mineral 10.8m
Waste 9.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Glacial sand and gravel	a Pebbly sand Gravel: fine with coarse and rare cobbles, subangular to rounded, sandstone and grit with andesite, conglomerate, siltstone, vein-quartz, schistose grit, rhyolite, psammite and dolerite Sand: medium with fine and some coarse, angular to subrounded, quartz with rock fragments and feldspar Fines: silt and clay, disseminated and in seams up to 100mm thick, moderate brown (5 YR 4/4) to pale brown (5 YR 5/2)	4.0	4.3
	b Pebbly sand Gravel: fine with coarse, subangular to subrounded, sandstone, conglomerate, quartzitic sandstone, andesite, vein-quartz, schistose grit, quartzite and siltstone Sand: medium with fine and rare coarse, angular to subrounded, quartz with rock fragments and feldspar Fines: silt, disseminated and in seams up to 50mm thick, greyish red (10 R 4/2)	6.8	11.1
Glaciolacustrine deposits	Silt, laminated, with some fine sand	2.7	13.8
Till	Silt and clay, sandy, stony, soft to firm, matrix variable, reddish brown to buff coloured. Clasts include sandstones, vein-quartz, conglomerate, quartzite, schistose grit, andesite, dolerite, gabbro, greenstone and felsite.	6.6+	20.4
	Borehole terminated owing to rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
				from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64	mm
a	9	76	15	0.3- 1.3	13	45	27	5	5	5	0	
				1.3- 2.3	10	22	48	8	10	2	0	
				2.3- 3.3	9	10	36	22	16	7	0	
				3.3- 4.3	5	19	52	8	6	2	8	§
				Mean	9	24	41	11	9	4	2	
b	6	89	5	4.3- 6.3	9	43	48	0	0	0	0	§
				6.3- 7.3	4	11	82	2	1	0	0	§
				7.3- 8.3	3	7	59	15	11	5	0	§
				8.3- 9.3	5	28	39	12	10	6	0	§
				9.3-11.1	5	39	56	0	0	0	0	§
				Mean	6	30	55	4	3	2	0	
a&b	7	85	8	Mean	7	28	50	7	5	2	1	

NN 91 SE 4 **9504 1217** **Woodend, Auchterarder** **Block E_3**

Altitude +86.21m (+282.8ft)
Water not struck
250mm and 200mm percussion
July 1981

Waste	2.2m
Bedrock	1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, gravelly, very stiff, dark reddish brown (10 R 3/4)	2.0	2.2
Lower Devonian (Sheriffmuir Formation)	Sandstone, fine-grained, moderate yellowish brown (10 YR 5/4), weathered to 3.1m	1.3+	3.5

NN 91 SE 5 **9595 1181** **Lochie, Auchterarder** **Block E_3**

Altitude +97.26m (319.01ft)
Water struck at 94.4m
200mm percussion
July 1981

Overburden	1.4m
Mineral	2.5m
Waste	1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty	0.5	0.5
Head	Silt, pebbly, sandy, clayey, slightly cohesive, mid-brown, some peaty fragments	0.9	1.4
Glacial sand and gravel	'Clayey' sandy gravel, poorly sorted Gravel: coarse and fine with cobbles, angular to rounded, sandstone, grit, andesite, vein-quartz, conglomerate, porphyry, schistose grit, siltstone and schist Sand: fine, medium and coarse, angular to subangular, quartz and rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 3/4)	2.5	3.9
Till	Clay, stony, stiff and very cohesive, dark reddish brown (10 R 3/4). Angular to rounded clasts include sandstone, andesite and vein-quartz	1.1+	5.0
	Borehole terminated owing 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	
13	44	43	1.4- 2.7	12	14	15	8	16	23	12	
			2.7- 3.9	15	16	19	16	19	15	0	§
			Mean	13	15	17	12	17	20	6	

H

NN 91 SE 6 **9722 1370** **Arns, Auchterarder** **Block E_4**

Altitude +47.42m (+155.6ft)
Groundwater level +43.8m
250mm percussion
July 1981

Overburden	0.2m
Mineral	6.8m
Waste	1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, mid to dark brown	0.2	0.2
Late-Glacial alluvium	Gravel Gravel: coarse and fine with cobbles, subangular to well rounded, andesite with sandstone, grit, dolerite, vein-quartz and rhyodacite Sand: medium and coarse with fine, angular to subrounded, quartz with rock fragments, moderate brown (5 YR 3/4) Fines: silt, disseminated	6.8	7.0
Till	Clay, pebbly, very stiff, dark reddish brown (10 R 3/4). Clasts include andesite and sandstone with vein-quartz	1.5+	8.5
	Borehole terminated owing to 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	
7	45	48	0.2- 1.2	6	6	15	16	21	30	6	
			1.2- 2.2	5	7	12	14	23	31	8	
			2.2- 3.2	9	9	17	15	24	26	0	
			3.2- 4.7	13	18	19	10	13	27	0	§
			4.7- 6.2	4	9	23	18	23	23	0	§
			6.2- 7.0	5	9	31	24	12	19	0	§
			Mean	7	10	19	16	19	27	2	

NN 91 SE 7 **9869 1485** **Mosshead, Dunning** **Block E_4**

Altitude +41m (+135ft)
Water struck at +33m
200mm percussion
July 1981

Overburden	0.3m
Mineral	4.5m
Waste	5.8m
Bedrock	0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, silty, moderate brown	0.3	0.3
Late-Glacial raised estuarine deposits	'Clayey' sand Gravel: fine with rare coarse, subrounded to well rounded, sandstone with andesite, schist, conglomerate, quartzite and vein-quartz; rare below 1.2m Sand: medium and fine with rare coarse, angular to subrounded, quartz with some feldspar and rock fragments, moderate brown (5 YR 3/4) Fines: silt, disseminated	4.5	4.8
Till	Clay, sandy, stony, stiff, clasts angular to subangular, chiefly of fine to medium grained, reddish brown sandstone	5.8	10.6
Lower Devonian (Sheriffmuir Formation)	Sandstone, micaceous, fine grained, weathered, dark greenish grey (5 GY 4/1)	0.2+	10.8

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
12	85	3	0.3- 1.4	16	20	49	8	6	1	0
			1.4- 2.6	8	38	53	1	0	0	0
			2.6- 3.6	11	46	43	0	0	0	0
			3.6- 4.8	15	34	47	2	1	1	0
			Mean	12	34	48	3	2	1	0

NN 91 SE 8 **9595 1181** **Lochie, Auchterarder** **Block E_3**

Altitude +97.26m (+319.1ft)
Water struck at +95.46m
Pit
April 1981

Overburden 1.3m
Mineral 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Head	Clay, silty, pebbly, homogeneous, medium reddish brown	0.9	1.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, sandstone, mudstone, conglomerate, andesite, dolerite, and vein-quartz Sand: medium with coarse and fine, subangular to subrounded, quartz and rock fragments, dark reddish brown Fines: silt and clay, disseminated	0.8+	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
1	39	60	1.3- 2.1	1	11	17	11	23	29	8

NN 91 SE 9 **9626 1231** **Thorn, Auchterarder** **Block E_3**

Altitude +82.87m (+271.9ft)
Water seepage at +81.37m
Pit
April 1981

Overburden 0.3m
Mineral 1.2m
Waste 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Sandy gravel Gravel: fine and coarse with cobbles, mainly rounded to well rounded, sandstone, conglomerate, mudstone, andesite, dolerite, grit, granite and vein-quartz Sand: medium and coarse with some fine, subangular to subrounded, quartz and rock fragments, medium brown Fines: silt and clay, disseminated	1.2	1.5
Till	Clay, pebbly, sandy, stiff, reddish brown	0.6+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	51	48	0.3- 1.5	1	6	24	21	20	12	16

NN 91 SE 10 **9781 1479** **Hall of Aberuthven, Auchterarder** **Block E_4**

Altitude +38m (+125ft)
Water seepage at +36.3m
Pit
April 1981

Waste 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Late-Glacial raised estuarine deposits	Silt, sandy with pebbles, orange-brown	0.9	1.2
	Silt, sandy, laminated, maroon	0.5	1.7
	Clay, homogeneous, maroon	0.5+	2.2

NN 91 SE 11 **9744 1469** **Damside Cottages, Auchterarder** **Block E_4**

Altitude +32m (+105ft)
Water struck at +30.4m
Pit
April 1981

Overburden 0.3m
Mineral 1.3m
Waste 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Gravel Gravel: coarse and fine with cobbles, mainly rounded to well rounded, sandstone, grit, conglomerate, andesite, dolerite, rhyodacite and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated	1.3	1.6
Late-Glacial raised estuarine deposits	Clay, silty, sandy, pebbly, laminated in places, reddish maroon	0.4+	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
**	33	67	0.3- 1.6	**	2	14	17	27	35	5

NN 91 SE 12 **9720 1371** **Arns, Auchterarder** **Block E_4**

Altitude +47.42m (+155.6ft)
Water not struck
Pit
April 1981

Overburden 0.4m
Mineral 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Late-Glacial alluvium	Gravel Gravel: coarse and fine with cobbles, mainly rounded, sandstone, grit, conglomerate, andesite, dolerite and vein-quartz Sand: coarse and medium with some fine, subangular to subrounded, quartz and rock fragments, medium reddish brown Fines: silt and clay, disseminated with a seam between 1.9 and 2.0m	1.8+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
1	29	70	0.4- 2.2	1	3	13	13	23	39	8

NN 91 SE 13 **9869 1485** **Mosshead, Dunning** **Block E_4**

Altitude +41m (+135ft)
Water not struck
Pit
April 1981

Overburden 0.4m
Mineral 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Late-Glacial raised estuarine deposits	Pebbly sand Gravel: fine with some coarse, well rounded, andesite, dolerite, rhyodacite and vein-quartz Sand: medium with fine and some coarse, subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated and in seams	1.8+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64 mm
2	93	5	0.4- 2.2	2	35	51	7	4	1	0

APPENDIX F

ANCILLARY BOREHOLE AND SHALLOW PIT RECORDS USED IN THE ASSESSMENT OF RESOURCES

Borehole/ pit number*	Grid reference	Thickness in metres				Mean grading percentage			Geological classification of mineral
		Over-burden	Mineral	Waste	Bedrock	Fines (-$\frac{1}{16}$mm)	Sand (+$\frac{1}{16}$-4mm)	Gravel (+4mm)	
NN 80 NW 1	8122 0773	-	2.1	3.3	15.9+	-	-	-	Glacial sand and gravel
NN 91 NE X1	9777 1509	0.4	8.1Ø	0.9+	-	13	70	17	Late-Glacial raised estuarine deposits
NN 91 NE X2	9772 1503	0.3	8.9+	-	-	2	61	37	Late-Glacial raised estuarine deposits
NN 91 SW X1	9499 1242	0.7	4.0+	-	-	4	23	73	Alluvium
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NN 91 SE X13§	9606 1304	0.3	2.2+	-	-	7	51	42	Late-Glacial alluvium
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NN 91 SE X19§	9700 1400	0.3	1.9+	-	-	trace	25	75	Late-Glacial alluvium

* By sheet quadrant. Site exploration records held by IGS are prefixed by the letter X
§ Shallow pit
Ø Including 1.1m of waste

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INSTITUTE OF GEOLOGICAL SCIENCES

INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND AND GRAVEL RESOURCES OF STRATHALLAN, TAYSIDE REGION

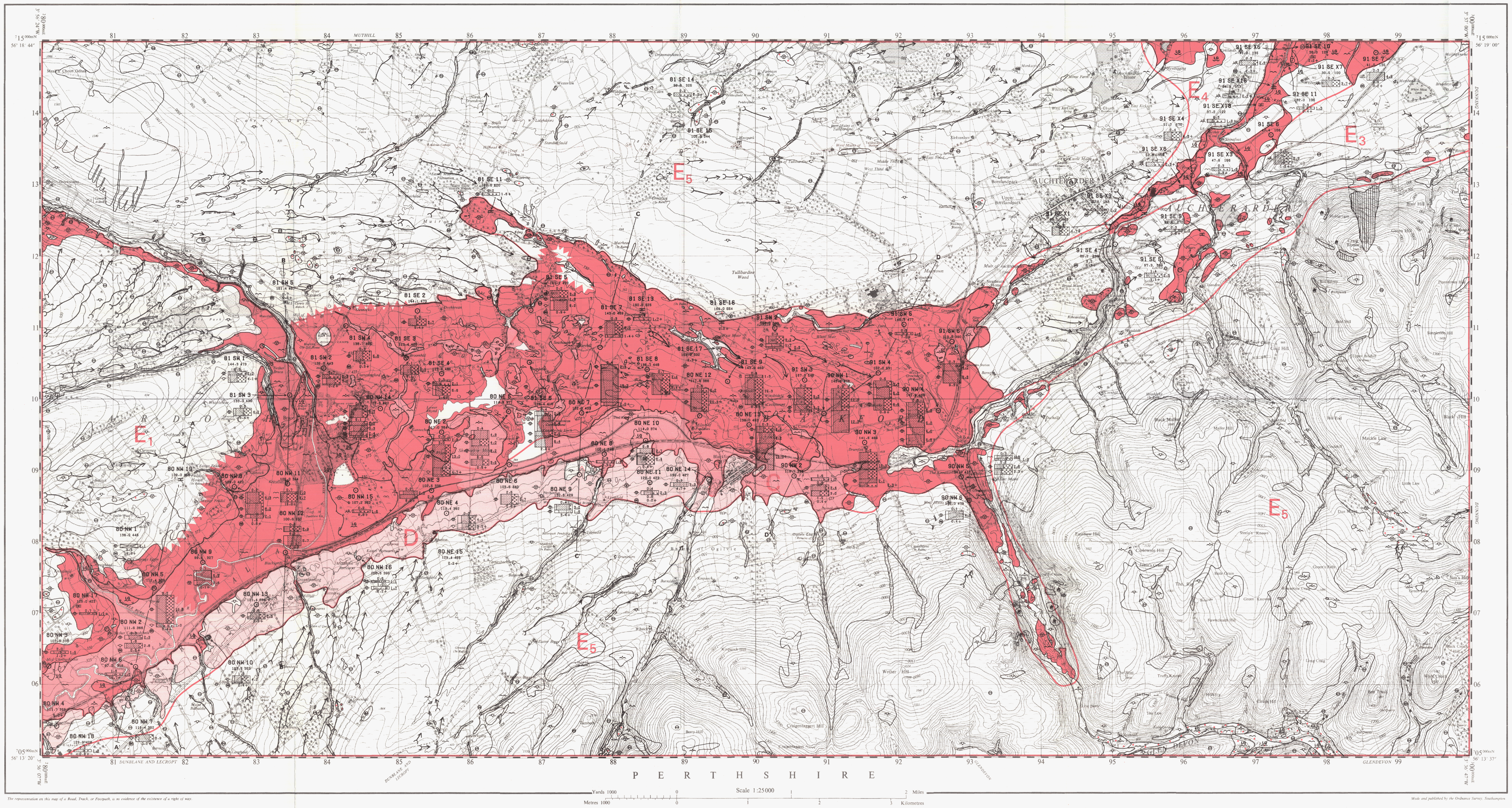
Scale 1:25 000 or about 2½ Inches to 1 Mile

ORDNANCE SURVEY
PARTS OF SHEETS NN 80, 81, 90 & 91
PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF STRATHALLAN, TAYSIDE REGION

132

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



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

Scale 1:25 000

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

Contour values are in feet.
1 square inch on this map represents 99·639 acres on the ground.

Data quoted for an individual sample point 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 volume and mean grading of the mineral as a whole in each Resource Block are given in the Report.

Compiled from 6" sheets last fully revised 1894-1930.
Other systematic revision 1938-54 has been incorporated.
Some major roads revised 1972.
Some afforestation revised 1967.

Original geological survey on the six-inch scale by R. L. Jack and J. S. G. Wilson about 1875

Revised by M. Armstrong, I. H. Forsyth and E. H. Francis between 1958 and 1961. J. R. Earp and T. R. M. Lawrie, District Geologists

Partial re-survey by M. Armstrong in 1981. J. H. Hull, District Geologist

Sand and Gravel survey by A. J. Shaw and A. M. Aitken in 1981 under the supervision of E. F. P. Nickless

R. G. Thurrell, Head, Industrial Minerals Assessment Unit

The 1:25 000 Sand and Gravel Resource Sheet published 1982
G. M. Brown, D. Sc., F. R. S., Director, Institute of Geological Sciences

Borehole Graphics drawn by computer using programs written by J. L. McInnes, N E R C Computing Service, I G S, Edinburgh

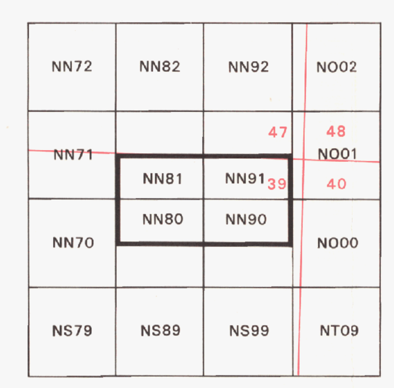


Diagram showing the relation of the National Grid 1:25 000 sheets with the One-Inch Geological Sheets 39, 40, 47 and 48

Produced for the Institute of Geological Sciences by Clyde Surveys Scotland Ltd, Livingston, West Lothian
Printed by John Bartholomew & Son Ltd, Edinburgh 1982

Detailed records may be consulted on application to the Officer-in-Charge, Industrial Minerals Assessment Unit, Institute of Geological Sciences, Murchison House, West Mains Road, Edinburgh EH9 3LA

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Made ground - waste and/or natural earth materials deposited on the original ground surface MG-3

Landslip L-1

DRIFT

Quaternary

Peat P-1

Alluvium (undifferentiated) - sand, gravel, silt and clay A-76

Alluvial fan AF-4

Scree and Head - talus and stony sandy clay respectively (the latter proved only in boreholes) SC-2

Late-Glacial alluvium - flattish spreads of sand and gravel LG-4

Late-Glacial raised estuarine deposits - sand with clay, silt and gravel LG-5

Glaciolacustrine deposits - fine sand, silt and clay, usually laminated (proved only in boreholes) G-5

Glacial sand and gravel - deposits vary from well sorted sand, gravel and silt beneath terraces to drapes of poorly sorted clayey sand and gravel GS-84

Till - stony clay, often sandy TL-19

SOLID

Bedrock, undifferentiated - Bedrock is predominantly of Lower Devonian age and forms part of the Lower Old Red Sandstone. It mainly comprises sandstones with interbedded siltstones, mudstones and conglomerates. Mudstone crops out towards the south-west of the resource sheet area. The Ochil Hills are composed of lavas and lava conglomerate (see Figure 3 in report)

BOUNDARY LINES

Geological boundary

Geological boundary following back-feature of terrace, downward slope in direction of arrowhead

Line marking back-feature of terrace, downward slope in direction of arrowhead

Glacial drainage channel, arrow shows direction of water flow

Inferred boundary between categories of deposits at surface

Inferred boundary between categories of deposits at depth

Resource block boundary

BOREHOLE AND OTHER DATA

SITE LOCATIONS

Industrial Minerals Assessment Unit (I M A U) boreholes

Other borehole

Shallow pit

I M A U BOREHOLES

Registration Number → 80 NW 2
111.6 366 ← Surface level in metres and feet above OD (Newlyn)
Borehole Site
Geological Classification
0.3 ← Overburden
2.9 ← Mineral (sand and gravel)
1.8 ← Waste
Grading Diagram
2.8
0.6+ ← 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

Registration Number

Each I M A U borehole is identified by a registration number, for example **80 NW 2**
The first numbers and letters refer to the quarter sheet and the final figures to the I G S serial numbers for that quarter. The unique designation for borehole **80 NW 2** is **NN 80 NW 2**

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**

Note:
When grading data are not sufficiently detailed or are absent the grading diagram is crossed through and shown without ornament

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 I M A U boreholes, for example, **80 NW 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, for example, **91 SE X5**

SHALLOW PITS

Where space permits the locations of shallow pits providing ancillary assessment data are shown by a distinctive symbol, thus ⌶. Otherwise information is shown in the same way as for boreholes

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

Discontinuous spreads of potentially workable sand and gravel exposed or beneath overburden CAT-D2

Sand and gravel not assessed 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, exposed or beneath overburden

Bedrock and waste, including overburden, are uncoloured

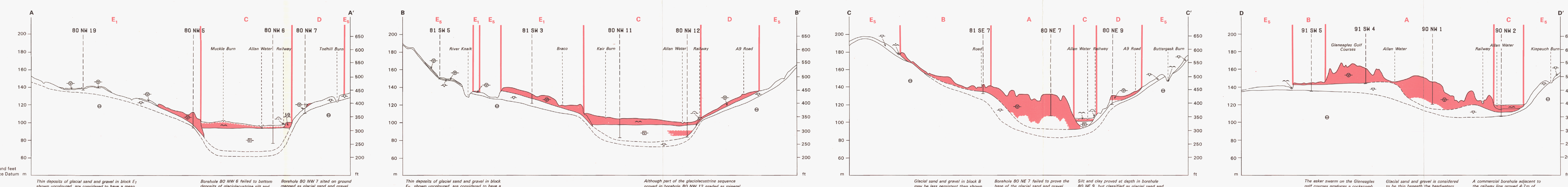
Geological boundary (broken line denotes uncertainty)

Inferred boundary limiting the extent of potentially workable material

Otherwise symbols and abbreviations as map legend

GENERALISED HORIZONTAL SECTIONS SHOWING RELATIONSHIPS OF DRIFT DEPOSITS

HORIZONTAL SCALE 1:25 000 VERTICAL EXAGGERATION x12·5



Thin deposits of glacial sand and gravel in block E1 shown uncoloured, are considered to have a mean thickness of less than one metre and are judged not potentially workable

Borehole 80 NW 6 failed to bottom deposits of glaciolacustrine silt and clay

Borehole 80 NW 7 sited on ground mapped as glacial sand and gravel failed to prove any, and although the till graded as mineral it has been excluded from the assessment

Thin deposits of glacial sand and gravel in block E5, shown uncoloured, are considered to have a mean thickness of less than one metre and are judged not potentially workable

Although part of the glaciolacustrine sequence proved in borehole 80 NW 12 graded as mineral the deposit has been excluded from the calculation of volumes

Glacial sand and gravel in block B may be less persistent than shown on the line of section

Borehole 80 NE 7 failed to prove the base of the glacial sand and gravel

Silt and clay proved at depth in borehole 80 NE 9, but classified as glacial sand and gravel, are also exposed lower down the hillslope to the north

The esker swarm on the Gleneagles golf courses produces a cockscomb effect on the line of section due to vertical exaggeration

Glacial sand and gravel is considered to be thin beneath the headwaters of the Allan Water

A commercial borehole adjacent to the railway line proved 4·7m of sand and gravel on till