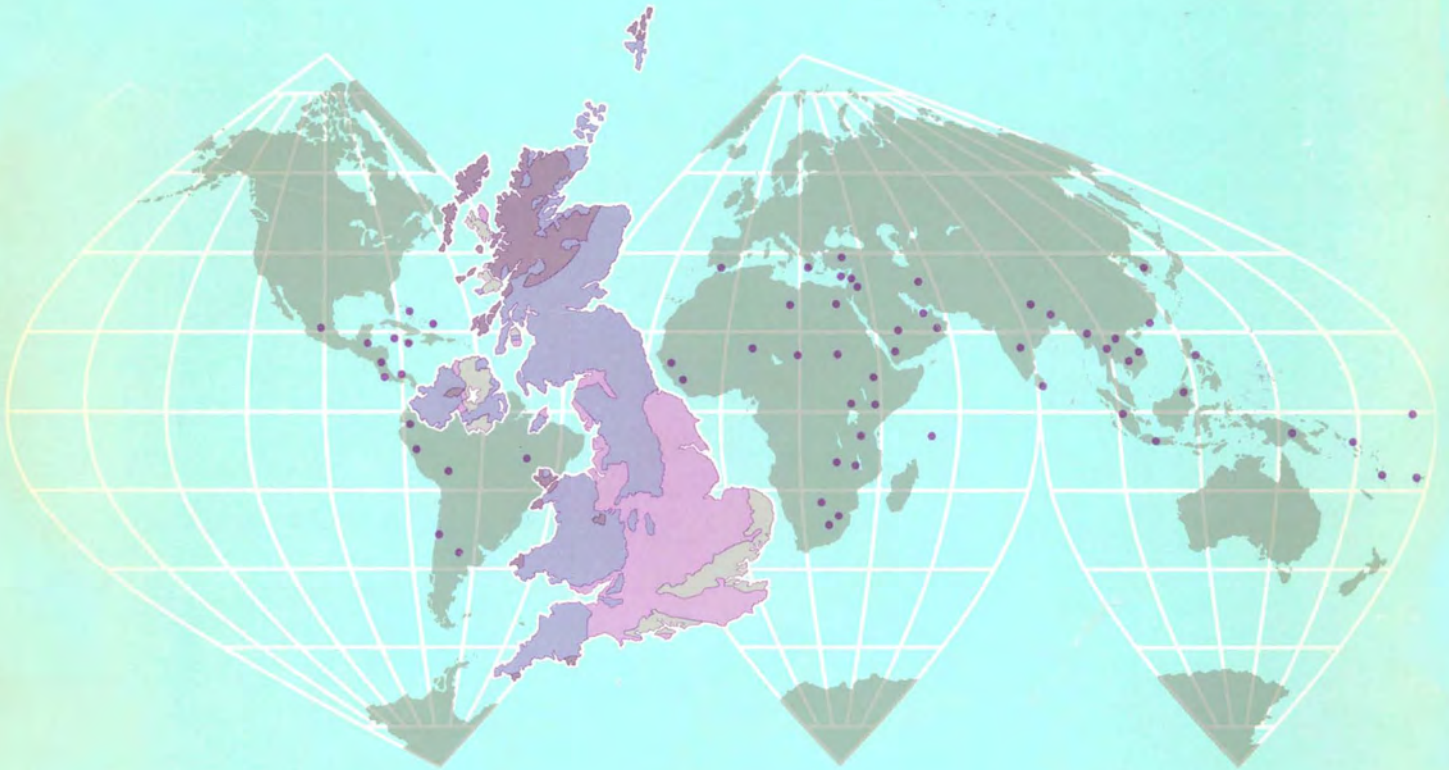




Sand and gravel resources of the Lothian Region of Scotland



INSTITUTE OF GEOLOGICAL SCIENCES

National Environment Research Council

Report 78/1

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Preface

This report is based upon published information, unpublished records in the Institute's files and recent observations in the field. It relates to resources and not to reserves. In the quantitative calculations little account has been taken of restraints to working the deposits, except that built-up areas have been indicated and mentioned in the text. Conservation and amenity considerations have been given only passing mention in the knowledge that detailed advice on these aspects can be had from the Nature Conservancy Council, 12 Hope Terrace, Edinburgh EH9 2AS.

The report has been assembled on the basis of information available at 30 April 1976. It is inevitably incomplete because of the uneven data cover. All quantities are approximate and, without doubt, silt, clay and other unsuitable materials have been included in places in the gross calculations. No account has been taken of deposits less than 2 m thick.

For each District the resources have been divided wherever possible into those above and those below the water table, so that the comparison can be made between the resources available to methods of extraction traditional in Scotland and resources available in some places by dredging. A list of working sand and gravel pits in each District, all of which were visited between February and April 1976, is given.

For many areas detailed records are available for consultation at the Institute of Geological Sciences, Murchison House, West Mains Road, Edinburgh EH9 3LA.

Mr McAdam has prepared the chapters on the City of Edinburgh, East Lothian and Midlothian, and has also compiled the whole report. Mr Collins contributed the chapter on West Lothian.

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Sand and gravel resources of the Lothian Region of Scotland

A. D. McAdam

Introduction

PHYSIOGRAPHY

The Lothian Region lies to the south of the Firth of Forth. It is bounded to the south by a watershed formed of the high ground around Fauldhouse and the Pentland, Moorfoot and Lammermuir Hills. The region is drained by several small north-easterly flowing rivers, mainly the Avon, which forms the north-westerly boundary, Almond, Water of Leith, North Esk, South Esk and Tyne. The Bathgate and Pentland Hills are the largest of several small hills that interrupt the general slope to the coast.

SOLID GEOLOGY

Most of the Lothian Region lies in the part of Scotland known geologically as the Midland Valley, which is bounded to the south-east by a major structure called the Southern Upland Fault. The part of the region formed by the Moorfoot and Lammermuir Hills lies south of this fault in an area of older rocks known geologically as the Southern Uplands.

The Southern Uplands area consists of greywackes and shales belonging to the Ordovician and Silurian systems. Greywackes are dark, hard, fissile, compact type of sandstone, siltstone and grit, generally dark grey in colour, but in places stained purple. As they are hard rocks and because much of the transport by ice and meltwater was northwards greywackes form a major component of gravels in the southern parts of the Region. Because the rock is fissile greywacke pebbles tend to be flattish in shape. The shales form only a small proportion of these strata, and being relatively soft rarely occur in the gravels.

The Midland Valley rocks belong to the Old Red Sandstone and Carboniferous systems. Old Red Sandstone sediments consist of red and pink sandstones and conglomerates, with red and green siltstones and mudstones. It is the sandstones and pebbles from the conglomerates which are hard and are found in the gravels. Carboniferous sediments are mainly inter-bedded grey mudstones and siltstones, white, brown and red sandstones, and grey limestones with thin bands of coal, oil-shale and ironstone. Generally it is the sandstones and more locally the limestones and ironstones that survive as pebbles in the gravels. Extrusive igneous rocks such as basalt and trachyte lavas and associated trachyte and dolerite intrusive igneous rocks

Bibliographical reference

McADAM, A. D. 1978. Sand and gravel resources of the Lothian Region of Scotland. *Rep. Inst. Geol. Sci.*, No. 78/1.

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occur throughout the Midland Valley part of the region, particularly in the Bathgate, Pentland and Garleton Hills. Being relatively hard rocks, pebbles from them form a significant part of the gravels in these areas.

SUPERFICIAL DEPOSITS

During the Ice Age, which ended less than 10 000 years ago, an ice sheet flowed generally eastwards across the Lothian Region. Detritus from this was deposited on the lower ground as boulder clay. During decay of the ice sheet glacial meltwater sorted and redeposited this material mainly in valleys in the form of mounds, ridges, terraces and flat spreads of sand and gravel. They are usually well-bedded and sorted with high proportions of gravel in the upper valleys and both sand and gravel in the lower areas. Silt and clay are present in the gravel matrix and as discrete beds in the sands. The majority of the pebbles in the gravels along the south of the region consist of greywacke. To the north the gravels contain mixed assemblages of pebbles mainly of Midland Valley origin. It is these deposits that are potentially the main sand and gravel resources of the region.

Some valleys of the preglacial river system have been recognised as buried channels infilled with debris which may include large volumes of sand and gravel as well as boulder clay. In most cases however these deposits are too little known or lie under too thick an overburden to be considered as resources.

Along the coastal areas of the region are raised beach deposits but these are mainly of silt, clay or fine sand with little good sand or gravel, and the deposits are largely built over. Associated with these are dunes of blown sand which are locally large enough to be considered resources.

Along the rivers are terraces and floodplains of alluvium. The constituent material of gravel, sand, silt and clay locally may offer some resources of sand and gravel, but it has not been possible to consider these in detail.

City of Edinburgh District

The City of Edinburgh District lies in a broad basin bounded to the south-east by the Pentland Hills and to the west by the Bathgate Hills in West Lothian. The land slopes gently north to the Firth of Forth, and is drained by the River Almond, the Water of Leith and their tributaries. The lower hills are generally formed by hard dolerite intrusions, and they have been moulded by glaciation into ridges lying in an east-west direction.

The rocks underlying the district are the main source of the material which forms the sand and gravel deposits. Their distribution largely controls the lithological content of the pebbles in each gravel deposit. The hardest and most durable rocks form the bulk of the

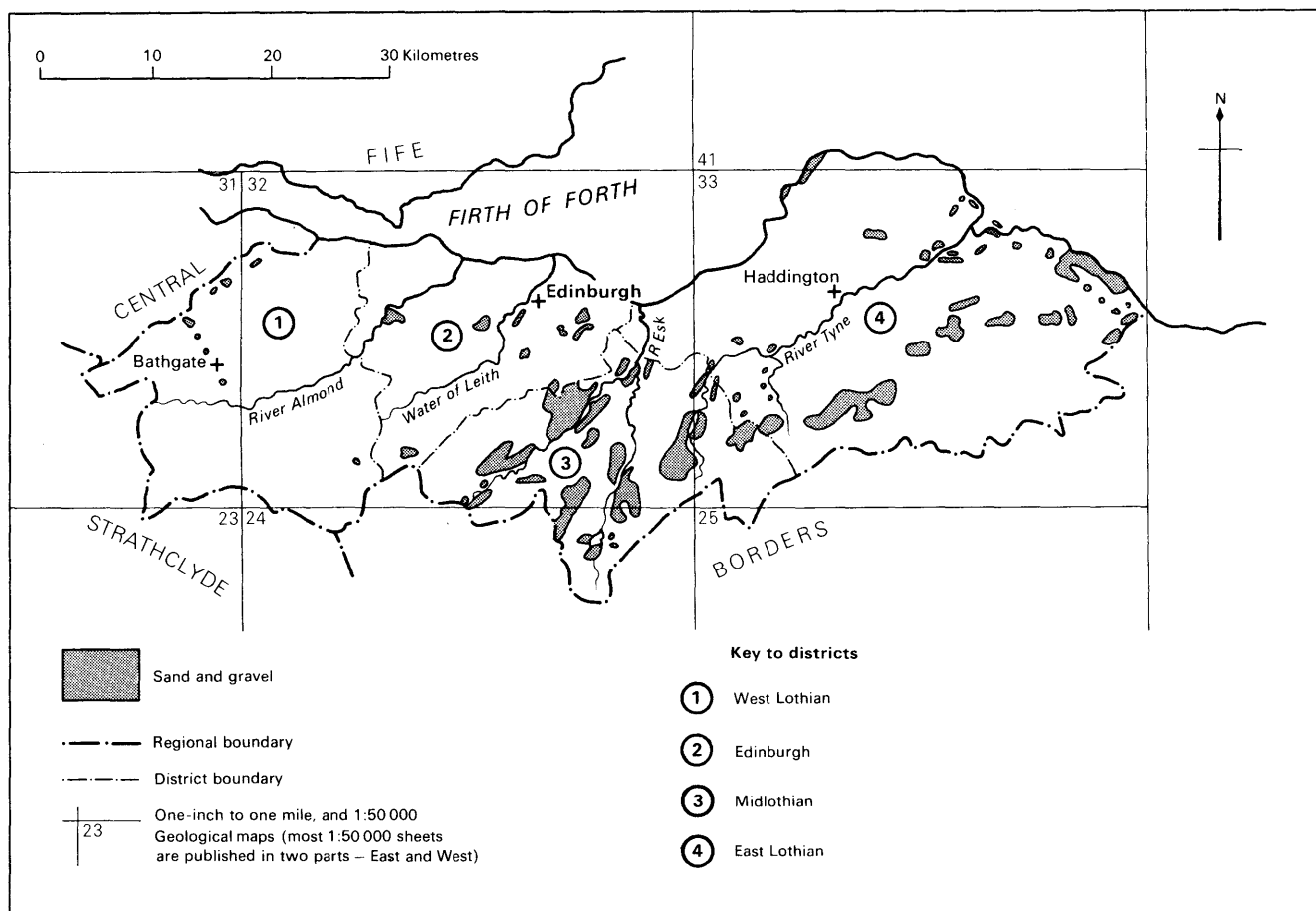


Figure 1 Sands and gravels of the Lothian Region

deposits. The main rock types occurring in Edinburgh can be summarised as follows:

White and brown sandstones with a few limestones and ironstones are the hardest of the Carboniferous sedimentary rocks which underlie most of the District both north-west and east of the Pentland Hills. Softer sedimentary rocks such as siltstone and mudstone occur in small proportions in some gravels, and coal in the form of fine fragments is common in the sands.

Red and pink sandstones of Old Red Sandstone age occur in a narrow belt along the north-west, north and north-east sides of the Pentland Hills.

Basalt and trachyte lavas, felsite intrusions and tuffs of Old Red Sandstone age make up the Pentland Hills. Similar basalt lavas and tuffs of Carboniferous age form Arthur's Seat, Calton Hill and Craiglockhart Hill.

Dolerite intrusions form many of the hills in the north-west half of the district, such as Corstorphine Hill and Dalmahoy Hill.

Vein quartz, the main minor constituent of the gravels, occurs in most of these rocks.

During the Ice Age an ice sheet flowed generally eastwards across Edinburgh, eroding the underlying rocks and depositing the debris as boulder clay on low ground. The boulder clay contains boulders and pebbles which generally correspond in composition to the underlying rocks. As the ice decayed glacial meltwater eroded both the boulder clay and the underlying rocks, washed out most of the clay and silt, and deposited the sand and gravel fractions. It is the few larger deposits of this kind that form the very limited sand and gravel resources of the Edinburgh District.

The main glacial meltwater flowed along the edge of

the ice sheet as it retreated north down the slopes from the Pentland Hills as far north as Newbridge and Corstorphine. Most of the associated deposits are however small and insignificant. Glacial meltwater in the Esk Valley laid down extensive sand and gravel deposits but these lie mainly in Midlothian District, only a small area at Straiton being in Edinburgh. Sand and gravel deposits that are sufficiently thick and extensive to be considered as resources are shown on Figure 2, numbers in circles referring to the localities described below.

During periods of higher sea level at the end of and after glaciation, raised beach deposits were laid down along the coastal areas. These however consist mainly of silt, clay and fine sand, and contain little coarser sand and gravel.

River action along the main valleys caused erosion of the glacial sand and gravel deposits, the boulder clay, and the underlying rock. This material was redeposited as alluvial deposits in the form of river terraces, floodplains, and lake alluvium which contain gravel, sand, silt and clay in varying proportions. As the proportion of sand and gravel in these deposits is small compared with silt and clay, they are unlikely to constitute a source of sand and gravel.

DEPOSITS ABOVE THE WATER TABLE Glacial sand and gravel

Locality 1: Bavelaw

On the slopes of the Pentland Hills near Bavelaw, 5 km south-south-west of Balerno are sandy deposits in the form of mounds from 5 to 15 m high. Small natural

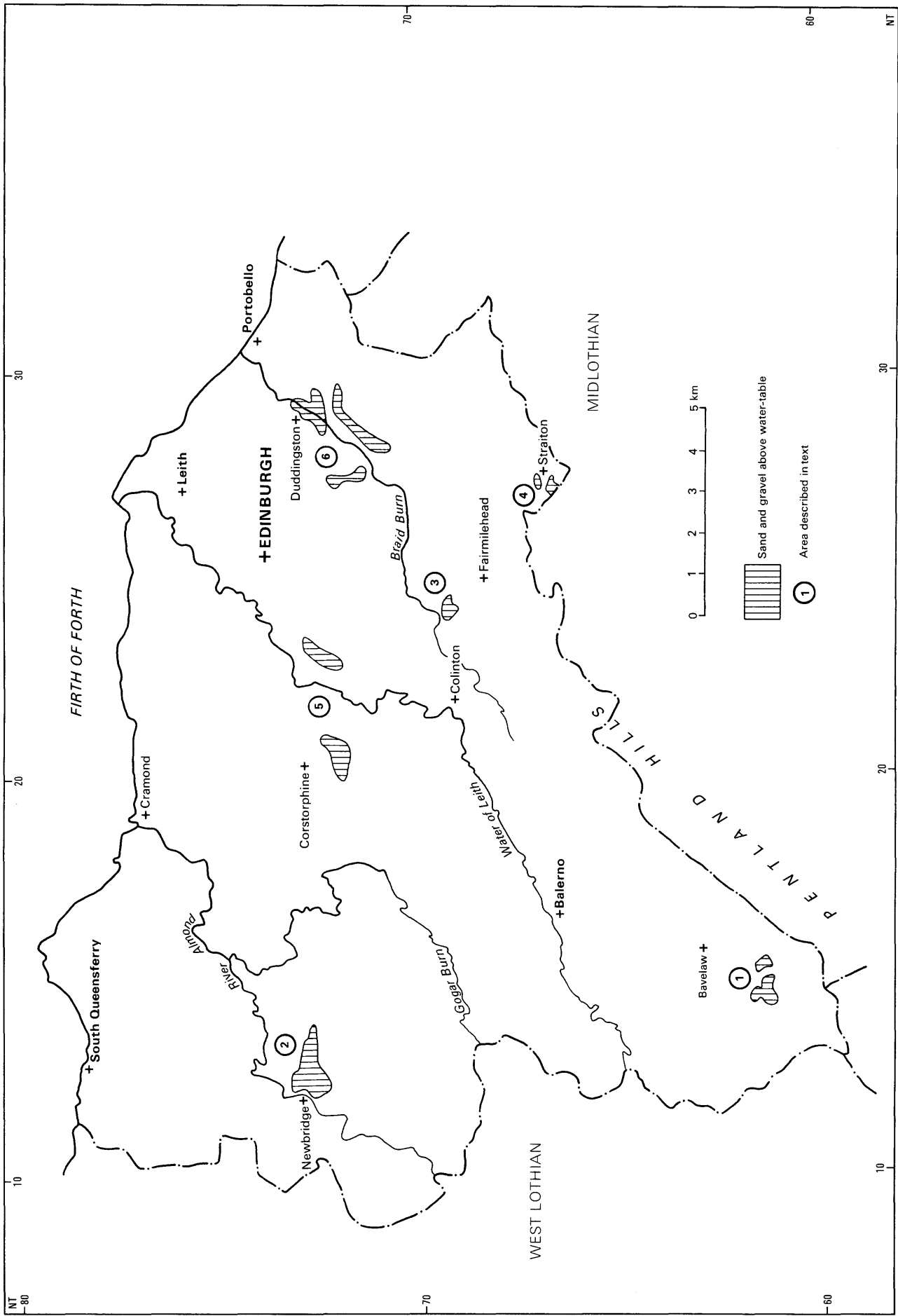


Figure 2 Distribution of sands and gravels in the City of Edinburgh

exposures suggest that the deposits consist mainly of fine sand and silt with minor proportions of medium and coarse gravel and boulders up to 30 cm. Half the pebbles consist of sandstone and the other half are mainly basalt, trachyte and tuff. The deposits cover 25 hectares, are estimated to average 5 m in thickness and contain resources estimated at 2.5 million tonnes. They lie in remote moorland, and several springs which contribute to the Edinburgh public water supply rise in this vicinity. These constraints and their poor quality make the deposits an unpromising prospect.

Locality 2: Newbridge

Moundy terrace deposits lie about 5 m above the alluvial flat of the River Almond at Newbridge. No natural sections were seen in these deposits, but several boreholes through them recorded 3 to 9 m of sand and gravel, probably of good quality. The deposits cover 75 hectares, are estimated to average 4 m in thickness and contain resources estimated at 6 million tonnes. Industrial, housing, road and airport developments have however sterilised virtually all of these otherwise promising deposits.

Locality 3: Fairmilehead

North of Fairmilehead lies a moundy deposit, some 5 hectares of which were worked out in the former Comiston Sand Pit. Sections in the pit showed the deposit to be at least 7 m thick and to consist mainly of sand with minor proportions of gravel. The remaining 20 hectares of deposits are estimated to average 4 m in thickness and contain resources estimated at 1.6 million tonnes. As they are entirely built over there is little prospect of these deposits being worked.

Locality 4: Straiton

The gently undulating upstanding ground at Straiton is formed of sand and gravel that is part of deposits extending over a large area of the Esk Valley in Midlothian. The deposits lie on a lower boulder clay and are usually concealed by an upper boulder clay 1 or 2 m thick. Several boreholes in the deposits indicate that the sand and gravel varies from 4 to 15 m in thickness, while sections in the now disused Straiton Pit [NT 273 667] show about 6 m of deposits. Two-thirds of these are of bedded fine silty sand with clay bands. The remainder consists of bedded gravel which is mainly fine to medium with bands of coarse sand, but also has coarse gravel with boulders up to 30 cm. The gravels are set in a medium sand matrix. Just under half the pebbles consists of white, brown and red sandstone, about half consists of basalt, trachyte and dolerite, and there are minor proportions of vein quartz, limestone, ironstone and shale. Only about 2 hectares of the deposits have been worked out leaving 30 hectares which underlie mainly arable land but with some road and industrial development. The deposits are estimated to average 6 m in thickness and contain resources estimated at 3.6 million tonnes. They constitute the only promising deposits in the Edinburgh District but any further development will increase the area of sterilisation.

Locality 5: Corstorphine

South of Corstorphine is a moundy plateau area some 6 m high of a sand and gravel deposit about which little is known. It is completely sterilised by urban development. Some 2 km to the east at Gorgie lies another area of deposit with at least 4.5 m of sand proved in one borehole. This area is also entirely built over. The deposits

cover 90 hectares, are estimated to average 3 or 4 m in thickness and contain resources estimated at 6.4 million tonnes.

Locality 6: Duddingston

In the west at Priestfield lies an area with mounds 3 to 5 m high about which little is known. It is completely built over. To the north-east a moundy deposit up to 6 m high thought to be sand and gravel underlies Duddingston Golf Course, other parkland and part of a nature reserve. At Craigmillar to the south-east is a terrace of sand gravel 3 to 5 m high, the eastern half of which has been built over, and the rest of which underlies arable land. The deposits cover 125 hectares, are estimated to average 3 m in thickness and contain resources estimated at 7.5 million tonnes. Only about 15 hectares at Craigmillar has not been sterilised so far.

Raised beaches

Along the coastal area most of the land below 30 m OD is underlain by raised beach deposits. Higher beach deposits from 30 m down to 8 m OD are generally about 5 to 8 m thick and consist mainly of silt, clay and fine sand, with minor proportions of coarser sand and gravel. The lower beach is in the form of a cliff-backed terrace at 8 m OD and generally has only thin deposits of sand and gravel. Almost the entire area of these deposits is built over. Raised beach deposits in this area offer no foreseeable potential as sources of sand and gravel.

DEPOSITS BELOW THE WATER TABLE

Buried channels

Evidence from borehole records shows that buried channels about 1 km wide filled with up to 70 m of glacial deposits lie along the valleys of both the River Almond and the Water of Leith. The buried channel of the Almond lies just to the north-west of the present river through Newbridge but from there it diverges to reach the coast at a point 2 km north-west of the present estuary. Sand and gravel form only a small proportion of the deposits recorded in boreholes into the buried channel, the bulk consisting of boulder clay and boulders. The buried channel of the Water of Leith is known from Colinton to Leith, but it is filled almost entirely with boulder clay, and is entirely built over. In this area buried channels offer little potential as sources of sand and gravel.

Alluvial deposits

Extensive areas of river terrace and floodplain alluvium occur in the valley of the River Almond around Newbridge, whereas along the Water of Leith and some of the other minor valleys only narrow floodplains are present. Lake alluvium has filled many hollows, the most notable deposits lying the east-west valley at Corstorphine. Although coarser sand and gravel are present in these alluvial deposits, they form only a small proportion, the bulk being silt, clay, fine sand and in places peat. These deposits are considered to have little potential as sources of sand and gravel.

East Lothian District

The East Lothian District slopes down from the Lammermuir Hills in the south to the Firth of Forth. The southern part of the district is drained by the River Tyne which flows on a broad plain around Haddington and then through a narrow gorge at East Linton before

reaching the coast. In the north a broad east-west valley drained by the Peffer lies between the Garleton Hills and high ground stretching from Gullane to Whitekirk.

The rocks underlying the district are the main source of the material which forms the sand and gravel deposits. Their distribution largely controls the lithological content of the pebbles in each gravel deposit. The hardest and most durable rocks form the bulk of the deposits. The main rock types occurring in East Lothian can be summarised as follows:

Greywackes of Ordovician and Silurian age form the Lammermuir Hills in the south, and they are common in the deposits which lie along the foothills. Greywacke is a dark compact type of sandstone, siltstone and grit.

White, brown and red sandstones, limestones and ironstones are the hardest of the Carboniferous sedimentary rocks which underlie extensive areas in the western and eastern parts of the district. Many of the sandstone pebbles, however, are quite soft compared with basalt, dolerite, limestone or quartzite. Even softer rocks such as siltstone and mudstone occur in small proportions in some gravels, and coal in the form of fine fragments is common in some sands.

Basalt and trachyte lavas, trachyte and dolerite intrusions and tuffs of Carboniferous age underlie an extensive area in the middle of the district from Garvald and Gifford in the south to Gullane, North Berwick and Whitekirk on the coast.

Of the minor constituents of the gravels, quartz occurs as veins in most other rocks, quartzite comes from beds of conglomerate which occur in the Eastern Lammermuir Hills and also interbedded with red sandstones, and pink felsite comes from minor intrusions in the greywackes of the Lammermuir Hills.

During the Ice Age an ice sheet flowed generally eastwards across East Lothian eroding the underlying rocks and depositing the debris as boulder clay on low ground. The boulder clay contains boulders and pebbles which generally correspond in composition to the underlying rocks. As the ice decayed glacial meltwater eroded both the boulder clay and the underlying rocks, washed out most of the clay and silt, and deposited the sand and gravel fractions. It is the many deposits of this kind that form most of the extensive sand and gravel resources of East Lothian.

Glacial meltwater flowed between the southern margin of the ice sheet and the north-west and north-east slopes of the Lammermuir Hills. As the ice margin retreated northwards and meltwater escaped by new and progressively more northerly routes into the valley of the River Tyne and to the sea. As a result deposits of sand and gravel dissected by glacial drainage channels are to be found all along the Lammermuir foothills from Humbie to Dunbar and along the coast to Oldhamstocks. Some meltwater escaped eastwards through the Lammermuir Hills via Halls and Woodhall laying down sand and gravel which now forms large ridges. At a time when ice was banked up against the north-facing slopes of the Garleton Hills similar but smaller mounds and ridges of sand and gravel were deposited around East Fortune.

Glacial sand and gravel was laid down in the form of flat spreads, kames (moundy areas often with damp hollows known as kettle holes) and eskers (narrow, sinuous, sharp-topped ridges). They usually lie on an irregular boulder clay surface. Later erosion by glacial or river drainage has in many places dissected the

spreads of sand and gravel and left the deposits as isolated terraces or plateaus often high above the present river. Although sand and gravel deposits are very widespread only certain parts are sufficiently thick and extensive to be considered as resources. These are shown on Figures 3.1 and 3.2, numbers in circles referring to the localities described below.

Raised beach deposits were laid down along the coastal areas towards the end of and after the glacial period when sea level was considerably higher than at present. These consist mainly of silt, clay and fine sand, and contain little coarser sand and gravel, except in the valley of the River Tyne below East Linton where some deposits consist predominantly of sand and gravel.

In some coastal areas beach and raised beach sand has been redeposited by wind action in mounds and dunes, some of which at Gullane and Whitekirk are big enough to constitute resources of sand. These deposits contain the only two working sand pits in the district.

River action along the main valleys caused erosion of the glacial sand and gravel deposits, the boulder clay and the underlying rock. The eroded material was redeposited as alluvial deposits in the form of river terraces, floodplains and lake alluvium which contain gravel, sand, silt and clay in varying proportions. As the proportion of sand and gravel in these deposits is small they are unlikely to constitute a source of sand and gravel.

DEPOSITS ABOVE THE WATER TABLE

Glacial sand and gravel

Locality 1: Ormiston

South of Ormiston three small sand and gravel deposits covering 30 hectares are a continuation of larger deposits at Oxenfoord in Midlothian. Terrace deposits occurring on both banks of the River Tyne are 5 to 8 m high. Further south is an area of mounds which reach 4 m in height. There is a scarcity of natural exposures, but from comparison with Oxenfoord the deposits probably contain sand and fine to coarse gravel which consists predominantly of sandstone pebbles. A flat area of 50 hectares lying north of Ormiston has been proved by boreholes to be underlain by up to 4.7 m of sand and gravel. The 80 hectares of deposits occupy arable land, are estimated to average 3 m in thickness and contain resources estimated at 4.8 million tonnes.

Locality 2: Pencaitland

At Pencaitland and south from there on the west bank of the Birns Water several small isolated terrace, mound and ridge deposits are all about 5 m high. Natural exposures indicate that they contain both fine to medium sand and medium to coarse gravel, with boulders up to 30 cm. Over half the pebbles are white, brown and red sandstones, with significant proportions of greywacke and basalt and small proportions of vein quartz, quartzite, ironstone, limestone and felsite. The deposits cover 35 hectares of arable land, are estimated to average 3 m in thickness, and contain resources estimated at 2.1 million tonnes.

Locality 3: Humbie

The north bank of the Keith Water and the area between the Keith and Humbie Waters are underlain by extensive deposits which have been dissected by numerous glacial and river channels and now lie high above the present river valley bottoms. The deposits in places are flat-topped but elsewhere there are mounds and

ridges from 4 to 10 m high. Exposures in natural sections and in several small disused sand pits show that the area has a complex sequence of at least two sand and gravel deposits and at least two boulder clays. Fine to coarse gravel with boulders up to 30 cm occurs in some of the mounds and generally in the upper deposits, whereas the lower deposits are mainly fine to medium evenly-bedded and cross-bedded sand with thin clay bands. In the natural section of Red Scar [NT 439 630] over 15 m of both sand and gravel have been recorded, and in two old pits [NT 450 640, NT 452 638] on either side of the valley east-south-east of Old Windy Mains, 6 to 7 m of sand are exposed. Over half the pebbles consist of white, brown and red sandstones, a fifth are of greywacke, a tenth of basalt, and there are small proportions of vein quartz, quartzite, dolerite, felsite and limestone. The deposits underlie 325 hectares of arable land. They are estimated to average 5 to 6 m in thickness in the centre, only 3 m towards the edges, and contain resources estimated at 36 million tonnes. Because of the complex sequence of these thick deposits they merit further investigation to establish their potential.

Locality 4: Kidlaw

In the west the deposits occur as mounded areas or isolated mounds up to 5 m high and to the east they form terrace deposits up to 5 m thick. Natural exposures indicate that the deposits are mainly medium to coarse gravel with boulders up to 50 cm set in a matrix of coarse sand, fine gravel and silty clay. Half to three-quarters of the pebbles and boulders consist of mainly red sandstone, most of the rest are of greywacke with small proportions of dolerite, basalt, felsite, vein quartz and quartzite. The deposits cover 70 hectares of arable and pasture land, are estimated to average 3 m in thickness, and contain resources estimated at 4.2 million tonnes.

Locality 5: Stobshiel

Two areas of mounded deposits 5 to 12 m high are located in the upper reaches of the Birns Water at Stobshiel. Natural exposures and an old pit [NT 500 623] with 6 m of deposits indicate that they consist mainly of medium to coarse gravel, boulders up to 30 cm and a few bands of coarse sand. The majority of the pebbles and boulders are purple greywacke with some red sandstone, vein quartz and igneous rocks, set in a silty matrix of coarse sand and fine gravel. The deposits lie close to Stobshiel Reservoir and its filter station. The deposits cover 20 hectares, are estimated to average 5 m in thickness, and contain resources estimated at 2 million tonnes.

Locality 6: Newton Hall

Around Newton Hall deposits up to 5 m thick form a dissected mounded plateau that is a continuation of the Kidlaw deposits. Surface information is scarce, but the deposits contain some fine sand as well as medium to coarse boulder gravel. The pebbles are predominantly sandstone, with some greywacke. The deposits underlie 130 hectares of arable land, are estimated to average 3 m in thickness, and contain resources estimated at 7.8 million tonnes.

Locality 7: Latch

Along the foot of the Lammermuir Hills at Latch deposits occur as mounded esker ridges 5 to 10 m high separated by deep glacial drainage channels. Natural sections show that the deposits contain fine to coarse

gravel with boulders up to 40 cm set in a silty coarse sand matrix. Over four-fifths of the pebbles and boulders consist of mainly purple greywacke, with some red and white sandstones and minor proportions of vein quartz, dolerite and felsite. In the east where the mounds are lower, sections in the Long Yester Pit [NT 533 641], which was just being established in 1976, show up to 5 m of fine to coarse boulder gravel and up to 8 m of fine bedded sand with red clay bands. This fine sand formed the bulk of the 8 m thick deposit in an old pit 600 m further south-east [NT 538 637]. The deposits cover 55 hectares part of which is afforested. They are estimated to average 5 m in thickness and contain resources estimated at 5.5 million tonnes.

Locality 8: Long Yester

Around Long Yester are extensive kame terraces and mounded esker ridges generally 5 to 10 m high dissected by glacial drainage channels. Natural exposures indicate that the deposits are mainly fine to coarse gravel with boulders up to 40 cm set in a coarse sand matrix. Some sand is probably present. Half to two-thirds of the pebbles and boulders consist of red, white and brown sandstones, about a third are greywacke, and there are small proportions of dolerite, basalt, felsite, vein quartz, quartzite, ironstone and shale. The deposits cover 200 hectares of arable land, are estimated to average 6 m in thickness in the south, 4 m in the north, and contain resources estimated at 20 million tonnes.

Locality 9: Garvald

Mainly south-west of Garvald lies a dissected mounded spread in the form of terraces and plateaus perched high above the glacial and river channels. The mounds are 3 to 8 m high and the terrace deposits about 5 m thick. Natural exposures indicate that fine to coarse gravel makes up the bulk of the deposits, though some sand is also present. Greywacke forms about half the pebbles and red, white and brown sandstones form about a third in the south-west; but to the north-east the proportion gradually changes to about a fifth and two-thirds respectively. Basalt, dolerite, trachyte, felsite, vein quartz and quartzite are the main minor constituents present. The matrix is generally coarse sand. The deposits cover 120 hectares of arable and upland ground, are estimated to average 3 or 4 m in thickness and contain resources estimated at 8.5 million tonnes.

Locality 10: Castle Moffat

Mounds of greywacke gravel 5 to 10 m high occur in small valleys at the foot of the Lammermuir Hills near Snawdon, Castle Moffat and Stonepath. In a small pit at Castle Moffat [NT 609 689] a typical 6 m section shows the deposits to be mainly fine to coarse gravel with boulders up to 30 cm set in a coarse greywacke sand matrix. There are also bands of fine to coarse sand. The pebbles are predominantly greywacke, with about a tenth being of sandstone, and smaller proportions of vein quartz, basalt and felsite. The deposits cover 60 hectares of remote upland, are estimated to average 5 m in thickness at Snawdon, 3 or 4 m elsewhere, and contain resources estimated at 4.4 million tonnes.

Locality 11: Stenton

Along both banks of the Biel Water, above and below Stenton, several isolated mounded terrace deposits have been dissected by glacial drainage channels and are now perched high above the deeply-incised river valley. The

mounds are generally 3 to 8 m high and the terraces up to 5 m thick. Surface evidence indicates that the deposits consist mainly of fine to coarse gravel, locally with boulders up to 50 cm, set in a matrix of fine to coarse sand. Red, white and brown sandstones form about two-thirds of the pebbles and boulders, with some greywacke and basalt, and minor proportions of vein quartz, quartzite, dolerite, trachyte and felsite. The deposits cover 95 hectares of arable land, are estimated to average 3 m in thickness, and contain resources estimated at 5.7 million tonnes.

Locality 12: Halls

In the upland area around Halls large kame-terrace and esker ridge deposits of greywacke gravel are 5 to 10 m thick. Surface evidence indicates that they are fine to coarse gravel with boulders up to 35 cm set in a matrix of coarse greywacke sand and silty clay. At least three-quarters of the pebbles and boulders consist of greywacke, the rest being mainly red sandstone with small proportions of vein quartz, felsite and dolerite. The deposits cover 65 hectares, are estimated to average 3 or 4 m in thickness, and contain resources estimated at 4.9 million tonnes.

Locality 13: Woodhall

Along the valley south of Woodhall several prominent east-west oriented esker ridges of greywacke gravel, 5 to 15 m high, lie well above the intervening glacial drainage channels. Farther east the deposits are smaller, mounded and less distinct. Evidence from natural exposures and small pits show that the deposits consist mainly of fine to coarse gravel with a matrix of coarse greywacke sand and silty clay. Locally there are boulders up to 40 cm and elsewhere there are indications of fine to coarse red sand. Greywacke, mainly purple-stained, forms over four-fifths of the pebbles and boulders, while red sandstone makes up most of the remainder, with some vein quartz, felsite and dolerite. The deposits cover 115 hectares of fairly remote upland area. They are estimated to average 4 or 5 m in thickness in the west, 3 m in the east, and contain resources estimated at 9.4 million tonnes.

Locality 14: Dunbar

South of Dunbar isolated areas of gravel mounds, the largest of which are 3 to 8 m high, lie on red boulder clay. Sections in a cutting for the A1 road at Broxburn through one such area showed deposits of fine to coarse gravel with a matrix of medium to coarse sand. Some bands of sand may also occur. Boulders up to 40 cm are found elsewhere in the deposit. About half of the pebbles and boulders consist of red and white sandstones, a third are greywacke, and basalt, trachyte, dolerite, vein quartz, quartzite and limestone also occur. The deposits underlie 130 hectares of arable land, are estimated to average 3 m in thickness, and contain resources estimated at 7.8 million tonnes.

Locality 15: Oxwellmains

A series of mounded kame-terraces 3 to 6 m high extend along the coast south-east of Dunbar. Boreholes through the deposits show that 5 to 11 m of sand and gravel rest on red boulder clay. Records of the now-restored Little Pinkerton Pit [NT 696 762] show the deposit to be at least 5 m thick consisting mainly of fine to coarse gravel with about a quarter being red sand. Two-thirds of the pebbles consist of greywacke, the remainder being mainly red and brown sandstone, with some vein quartz, quartzite, basalt, dolerite, trachyte, felsite and limestone.

The deposits underlie 365 hectares of arable land, are estimated to average 3 or 4 m in thickness, and contain resources estimated at 25 million tonnes.

Locality 16: Innerwick

Numerous isolated gravel mounds 3 to 13 m high rest on red boulder clay slopes along the higher coastal area from Innerwick to Bilsdean. Natural exposures indicate that the deposits consist mainly of fine to coarse gravel with a coarse sand matrix, though some sand may also be present. The pebbles are predominantly greywacke, with some red and brown sandstone and minor proportions of vein quartz, quartzite and igneous rocks. The deposits underlie 130 hectares of arable land, the mounds forming prominent features on the landscape. They are estimated to average 3 or 4 m in thickness, and contain resources estimated at 8.9 million tonnes.

Locality 17: Oldhamstocks

High mounded plateaus of sand and gravel occur along the valley below Oldhamstocks and are part of large sand and gravel deposits extending as far as Cockburnspath in Berwickshire, where they are worked in a pit at Kinegar. The mounds are generally 5 to 10 m high, are dissected by glacial drainage channels, and lie high above the deeply-incised river valleys. The valley west of Oldhamstocks is almost blocked by Haystall Knowe, a very large ridge covering 8 hectares, the top 15 m of which appears to be gravel. Natural exposures indicate that the deposits contain fine to coarse gravel with a red silty sand matrix, but comparison with the Berwickshire deposits suggests that at least half of the deposits could be sand. Greywacke makes up the majority of the pebbles, the small proportion of red and brown sandstone diminishing upstream, and there are a few vein quartz, felsite and dolerite pebbles. The deposits cover 95 hectares, are estimated to average 10 m in thickness at Haystall Knowe, 5 m elsewhere, and contain resources estimated at 9.7 million tonnes.

Locality 18: East Linton

On both banks of the River Tyne below East Linton mounded sand and gravel deposits have been partly modified into raised beach terraces by marine action when sea level was between 20 and 25 m OD. The mounds are from 3 to 8 m high and the terraces about 4 or 5 m high. Natural exposures indicate that the deposits consist of sand and fine to medium gravel, locally where mounded with some coarse gravel. The pebbles are mixed, about two-fifths being sandstone, one-fifth greywacke, the rest mainly basalt, trachyte and dolerite, with a few vein quartz, quartzite, limestone and mudstone pebbles. Some 45 hectares of the deposits have been built over at East Linton, the remaining 225 hectares underlie arable land, are estimated to average about 3 m in thickness, and contain resources estimated at 16 million tonnes.

Locality 19: East Fortune

Mounds 3 to 8 m high, of sand and gravel form a kame and kettle topography on the watershed between the two Peffer Burns at East Fortune. Natural exposures show that both sand and fine to coarse gravel are present in the deposits. Brown and red sandstones make up over half the pebbles, while the rest are a mixture of greywacke, basalt, trachyte and dolerite, with a few of vein quartz, quartzite, limestone and mudstone. The deposits underlie 80 hectares of arable land, are estimated to average 5 m in thickness, and contain resources estimated at 8 million tonnes.

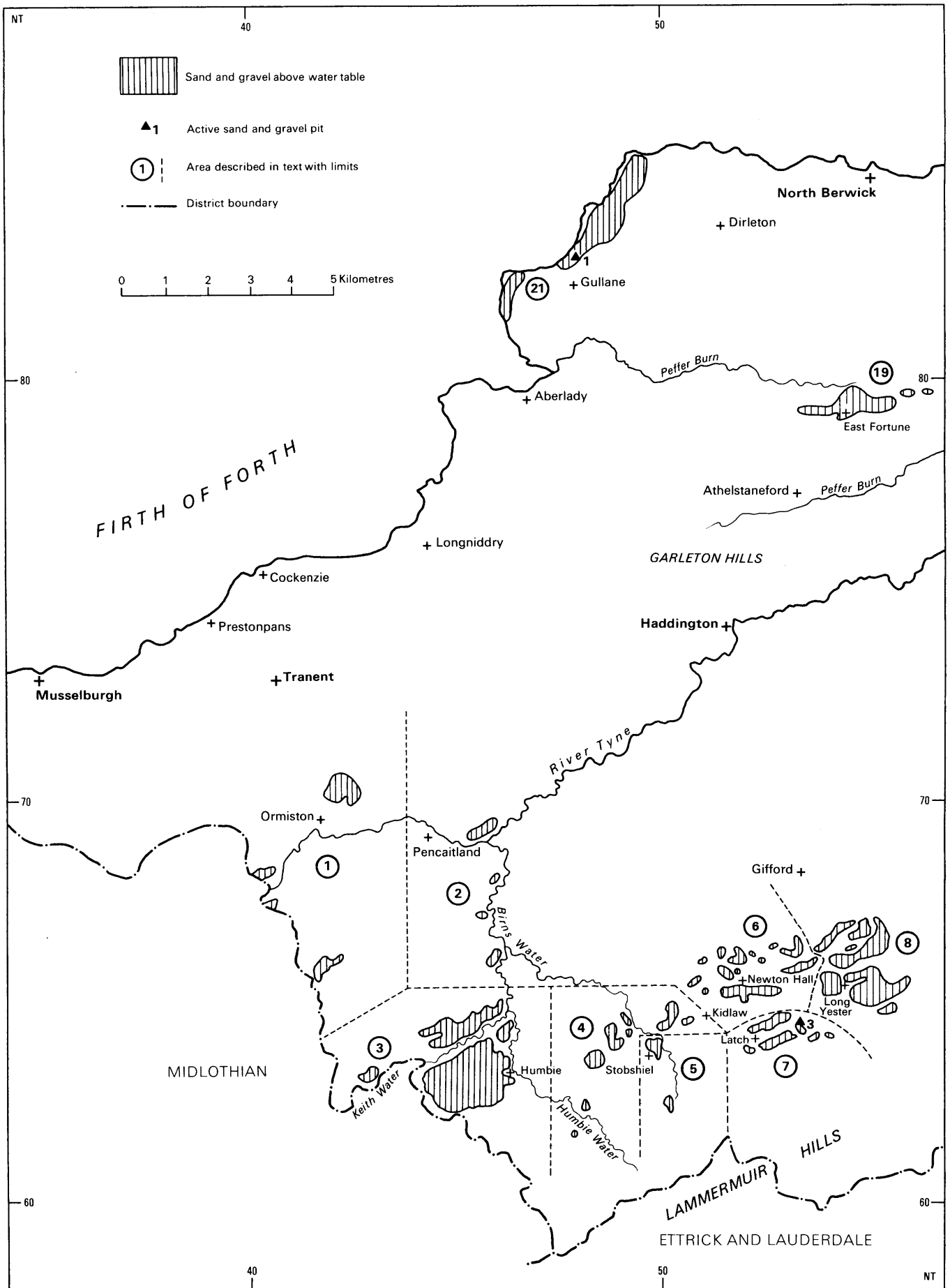


Figure 3.1 Distribution of sands and gravels in East Lothian (west part)

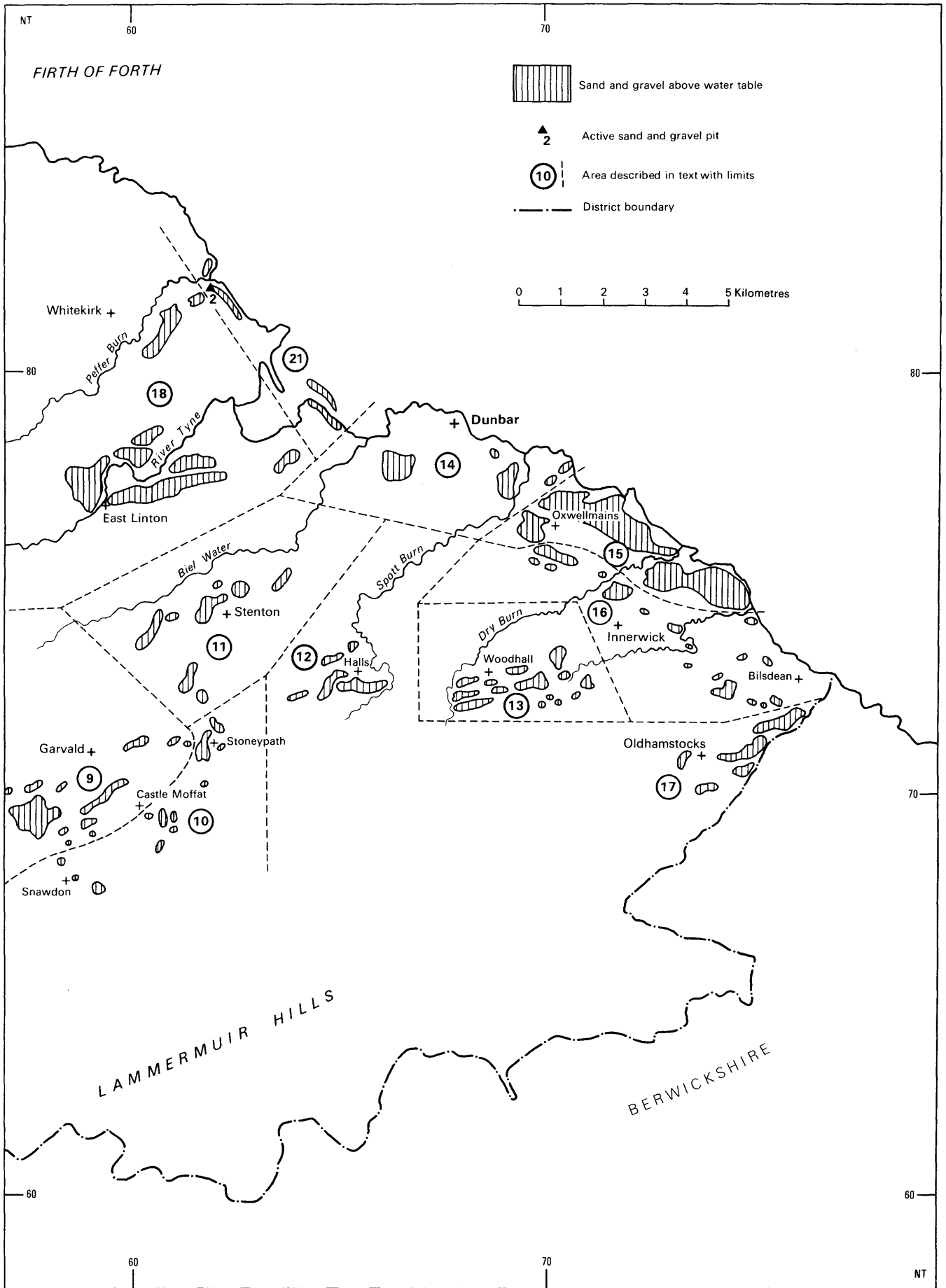


Figure 3.2 Distribution of sands and gravels in East Lothian (east part)

Raised beaches

Along the coastal areas much of the land below 30 m OD in the west and 20 m OD in the east is underlain by raised beach deposits. Higher beach deposits from 30 m down to 8 m OD in the west are generally thin and patchy with little sand and gravel, except in the Musselburgh area where the deposits are mainly built over. In the valleys of both Peffer Burns and the estuary of the River Tyne, the higher beach deposits though thick and well-developed consist mainly of silt and clay, except those in the East Linton area. The lower beach at 8 m OD is either in the form of a cliff-backed terrace generally with only a thin cover of sand and gravel, or extensive estuarine flats which consist mainly of silt and clay. Raised beach deposits in this area offer little potential as sources of sand and gravel.

Blown sand

Locality 21: Gullane and Whitekirk

Dunes of blown sand have developed all along the East Lothian coastline wherever there are extensive sandy beach or raised beach deposits. In many places the dunes are only a metre or two high, but at Gullane an extensive complex of dunes ranges from 3 to 12 m high while between Whitekirk and Dunbar the coastal dunes are up to 10 m in height. Small working pits are active in each area, Gullane Pit [NT 481 835] and Lochhouses Pit [NT 622 822]. Both show dunes of evenly-bedded and cross-bedded fine sand, the bulk of which is formed of fine quartz grains, about a tenth is coarse shell debris and a twentieth is very fine grains of dark minerals. At Gullane the deposits cover 175 hectares, are estimated to average 4 or 5 m in thickness, and contain resources estimated at 16 million tonnes. At Whitekirk they cover 25 hectares, are estimated to average 3 or 4 m, and contain resources of 1.8 million tonnes. These deposits are probably of limited potential because of restraints of amenity and conservation and the erosional dangers associated with breaching the protective vegetation.

DEPOSITS BELOW THE WATER TABLE

Alluvial deposits

Extensive areas of river terrace and floodplain alluvium occur in the valley of the Tyne at Haddington and below East Linton, whereas only narrow floodplains and terraces are present in the smaller valleys. Lake alluvium has filled many of the hollows in the irregular glaciated topography. Although coarser sand and gravel are present in these alluvial deposits, they form only a small proportion, the bulk being silt, clay, fine sand and in places peat. These deposits are considered to have little potential as sources of sand and gravel.

Midlothian District

The Midlothian District mainly comprises the twin valleys of the River North Esk and the River South Esk. These are bounded by the Pentland Hills to the west and by the Moorfoot Hills in the south. To the east the low ridge of Roman Camp separates the Esk drainage from the Tyne Water drainage, the headwaters of which lie within the district.

The rocks underlying the district are the main source of the material which forms the sand and gravel deposits. Their distribution largely controls the lithological content of the pebbles in each gravel deposit. The hardest and most durable rocks form the bulk of

the deposits. The main rock types occurring in Midlothian can be summarised as follows:

Greywackes of Ordovician age underlie only the small part of the district formed by the Moorfoot Hills, but, because much of the transport of material was northwards, greywackes form an important part of the gravel deposits in the southern half of the district. Greywackes are a dark, compact type of sandstone, siltstone and grit.

White and brown sandstones, limestones and a few ironstones are the hardest of the Carboniferous sedimentary rocks which underlie most of the district. Many of the sandstone pebbles, however, are quite soft compared with basalt, dolerite, limestone or quartzite. Even softer rocks such as siltstone and mudstone occur in small proportions in some gravels, and coal in the form of fine fragments is common in the sands.

Red and pink sandstones of Old Red Sandstone age form part of the Pentland Hills and occur in gravels in the west of the district. Quartzite has come from beds of conglomerate amongst the sandstones.

Basalt and trachyte lavas, felsite intrusions and tuffs of Old Red Sandstone age make up the rest of the Pentland Hills and also occur in gravels mainly in the west of the district.

Of the other minor constituents of the gravels, quartz occurs as veins in most other rocks and pink felsite comes from minor intrusions in the Ordovician greywackes.

Dolerite does not crop out in Midlothian. Pebbles found in the gravels have been transported most likely from Edinburgh and West Lothian.

During the Ice Age an ice sheet flowed generally eastwards across Midlothian, eroding the underlying rocks and depositing the debris as boulder clay on low ground. The boulder clay contains boulders and pebbles which generally correspond in composition to the underlying rocks. As the ice decayed glacial meltwater eroded both the boulder clay and the underlying rocks, washed out most of the clay and silt, and deposited the sand and gravel fractions. It is the many deposits of this kind that form the extensive sand and gravel resources of the Midlothian District.

Glacial meltwater flowed between the southern margin of the ice sheet and the north-facing slopes as the margin of the ice retreated northwards away from the Moorfoot and Pentland Hills towards the Firth of Forth. As the ice margin continued to retreat the meltwater flowed to the sea by new and progressively more northerly routes. In the west and north meltwater off the Pentland Hills flowed down the valley of the North Esk laying down extensive terrace deposits of sand and gravel particularly around Penicuik, Loanhead and Dalkeith. Some meltwater crossed the watershed into the valley of the South Esk at Howgate and Rosewell depositing sand and gravel in mounds and sinuous ridges. From the basin around Gladhouse meltwater flowed down the valley of the South Esk, leaving extensive spreads of sand and gravel as far north as Carrington. At times when this valley was blocked by ice, meltwater flowed through the Borthwick Gap at North Middleton into the valley of the Tyne Water laying down extensive deposits both in the gap and along the Tyne around Crichton and Pathhead. Meltwater escaping through another gap into the valley of the Keith Water produced the deposits around Fala. Around Roslin and Loanhead a thin upper boulder clay conceals the sand and gravel deposits.

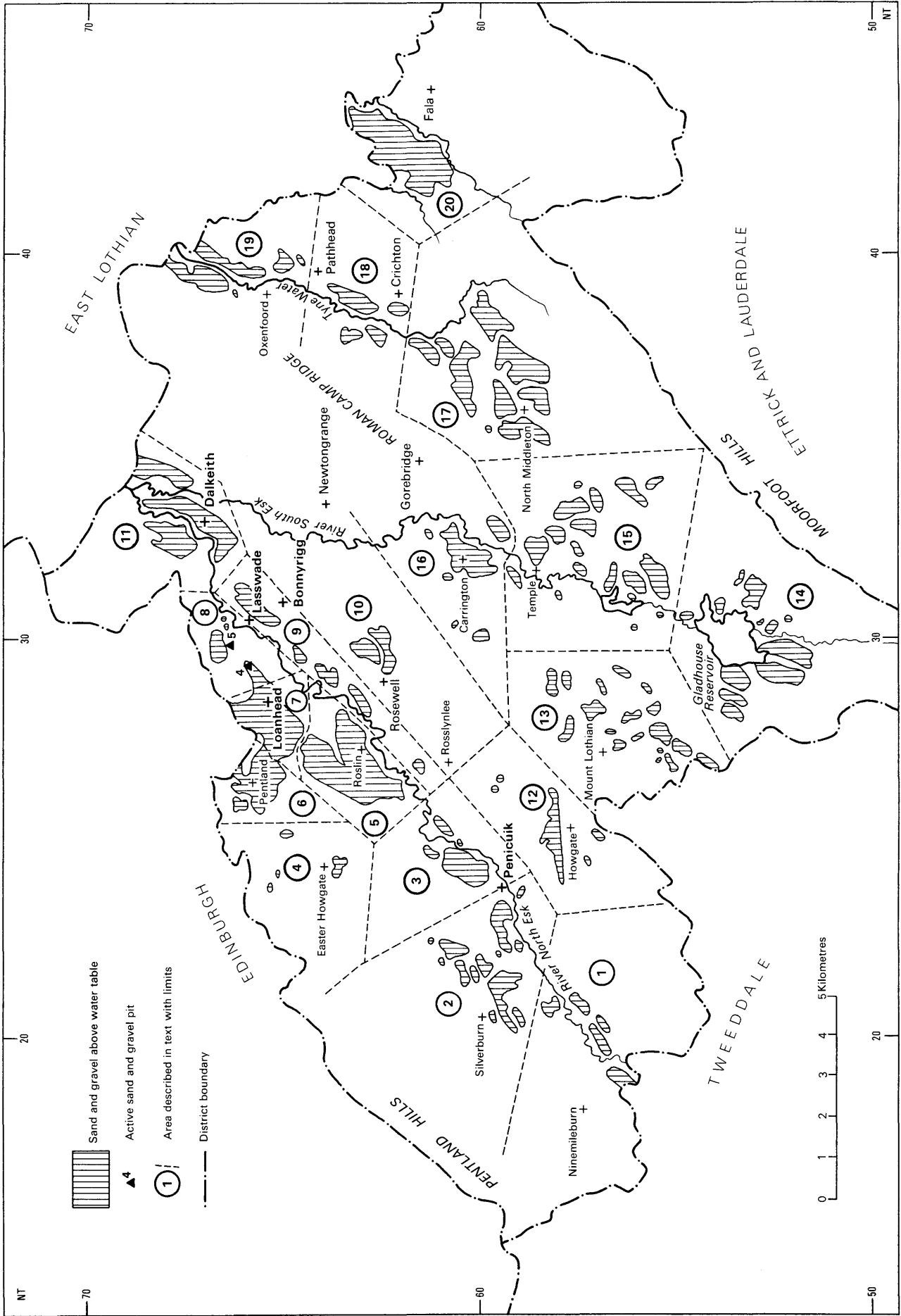


Figure 4 Distribution of sands and gravels in Midlothian

Glacial sand and gravel was laid down in the form of flat spreads, kames (moundy areas often with damp hollows known as kettle holes) and eskers (narrow, sinuous, sharp-topped ridges). They usually lie on an irregular boulder clay surface. Later erosion by glacial or river drainage has in many places dissected the spreads of sand and gravel and left the deposits as isolated terraces or plateaus often high above the present river. Although sand and gravel deposits are very widespread only certain parts are sufficiently thick and extensive to be considered as resources. These are shown on Figure 4, numbers in circles referring to the localities described below.

River action along the main valleys caused erosion of the glacial sand and gravel deposits, the boulder clay and the underlying rock. The eroded material was redeposited as alluvial deposits in the form of river terraces and floodplains which contain gravel, sand, silt and clay in varying proportions. As the proportion of sand and gravel in these deposits is small compared with that of silt and clay, they are unlikely to constitute a source of sand and gravel.

DEPOSITS ABOVE THE WATER TABLE

Glacial sand and gravel

Locality 1: Nine Mile Burn

Along the sides of the valley of the North Esk east of Nine Mile Burn moundy terrace deposits are perched some 30 or 40 m above the floor of the deeply-incised valley. The mounds vary from 3 to 6 m high and in the south form a kame and kettle topography. Here a borehole proved the deposits to be at least 11 m thick. Natural exposures show that the deposits in the south contain fine to medium gravel and fine to medium sand, while in the north coarse gravel with sandstone boulders up to 60 cm is also present. Over a third of the pebbles consist of basalt and trachyte, a third are of greywacke, a fifth of red, white and brown sandstones, with minor proportions of vein quartz, quartzite and felsite. The deposits underlie 55 hectares of mainly arable land which is crossed by both a water conduit and a gas pipeline. They are estimated to average 5 m in thickness in the south, 3 m in the north, and contain resources estimated at 3.9 million tonnes.

Locality 2: Silverburn

A moundy dissected spread of sand and gravel lies on the west bank of the North Esk between Silverburn and Penicuik. The mounds are generally 5 to 12 m high, and are particularly well-developed in the central area immediately south-east of Silverburn. Damp hollows between the mounds show the presence of the underlying boulder clay. Natural exposures indicate that the deposits contain both fine to medium sand and fine to medium gravel with some coarse gravel pebbles up to 25 cm. About half the pebbles consist of red, white and brown sandstones, about half of basalt and trachyte, and there are small proportions of greywacke, limestone, vein quartz, quartzite and felsite. The deposits underlie 145 hectares of mainly arable land and are crossed by a water conduit. They are estimated to average 5 m in thickness in the central area, 3 m elsewhere and contain resources estimated at 11 million tonnes.

Locality 3: Penicuik

In the south the deposits form a high moundy plateau up to 12 m high. Records from a sand pit, now restored [NT 236 603], where 7.5 m of bedded sand was once

exposed, indicate that most of the deposits consist of fine to medium sand. Natural exposures show that they also contain mainly fine to medium gravel with a coarse sand matrix. Over half the pebbles consist of red, white and brown sandstones, about a third are basalt and trachyte, with minor proportions of greywacke, vein quartz, quartzite, dolerite and felsite. The areas to the north and east are lower moundy terraces with mounds from 3 to 5 m high. The few exposures suggest that these also are mainly sand deposits. Urban development around Penicuik has sterilised all 25 hectares of the high plateau deposits and 60 of the 100 hectares of deposits to the north and east. The higher deposits are estimated to average 8 m in thickness, the others only about 3 or 4 m, and together they contain resources estimated at 11 million tonnes.

Locality 4: Easter Howgate

Four small isolated deposits are located in this area. Those to the south and east are mounds 3 to 8 m high which consist mainly of sand. They cover 15 hectares of arable land, are estimated to average 3 m in thickness and contain resources estimated at 0.9 million tonnes. The two deposits to the north-west lie on the slopes of the Pentland Hills. They consist of fine to coarse gravel with boulders up to 30 cm set in a silty sand matrix. The pebbles are almost entirely of basalt and trachyte, with minor proportions of vein quartz, quartzite, sandstone, greywacke, dolerite and felsite. The deposits cover over 5 hectares of hillside most of which is used as a firing range, are estimated to average 3 m in thickness and contain resources estimated at 0.3 million tonnes.

Locality 5: Roslin

Around Roslin much of the ground which stands some 6 or 10 m above the surrounding land is thought to be underlain by part of extensive sand deposits known as the Midlothian Middle Sands. These are usually covered by a tough, reddish, upper boulder clay, up to 3 m thick, the presence of which tends to obscure the full extent of the underlying sand deposits. Several pits in the area formerly worked the sands which varied from 4 m thick at the restored Bilston Pit [NT 263 643] to 9 m at the infilled Oatslie Pit [NT 264 628]. The small proportion of fine to coarse gravel that occurs with the sands contains a mixed assemblage of sandstone, basalt, trachyte, greywacke and other pebbles. Almost 20 hectares of the Middle Sands have been worked and 25 hectares have been sterilised by Roslin but they probably underlie a further 245 hectares of mainly arable land. They are estimated to average 5 m in thickness and contain resources estimated at 27 million tonnes. Further investigation of their thickness and extent is necessary to verify the potential of these deposits.

Locality 6: Pentland

The Midlothian Middle Sands underlie an extensive area around Pentland. Here the upper boulder clay is only about 1 m thick. The deposits were once worked in several sand pits now all infilled except for the largest, the Clippens Pit [NT 268 660], where the deposit is up to 12 m thick. In the east face of the pit 8 m of deposits consist of equal proportions of fine to medium evenly-bedded, ripple-bedded and cross-bedded sand and fine to medium gravel with some coarse gravel up to 20 cm; records from other faces in the pit and from adjacent areas at Roslin and Straiton indicate that sand normally forms three-quarters or more of the deposit. Over half the pebbles consist of white, brown and red

sandstones, about a third consists of basalt, trachyte and dolerite, and there are minor proportions of vein quartz, limestone, ironstone and mudstone. At Old Pentland an esker ridge, 3 to 6 m high, is composed mainly of fine to coarse gravel. About 8 hectares have been worked out and there remain 115 hectares which underlie mainly arable land but with some road and industrial development. The deposits are estimated to average 5 m in thickness to the south, 8 m to the north, and contain resources estimated at 16 million tonnes. These deposits merit further investigation to establish their potential.

Locality 7: Loanhead

The Midlothian Middle Sands extend under Loanhead, where former workings extracted sand from almost 10 hectares in pits, the largest of which, the now restored Burghlee Pit [NT 280 653], had clayey sands 6 to 9 m thick. Little is known of the deposits but they are probably similar to the sands and gravels at Pentland. Urban development around Loanhead has sterilised almost the entire 215 hectares, which with an estimated average thickness of 5 m contain resources estimated at 21 million tonnes.

Locality 8: Lasswade

Between Loanhead and Lasswade lie two important areas of the Midlothian Middle Sands which contain the only two working sand pits in Midlothian. To the south-west a ridge 8 to 10 m high is being worked at the Haverall Wood Pit [NT 292 661] where the faces show 1 to 2 m of upper boulder clay lying on 6 m of fine bedded sand. There are a few beds of coarse sand and fine to medium gravel, particularly along the edge of the ridge. Over half the high mounded area to the north has been worked out at the Melville Pit [NT 300 664] in which the main north face shows 10 to 11 m of deposits. These consist mainly of fine evenly-bedded and ripple-bedded silty sand overlain by 1 to 1.5 m of fine to medium bedded gravel with bands and matrix of coarse sand; towards the south edge of the pit gravels form up to half of the deposits. The pebbles are very mixed in content, the major constituents being white, brown and red sandstones, basalt, trachyte, dolerite and greywacke, and the minor constituents vein quartz, quartzite, limestone, ironstone and mudstone. Silt and clay form up to two-fifths of the sand deposits and fragmental coal also occurs commonly in the sands. The deposits all underlie arable land. At Haverall Wood 3 hectares have been worked out, leaving 17 hectares of deposits which are estimated to average 6 m in thickness and contain resources estimated at 2 million tonnes. At Melville 40 hectares have been worked, 25 hectares remain, the estimated average thickness is 8 m and the resources are estimated at 4 million tonnes.

Locality 9: Bonnyrigg

Along the east side of the valley of the North Esk from Rosslynlee to Bonnyrigg several small isolated mounded terrace deposits are located high above the deeply incised valley-bottom. Natural exposures indicate that these deposits contain both fine to medium sand and fine to medium gravel with some coarse gravel up to 20 cm, though the proportions of sand to gravel are unknown. The pebbles are mixed in content being mainly white, brown and red sandstones, basalt and trachyte. Some 35 hectares of these deposits have been built over at Polton and Bonnyrigg and the remaining 90 hectares underlie arable ground. They are estimated to average 3 m in

thickness and contain resources estimated at 7.5 million tonnes.

Locality 10: Rosewell

East of Rosewell lies a mounded area some 5 to 15 m high dissected by glacial drainage channels. Several boreholes in the north part of the area indicate that the deposits are 9 to 18 m thick and consist mainly of sand. This was also shown by sections in the largest of the pits which once worked the deposits, the infilled Parkburn Pit [NT 299 633], where up to 9 m of sand was recorded. Although the bulk of the deposit is sand a little fine to medium gravel with some coarse gravel up to 20 cm does occur. The pebbles, as seen in surface exposures, consist mainly of red, white and brown sandstone and greywacke, with minor proportions of basalt, trachyte, vein quartz, quartzite and mudstone, and these are set in a medium to coarse sand matrix. Some 5 hectares of the deposits have been worked and 70 hectares remain underlying arable land. They are estimated to average 8 m in thickness and contain resources estimated at 11 million tonnes.

Locality 11: Dalkeith

High above the valleys of the North Esk and South Esk at their confluence below Dalkeith lie several areas of plateau terrace deposit. Boreholes in the deposits show they are up to 7 m in thickness. Little else is known of the deposits other than that they contain fine to medium sand and fine to medium gravel, comparable to the Midlothian Middle Sands. About 125 hectares are sterilised by Dalkeith, while the remaining 170 hectares of deposits underlie arable and estate land. They are estimated to average 3 m in thickness and contain resources estimated at 18 million tonnes.

Locality 12: Howgate

Isolated mounds and esker ridges from 3 to 15 m high occur in the valley north of Howgate. Low, wet ground between the mounds indicates the outcrop of the underlying boulder clay. Natural exposures suggest that the deposits contain medium and coarse gravel but there is probably also some sand and fine gravel. About half the pebbles consist of greywacke, while the rest are mainly sandstone and basalt. The deposits underlie 70 hectares of fairly remote arable land, are estimated to average 6 m in thickness in the main ridge, 3 m in the other mounds, and contain resources estimated as 7.4 million tonnes.

Locality 13: Mount Lothian

In the area east and south of Mount Lothian there are numerous isolated mounds and esker ridges of sand and gravel. Generally these are from 3 to 10 m high, though one borehole 1 km north-east of Mount Lothian proved over 19 m of sand and gravel. The deposits rest on boulder clay which forms the intervening low somewhat boggy ground. Natural exposures indicate that the deposits consist partly of medium to coarse gravel containing boulders locally up to 40 or 50 cm in a coarse sand matrix. It is probable that the deposits also contain fine gravel and sand. In the northern deposits over half the pebbles and boulders consist of white, brown and red sandstone, about a third is greywacke, a fifth is basalt and there are minor proportions of vein quartz, quartzite, limestone, mudstone, dolerite and felsite. The content changes rapidly towards the south where over three-quarters of the pebbles and boulders consist of greywacke with small proportions of sandstone, basalt, vein quartz and felsite. The area is remote pastureland

and is crossed by a gas pipeline. The deposits cover 133 hectares, are estimated to average 5 m in thickness in the parts of the area, 3 m elsewhere, and contain resources estimated at 11 million tonnes.

Locality 14: Gladhouse Reservoir

In the basin around Gladhouse Reservoir lies an extensive dissected spread of low quality greywacke gravel. Locally there are mounds and esker ridges from 3 to 8 m high. The intervening ground formed by the underlying boulder clay is boggy or peaty in many places. Natural exposures indicated that the deposits contain mainly medium to coarse gravel with boulders up to 30 cm set in a matrix of silty clay, coarse sand and fine gravel. Almost all the pebbles consist of greywacke, though locally sandstone is quite common, and there are small proportions of vein quartz, felsite and basalt. The deposits lie in a remote moorland area and the reservoir is a Site of Special Scientific Interest. They cover 205 hectares, are estimated to average 3 or 4 m in thickness, and contain resources estimated at 13 million tonnes.

Locality 15: Temple

In the valley of the South Esk north from Gladhouse Reservoir towards Temple lies an extensive spread of sand and gravel. It has been dissected into numerous mounded terrace and plateau deposits which in the north lie high above the valley bottom of the deeply incised River South Esk. The mounds range from 3 to 12 m high and several boreholes through the deposits proved sand and gravel up to 11 m in thickness. Natural exposures show that the deposits contain fine to medium gravel, with some coarse boulder gravel locally up to 30 cm, set in a sandy matrix. About half of the pebbles consist of greywacke, and about half of red, white and brown sandstones, with small proportions of basalt, dolerite, felsite, vein quartz, quartzite, limestone and ironstone. The deposits underlie 295 hectares of mainly arable land. They are estimated to average 5 m in thickness in some areas, 3 m in other areas, and contain resources estimated at 23 million tonnes.

Locality 16: Carrington

At Carrington in the valley of the South Esk sand and gravel is disposed in a dissected mounded plateau. The mounds are from 3 to 10 m high and several bores have proved sand and gravel up to 9 m in thickness. Exposures show that fine to coarse gravel with boulders up to 30 cm are present in the deposits, but the boreholes indicate that they also contain a high proportion of sand. Somewhat less than half of the pebbles consist of greywacke, a similar fraction of sandstones, with smaller proportions of basalt, dolerite, felsite, vein quartz, quartzite, limestone and mudstone. The deposits cover 120 hectares of arable land, are estimated to average 3 or 4 m in thickness and contain resources estimated at 8.3 million tonnes.

Locality 17: North Middleton

Large deposits of sand and gravel extend along the Borthwick Gap between the valleys of the South Esk and Tyne. They form mounded terraces and dissected plateaus banked against the boulder clay slopes and lying up to 75 m above the valley floor. The mounds are generally from 3 to 10 m high and the plateaus and terraces are wedge-shaped deposits up to about 15 m thick. Part of the deposits consists of fine to coarse gravel set in a matrix of coarse angular greywacke sand, as seen in surface exposures and in the 4.5 m face of the

limestone pit at Middleton Lime Works [NT 353 579]. The deposit also contains fine to medium sand and laminated silt and clay which is exposed in the 12 m face of a disused pit north of Borthwick [NT 365 605]. Greywacke forms over half the pebbles, red, white and brown sandstone about a third, and there are minor proportions of limestone, basalt, dolerite, vein quartz, quartzite and felsite. Locally at North Middleton limestone blocks up to 50 cm may occur in the deposits. Limestone beds underlie the sand and gravel in places and it may be possible to remove and use the sand and gravel prior to winning the limestone. The deposits cover 360 hectares of mainly arable land. They are estimated to average about 8 m in thickness in the centre of the area, only 4 or 5 m elsewhere, and contain resources estimated at 42 million tonnes.

Locality 18: Crichton

Along both sides of the valley from Crichton to Pathhead are small mounded terrace deposits of sand and gravel. One mound at Crichton is 12 m high, but elsewhere the mounds are low, whereas the terraces are 3 to 6 m high. Little is known of the deposits from natural sections but they are probably similar to those upstream at North Middleton, the main difference being a higher content of sandstone up to about a half, in the pebbles, and only about a quarter of greywacke. The deposits underlie 75 hectares of arable land, are estimated to average 3 m in thickness, and contain resources estimated at 4.5 million tonnes.

Locality 19: Oxenfoord

Below Pathhead are mounded terrace deposits of sand and gravel. The mounds generally are 3 to 6 m high and the terraces 3 to 8 m high, while borehole records indicate 3 to 8 m of sand and gravel. Natural exposures show that the deposits contain medium to coarse gravel with numerous boulders up to 40 cm, but sand and fine gravel is probably also present. About two-thirds of the pebbles consist of white and brown sandstones, with appreciable proportions of dolerite, basalt and limestone, and small proportions of vein quartz and greywacke. The deposits cover 130 hectares, are estimated to average 3 m in thickness, and contain resources estimated at 7.8 million tonnes.

Locality 20: Fala

Extensive deposits of sand and gravel occur north-west of Fala in the ground between the headwaters of the Keith Water. They are an extension of well-developed deposits in the Humbie area of East Lothian. The deposits form a slope and terrace feature on which mounds are from 3 to 10 m high. Little is known of the thickness and some of the lower ground may have very little sand and gravel on the underlying boulder clay. Natural exposures indicate that the deposits contain both fine to coarse gravel in a medium to coarse sand matrix and fine to medium bedded sand. Under half of the pebbles consist of greywacke, a similar fraction of sandstones, with small proportions of basalt, limestone, felsite, vein quartz and quartzite. The deposits cover 250 hectares, are estimated to average 5 m in the north, 3 m in the south and contain resources estimated at 21 million tonnes.

DEPOSITS BELOW THE WATER LEVEL

Alluvial deposits

Narrow strips of river terrace and floodplain alluvium occur all along the valleys of the River North Esk, the

River South Esk and the headwaters of the Tyne Water. In addition alluvial deposits are present in the bottom of many of the glacial drainage dry valleys the largest of which is the Borthwick Gap. Although coarser sand and gravel are present in these alluvial deposits, they form only a small proportion, the bulk being silt, clay, fine sand and in places peat. These deposits are considered to have little potential as sources of sand and gravel.

West Lothian District

The West Lothian District lies between hills and high moorland to the south and the Firth of Forth in the north. The main topographic feature is the Bathgate Hills which lie between the valley of the River Avon which forms the north-westerly boundary of the District and the valley of the River Almond which with its tributaries drains the southern part of the District.

The underlying rocks are the source of the material which forms the sand and gravel deposits of the district. Their distribution largely controls the lithological content of the pebbles in each gravel deposit. The hardest and most durable rocks form the bulk of the deposits. The main rock types occurring in West Lothian can be summarised as follows:

White and brown sandstones with a few limestones and ironstones are the hardest of the Carboniferous sedimentary rocks which underlie most of the District. Softer sedimentary rocks such as mudstone and shale occur in small proportions in some gravels, and coal in the form of fine fragments is common in the sands.

Basalt lavas of Carboniferous age occur in the Bathgate Hills.

Dolerite intrusions of similar age form many of the other low hills.

Vein quartz, the main minor constituent of the gravels, occurs in most of these rocks. Some quartzite pebbles originated in the Highlands.

During the Ice Age an ice sheet flowed generally eastwards across West Lothian, eroding the underlying rocks and depositing the debris as boulder clay on low ground. The boulder clay contains boulders and pebbles which generally correspond in composition to the underlying rocks. As the ice decayed glacial meltwater eroded both the boulder clay and the underlying rocks, washed out most of the clay and silt, and deposited the sand and gravel fractions. It is the few larger deposits of this kind that form the very limited sand and gravel resources of the West Lothian District.

Glacial meltwater flowed eastwards from Linlithgow to the coast at Abercorn and laid down deposits known as the Polmont Kame. Further south meltwater flowed from the valley of the River Avon near Torphichen through the dry valley at Bathgate into the valley of the River Almond at Livingston leaving patches of sand and gravel. Meltwater flowing along the edge of ice banked up against the Pentland Hills left some patchy deposits on the lower hill slopes. Sand and gravel deposits that are sufficiently thick and extensive to be considered resources are shown on Figure 5, numbers in circles referring to the localities described below.

River action along the main valleys caused erosion of the glacial sand and gravel deposits, the boulder clay and the underlying rock. This material was redeposited as alluvial deposits in the form of river terraces and floodplains which contain gravel, sand, silt and clay in varying proportions. As the proportion of sand and

gravel in these deposits is small compared with silt and clay, they are unlikely to constitute a source of sand and gravel.

DEPOSITS ABOVE THE WATER TABLE

Glacial sand and gravel

Locality 1: Linlithgow

In the north-west of the District, the Polmont Kame extends from Linlithgow eastwards for a distance of about 8 km. The bulk of the deposit is less than 2 m in thickness, as indicated by information from boreholes and from sections recorded during construction of the M9 motorway. However, three areas are worthy of mention, all within close proximity to Linlithgow.

The first is a ridge east of Linlithgow at Baron's Hill [NT 007 773] where realignment of the A903 road from Linlithgow to the M9 junction exposed sand up to 8 m thick. This deposit is also seen in a disused sand pit on the western edge of Baron's Hill. The sand is almost devoid of pebbles, but is contaminated with coal and shale particles. The deposit covers an area of 2.5 hectares, the southern half of which has been sterilised by building, is estimated to average 4 m in thickness and contains resources estimated at only 0.2 million tonnes.

The other two areas are terrace deposits lying south-west of Linlithgow at Kettlestoun Mains [NS 988 764] and Woodcockdale [NS 973 760]. The former deposit may be up to 25 m thick. Sections cut during realignment of the A706 road showed deposits of at least 10 m thickness and indicated that about 60 per cent consists of coarse gravel with boulders up to 35 cm, and the remainder is sand. The pebbles consist mainly of sandstone, but include quartzites, basalt, shale and some coal. The deposits cover 13 hectares, are estimated to average about 10 m in thickness and contain resources estimated at 2.6 million tonnes.

The deposits at Woodcockdale are much smaller. Evidence from natural exposures suggest they are higher in sand content although fine to medium gravel pebbles mainly of sandstone occur. The deposits cover 1.5 hectares, are estimated to average 5 m in thickness and contain resources estimated at only 0.1 million tonnes. The deposits lie perched on the edge of the Avon River gorge.

Locality 2: Torphichen

In the area between the Logie Water and the River Avon at Crawhill lies an extensive mounded terrace of sand and gravel, covering an area of 21 hectares, and having an average thickness of 6 m. To the south-east at Westfield lie two mounds of sand and gravel estimated to average 4 m in thickness and covering 5 hectares, a further 5 hectares having been already removed. Typical exposures of these deposits are seen in Couston Pit [NS 952 713], which has a face between 2 and 12 m in height, mainly composed of false-bedded sand, lenses of fine to coarse gravel forming up to a fifth of the section. The sand is clayey in places and contains a fine fraction of coal. Three-quarters of the pebbles consist of quartzites and sandstones, with some coal, shale and basalt. The deposits cover 26 hectares in total, are estimated to average 4 to 6 m in thickness, and contain resources estimated at 2.9 million tonnes.

Locality 3: Bathgate

Although sand and gravel deposits occur in the Bathgate area and have been worked in several small pits, most of

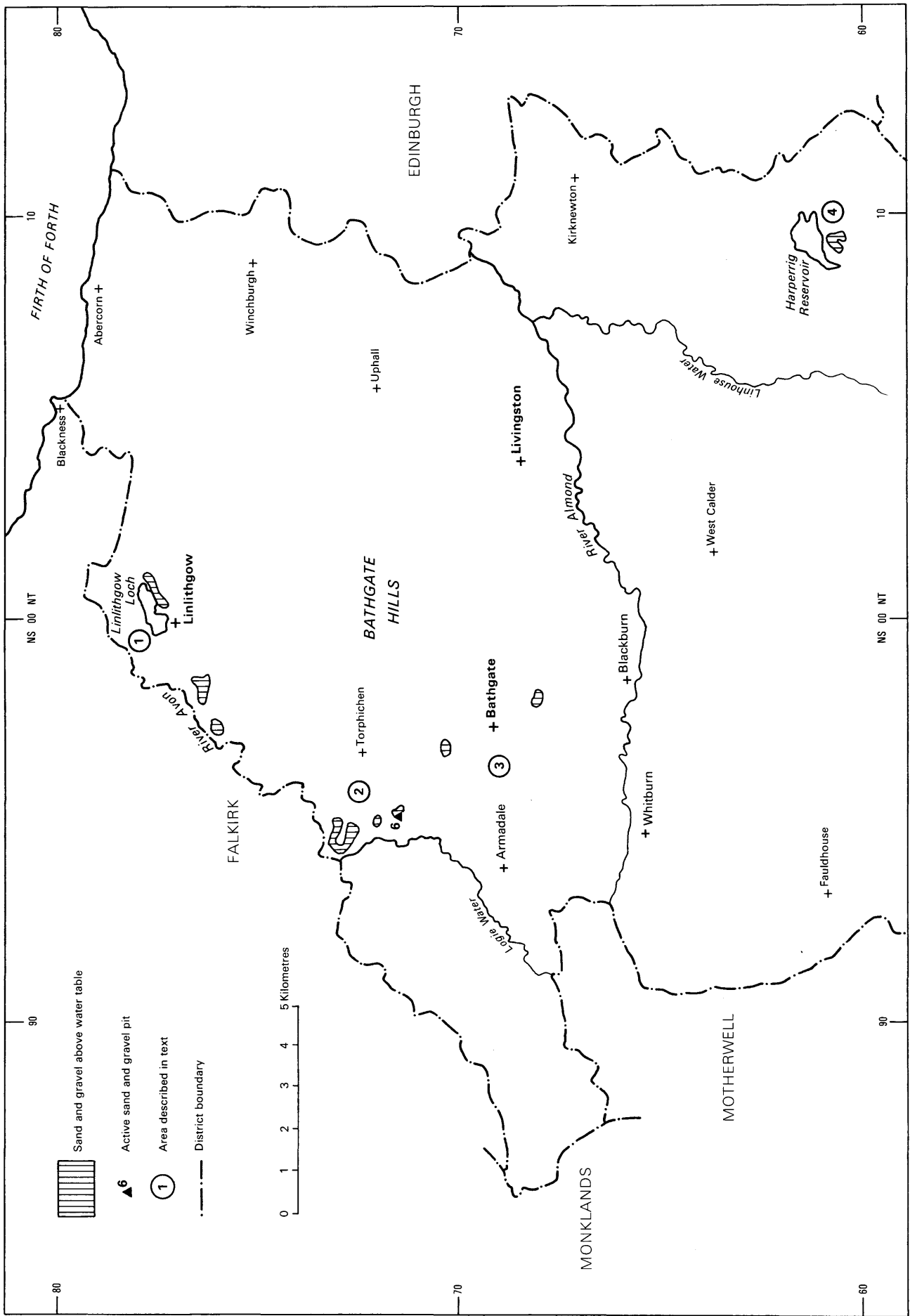


Figure 5 Distribution of sands and gravels in West Lothian

these have been sterilised by building or colliery waste heaps, and only two small areas of relatively thick deposit were considered. To the north of Bathgate at Dykeside [NS 968 702] is an area of sand and gravel extending to 4 hectares. Borehole evidence shows the deposit exceeds 3m in thickness. The few exposures indicate the deposit consists chiefly of sand, sometimes contaminated with coal, and has subordinate gravel chiefly sandstone in composition. Poorly drained land to the south, towards the site of Ballencrieff House [NS 973 698] may be worthy of further investigation. Immediately to the south of the site of Bathgate Castle [NS 982 678] lie deposits which form the only topographic relief on Bathgate Golf Course and are difficult of access. They cover an area of 3 hectares and are up to 8 m thick. The deposits are predominantly of sand with some lenses of gravel, the pebbles being chiefly of sandstone, with some basalt and vein quartz. There is contamination from coal and shale. Old workings have removed much of the deposits but some 3 hectares remain which are estimated to average 4 m in thickness. In total the deposits contain resources estimated at 0.5 million tonnes.

Locality 4: Harperrig

South of the reservoir lie deposits of sand and gravel covering some 14 hectares. One mound is over 12 m high, but the deposits are estimated to average 5 m in thickness feathering out north towards the reservoir. Natural exposures suggest that the bulk of the deposit is sand, with some mainly fine and medium gravel. The pebbles are mainly sandstone with some basalt, felsite and vein quartz. Silt and clay form a high proportion of this deposit and considerably reduce its quality. The deposit contains resources estimated at 1.4 million tonnes. As well as the poor quality, an important obstacle in working this deposit is the presence of two water conduits laid through the deposits, carrying water from higher reservoirs to the Edinburgh area.

DEPOSITS BELOW THE WATER TABLE

Buried channels

Evidence from borehole records shows that buried channels about 1 km wide filled with up to 40 or 50 m of glacial deposits lie along the valleys of the River Avon and River Almond. The buried channel of the Avon follows a different course from the present river north-eastwards to the coast at Blackness, whereas the channel of the River Almond lies close to the present course of the river. From borehole records it is clear that the bulk of the infilling deposits is boulder clay. At Linlithgow, though, where the channel of the River Avon is built over, the predominant deposits are sand and gravel, and similar deposits fill the channel of the River Almond in the vicinity of Midcalder. Nevertheless the potential at both localities is low.

Alluvial deposits

Narrow strips of river terrace and floodplain alluvium occur along the valleys of the River Avon and River Almond and their tributaries, and in the dry valley at Bathgate. Although coarser sand and gravel are present in these alluvial deposits, they form only a small proportion, the bulk being silt, clay and fine sand. These deposits are considered to have little potential as sources of sand and gravel.

List of working pits, spring 1976

Numbers preceding pits refer to the numbered pits shown on Figs. 3, 4 and 5.

City of Edinburgh District

There are no working pits

East Lothian District

- Gullane [NT 481 835], Gullane
1:50 000 OS Sheet 66; 1:50 000 Geological Sheet 33W;
1:10 000 Sheet NT 48 SE
Owner: R. Dobson & Sons, Main Street, Gullane, East Lothian, EH31 2AA
Preparation: none
Uses: sand for concrete
Markets: East Lothian
- Lochhouses [NT 622 822], Tynninghame
1:50 000 OS Sheet 66; 1:50 000 Geological Sheet 33E;
1:10 000 Sheet NT 68 SW
Owner: B. Mullen & Sons Ltd., Crookston, Musselburgh, East Lothian, EH21 8QF
Preparation: none
Uses: sand for building
Markets: East Lothian
- Long Yester [NT 533 641], Gifford
1:50 000 OS Sheet 66; 1:50 000 Geological Sheet 33W;
1:10 000 Sheet NT 56 SW
Owner: Truckrete Ltd., Station Road, Earlston, Ettrick & Lauderdale
Being established in 1976

Midlothian District

- Haverall Wood [NT 292 661], Lasswade
1:50 000 OS Sheet 66; 1:50 000 Geological Sheet 32E;
1:10 000 Sheet NT 26 NE
Owner: Sand Marketing Co. (Lasswade) Ltd., Haverall Wood, Lasswade, EH18 1HS
Preparation: washing, screening
Uses: sand for building and concrete
Markets: Lothian Region
- Melville [NT 300 664], Lasswade
1:50 000 OS Sheet 66; 1:50 000 Geological Sheet 32E;
1:10 000 Sheets NT 26 NE, NT 36 NW
Owner: Kings & Co. Ltd., 76 Drum Street, Edinburgh, EH17 8RN
Preparation: washing, screening, grading
Uses: sand for building, concrete and asphalt; gravel for asphalt
Markets: Edinburgh District, Fife and Borders Regions

West Lothian District

- Couston [NS 952 713], Torpichen
1:50 000 OS Sheet 65; 1:50 000 Geological Sheet 31E;
1:10 000 Sheet NS 97 SE
Owner: Forth Sand and Gravel, 131 Lower Bothville, Armadale, EH48 2JT
Preparation: screening
Uses: sand for building and pipeline bedding
Markets: West Lothian

Table 1 Estimated resources

	Estimated area (ha)	Estimated* thickness (m)		Estimated† quantity (m.t.)	Remarks
		Av.	Max.		
<i>City of Edinburgh District</i>					
1. Bavelaw	25	5	15	2.5	Poor quality
2. Newbridge	75	4	9	6.0	Mainly sterilised
3. Fairmilehead	20	4	7	1.6	All sterilised
4. Straiton	30	6	15	3.6	Promising, sand
5. Corstorphine	90	3-4	6	6.4	All sterilised
6. Duddingston	125	3	6	7.5	Mainly sterilised
<i>East Lothian District</i>					
1. Ormiston	80	3	8	4.8	
2. Pencaitland	35	3	5	2.1	
3. Humbie	325	3-6	15	36	Merits further investigation
4. Kidlaw	70	3	5	4.2	
5. Stobshiel	20	5	12	2.0	Greywacke gravel
6. Newton Hall	130	3	5	7.8	
7. Latch	55	5	10	5.5	Greywacke gravel
8. Long Yester	200	4-6	10	20	
9. Garvald	120	3-4	8	8.5	
10. Castle Moffat	60	3-5	10	4.4	Greywacke gravel
11. Stenton	95	3	8	5.7	
12. Halls	65	3-4	10	4.9	Greywacke gravel
13. Woodhall	115	3-5	15	9.4	Greywacke gravel
14. Dunbar	130	3	8	7.8	
15. Oxwellmains	365	3-4	11	25	
16. Innerwick	130	3-4	13	8.9	Isolated, prominent mounds
17. Oldhamstocks	95	5-10	15	9.7	Greywacke gravel
18. East Linton	270	3	8	16	45 ha, 2.7 m.t. sterilised
19. East Fortune	80	5	8	8.0	
21. Gullane	175	4-5	12	16	Blown sand
„ Whitekirk	25	3-4	10	1.8	Blown sand
<i>Midlothian District</i>					
1. Nine Mile Burn	55	3-5	11	3.9	
2. Silverburn	145	3-5	12	11	
3. Penicuik	125	3-8	12	11	Mainly sand; 85 ha, 7.6 m.t. sterilised
4. Easter Howgate	20	3	8	1.2	
5. Roslin	270	5	15	27	Mainly sand; 25 ha 2.5 m.t. sterilised
6. Pentland	115	5-8	12	16	Mainly sand
7. Loanhead	215	5	9	21	All sterilised
8. Lasswade	42	6-8	11	6.0	Mainly sand
9. Bonnyrigg	125	3	10	7.5	35 ha, 2.1 m.t. sterilised
10. Rosewell	70	8	18	11	Mainly sand
11. Dalkeith	295	3	7	18	125 ha, 7.5 m.t. sterilised
12. Howgate	70	3-6	15	7.4	
13. Mount Lothian	133	3-5	19	11	Remote
14. Gladhouse Reservoir	205	3-4	8	13	Remote. Greywacke gravel
15. Temple	295	3-5	12	23	Dissected deposits
16. Carrington	120	3-4	10	8.3	
17. North Middleton	360	4-8	15	42	
18. Crichton	75	3	12	4.5	
19. Oxenfoord	130	3	8	7.8	
20. Fala	250	3-5	10	21	Poorly known
<i>West Lothian District</i>					
1. Linlithgow	17	4-10	25	2.9	
2. Torphichen	26	4-6	12	2.9	
3. Bathgate	7	3-4	8	0.5	Amenity
4. Harperrig	14	5	12	1.4	Poor quality

* Where a range of values is given, two or more smaller areas with different average thicknesses have been grouped together.

† Calculated to two significant figures.

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