Historic England

# Greater London

## Building Stones of England

# The Building Stones of England

England's rich architectural heritage owes much to the great variety of stones used in buildings and other structures. The building stones commonly reflect the local geology, imparting local distinctiveness to historic towns, villages and rural landscapes.

Historic England and the British Geological Survey (BGS), working with local geologists and historic buildings experts, have compiled the Building Stones Database for England to identify important building stones, where they came from and potential alternative sources for repairs and new construction.

Drawing on this research, plus BGS publications and fieldwork, guides like this one have been produced for each English county. The guides are aimed at mineral planners, building conservation advisers, architects and surveyors, and those assessing townscapes and countryside character. The guides will also be of interest if you want to find out more about local buildings, natural history, and landscapes.

This guide was prepared by Andy King (Geckoella Ltd) and Phil Collins (Phil Collins Associates) for Historic England.



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Front cover: Winchester Palace, Southwark. Kentish Ragstone cobbles and some chalk and flint pebbles. Reigate Stone rose window. © Jackie Wilkinson / Stockimo / Alamy Stock Photo.

# How to Use this Guide

Each guide describes the local building stones in their geological timescale order, starting with the oldest layers through to the youngest. The guide ends with examples of other notable building stones from other parts of England and further afield.

## Geological time periods, groups, formations and building stones

Each building stone is listed under the relevant geological timescale, group and formation. A formation may be divided into members and where relevant these are referenced in individual building stone sections.

**Middle Jurassic**
↑— geological time period

**Inferior Oolite Group, Lincolnshire Limestone Formation**
↑— geological group ↑— geological formation

**Lincolnshire Limestone**
↑— building stone (alternative or local name)

## Bedrock geology map and stratigraphic table

To help you with the geology of the area, there is a bedrock geology map and a stratigraphic table which shows the layers of rocks and the associated building stones in this geological timescale, group, formation order.

Page numbers for each building stone are included in the stratigraphic table for ease of reference. The page numbers are inverted to correspond with the geological age order.

## Contents list

If you click on the page number for a building stone in the Contents list, you will go straight to the relevant section in the guide.

## Building stone sources and building examples

A companion spreadsheet to this guide provides:

- More examples of buildings. Information is included on building type, date, architectural style, building stone source, and listed/ scheduled status
- A list of known (active and ceased) building stone sources such as quarries, mines, pits and delphs
- Additional information on building stones including lithology, grain size, sedimentary structures, key identification features, and notes on failure/weathering, and use.

The Building Stone GIS map allows you to search the Building Stones Database for England for:

- A building stone type in an area
- Details on individual mapped buildings or stone sources
- Potential sources of building stone sources within a given proximity of a stone building or area
- Buildings or stone sources in individual mineral planning authority area.

## Further Reading, Online Resources and Contacts

The guide includes geological and building stone references for the area. A separate guide is provided on general Further Reading, Online Resources and Contacts.

## Glossary

The guides include many geological terms. A separate Glossary explaining these terms is provided to be used alongside the guides.

The guides use the BGS lexicon of named rock units.

## Mineral and local planning authorities

This guide covers the planning and mineral planning authority areas of the 33 boroughs that comprise Greater London, namely: Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Camden, City of London, City of Westminster, Croydon, Ealing, Enfield, Greenwich, Hackney, Hammersmith and Fulham, Haringey, Harrow, Havering, Hillingdon, Hounslow, Islington, Kensington and Chelsea, Kingston upon Thames, Lambeth, Lewisham, Merton, Newham, Redbridge, Richmond upon Thames, Southwark, Sutton, Tower Hamlets, Waltham Forest and Wandsworth.

# Contents

# 1 Introduction

The oldest rocks that crop out at surface in Greater London are white chalky limestones assigned to the Upper Cretaceous White Chalk Subgroup. These occur mainly in the boroughs adjoining Surrey and Kent, namely Sutton, Croydon, Bromley and Bexley. A band of chalk also extends east to west, broadly along the edge of the River Thames within the boroughs of Southwark, Lewisham and Greenwich. A small outcrop is also present in north-west Hillingdon. The chalk is an important source of flint, one of the most widespread and commonly used indigenous building stones in Greater London. Like much of the overlying Palaeogene deposits in this area, the chalk is substantially covered by Quaternary-aged superficial deposits.

During early Palaeogene times, much of Greater London was a shallow basin structure, although sea levels oscillated and the Lambeth Group, for example, contains marine, terrestrial and estuarine deposits. The Upnor Formation is entirely marine and is now known to be a possible local source of Hertfordshire Puddingstone, which occurs in situ at Pinner Chalk Mines. Overlying the Lambeth Group is the marine Thames Group, which contains the London Clay Formation; geographically, this clay formation represents the most widespread bedrock type within Greater London.

The landscape of Greater London was greatly modified during the Quaternary period. A series of superficial sediments, mainly fluvial gravels and sands, was deposited by former courses of the River Thames (the 'proto-Thames') and its tributaries, many of which entered the London Basin from the Weald to the south and joined the Thames as it flowed eastwards towards the coast. During the Anglian Glaciation that followed, around 450,000 years ago, a major ice sheet impinged on north London and extended as far south as the Colne Valley and the Finchley and Hornchurch areas, where traces of glacial till occur. During this period of glaciation, most of the Greater London area would have been subjected to periglacial conditions and processes, which diverted the River Thames to its present valley.

After the Anglian Glaciation, a sequence of river terrace gravels was deposited in the lower reaches of the Thames Valley in the east of London. These form tiers, in which the highest terrace is stratigraphically the oldest. They provide a highly detailed record of climate change in the Greater London area over much of the past 450,000 years; the interglacial deposits are particularly important and contain assemblages of fossil mammals and molluscs as well as Palaeolithic archaeology. These deposits provide evidence of the last interglacial period (the Ipswichian Interglacial, 125,000 years ago) in England. One of the best-known locations where such deposits

have been found is Trafalgar Square in central London, where the fossil remains of hippopotamus, lion and rhinoceros were recovered from building foundation works in the 1950s.

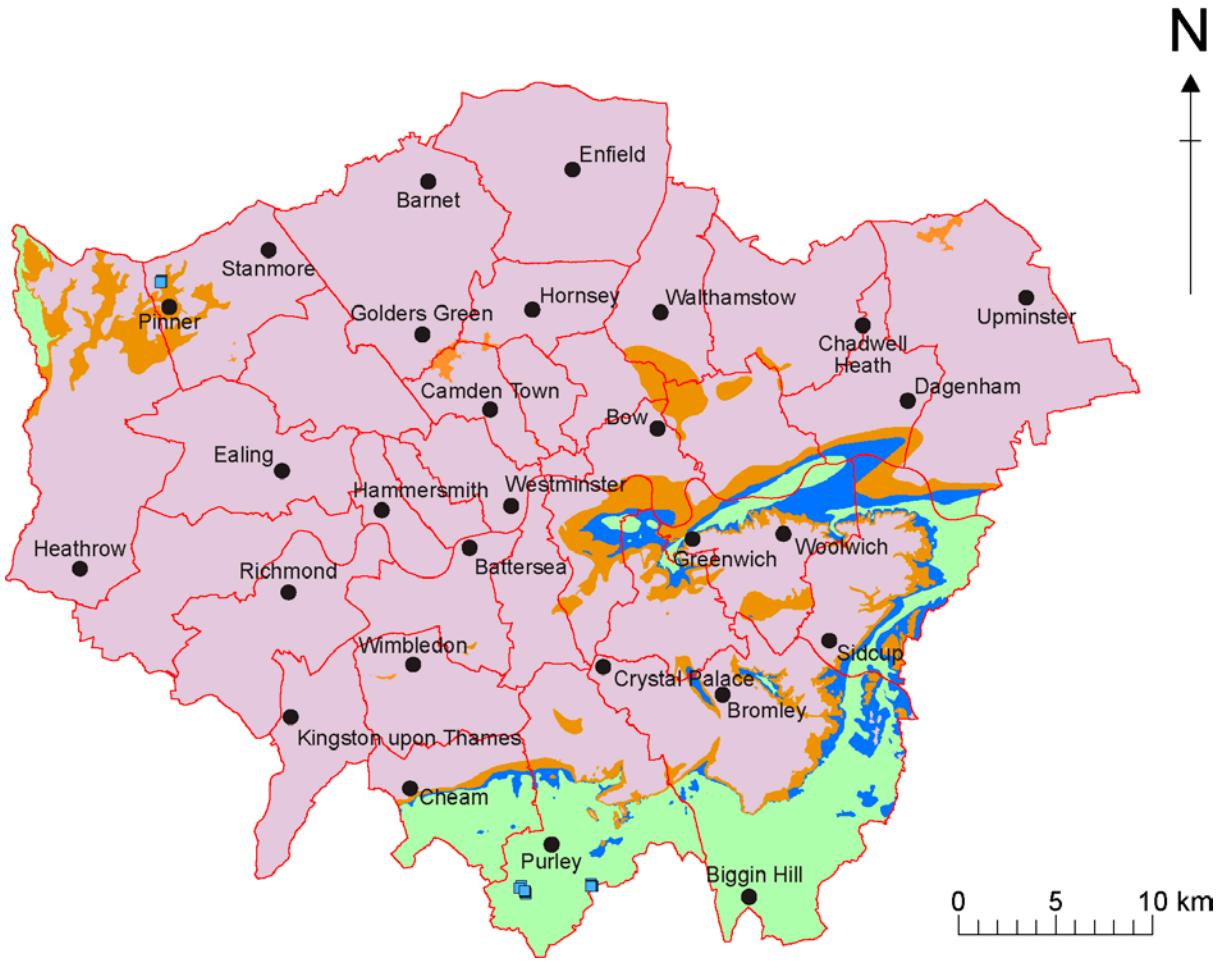
Quaternary-aged deposits in Greater London represent important sources of local building stone. The river terrace gravels have yielded extensive volumes of flint pebbles and nodules that have been widely employed across Greater London. Quaternary deposits are also the likely source of the various forms of ferricrete used in churches in the north-west of the area, although the precise stratigraphical level of these ferricrete beds remains uncertain.

# Stratigraphic Table

| Geological timescale | Groups | | Formations | | Building stone | Page |
|---|---|---|---|---|---|---|
| Quaternary | various | | various | | Quaternary Flint (River terrace gravel flint)<br>Ferricrete (Ironstone)<br>Conglomeratic Ironstone<br>Cinderstone | 31<br>29<br>28<br>27 |
| Tertiary | Bracklesham Group | | Bagshot Formation | | | |
| | Thames Group | | London Clay Formation | | Septaria (Cementstone) | 26 |
| | | | Harwich Formation | | | |
| | Lambeth Group | | Reading Formation | | | |
| | | | Woolwich Formation | | | |
| | | | Upnor Formation | | Hertfordshire Puddingstone | 22 |
| | Not assigned | | Thanet Formation | | | |
| Cretaceous | Chalk Group | White Chalk Subgroup | Upper Chalk | Undivided | Quarry Flint (Fresh Flint)<br>Chalk (Clunch) | 22 |
| | | | | Lewes Nodular Chalk Formation | | |
| | | | Middle Chalk | New Pit Chalk Formation | | |
| | | | | Holywell Nodular Chalk Formation | | |

Building stones in geological order from the oldest through to the youngest layers.

# Bedrock Geology Map




**Key**

Building stone sources

**Bedrock geology**

Bracklesham Group — sand

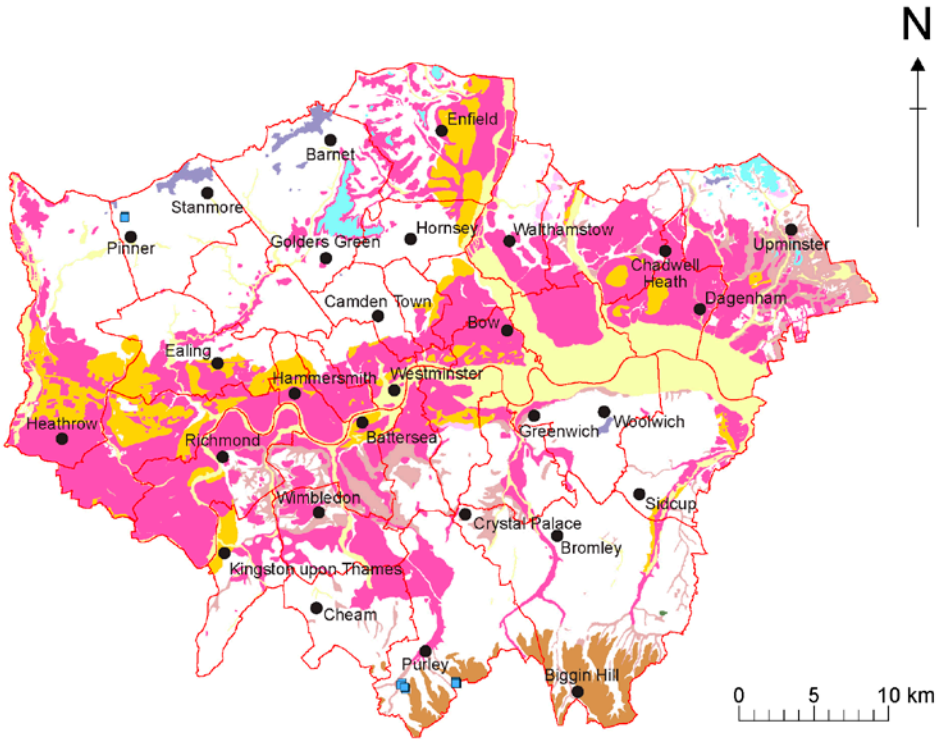
Thames Group (including London Clay Formation) — clay, silt, sand, gravel, septaria and cementstone

Lambeth Group — clay, silt and sand

Thanet Formation — sand

White Chalk Subgroup — chalk , clunch and quarry flint

# Superficial Geology Map




**Key**

Building stone sources

**Superficial geology**

Alluvium — clay, silt, sand, gravel and peat

Brickearth — clay and silt

Head — clay, silt, sand and gravel

River terrace deposits — sands and gravels

Glaciofluvial and glaciolacustrine deposits — clay, silt, sands and gravels

Glacial tills — clay, sands and gravels

Clay-With-Flints Formation — clay, silt, sand and gravel

Other sand and gravel — sand and gravel

Crag group — sand and gravel

# 2 The Use of Stone in Greater London's Buildings

## Background and historical context

Greater London has more than 19,000 listed buildings, ranging from graveyard monuments, railings and lamp standards to 20th-century offices. There are more than 1,000 conservation areas, too.

Much of the Greater London area was countryside until the 18th century. Most of the outer area, formerly parts of Surrey, Kent and Hertfordshire, was incorporated into Greater London in the 1960s and there are still significant rural areas within the outer fringes of Greater London. There is a paucity of local stone suitable for building purposes in Greater London, and even from its earliest times, there has been a high dependency on imported stones, especially for the construction of prestigious buildings.

Roman Londinium was established in *c*. AD 47–50 at the lowest fording point of the tidal Thames. The settlement became the major port and commercial centre of Roman Britain until its abandonment in the 5th century. During the Roman period, imported Kentish Ragstone, Quaternary Flint, French Caen Stone, Barnack Stone, Reigate Stone, chalk and Quarry Flint were primarily used. There is also evidence of the early use of Lincolnshire Limestone, Cotswold Stone, White Lias, Welsh Slate and other stones imported from Italy, Belgium, Greece and Egypt.

Figure 1: Roman Temple of Mithras, City of London. Kentish Ragstone.

During the Anglo-Saxon period, the City of London was re-established as the main city and commercial centre of England. After the Norman Conquest in the 11th century, William I built the Tower of London using Caen Stone, Quarr Limestone and Kentish Ragstone, with Reigate Stone dressings. The Tower was partly refaced in Portland Stone in the 18th century.

Within its Roman walls, the medieval City of London contained more churches and religious buildings than any other city in Europe. Immediately outside the walls were establishments such as St Mary Overie, Southwark, the Priory of St John of Jerusalem, Clerkenwell, and within the city, the Temple Church. After the Norman Conquest, a religious revival led to an expansion in the number of religious houses, including the Abbey of SS Mary and Thomas the Martyr at Lesnes in Bexley, Bermondsey Abbey, Merton Priory and Ruislip Priory.

A Benedictine abbey was established at Westminster in *c*. 970 which was enlarged by Edward the Confessor in the 11th century. The abbey was mainly reconstructed in Kentish Ragstone, Caen Stone and Cambridgeshire Clunch, with decorated columns of Purbeck Marble. In 1245, Henry III initiated the rebuilding of Westminster Abbey in Gothic style, using large quantities of Kentish Ragstone. The west front was rebuilt with two towers in the 18th century by Nicholas Hawksmoor in Portland Stone and Bath Stone.

During the medieval period, Reigate Stone became the principal freestone used in high-profile projects across central London, but other materials continued to be imported. For example, Caen Stone, Portland Stone and Tuffeau Limestone (from the Loire Valley) were used in Henry VII's chapel at Westminster Abbey. Reigate Stone was frequently used for detailing. It was employed in place of Caen Stone, especially after the loss of the Duchy of Normandy by King John in 1204. It was also used for more than 300 years for works at Westminster Abbey and in buildings such as St Mary Spital, Bishopsgate, as well as for the 16th-century tracery at Hampton Court, Richmond.

Significant numbers of the churches of medieval London survived until the restoration and rebuilding frenzy of the 19th century. Frequently, medieval parish churches were sited close to the Thames. South of the river, there were many small settlements with little more than a church and a manor, such as Charlton and Morden, and larger settlements including Bermondsey, Clapham, Lewisham, Merton and Carshalton. There was easy access to a range of stones brought by river, such as flint, chalk, ferricrete and Reigate Stone, as well as Purbeck Stone, Collyweston Stone slate and Caen Stone from further afield.

North of the Thames lay the numerous villages and the larger townships of Barking, Romford, Stratford and West Ham. Many of these ancient parishes have churches with medieval fabric. A range of local materials were used, including chalk, flint, ferricrete and septaria. Dressed stone, such as Reigate Stone, Barnack Stone and Caen Stone, was imported.

Figure 2: Westminster Abbey, Westminster. Kentish Ragstone, Portland Stone and Bath Stone.

Figure 3: Pyx Chamber, Westminster Abbey, Westminster. Reigate Stone.

By the 14th century, the City of London was England's leading commercial centre and Westminster was the royal, political and legal capital. The Black Death in the mid-14th century impacted London's growth adversely for two centuries. However, in later medieval times, trade flourished and London became the major centre for importing and distributing goods to elsewhere in the country. Trades organised themselves into a complex system of guilds and the Guildhall, Moorgate, served as the town hall for several hundred years. Built of Kentish Ragstone (with later additions in Portland Stone), it is said to have the largest Collyweston Stone slate roof ever constructed.

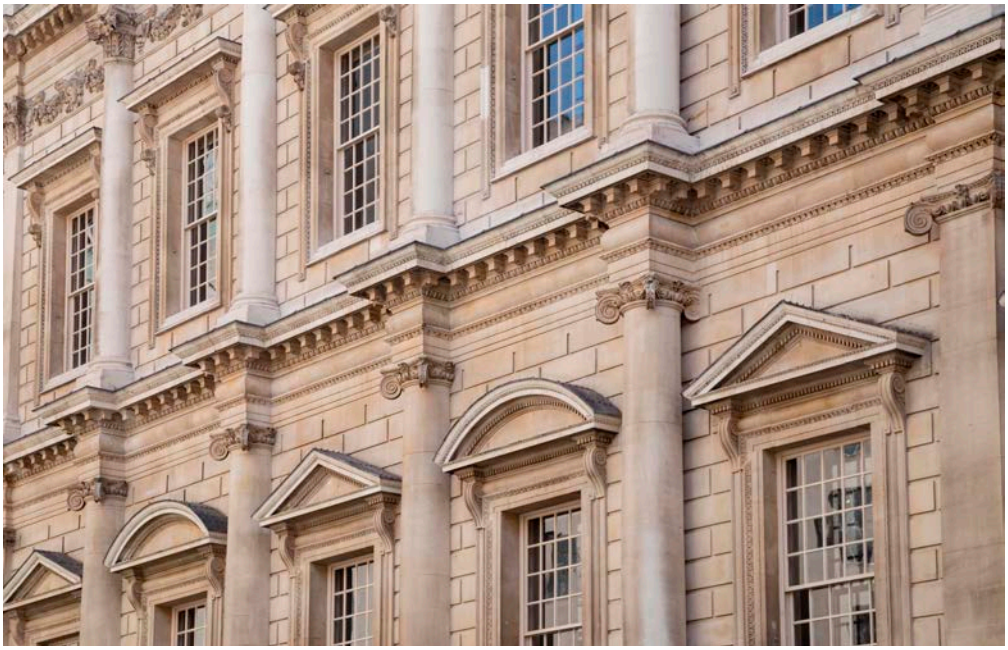
Figure 4: Guildhall, City of London. Kentish Ragstone and Portland Stone, with Collyweston Stone slate roof.

By the 16th century, London had expanded beyond the old Roman walls. It had joined with Westminster westwards along the Strand, where large houses and the Inns of Court existed. The Tudor monarchs built or expanded palaces in and around London, of which the most important was at Greenwich. The Dissolution of the Monasteries (1536–41) released land, buildings and materials formerly owned by the monasteries; Reigate Stone from the demolition of Merton Priory was used to build Nonsuch Palace in Surrey, for example.

From the 16th century, quarries in places such as Portland, Bath and Oxfordshire were exploited on a large scale, and stone was transported along the coast or later by the developing canal network. Significant quantities of the early medieval masonry of major buildings in the City of London and Westminster required replacement and repair in response to decay, particularly of less durable materials such as Reigate Stone. Portland Stone was used initially, largely to enhance buildings for the Crown, such as the Banqueting House, Whitehall, designed by Inigo Jones. This set a trend for the stone.

The Great Fire of London in 1666 destroyed 89 churches within the City, and the New Churches Act of 1711 required replacements to be built of stone. Architects Christopher Wren, Nicholas Hawksmoor and John Vanbrugh used Portland Stone for the construction of 51 new churches, including St Paul's

Figure 5: Banqueting House, Whitehall. Portland Stone.



Cathedral, Ludgate Hill, the Church of St George, Bloomsbury, the Church of St Luke, Islington and the Church of St Leonard, Shoreditch. However, Reigate Stone was also used by Christopher Wren at St Paul's and for other city churches. Portland Stone was employed for major public buildings such as the Bank of England, City of London, Somerset House, Westminster, and Mansion House, City of London. The National Westminster Bank (12 Angel Court) and the Royal Exchange, City of London are also built of Portland Stone and feature Cornish Granite in their plinths.

From the early 18th century, turnpike trusts improved the road system and development spread along the turnpike roads, enveloping villages such as Camberwell, Dulwich, Stockwell and Clapham to the south and Stratford to the north-east. New bridges were also constructed across the Thames, including Westminster Bridge.

Figure 6: British Museum, Bloomsbury. Portland Stone.

London continued to expand through the Georgian and Regency periods, driven by its importance as a port at the centre of an expanding empire. Two large-scale housing developments were constructed: the Grosvenor Estate, Mayfair, and the Bedford Estate, Bloomsbury. The terraces of houses and mansions were nearly all constructed in brick, with Portland Stone used sparingly for facade and window detailing, and Peterhead Granite also employed occasionally for pilasters. More prestigious housing was established westwards along the river at Chelsea, Hammersmith and Chiswick.

The enclosure of common land in the early 19th century, for example at Lambeth in 1806, facilitated the suburbanisation of the old villages of the surrounding parts of Essex, Kent, Middlesex and Surrey that now fall within Greater London. During the Regency Period (1811–20), the material of choice for the new villas and terraces was stucco which could be applied over brickwork and finished to look like stone, but for a fraction of the cost. Septaria were dredged from the sea off Harwich and were used to make Roman cement which was a constituent of stucco from 1790s.

The development of the canal network (from 1790) and the rail network (commencing with the Surrey Iron Railway in 1802) enabled the importation of stone from further afield and reduced the dominance of Portland Stone. Building stones could be sourced from anywhere in the UK. The growing rail network facilitated the rapid expansion of housing as people moved out from the crowded centre. At the same time, the absorption of neighbouring towns and villages accelerated across much of the north and north-east of the historic county of Surrey, the north and west of Kent, the west of Essex and much of eastern Middlesex. A large amount of the new construction was in brick which was cheaper than stone.

From the mid-19th century, the rapid expansion of the suburbs led to a demand for new churches and civic and commercial buildings. The Gothic Revival movement particularly favoured structural and decorative stone, resulting in a huge expansion and diversification in their use. Quarry Flint, Quaternary Flint and Kentish Ragstone were popular among Gothic Revival architects, with dressings and details in a wide variety of stones, including Scottish granites, Corsham Down (Bath) Stone and Forest of Dean Stone. Bath Stone was so cheap that it was used in place of hardwoods for a significant proportion of the bay windows of the thousands of 19th-century middle-class residences. The slate industries of Cornwall, Cumbria and Wales provided much of the material for London's roofing, and the city's streets were paved with stone sourced from Yorkshire, Lancashire, South Wales and Caithness.

A wide range of stones was used in civic and commercial structures, including Pennine sandstones, Lincolnshire limestones and equivalents (such as Ketton Stone, Weldon Stone, Ancaster Stone and Clipsham Stone) and Jurassic limestones from Oxford, Wiltshire and Somerset (including Doulting Stone and Ham Stone). Magnesium Limestone from North Anston, South Yorkshire, was employed in the construction of the

Houses of Parliament, Westminster. Cornish and Scottish granites, Cornish greenstones and serpentines were particularly favoured for frost-susceptible lower work, such as basements and foundations. A noteworthy example is Nelson's Column in Trafalgar Square, which is built of massive drums of grey Dartmoor Foggintor Granite, with the statue itself carved from Scottish Craigleith Sandstone.

Figure 7: Nelson's statue, Trafalgar Square. Craigleith Sandstone.

From the 19th century, stone imported from overseas was used increasingly in commercial and other buildings. London lost many historic buildings during the Second World War bombing raids. The result is a mixture of old and new, where a medieval church can sit in the centre of a modern urban office development. The introduction of planning controls and the green belt after the war limited the expansion of urban London. From the 1960s, high-rise and other developments have increasingly been built in the area, particularly along the Thames, in the City area and throughout the extensively redeveloped docklands. The use of a wide range of imported stone cladding from international sources is now ubiquitous.

## National Character Areas (NCAs)

Local landscape character and the combination of history, cultural and economic activity, geodiversity and biodiversity have been mapped for the whole of England, and National Character Areas (NCA) defined (see Further Reading). For each NCA there is a profile document which describes the natural and cultural features that shape the landscapes, how the landscapes have changed over time, the current key drivers for ongoing change, and a broad analysis of each area's characteristics and ecosystem services. The profiles include notes on local vernacular and building materials, which are expanded in the following section on the seven NCAs covered in this guide:

NCA 81 Greater Thames Estuary
NCA 111 Northern Thames Basin
NCA 112 Inner London
NCA 113 North Kent Plain
NCA 114 Thames Basin Lowlands
NCA 115 Thames Valley
NCA 119 North Downs

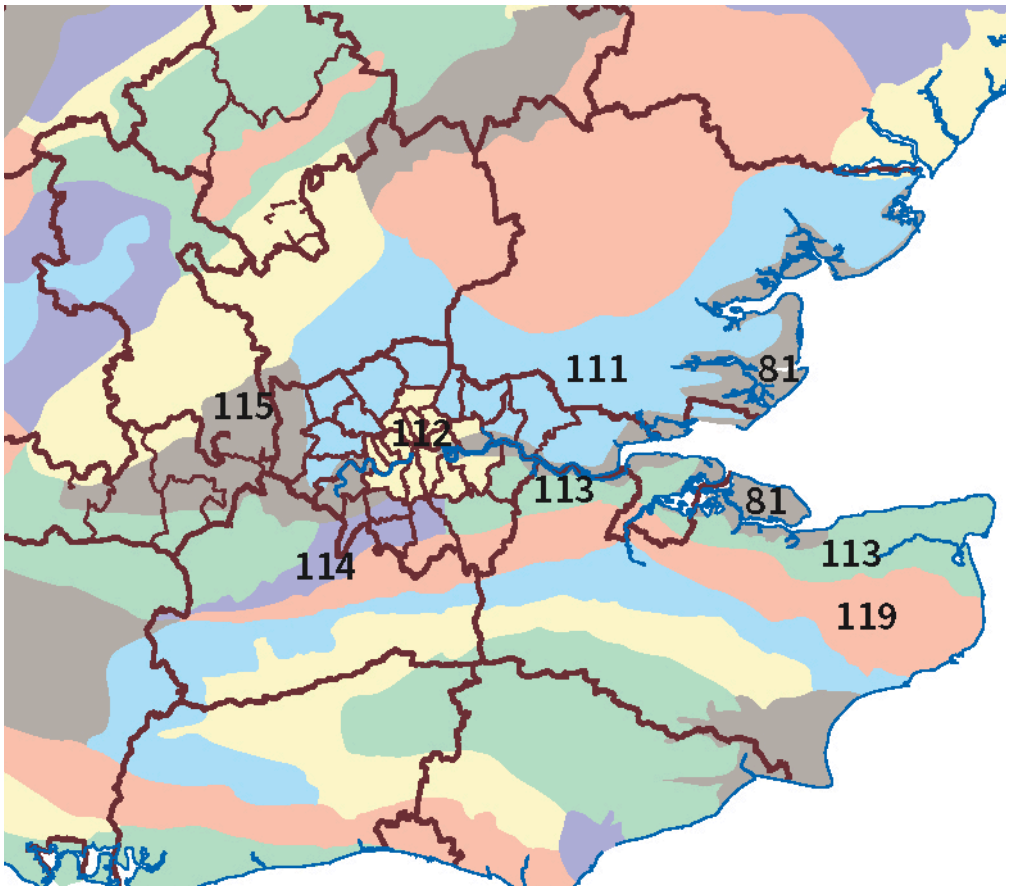



Figure 8: Map showing the National Character Areas (and the NCA numbers).

## Greater Thames Estuary

During the pre-Roman and Roman periods, settlements, ports and a salt industry were all established within the Greater Thames Estuary. Fishing and boat building and repair had developed around the villages of Wapping, Shadwell, Limehouse, Poplar and Blackwall by the mid-14th century. Along the south bank, Greenwich, Woolwich and Plumstead were all fishing

villages, although Greenwich developed as a prestigious settlement when a royal palace, Palace of Placentia, was built in 1443 on the same site as the later naval hospital. A few medieval churches survive, including the 12th-century Church of St John the Baptist at Erith, which exhibits a range of local its construction and repair.

Figure 9: Church of St John the Baptist, Erith. Quaternary Flint, with chalk and stone reused from Lesnes Abbey, Bexley.

By the 15th century, shipbuilding was being undertaken at Greenwich, and later on at Rotherhithe, and Blackwall Yard. Further docks were built in the late 18th century. Woolwich developed as an industrial and prominent military centre, with the Royal Arsenal established in the late 17th century. Historic naval docklands survive at Sheerness and Chatham, while Deptford and Woolwich also contain fine historic naval buildings. Greenwich benefited from significant royal patronage in the 17th century. Indigo Jones's Queen's House was completed in *c*. 1635, and Christopher Wren's Royal Naval Hospital in 1694, both employing Portland Stone.

Imported stones, including various granites and types of Millstone Grit were used extensively in the late 18th and early 19th centuries to build the quay walls and copings of London's docks, including at West India Docks, Isle of Dogs. Granite was employed to construct the Blackwall Basin, and Portland Stone was used for the dressings and cornices to warehouses London Dock, Wapping, was built in 1805 and Limehouse Basin on Regent's Canal in 1820. St Katharine's Dock, Tower Hamlets, was completed in 1850. The quays are built of brick with granite copings and dressings.

By the 1840s, many areas to the north and south banks of the Thames were notorious for their slums. Mission churches such as the Church of St Mary at Shadwell and Church of SS Mary and Michael at Stepney were built of Kentish Ragstone, often with Bath Stone dressings and Welsh Slate roofs.

Model dwellings started to be created from the 1860s. To the south bank, rapid population and suburban expansion took place inland from the second half of the 19th century. Dock development was extensive, uniting as the

Surrey Commercial Docks in 1864. Further east, the Royal Docks at Silvertown and Beckton were the last docks to be built in London, constructed between 1850 and 1921. However, these were built with earth banks, cast iron piling and concrete rather than stone. Much of the dockland area was destroyed by bombing in the Second World War. The modern redevelopment, including Canary Wharf, has used many imported stones, especially for cladding.

## Northern Thames Basin

The Northern Thames Basin comprises several distinct areas with differing landscapes and histories of settlement and land use. The area is divided by the Lea Valley into western and eastern halves. To the west lie the Ruislip, Barnet and Finchley Ridges and to the east the Essex Plateau, with the North Thames Terraces to its south. Both the Essex Plateau and North Thames Terraces are dissected by the valleys of the Brent and Roding. There was considerable variation in the availability of local stone and imported stone within the area.

West of the Lea Valley, the Thames Basin provided a range of ferruginous sandstones (ferricretes), flints and septaria, in addition to various derived sandstone and quartz-rich boulders for building purposes. Hertfordshire Puddingstone and similar conglomerates were available from the Colne Valley. On the Finchley Ridge, Quaternary Flint was likely sourced from fluvio-glacial pebble gravels in the area from Chipping Barnet to Stanmore and Bushey. Many of these stone types, notably various ferricretes, were employed in local churches such as at Friern Barnet, Pinner, Ruislip, Little Stanmore, Great Stanmore, Greenford and Monken Hadley, along with Quaternary Flint and Kentish Ragstone. Dressings were often of Bath Stone or Reigate Stone.


Figure 10: St John the Baptist Church, Pinner. Hertfordshire Puddingstone with flint and ironstone quoins.

Brick was used increasingly from the late 17th century, and the construction of the railways stimulated the expansion of existing towns and villages and the development of commuter settlements in the 19th and 20th centuries. The extensive rail network enabled a wide range of stone to be used. Materials such as Ancaster Stone, Ketton Stone, Bargate Sandstone, Bath Stone, Caen Stone and Portland Stone were all employed, although Kentish Ragstone was the most frequently used material for 19th-century churches.

During the interwar period, development was extensive across the area, including at Harrow, Northwood, Hendon, Finchley, Friern Barnet, Southgate, Barnet, Ilford, Romford and Dagenham. Suburban expansion continued through the 1960s and 1970s.

Public buildings in the area tend to date from the early 20th century. In Tottenham, the Town Hall, Public Baths and Fire Station are all built of red brick, with Portland Stone dressings and hipped Welsh Slate roofs.

## Inner London

The Inner London NCA contains more than 13,200 listed buildings and includes three World Heritage Sites (parts of Maritime Greenwich and its buffer zone, Palace of Westminster and Westminster Abbey including Saint Margaret's Church and the Tower of London).

North of the Thames, medieval parish churches survive in a few places. Examples include St Pancras Old Church at Somers Town, which is constructed mainly of Kentish Ragstone, and Old St Mary's Church at Hornsey, with various stone dressings and a Quaternary Flint facade, the tower of which is built mostly of ferricrete rubble with Kentish Ragstone quoins.

Figure 11: St Pancras Old Church, Somers Town. Kentish Ragstone with various stone dressings.

During the Middle Ages, Southwark was the only significant settlement south of the Thames. Parts of the Norman Augustinian Priory Church of St Mary Overie were later reworked in Southwark Cathedral during its alteration between 1220 and 1420. The main materials used for rebuilding in the 19th century were knapped Quaternary Flint, with dressings in Bath Stone and Purbeck Marble pilasters. Part of the 14th-century Bishop of Winchester's Palace survives at Southwark. It is built of Kentish Ragstone cobbles, with some chalk and flint pebbles; the tracery to the rose window is in Reigate Stone.

Lambeth Palace has served as the Archbishop of Canterbury's London residence since the 13th century. It includes a group of buildings of varying periods that exhibit the changes in the building stones used through time. The 13th-century chapel was constructed of Reigate Stone, with Purbeck dressings; the 15th-century Water or Lollards' Tower was built of Kentish Ragstone, with ashlar quoins and a brick turret; the 17th-century Laud's Tower is in similar materials with some flint; the 17th-century Great Hall is made of red brick with Portland Stone framed windows and the 19th-century residential apartments were constructed in Bath Stone.

From the 1840s onwards, many churches were built of Kentish Ragstone, often with Bath Stone or Portland Stone dressings. Examples include the Church of St Ann at South Tottenham, the Church of St Martin at Gospel Oak and Christ Church at Crouch End. Churches built in the early 20th century were constructed mainly in brick.

From the late 17th century until the end of the 19th century, terrace housing dominated the suburban development of Inner London. Much of this housing was constructed in brick, with relatively little stone used. From the 1860s, brick-built Welsh Slate-roofed terraces, often with stone doorways, became the predominant type of construction in Inner London.

Much use was made of Portland Stone to construct a wide range of public buildings from the 1800s onwards. Examples include the London Leather Hide and Wool Exchange, Southwark, the reconstruction of Waterloo Station, Freemasons' Hall, Holborn, and the University of London Senate House, Bloomsbury. The development of the railways also enabled a far greater range of stone to be imported. For example, the Houses of Parliament were partially rebuilt using North Anston Limestone and Cadeby Stone; St Pancras Station and its adjoining hotel were constructed mainly of brick, with imported Ancaster Stone dressings and pillars of grey and red Peterhead Granite.

Since the early 20th century, and particularly during the post-war period, a very wide range of imported stone from international sources has been employed in commercial buildings. The ground floor of Denman House, Piccadilly is clad with Larvikite from Norway. The Swan pub (46 Broadway) in Hammersmith is clad with Swedish red granite.


Figure 12: London Leather Hide and Wool Exchange, Southwark. Brick and Portland Stone dressings.

## North Kent Plain

The North Kent Plain includes the south London pebbly sands and the valleys of the Rivers Cray and Ravensbourne, as well as the settlements of Eltham, Bromley, Bexley and Beckenham. Historically, the area was lightly settled until the 19th century when there was limited suburban expansion around Bromley and Eltham, and also along the top of the ridge overlooking the Thames. Commuter towns such as Bromley developed from the late 19th century. However, most of the area remained largely undeveloped until the 20th century, when large-scale interwar suburbanisation occurred.

A range of building stones has been used in this area. One of the oldest surviving structures is the Abbey of SS Mary and Thomas the Martyr at Lesnes, Bexley, founded in 1178. The ruins consist of portions of walls and footings built of Kentish Ragstone, Quaternary Flint, Quarry Flint and chalk.

Figure 13: Eltham Palace, Eltham. Red brick and Clipsham Stone dressings.

The Great Hall of Edward II's moated Eltham Palace is built of brick but faced in Kentish Ragstone and Caen Stone. In the 1930s, a new home was built – incorporating the medieval palace – with extensive use of Clipsham Stone dressings.

The surviving medieval churches, and churches in this area often feature Kentish Ragstone in their construction. The former 12th-century church at East Wickham, now a Greek orthodox church, is built of Quarry Flint, Quaternary Flint, chalk and Kentish Ragstone. Many churches were restored or built as a response to the rapid expansion of the suburbs in the 19th century. For example, the Church of St George at Beckenham and the Church of St Mary the Virgin at Lewisham (incorporating a late medieval tower base) are both built substantially of Kentish Ragstone. Unusually, the 12th-century Church of St Paulinus at Crayford is constructed mainly of various forms of flint, with tufa used in some quoins.

Large estates and grand houses were built along the Thames from the 15th to the 16th century. Some survive, such as Hall Place, Bexley, which is constructed of chalk, Kentish Ragstone and Quaternary Flint, the last of which was also used for chequerwork and galleting. Bath Stone was employed extensively for repairs. Many villas were built in the area from the 1750s; Danson Park Mansion, for example, uses Portland Stone.

In the 19th and first half of the 20th century, new public and commercial buildings were constructed to serve the expanding population. These often feature combinations of brick and Portland Stone, as seen in several buildings in Bromley, including the Public Hall and the Town Hall.

Figure 14: Church of St George, Beckenham. Kentish Ragstone.

## Thames Basin Lowlands

The Thames Basin Lowlands was densely settled in the medieval period with a varied pattern of towns, villages and isolated farmsteads, including the historic settlements of Croydon, Mitcham, Merton, Morden, Carshalton, Sutton and Chessington. Most of the built development dates from the Victorian period and the boom in housing that followed the growth of the railways. Railway electrification in the first two decades of the 20th century encouraged further expansion.

Timber frame was the dominant form of construction for vernacular houses. Brick, sometimes with flint, became common from the 17th century. Quaternary Flint was used extensively in medieval churches, with original dressings of chalk. Such dressings have frequently been replaced with a variety of imported limestones following their deterioration. Most of the area's churches were heavily restored and altered or rebuilt in the 19th century; knapped flint was often used to reface them. Examples include the Church of St Mary the Virgin at Beddington, Church of St Mary at Merton and the old Parish Church of St John the Baptist at Croydon. Dressings are usually of Bath Stone or Ancaster Stone. Bargate Stone dressings were also used occasionally, as seen in the Church of St Augustine at Croydon. Other stones employed in the construction of 19th-century churches in this area include Bath Stone (Church of the Holy Innocents at South Norwood) and Kentish Ragstone (several churches in Croydon, including the Church of St Andrew, Church of St Mark and West Croydon United Reform Church).

New public buildings were provided to serve the growing community of the late 19th and 20th centuries. They were generally built of brick with slate roofs, sometimes with Portland Stone dressings. Examples include Sutton Police Station and Croydon Town Hall and Library. Portland Stone was also used for cladding at Colliers Wood and South Wimbledon Underground Stations.

Figure 15: London Underground Station, South Wimbledon. Portland Stone cladding.


## Thames Valley

The Thames Valley NCA includes the former areas of Surrey from the south of the Thames to Wimbledon and New Malden, and an area the north of the Thames from Acton to Heathrow. It also incorporates parts of the former county of Middlesex as far north as Harefield. Most of the area was rural until the 18th century, with settlements along the banks of the Thames and small villages, farms and manor houses inland. A variety of local materials were available, reflecting the varied geology of the area.

In the Colne Valley, the historic cores of medieval settlements remain at Harefield, Uxbridge, West Drayton and Harmondsworth. Medieval churches of the area were built of a variety of local materials, including chalk, locally sourced Quaternary Flint pebbles and ferricrete (Conglomeratic Ironstone), along with Roman brick and imported Jurassic limestones. The limestones were mainly used for quoins, mullions and other decorative features. Examples include the 12th-century Churches of St Mary and of SS Peter and Paul, both at Harmondsworth. At Harmondsworth, the Great Barn aisle posts stand on blocks of Reigate Stone, and the sill walls are constructed of large blocks of ferricrete (Conglomeratic Ironstone) and lesser amounts of Quaternary Flint, Reigate Stone and brick.

Elsewhere, Kentish Ragstone is one of the most prevalent building stones encountered, and it was employed extensively for churches in the second half of the 19th century. For example, the Churches of St Paul and St Nicholas at Hounslow) and at Farnell's Almhouses, Feltham. In the Upper Thames area, Kentish Ragstone was used for older structures, such as the 14th-century Lovekyn Chapel at Kingston upon Thames. Kentish Ragstone was also employed for the new Victorian Churches of St Stephen and St John, both at Richmond upon Thames; the dressings of many such churches were of Bath Stone.

As elsewhere, many public buildings, such as the Market House and Surrey County Hall, Kingston upon Thames, were constructed largely of Portland Stone with Welsh Slate roofs. Portland Stone was also employed as the facing stone for Chiswick Bridge, constructed in 1933 mainly from reinforced concrete.

Figure 16: Chiswick Bridge. Portland Stone facing on reinforced concrete.

## North Downs

The Greater London parts of the North Downs is underlain by chalk bedrock. Patterns of settlement largely reflect the historic lines of communication along the valleys and sheltered valley side slopes. There are older settlements with medieval churches at, for example, Old Coulsdon, Downe, Cudham, Farnborough and Sanderstead. Extensive interwar and post-war residential development took place. Villages such as Purley, Selsdon, Sanderstead, Farnborough and Coulsdon merged into an urban sprawl. Elevated land with a relatively even slope was developed as airfields at Biggin Hill and Kenley. In the east, some villages that were formerly in Kent, such as Downe, Cudham and Chelsfield, retain more of their rural character.

Timber frame was the traditional building form, sometimes roughcast or tile hung with thatch for roofing, although thatch was largely replaced by plain clay tiles from the Weald from the 17th century, and later by slate. The use of brick started in the 15th century and became common from the 17th century onwards.

A range of stones was employed to construct medieval churches, including Quarry Flint, Quaternary Flint, chalk, ferricrete and brick. Typically, the enlarged suburban settlements often retain their medieval churches at the heart of the original village. Examples include the late 13th-century Churches of St John the Evangelist at Coulsdon and All Saints at Sanderstead, as well as the late 11th or early 12th-century Church of St Martin of Tours at Chelsfield. Flint was also employed for facing; an early example of this is the Priory at Orpington (15th–17th century).

Occassionally, chalk was used for walling to cottages and houses. An example of its use nearby in the Thames Basin Lowlands area is the Honeywood Museum at Carshalton where the original walls are built of chalk.

Urban expansion led to new churches being built, such as the Church of St Mark at Woodcote. Like many churches of the time, it was constructed of Kentish Ragstone.

Figure 17: The Priory, Orpington. Quaternary Flint and chalk with Portland Stone dressings.

# 3 Local Building Stones

## Cretaceous

### Chalk Group, White Chalk Subgroup

In the Greater London area, the white chalky limestones of the White Chalk Subgroup occur mainly in the south-eastern boroughs adjoining Surrey and Kent, namely Sutton, Croydon, Bromley and Bexley. A band of chalk also extends east to west, broadly along the edge of the River Thames within the boroughs of Southwark, Lewisham and Greenwich. A small outcrop is present in north-west Hillingdon.

#### Chalk (Clunch)

Chalk is a white to very pale grey or pale buff limestone, which in places contains fossil bivalves (including oysters, inoceramids) and echinoids, and occasionally crinoids, brachiopods and belemnites. Apart from occasional fine lamination, chalk is typically massive and structureless. It is generally unsuitable for exterior masonry because repeated wetting and drying (coupled with frost action) causes the relatively soft rock to powder and disintegrate into small angular brash.

Figure 18: Greek Orthodox Church of Christ the Saviour, East Wickham. Knapped Quarry and Quaternary Flint, chalk, Cretaceous sandstone and brick.

Much of the chalk bedrock strata in the Greater London area is covered by younger superficial deposits. Consequently, chalk was only seldom employed as an external building stone, and it is usually found in association with other stone types. Examples of its use include the north face and wing of Hall Place, Bexley, and the Greek Orthodox church at East Wickham. Chalk can also be seen in the ruins of Lesnes Abbey, Bexley, and the remains of Winchester Palace, Southwark (along with Kentish Ragstone and flint). Chalk was also employed with flint and other rubble in the former Roman Bath House, Tower Hamlets.

### Quarry Flint (Fresh Flint)

Quarry Flint occurs as bands or isolated nodules within the chalky limestone beds of the White Chalk Subgroup. It is an extremely fine-grained (cryptocrystalline) and hard form of silica, containing microscopic quartz-crystal aggregates. Quarry Flint usually occurs as irregular-shaped nodules that are 100 to 200mm across, or as (sub-) rounded pebbles or cobbles. Occasionally, it is also found as weakly banded tabular sheets or layers up to 200mm thick. The colour is very distinctive: fresh nodules have a white outer cortex with a black or dark grey interior.

Quarry Flint breaks with a characteristic conchoidal fracture, producing razor-sharp fine edges. The cleaved surfaces may exhibit banding, resulting from the alternating layers of slightly different composition. Flint nodules may contain cavities lined with translucent botryoidal chalcedony or small transparent quartz crystals. Some nodules contain well-preserved fossils, with echinoids, sponges, bivalves, burrow structures and occasionally belemnites being encountered.

Only a relatively minor proportion of flint employed in Greater London buildings appears to be Quarry Flint (Fresh Flint) sourced directly from the Cretaceous strata. However, it is known to have been used in the boroughs of Barnet, Islington, Tower Hamlets, Kingston upon Thames, Merton and Bexley. Where encountered, it often occurs with Quaternary Flint. It was employed in a variety of ways, including as knapped, faced or trimmed stone and sometimes in squared chequerwork. Fine examples (including chequerwork) can be seen in the Church of St John the Baptist at Chipping Barnet and Church of All Saints at Kingston upon Thames.

Figure 19: Church of St Mary, Harmondsworth. Knapped Quarry Flint nodules.

Figure 20: Church of St John the Baptist, Chipping Barnet. Quarry Flint, Quaternary Flint, Bath Stone and Ancaster Stone.

## Palaeogene

### Lambeth Group, Upnor Formation

#### Hertfordshire Puddingstone

Hertfordshire Puddingstone is one of the most distinctive stone types encountered in Greater London. It is now known to occur in situ in underground workings at Pinner, which were part of the former chalk mines. Here, the Puddingstone forms part of the coarse-grained pebble deposits assigned to the Upnor Formation, which overlies the Cretaceous White Chalk Subgroup.

The puddingstone is a conglomerate containing sub-rounded pebbles of flint, which mainly exhibit grey interiors but may also be stained by various iron compounds to produce attractive hues of red, orange or (occasionally) green. The size of the pebbles varies considerably, even within a single block, but they typically range from 10 to 100mm. However, much larger cobbles sometimes occur. The pebbles are cemented by relatively uniform pale grey or buff quartz, as well as patches of iron-rich sand. Some blocks are intensely clast-dominated, with relatively very minor amounts of matrix.

Overall, Hertfordshire Puddingstone is a hard, coherent and durable rock that tends to break in a regular planar manner both around and through pebbles. Synthetic concrete may resemble Hertfordshire Puddingstone, but it fractures unevenly. Conglomeratic Ironstone is much darker coloured and has an iron-rich cement (the cement in Hertfordshire Puddingstone is pale grey and siliceous).

Hertfordshire Puddingstone is only employed very occasionally as a building stone in the Greater London area, notably in the north-western boroughs of Barnet and Harrow adjoining Hertfordshire. It is used as small, mainly isolated, blocks in the church towers of St Margaret of Antioch at Edgware and St Lawrence at Little Stanmore, as well as at the Church of SS Peter and Paul at Harlington.

Figure 21: Church of St Margaret of Antioch, Edgware. Hertfordshire Puddingstone and other stones.

Figure 22: Church of SS Peter and Paul, Harlington. Hertfordshire Puddingstone, Conglomeratic Ironstone and Quaternary Flint.

## Thames Group, London Clay Formation

### Septaria (Cementstone)

Septaria are dark brownish-grey to ochreous, fine-grained, calcareous mudstone concretions. They occur within the Eocene-aged London Clay Formation, which crops out over much of the Greater London area, beneath the covering of younger superficial deposits. Septaria are typically featureless, but sometimes exhibit a weathered outer greyish-coloured 'skin' and 'blocky' internal structure. Their surfaces are typically curved and smooth, but they may also display hairline cracks that indicate future areas of weathering and decomposition.

Unfortunately, septaria fracture and weather relatively easily to a yellow-brown, ochreous colour and either exfoliate in layers or sometimes disintegrate in a cuboidal fashion.

Septaria are only employed very occasionally as a building stone in the Greater London area. One notable example is the tower of the Church of St Mary the Virgin at Monken Hadley.

Figure 23: Church of St Mary the Virgin, Monken Hadley. Septaria and Quaternary Flint nodules, with Bath Stone dressings.

## Quaternary

### Various Groups, Various Formations

#### Cinderstone

Cinderstone is a dark-coloured variety of ferricrete, typically appearing blackish-purple and massive in form. It is generally a finer grained stone than Conglomeratic Ironstone, although small scattered flint clasts or pebbles (pebbly Cinderstone) may be present. Cinderstone typically exhibits closely spaced, irregular cavities of 5 to 15mm in size, which have near-black linings of iron-oxide cemented coarse silt or sand. The weathered surfaces of blocks often display a blackish iron-oxide 'sheen'.

Typically, Cinderstone is a hard durable stone and it is relatively resistant to weathering. It is only occasionally encountered in the Greater London area, but examples can be seen in the walls of the Church of St Mary at East Bedfont, Church of St James at Whetstone near Friern Barnet and Church of St Mary at Finchley.

Figure 24: Church of St Mary the Virgin, East Bedfont. Cinderstone.

#### Conglomeratic Ironstone

Conglomeratic Ironstone is a very distinctive conglomeratic variety of ferricrete. The main rock type seen is a clast-supported conglomerate, comprising a dark purple-black-coloured, coarse-grained, iron-rich matrix, in which pebbles of orange-brown chert or blackish Quaternary Flint occur. These pebbles are usually well rounded and vary in diameter from 20 to around 70mm. Typically, smaller subangular clasts or flakes of chert and Quaternary Flint are also present, sandwiched between the larger rounded pebbles. The clasts show no obvious preferred orientation. Some blocks of Conglomeratic Ironstone lack any larger rounded pebbles and instead contain smaller subangular clasts (up to 20mm in diameter) of chert, sandstone and (occasionally) flint, set in a purple-black, iron-rich matrix. These blocks may be classed as matrix-supported breccio-conglomerates.

Intermediate varieties of Conglomeratic Ironstone occur, sometimes within the same block.

Typically, Conglomeratic Ironstone is a hard, durable stone, relatively resistant to weathering. Some blocks may superficially resemble Hertfordshire Puddingstone, but they are readily distinguished by their overall darker colour and iron-rich matrix. These features contrast strongly with the much paler Hertfordshire Puddingstone, with its light grey, siliceous matrix.

Conglomeratic Ironstone is rarely encountered in buildings in the Greater London area, but occurs occasionally as irregular blocks, especially within church walls. Examples can be seen at the Church of St Mary at East Bedfont, Church of St Mary at Harmondsworth and Church of St James at Whetstone near Friern Barnet. A particularly fine example is found at the Great Barn at Harmondsworth, where large blocks have been used in the lower courses of the walls.

Figure 25: Great Barn, Harmondsworth. Conglomeratic Ironstone and Quaternary Flint.

Figure 26: Church of St Mary, Harmondsworth. Conglomeratic Ironstone and Quaternary.

## Ferricrete (Ironstone)

The term ‘ferricrete’ is applied here to an important group of closely related building stones that formed in geologically recent times as the result of iron-rich groundwaters cementing various sands, gravels and conglomerates. In older literature, ferricrete has typically been used in a broad sense to encompass a range of ironstones, including the distinctive Conglomeratic Ironstone and Cinderstone recognised here.

Ferricrete is a fine to coarse-grained, deep blackish-brown, red-brown to orange-brown-coloured, iron-rich sandstone. It tends to be relatively massive and featureless, apart from occasional laminations or lines of small flint or quartzite clasts. Some blocks appear to be quite ‘pebbly’ and may grade towards a Conglomeratic Ironstone variety. Blocks often lack discernible bedding structures; the clasts show no obvious preferred orientation. Typically, ferricrete is a hard, durable and tough stone that possesses excellent weathering properties.

The origin of ferricrete is not known. A possible source could lie within Neogene or Quaternary superficial deposits. Alternatively, the stone could derive from iron-rich strata within the Palaeogene Bracklesham Group.

Although ferricrete has been employed only occasionally for building purposes in the Greater London area, it is highly distinctive and conspicuous where it occurs. It is mainly found in the north-western boroughs of Barnet, Harrow, Hillingdon and Hounslow, but was also used in the boroughs of Ealing, Haringey and (to the east of the area) Havering. Typically, it has been employed in wall fabrics as roughly tabular to larger sized blocks, but it can also be found as small irregular lumps. Slabby forms are very rare because the stone tends to lack bedding structures.

Figure 27: Church of St Mary, East Bedfont. Ferricrete and Bath Stone dressings.

Particularly good examples of ferricrete can be seen at the Church of St Mary the Virgin at Monken Hadley, Church of St James at Whetstone near Friern Barnet, Church of St Mary at Harrow on the Hill, Church of SS Mary and Peter at Wennington, Church of SS Peter and Paul, Harlington, Church of St Mary at East Bedfont and the tower of the old Church of St Mary at Hornsey.

Figure 28: Church of SS Peter and Paul, Harlington. Ferricrete.

## Flint

### Quaternary Flint (River Terrace Gravel Flint)

Quaternary Flint originates from Quarry Flint nodules, which have been recycled by natural processes into Quaternary superficial deposits. Its extreme hardness, durability, resistance to weathering and ready availability have resulted in Quaternary Flint being the most common and widely used indigenous building stone in the Greater London area.

Quaternary Flint typically occurs as rounded pebbles (sometimes as irregular nodules) within fluvio-glacial, alluvial and river terrace gravels and sands. The size of the pebbles typically ranges from 50 to 200mm. The colour is variable: less weathered flint nodules or pebbles have a cream outer cortex with a darker coloured (greyish) interior; weathered flints, or those that have lain in soil or superficial deposits for a long period of time, may be variously discoloured or bleached, and often have brown-stained interiors due to the precipitation of iron hydroxides from percolating ferruginous waters. Some Quaternary Flint pebbles display ‘chatter marks’ (small curved pits, indentations or cracks) on their highly weathered surfaces; others may be coloured red, indicating they have been burnt. This weathered appearance helps distinguish field flint from the much fresher looking Quarry Flint.

Quaternary Flint is encountered in the wall fabric of many buildings (especially churches) in almost all boroughs of Greater London. It was mainly employed as nodules or pebbles laid randomly or roughly to course, but occasionally as knapped, faced, trimmed or cleaved-faced stone in random or decorative arrangements.

Particularly fine examples can be seen north of the River Thames at Chipping Barnet (Christ Church), Greenford (Church of the Holy Cross), Harmondsworth (Church of St Mary), Leytonstone (Church of St Andrew), Northwood (Church of the Holy Trinity), Oakleigh Park (Church of All Saints), Pinner (Church of St John the Baptist), Tottenham (Church of All Hallows) and Wembley (Church of St John). South of the River Thames, fine examples of Quaternary Flint are seen at Bexley (Church of St Mary the Virgin), Carshalton (Church of the Holy Trinity), Chiswick (Christ Church), Downe (Church of St Mary the Virgin), Streatham (Coach House, Flint Cottage), Norwood Green (Church of St Mary), Palmer's Green (Church of St John the Evangelist), Richmond upon Thames (Church of St Mary Magdalene) and Wimbledon (Church of the Sacred Heart).

Figure 29: Church of All Saints, Oakleigh Park. Quaternary Flint, Ancaster Stone and Bath Stone.

Figure 30: Church of St Mary, Harmondsworth. Quaternary Flint nodules.

# 4 Examples of Imported Building Stones

A very diverse range of imported building stones from around the UK has been employed in the Greater London area, including Scottish granites, Welsh and Cumbrian slates, Derbyshire limestones, and Cornish granites. In this section, only a small selection of the more frequently encountered sedimentary stone types from England are covered. There are also many different stones sourced from around the world.

## Upper Carboniferous

### Millstone Grit Group, Hebden Formation

#### Libishaw Sandstone, North Yorkshire (West)

A durable, fine to medium-grained, micaceous, feldspathic, thinly bedded sandstone. Libishaw Sandstone is of variable colour, ranging from pale grey to a buff or pale brown (particularly when weathered), and typically displays lamination and cross-bedding structures. The main workings at Scotgate Ash were well known for their flagstones and landing stones, as well as for general building stone. Several variants of the stone were marketed during the 1880s, including Block Stone (a homogenous stone employed for high-class masonry and monumental purposes) and Grit Stone (a coarser grained stone used mostly for dock walls and cheaper masonry). After the railway reached Pateley Bridge in 1862, the Scotgate Ash quarries expanded and sent stone all over the country. Libishaw Sandstone from Scotgate Ash was used in several prestigious buildings in London, including the National Gallery in Trafalgar Square and the South Kensington museums.

## Permo-Carboniferous

### Bodmin Moor, St Austell, Carnmenellis and Land's End Plutons

#### Cornish Granites, Cornwall

A coarse-grained igneous rock, often pale grey in colour (although other coloured varieties occur), comprising an interlocking mosaic of grey quartz and white (sometimes pink) feldspar crystals. The latter are often conspicuously large (such crystals are termed phenocrysts) and display good crystal shapes. Smaller amounts of darker iron and magnesium-bearing minerals, and glinting flakes of mica, are also usually present. Many types of granite have been employed in Greater London. It is seen, in dressed and polished guises, as structural or decorative elements of buildings (including


Figure 31: National Gallery, Trafalgar Square. Portland Stone and Libishaw Sandstone.

banks and offices), bridges and memorials, or in more roughly fashioned form as paving setts and kerb stones. Cornish Granite is very durable and has been used in many constructions flanking the River Thames, especially in embankments and riverside walls, and as bridge foundations and piers. For example, Bodmin Granite was employed for Tower Bridge and London Bridge. Land's End Granite (including granite from Lamorna) was used in the construction of the Albert Embankment opposite the Houses of Parliament.

Figure 32: Tower Bridge, River Thames. Cornish Granite foundations, Kentish Ragstone and Portland Stone towers.

## Permian

### Zechstein Group, Cadeby Formation

#### Anston Stone (Magnesian Limestone), North Anston, South Yorkshire

The Houses of Parliament were originally constructed of Anston Stone. In 1840, over 14,000m$^3$ were extracted from quarries at North Anston and transported to Westminster via the Chesterfield Canal and the tidal Trent. However, the stone decayed quickly due to a combination of atmospheric pollution in the capital and poor quality control at the source quarries. Consequently, a further 22, 653m$^3$ of stone was taken to London in 1902 for repair work. Additional restoration projects commenced at Parliament in the 1930s, when it was deemed necessary to employ Clipsham Stone (a honey-coloured limestone from Medwells, Rutland) to replace the decayed Anston Stone.

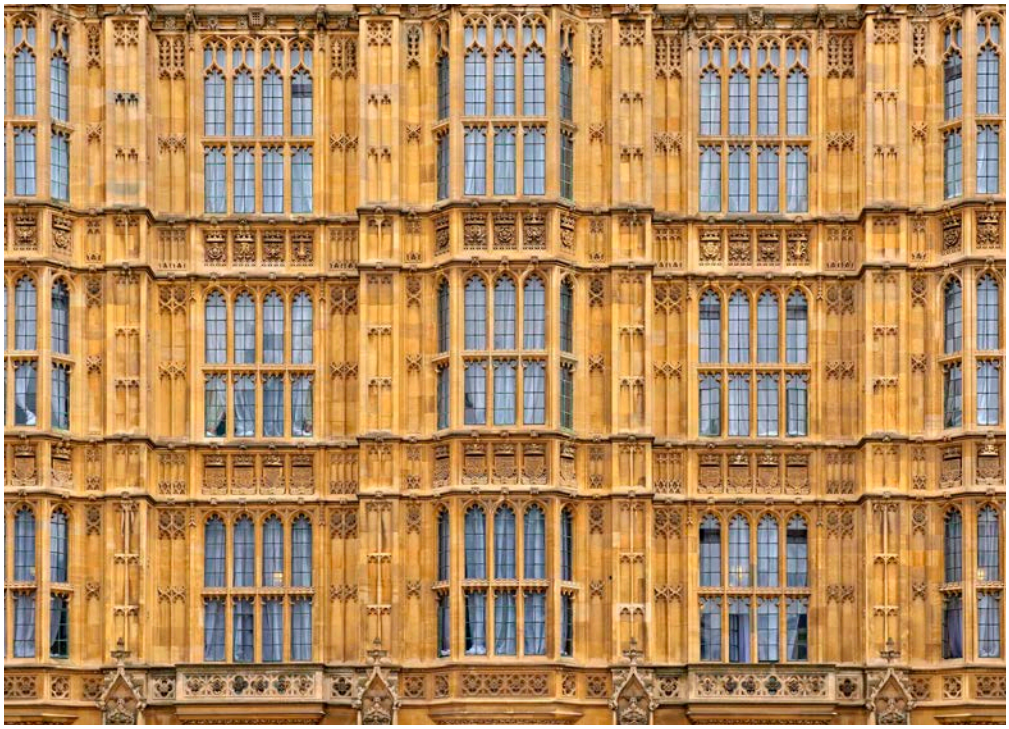


Figure 33: Houses of Parliament, Westminster. Anston Stone, restored with Clipsham Stone.

## Permo-Triassic

### Zechstein and Sherwood Sandstone Groups, Various Formations

#### Mansfield Red Sandstone, Nottinghamshire and Permo-Triassic New Red Sandstone, various counties

Mansfield Red Sandstone is a pale red to red-brown, fine to medium-grained, dolomitic sandstone, which often displays cross-beding and lamination. Other similarly coloured, non-dolomitic sandstones of Permian or Triassic age have also seen use across Greater London. These other Permo-Triassic or New Red sandstones are often impossible to provenance in the absence of documentary or petrological evidence. Mansfield Red Sandstone and Permo-Triassic sandstone have been employed sporadically in Greater London,

typically as dressings or for decorative purposes. Examples include the former Congregational Church at Forest Gate and the Dyce Drinking Fountain at Streatham Green.

Figure 34: Former Congregational Church, Forest Gate. Knapped flint with Permo-Triassic sandstone and brick dressings.

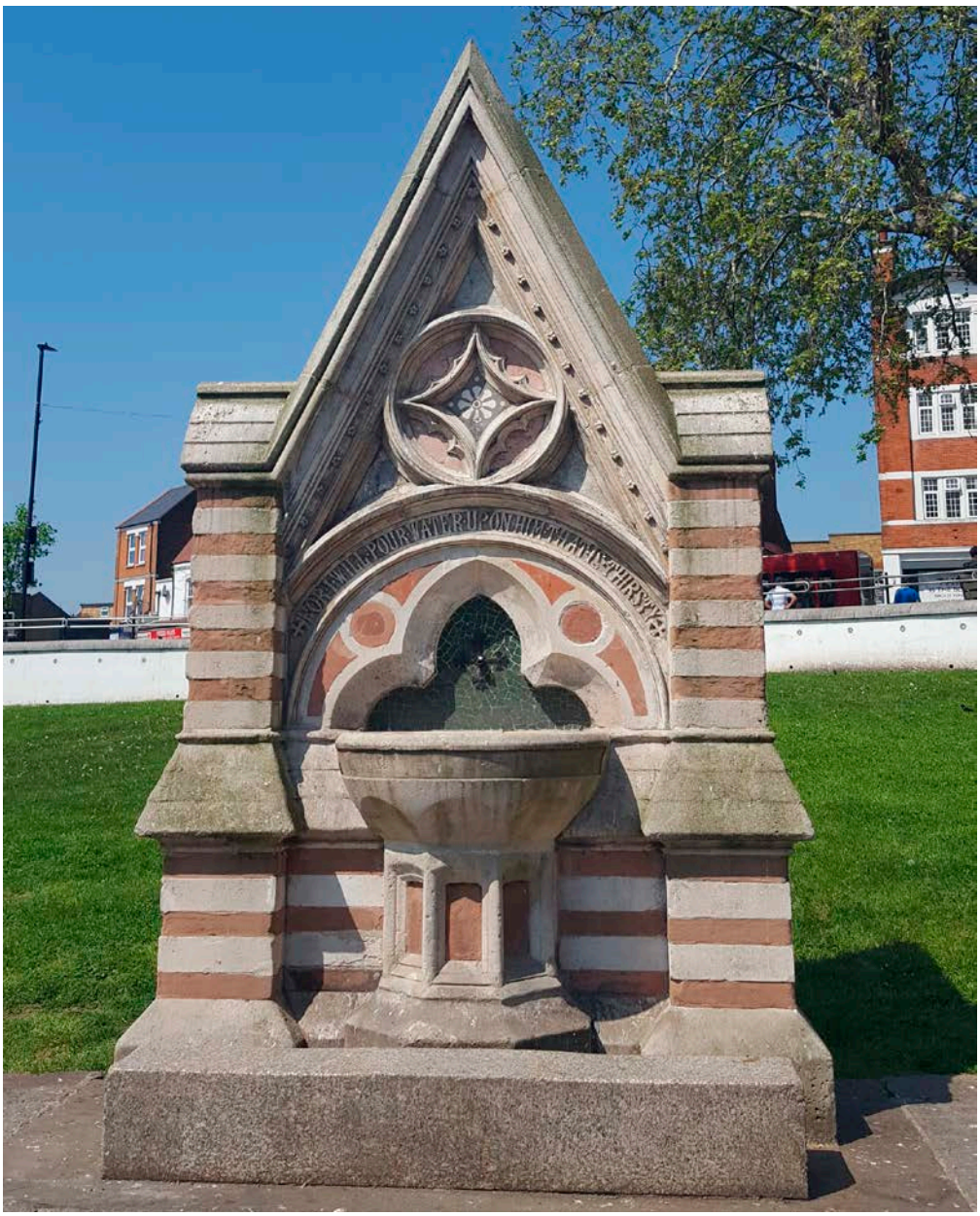


Figure 35: Dyce Drinking Fountain, Streatham Green. Portland Stone and possibly Mansfield Red Sandstone on a Cornish or Devon granite base.

## Middle Jurassic

### Ravenscar Group, Saltwick Formation and Cloughton Formation

#### Aislaby Stone, Aislaby Quarries, Whitby, North Yorkshire

A variegated (pale grey, yellowish-buff to pale brown), medium to coarse-grained sandstone. Blocks typically show coarse cross-bedding features and tend to weather in an irregular manner, almost becoming honeycombed at times. High-quality Aislaby Stone was exported from the larger and most productive quarries on Aislaby Moor (south-west of Whitby) for use in London, including at Covent Garden.

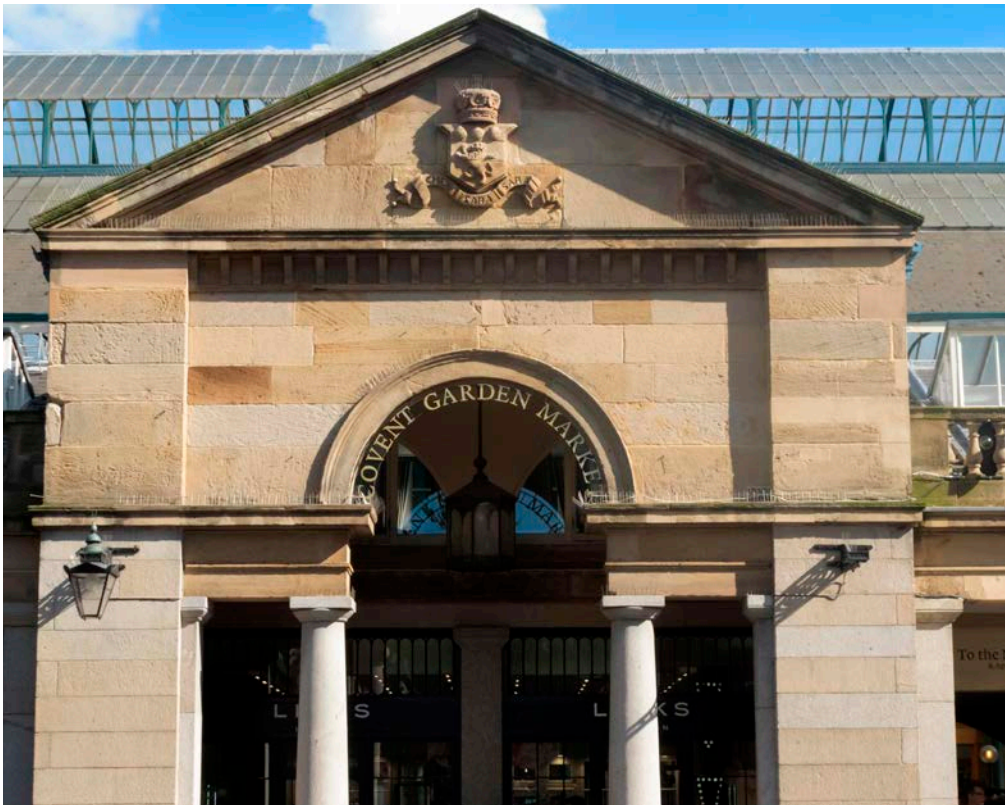



Figure 36: Market building, Covent Garden. Aislaby Stone and Aberdeenshire Dancing Cairns Granite columns.

## Middle Jurassic

### Inferior Oolite Group, Lincolnshire Limestone Formation

#### Ancaster Stone, Ancaster, Lincolnshire

A medium to coarse-grained, creamy-white to pale yellow (occasionally ochreous), ooidal and bioclastic limestone, which exhibits cross-bedding structures and often assumes a distinctive ‘streaky bacon’ appearance upon weathering. In Greater London, Ancaster Stone has been used sporadically, mainly for ornate front portals of commercial buildings or for the dressings of churches and civic buildings.


Figure 37: Town Hall, Holborn. Ancaster Stone.

## Great Oolite Group, Chalfield Oolite Formation

### Bath Stone, Bath, North East Somerset and Corsham, Wiltshire

A cream to buff-yellow-coloured, variably bioclastic, ooidal limestone. Bath Stone was used extensively throughout Greater London, especially in Victorian new-builds and church refurbishments. It was commonly employed as window and door mouldings, but also as ashlar in important civic buildings.

Figure 38: Town Hall, Ilford. Bath Stone.

## Upper Jurassic

### Portland Group, Portland Stone Formation

#### Portland Stone (and varieties), Dorset

A near-white or very pale-coloured ooidal and/or bioclastic limestone that (in its basebed guise at least) is typically a fine and even-grained freestone. Several distinctive textural varieties are quarried, including Roach, which contains conspicuous casts of turreted fossil gastropods. The presence of finer comminuted fossil shell bioclasts may be sufficiently numerous in some varieties to impart a very pale greyish hue to blocks of the stone.

Portland Stone is one of the most common and distinctive building stones found in Greater London and it was the stone of choice for many landmark buildings and monuments. It was used extensively during the 17th to 19th centuries and was favoured by Christopher Wren. He employed it in many of his buildings, including St Paul's Cathedral, Queen Mary Court and Queen Anne Court at Greenwich Hospital, Hampton Court Palace, Temple Bar Gate and numerous churches such as St Michael Paternoster Royal, St Mary-le-Bow and St Edmund, King and Martyr in the City of London. It was also used by Inigo Jones to build what is now the National Maritime Museum, Greenwich. Portland Stone has been employed as a high-quality ashlar walling, notably in civic, administrative, military and financial buildings, and has been widely used for monuments, war memorials, gravestones, fountains and columns.

Figure 39: St Paul's Cathedral, City of London. Portland Stone including Jordans Basebed variety and some Weldon Stone.

Figure 40: BBC Broadcasting House, Portland Place. Portland Stone and Bowers Roach variety.

Figure 41: National Maritime Museum, Greenwich. Portland Stone and Fancy Beach Whitbed variety.

Figure 42: White Tower, Tower of London. Kentish Ragstone, with some Portland Stone, Quarr Stone, Binstead Stone and Reigate Stone.

## Lower Cretaceous

### Lower Greensand Group, Hythe Formation

#### Kentish Ragstone, Kent

A medium to coarse-grained, pale greenish-grey or pale brown limestone that contains greater or lesser amounts of quartz, glauconite and fossil shell debris. Some beds (and the stone blocks produced from them) are chert-rich. Kentish Ragstone has been widely employed throughout south-east England and Greater London. Its use in Greater London dates from Roman times, when quarries located in the upper Medway Valley were worked extensively for 'ragstone' for the construction of Londinium. Quarrying of Kentish Ragstone resumed during the Norman period, and both Westminster Abbey and the White Tower (the oldest surviving part of the Tower of London) feature the stone in their structures. More recently, Kentish Ragstone was used extensively in the building of Victorian churches and other ecclesiastical structures, often in association with Bath Stone (for dressings) and occasionally Quaternary or Quarry Flint (for decorative purposes).

### Lower Greensand Group, Sandgate Formation

#### Bargate Stone (Bargate Sandstone), Surrey

A hard, medium-grained, rich honey-brown-coloured, calcareous sandstone. Varieties include dark fawn-brown or grey-green, glauconitic, flaggy, calcareous sandstones and pale brown, coarse-grained 'gritstones', which contain small (2–5mm in diameter) clasts of quartz, quartzite, flint, chert and sandstone. It is often well-bedded and readily breaks into slabs 100 to 150mm thick, which can be used characteristically as brick-sized blocks.

The last working source of Bargate Stone in Surrey was Stockstone Quarry, located just north of Hindhead, which ceased production during the early 1990s. Bargate Stone is only rarely encountered in Greater London.

Figure 43: Church of St John, Belmont. Bargate Stone, with Ketton Stone (and possibly Bath Stone) dressings.

## Selborne Group, Upper Greensand Formation

### Reigate Stone, Surrey

A massive, pale grey to off-white calcareous siltstone with a sub-conchoidal fracture that weathers to a pleasant pale buff, grey or cream colour. It is rarely fossiliferous. From a distance, weathered Reigate Stone can resemble chalk, but the latter powders easily when scratched. It is usually more durable, especially the forms that contain more chert and calcite cement. Reigate Stone was employed occasionally in Greater London, often in association with other stone types, mainly in high-status ecclesiastical buildings and fortifications.

Figure 44: Church of St Mary the Virgin, Hayes. Quaternary Flint with Reigate Stone dressings.

# 5 Further Reading

The Further Reading, Online Resources and Contacts guide provides general references on:

- Geology, building stones and mineral planning
- Historic building conservation, architecture and landscape.

There is also a separate glossary of geological terms.

## Greater London references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## Figures

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