British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Future Thames

Cities, catchments and coasts: applied geoscience for decision-making in London and the Thames Basin

Cities, catchments and coasts

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Applied geoscience for decision-making in London and the Thames Basin

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Introduction

Cities, catchments and coasts: applied geoscience for decision-making in London and the Thames Basin

The Thames Basin is the UK's principal aquifer. It encompasses London, which is Europe's largest megacity, and has an extensive coastal zone. It presents a unique conjunction of geological, hydrogeological, environmental, and socio-economic factors that are intrinsically linked by the effects of environmental change. The British Geological Survey (BGS) is responding to this challenge through its FutureThames initiative.

FutureThames aims to initiate, facilitate, and support interdisciplinary and collaborative geoscience research in an attempt to understand the effects of environmental change in the Thames Basin. The project endeavours to involve not only the diverse threads of geoscience within the BGS, but also the wider environmental communities, public bodies and industry to provide a holistic approach to predicting and mitigating the effects of environmental change. Providing a relevant and focussed geoscience knowledge base and encouraging knowledge exchange between researchers and practionners is essential if the impacts of environmental change in the Thames Basin are to be quantified.

This document highlights some of the key challenges affecting the Thames Basin that geoscience can play a role in addressing. Examples of applied research and data from the region show how geoscience can be used to reduce risk and support economic growth. This document provides a starting point to encourage the use of geoscience as part of an integrated solution.

For more information about FutureThames, contact futurethames@bgs.ac.uk

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Vision

To bring together diverse threads of geological knowledge, capability and research into a fully attributed three-dimensional model of physical properties and processes, and support effective decision-making to help mitigate the effects of environmental change within the Thames Basin.

The importance of geology

Understanding the geology of the UK is essential for continued economic and social development to improve our quality of life. It is necessary for protection of the natural environment, the quality and character of the countryside, the built environment and existing communities. It is important for using and protecting agriculture, forestry, water and mineral resources, soils, and contributing to research into environmental change. Nearly everything we use in daily life, from roads and computers to toothpaste, originates from components of rocks, or of plant material relying on the minerals in the rock for growth.

The importance of geology in the Thames Basin – a few examples

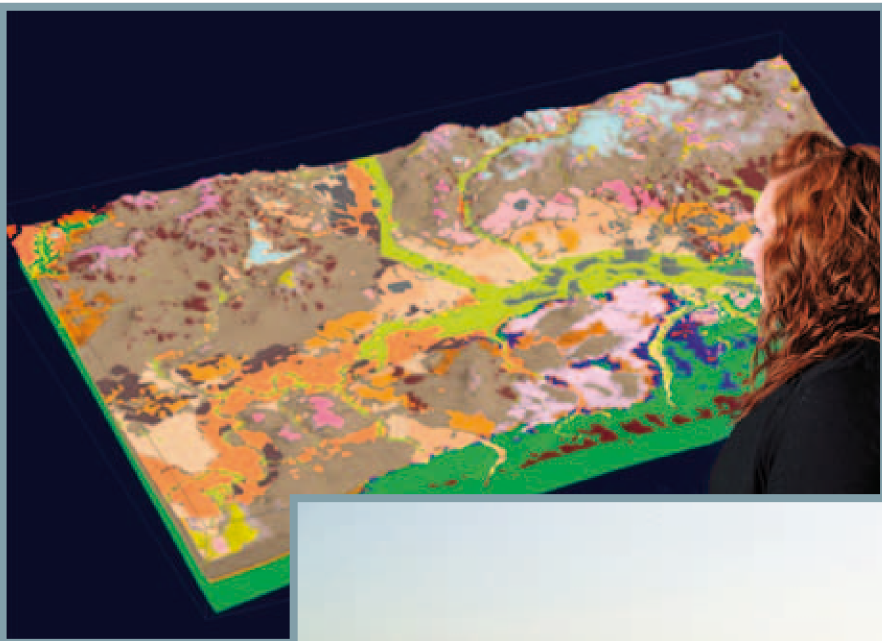
The Chalk aquifer, underlying much of the Thames Basin, supports 70% of public water supplies and sustains many rivers and wetlands. However, there is uncertainty about how climate change will impact on groundwater. Geological understanding is vital in meeting the environmental and development challenges we face in the Thames Basin.

The shrink–swell behaviour exhibited in clay-rich soils, such as those derived from the London Clay Formation, is the most damaging geohazard in Britain today, costing the economy an estimated £3 billion over the past 10 years. If the expansive nature of these soils is not taken into consideration during the planning and construction of new developments, it could lead to undesirable consequences.

Adequate supplies of construction aggregates are essential to the delivery of the Government's future objectives of affordable housing, sustainable communities and major, high profile regeneration and construction projects, such as the Thames Gateway, the 2012 Olympics and Crossrail. Significant quantities will also be required for climate change adaptation, e.g. for coastal and inland flood defences.

As a public sector organisation, BGS is responsible for advising the UK government on aspects of geoscience as well as providing impartial geological advice to industry, academia and the public. One ambition of FutureThames is to develop an integrated three-dimensional model of the physical properties and processes of the subsurface within the Thames Basin to enable the simulation of 'real world' responses to various 'what if' scenarios, such as, 'What will happen to groundwater if a new housing estate is built here?' or 'How will sea-level rise affect my property?'. Analysis of these simulations will inform sustainable solutions to mitigate anthropogenic and environmental change impacts within the region. Achieving this ambition will require the integration of data, understanding and research across academia, government and industry.

Urban geoscience plays an important role in supporting the sustainable use of the subsurface. The subsurface provides a range of services to society, including space for engineered development, capacity for waste disposal, heat and cooling. The 3D characterisation of the ground beneath cities, including London, contributes to an improved understanding of the capacity of the subsurface to provide these services, as well as identifying the impacts of land use change and the legacy of deposits including potential contaminants. This understanding may become increasingly relevant as society's interaction with the subsurface changes in response to environmental change and a range of adaptation strategies.



3D geological model of the central London area.

An integrated approach

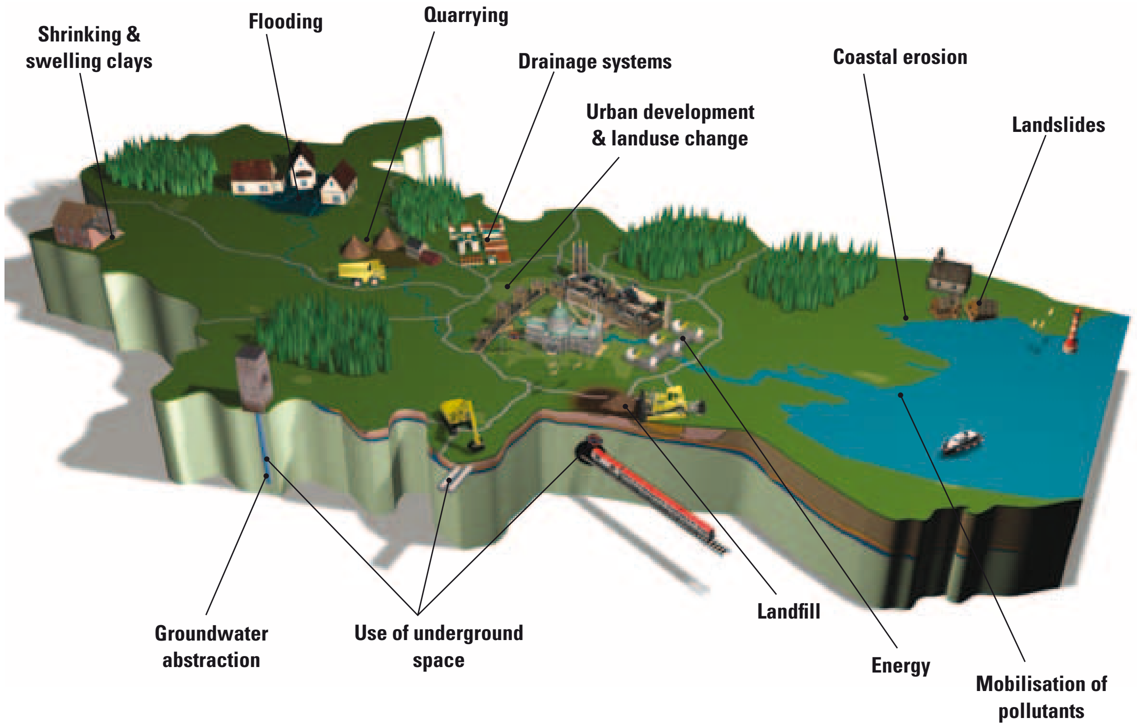
FutureThames will provide a hub for data and knowledge to encourage an integrated approach to geo-environmental research and capability, knowledge exchange and decision-making within the Thames Basin. Crucially, FutureThames encourages collaboration between BGS, the research community, and public and private sector organisations that have an interest in the effects of environmental change within the Thames Basin. It is only through such an integrated approach that society will be able to fully understand potential impacts of climate change and policy-makers make more informed, effective and sustainable decisions. The project also aims to provide generic capability and methodologies that can be applied to other catchments or areas and situations in need of focussed interdisciplinary problem solving.

Getting involved

Collaboration with a diverse community of organisations will be vital to fully understand and tackle the challenges being faced within the Thames Basin. These collaborators may include:

- academic groups (university departments, research institutes, research councils etc.)
- national and local government organisations
- construction industry
- waste and water companies
- conservation managers
- environmental consultancies
- meteorologists and climate modellers
- urban planners
- utility providers
- mineral and natural resource organisations
- engineers
- insurers and value added resellers
- managers/developers of infrastructure (road, rail, waterways etc.)

FutureThames would like to hear from any organisations interested in collaborating on research within the Thames Basin.
Contact FutureThames@bgs.ac.uk for more information.



The Thames Basin faces significant challenges, in terms of meeting demand for resources (energy, water, commodities etc.) and providing infrastructure for a growing population, as well as understanding and managing the effects of environmental change and natural geological hazards.

Sustainable use of the subsurface

What are the environmental impacts of an increased reliance on underground space and how can this be effectively managed?

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Questions/challenges

- How can the development of underground space be achieved sustainably?
- How can we ensure that subsurface resources, such as aggregates, are safeguarded for future use?
- How can the impacts of subsurface engineering on groundwater systems be effectively measured and managed?
- How might surface sealing in conjunction with climate change impact on local drainage?
- What will be the effect of the changing environment on ground stability and how might this impact on subsurface engineering?

As population density continues to rise, society is becoming increasingly reliant on underground space to accommodate its growing infrastructure, such as water and sewage management, transport, parking and extraction of natural resources through quarrying or mining. The challenge is not simply in understanding what the impact of this increased subsurface engineering will have on the environment but also how the changing environment will impact on the efficiency of these systems.

For example, how might changes in ground conditions due to climate change affect natural geological hazards and ground stability and how might this, in turn, affect engineered systems underground, such as ground source heat pumps or sewage networks. Understanding this two-way process between natural phenomena and human intervention is needed to support effective and sustainable management of the subsurface through improved spatial planning and implementation of appropriate policies.

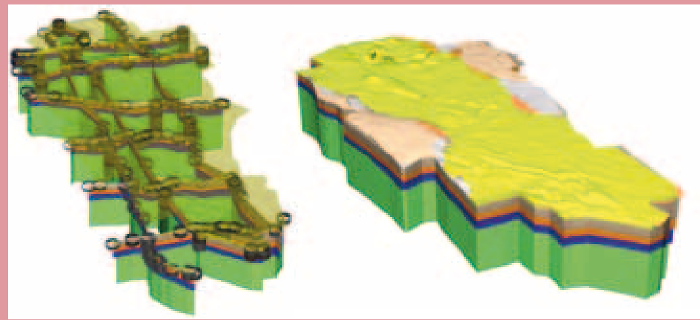
How can the BGS contribute?

MineralsUK.com – minerals information online

An online resource of mineral information and statistics for minerals planning at the local and regional scales.

3D geological modelling

3D geological models enable us to predict not only the geology but engineering and hydrogeological properties of the ground beneath us, which is essential for assisting in strategic planning and sustainable development.



Cross-sections and 3D geological models of the Olympic Park have helped with assessing ground conditions for construction.

MineralsUK

Mineral resources are vital national assets and their extraction and use makes an essential contribution to the UK economy. Adequate supplies are necessary for the development of a modern economy and are required for manufacturing, construction, power generation, transportation and agriculture. We must make the best use of these valuable assets whilst limiting the effect their extraction has on the environment. It is, therefore, important that planners have access to information that will assist them to make the most sustainable use of mineral resources. National policy for England dictates how local authorities should plan for minerals issues and the BGS feeds into this process by advising government on these policies, by producing guidance material and by producing mineral resource information. The data is designed to enable planners, government, industry and other users to make an initial assessment of potential mineral resources, taking into account mineral planning permissions and environmental designations. More detailed information is available under licence from the BGS' Mineral Resource Maps and MineralsUK website.

Publications and resources

Royse, K R, Entwhistle, D, Price, S, Terrington, R, and Venus, J. (2006). The Geology of Olympic Success. Geoscientist, 16(5):4–8.

Brown, T, McEvoy, F, Mankelow, J, Ward, J, Bloomfield, S, Goussarova, T, Shah, N, and Souron, L. 2008. The need for indigenous aggregates production in England. Keyworth, Nottingham, British Geological Survey, 74pp. (OR/08/026)

Ground stability and geohazards

What are the implications for engineering development and geohazards in the future, with respect to the changing climate?

Questions/challenges

- What effect will extremes in climate and environmental changes have on the physical properties of geological materials?
- How might these changes manifest themselves in terms of ground stability issues (geohazards)?
- How can we ensure that infrastructure, both above and below ground, will be resilient enough to withstand changing ground conditions due to climate change?
- How will the built environment be affected by changing ground conditions, and how can advances in technology combat such changes?

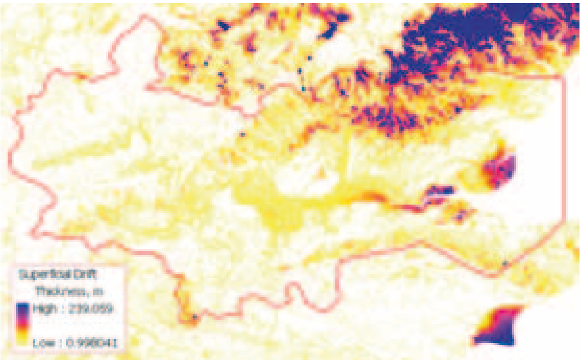
The physical properties of geological materials are incredibly complex and take into account their engineering properties, strength, ability to absorb water and other fluids as well as their susceptibility to compression, collapse, shrink or swell. These characteristics are strongly influenced by water content, temperature and frost, which in turn are influenced by weather and climatic conditions.

With the extremes in weather that the UK has experienced in recent years, from flooding, to drought, to heavy and persistent snow fall, the ground conditions have been incredibly sensitive to these changes and have placed buildings and infrastructure at risk from persistent damage. It is essential that we understand how geological materials react to changes in climate. This will ensure that we can sensibly plan for future developments and take account of potential hazards. Shrink-swell behaviour exhibited in clay-rich soils, such as those derived from the London Clay Formation is the most damaging geohazard in Britain today costing the economy an estimated £3 billion over the past decade. Better understanding of the relationship between ground conditions and climate change will help reduce these costs. It is essential that we understand how geological materials react to weather and climate to ensure that we can sensibly plan for future developments and take into account any potential hazards to help minimise the cost of repairing such damage.

How can the BGS contribute?

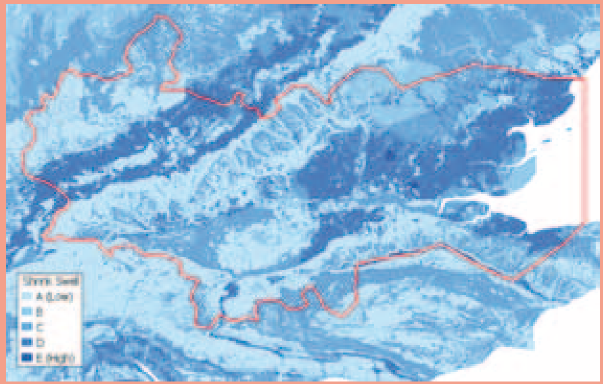
Superficial drift thickness models

The thickness of superficial deposits indicates the depth to the bedrock surface, at which properties like strength, lithology, conductivity, porosity and permeability can significantly change. Knowing this depth is critical in a number of areas of work, for example in civil engineering, the evaluation of groundwater resources and possible water pollution, and in the prediction of surface hazards such as landslides and the collapse of underlying rocks.



GeoSure

The BGS has developed a series of natural ground stability datasets, including compressible deposits, collapsible deposits, shrink–swell clays, running sand, soluble rocks and landslides, that indicate the potential for ground movement or subsidence. Knowing the locations of these hazardous deposits is essential to ensure that future engineering construction work is located in the most appropriate places, and that the correct design strategy is adopted to prevent the need for costly remedial measures.



The Lea Valley – London

Geohazard mapping in the Lea Valley, north London has identified areas with significant deposits of shrink–swell clays and other areas where compressible deposits and running sand may pose moderate to significant threats. Areas of compressible ground become a problem when an overlying load (buildings for example) causes fluid in the pore space to be squeezed out, thus reducing the thickness of the deposit. This can result in subsidence which can cause significant problems to buildings. Shrink–swell clays are so called because they swell, and thus increase in volume, when they get wet and shrink when they dry. Such changes can affect low-rise building foundations, pipelines or shallow services.

Publications

Jones, L D, and Terrington, R. (2011). Modelling volume change potential in the London Clay. Quarterly Journal of Engineering Geology and Hydrogeology 2011; v. 44; p. 109–122.

Walsby, Jennifer. (2008). GeoSure : a bridge between geology and decision-makers. 81–87 In: Liverman, D G E; Pereira, C P G, Marker, B R (eds). Communicating environmental geoscience. London, UK, Geological Society of London. (Special Publications, 305).

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Changing land use

What are the impacts on the environment and society of changing land use and how can we best manage these?

Questions/challenges

- How do changes in land use affect water resources?
- What are the impacts of urbanisation on soil chemistry and quality and how might this affect the soil's natural ability to buffer against contaminants?
- How can we avoid sterilising resources within the region?
- How can we model future mobility of contaminants and how will these be affected by climate change?
- Where are contaminants within the catchment coming from and going to? How does this vary from one contaminant to another?

Rapidly changing human activity within the Thames Basin can put huge pressures on the natural environment's ability to adapt and change. These may be further complicated by the influences of climate change, such as extremes in weather. Maintaining a balance between urban development and natural systems is essential to ensure that, for example, soils are still able to buffer potential contaminants or that ground stability is sustainable for buildings and infrastucture.

Understanding the full environmental impact of land-use change requires a whole-system approach, that is investigating not only natural but anthropogenic effects on land-use change and considering how, for example, changes in near-surface soils may affect deeper and distal parts of the system. Establishing these links offers the possibility of identifying and addressing the source of potential problems and more effectively managing those parts of the system.

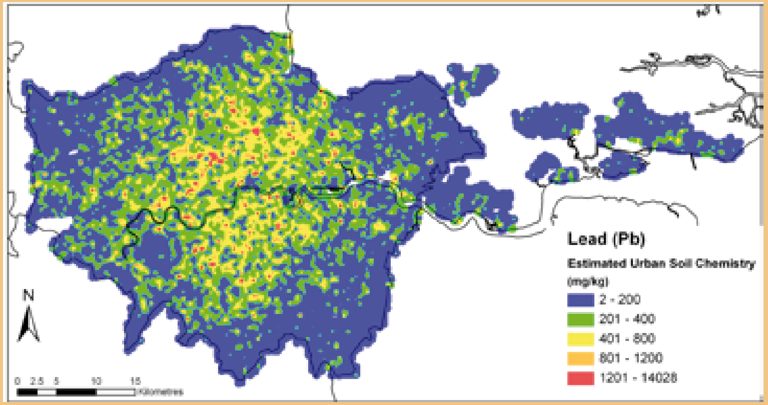
How can the BGS contribute?

London Earth – soil geochemistry

London Earth has collected soil samples at a density of four sites per square kilometre, comprising over 6600 sample sites across the entire Greater London Authority area. At each site over 50 chemical elements have been measured including potentially harmful and environmentally sensitive elements.

Soil chemistry data for GB

The BGS URBAN SOIL CHEMISTRY DATA for Great Britain is a product derived from high-resolution urban soil geochemical data from the Geochemical Baseline Survey of the Environment (G-BASE) project. It gives concentrations of potentially harmful chemical elements (PHEs) such as arsenic (As), cadmium (Cd), chromium (Cr), nickel (Ni) and lead (Pb) in topsoils of 24 urban areas. It can be used to assist local planning authorities to identify areas where a risk assessment may need to be carried out by developers.



London Earth – soil geochemistry

London Earth is part of a national programme (the Geochemical Baseline Survey of the Environment (G-BASE)) to measure and map the chemical status of the UK surface environment. Through this survey, the BGS provides national capability in quantifying the geochemical variation of the shallow subsurface – including the soils beneath our cities. Results from the *London Earth* project will provide unique information on soil chemistry in the urban environment which will be of direct relevance to land-use planning and development, urban regeneration, ecosystem protection and contaminated land assessment. Characterising the soil quality of London will enhance our understanding of interactions between people and ecosystems, and of water resource protection.

Publications

Flight, D M A, and Scheib, A J. 2011. Soil Geochemical Baselines in UK Urban centres: The G-BASE Project. Chapter 13, 186–206. In: *Mapping the Chemical Environment of Urban Areas.* Johnson C C, Demetriades, A, Locutura, J, and Ottesen, R T (eds). John Wiley & Sons, Ltd, Chichester, UK.

Johnson, C C, Breward, N, Ander, E L, Ault, L. 2005. G-BASE: Baseline geochemical mapping of Great Britain and Northern Ireland. *Geochemistry: exploration, environment, analysis*, Vol. 5 (4), 347–357.

Flooding

How can the impacts of flooding on society, the economy and the environment be better understood?

Questions/challenges

- How can we improve forecasts of where and when flooding may occur?
- How can we improve flood warning services for the public in affected areas?
- How can we provide better advice to environmental regulators and responsible authorities on flooding mitigation strategies?
- Can uncertainty in models of flooding events be reduced?
- What is the role of geology and hydrogeology in contributing to flooding events in complex floodplain environments?

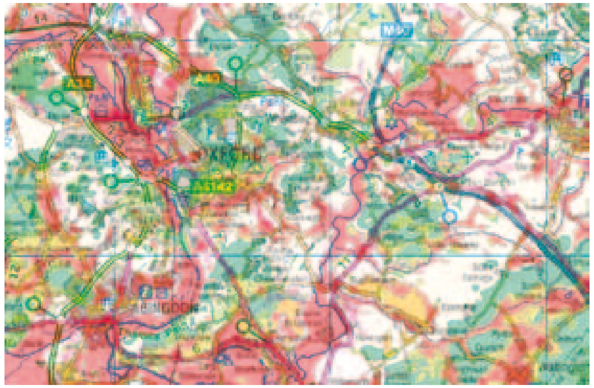
Environmental change is likely to result in greater flood risk, both from surface flooding and from groundwater flooding. Rising groundwater was a significant causative factor for the summer 2007 floods in Oxford. Adopting an integrated catchment approach to flooding could lead to more accurate flood predictions and better-informed policy on flood-risk management within the Thames Basin.

In addition, these natural processes need to be considered in conjunction with human interaction and understanding the potential impacts requires an integrated approach that brings together a range of environmental experts, scientists and planners. An integrated approach can potentially contribute to more accurate flood predictions and better-informed policy on flood risk management.

How can the BGS contribute?

Groundwater flooding susceptibility (GSF) mapping

The GSF mapping is based on DiGMapGB-50 (1:50 000 digital geological map of GB). It shows areas of Great Britain that are potentially susceptible to groundwater flooding based on hydrogeological considerations, and can be used as part of any systematic risk assessment for groundwater flooding.



Geological indicators of flooding (GIF) mapping

This digital map is based on DiGMapGB-50 (1:50 000 geological maps of GB). It characterises superficial deposits in terms of likely susceptibility to flooding, either from coastal inundation or fluvial (inland) water flow.

Flooding in Oxford

The BGS, in collaboration with the Environment Agency (EA), has investigated the causes of groundwater flooding in urbanised areas of the River Thames floodplain within the city of Oxford. This has helped the EA in the development of their flood management strategy for the city. The aims of the project were to identify factors controlling groundwater flooding within the Oxford area and use these to ensure that the proposed flood risk management scheme addressed the risk due to groundwater flooding. BGS involvement included building a detailed 3D geological model from which a greater understanding of the groundwater processes can be achieved. The combination of detailed geological and groundwater flow modelling, along with a better understanding of the hydrogeological processes involved in groundwater flooding has enabled the EA to devise the best strategies for mitigation in the Oxford area which address the risk from groundwater flooding. The knowledge and methodologies developed through this project can be applied to similar scenarios elsewhere.

Publications

Adams, B, Bloomfield, J P, Gallagher, A J, Jackson, C R, Rutter, H K, and Williams, A T. (2010). An early warning system for groundwater flooding in the Chalk. Quarterly Journal of Engineering Geology and Hydrogeology, 43 (2):185–193. DOI: 10.1144/1470–9236/09–026.

Macdonald, D M J, Bloomfield, J P, Hughes, A, MacDonald, A, Adams, B, and McKenzie, A. (2008). Improving the understanding of the risk from groundwater flooding in the UK. In: FLOODrisk 2008, European Conference on Flood Risk Management, Oxford, UK, 30 Sept –2 Oct 2008. The Netherlands, CRC Press.

Water security

How will the effects of climate change affect water security within the region and how can we best manage this?

Questions/challenges

- What impact will long-term environmental change have on water resources within the Thames Basin?
- How can we ensure safeguarding of water resources during times of increased urbanisation and development?
- How can river and groundwater quality be managed to achieve sustainability?
- What will the impact be of changing land use on remobilisation of contaminants and how might this affect on water resources?
- How will increased use of the subsurface affect groundwater processes and how can we manage these to ensure water resources are not sterilised?

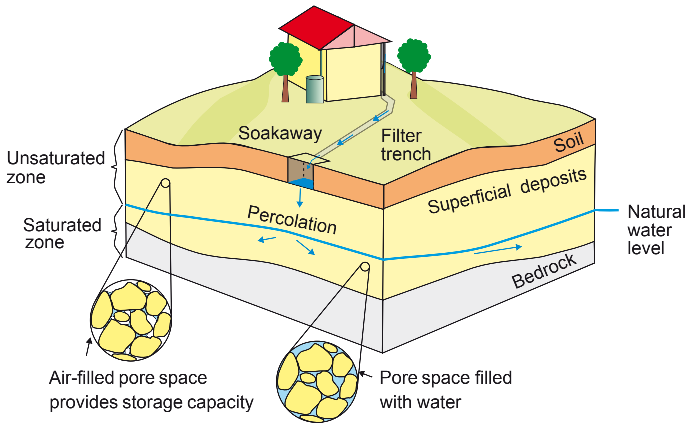
One of the major geological units beneath the Thames Basin is the Chalk, which represents one of the largest aquifers within the UK and is therefore an essential water resource for the Thames region. This not only includes water resources for several essential services, including public drinking water, but also plays a major contribution to river flow and wetland habitats within the catchment.

The security of this water resource is under threat from a number of factors including changing climate, particularly sea-level rise and its effect on groundwater processes, as well as demand from an increasing population and urbanisation. One of the major challenges in securing future water resources for the region is understanding how groundwater processes will respond to climate change and what the potential impacts of these changes may be. This knowledge will help devise suitable strategies for future development and enable policy-makers to make more informed decisions.

How can the BGS contribute?

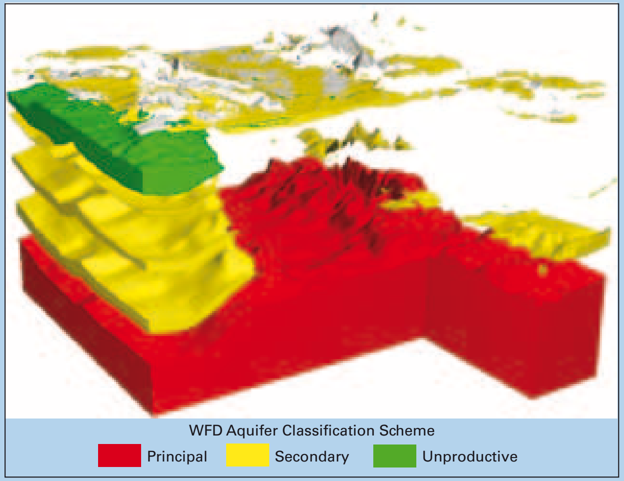
Sustainable drainage systems (SuDS)

A national dataset is being developed to enable preliminary decision-making on the suitability of the subsurface for the installation of infiltration-based SuDS.



Chalk property domain maps for London and Thames Gateway

Exploded 3D geological model of the chalk beneath Thames Gateway, attributed according to aquifer properties.



Infiltrating SuDS map

Sustainable drainage systems (SuDS) are surface water management techniques that are designed to modify surface water flow rates and provide pollutant attenuation capacity, such that they mimic drainage in natural systems. Such systems are likely to become more commonplace following the enactment of the Floods and Water Management Act 2010 which encourages the use of SuDS techniques. The BGS is particularly interested in those SuDS that infiltrate to the ground, such as soakaways, permeable paving and infiltration basins. These systems rely on the subsurface to store surface water and provide pollutant attenuation and hence the properties of the ground must be understood to determine the suitability of the ground for infiltration. The BGS has responded to the change in legislation by developing a national dataset that provides information on where infiltration-based SuDS systems are appropriate with regards to a) subsurface drainage; b) ground stability; and c) subsurface pollutant filtration. The system is designed to enable local authorities, planners, industry and others to make an initial assessment of whether infiltration-based SuDS are appropriate in a given location.

Publications

Dearden, R, and Price, S. (2010). Surface water flooding: Sustainable drainage to the ground. UK Groundwater Forum, http://www.groundwateruk.org/Groundwater-issues-SUDS.aspx

Lapworth, D J, Gooddy, D C, Allen, D, Old, G H. (2009). Understanding groundwater, surface water and hyporheic zone biogeochemical processes in a Chalk catchment using fluorescence properties of dissolved and colloidal organic matter. Journal of Geophysical Research, 114, G00F02. 10, pp. DOI: 10.1029/2009JG000921.

Protecting coastal communities and habitats

What challenges do waterfront communities face from environmental change and how can we manage this in a sustainable way?

Questions/challenges

- How will sea-level rise affect coastal erosion, coastal landslide triggering and coastal inundation?
- How have human influences, such as hard-engineered flood defences, affected the natural balance of the geosphere and how can we ensure ecological balances are maintained?
- What are the main sources of sediment associated pollutants, how are they transported and what hazard/risk do they pose?
- How has sediment contamination changed through time and could remobilisation of buried sediments through flooding and sea-level rise impact sensitive estuarine ecosystems?
- What are the past rates of sea-level change in the Thames estuary and how can this information be used to predict future sea-level changes?

The Thames estuary provides a focal point for waterfront development and supports many unique and internationally significant habitats for wildlife. These communities and habitats face particular threats from environmental change, including sea-level rise, flooding and storms as well as diminishing sediment quality due to sustained urban and industrial pollution. The BGS has developed a methodology to help track human-induced environmental change over time in coastal and fluvial systems.

One of the major challenges in evaluating and managing sediment quality in the Thames Basin is understanding how pollution spreads through the basin and locating its source. Historical contamination hot spots are usually observed in the deeper sediment layers, thus a key question is will these contaminated sediments layers be uncovered and transported as the impacts of climate change such as sea-level rise, increased storminess and flooding become more frequent.

How can the BGS contribute?

Chemical Anthropocene in the Thames System (CATS)

Humans have had such an impact on the environment that scientists are debating whether we have entered a new geological time epoch — The Anthropocene. However, for the Anthropocene to become a useful concept, it needs some quantification.

The BGS national landslide database (NLD)

The BGS national landslide database is the most extensive source of information on landslides in Great Britain. The database currently holds over 15 000 records which are continually being updated. New records are added as landslide information is made available.

Chemical Anthoprocene in the Thames System (CATS)

The persistence of certain organic pollutants within the environment ranges from hours through decades to centuries. Estuaries are highly dynamic systems, meaning that historic sediments polluted by London's legacy of industry and urbanisation may be mobilised by either human activities (dredging, civil engineering) or natural processes (bioturbation, flooding, sea level rise) and be fed back into the zone of ecological and human interaction causing a deterioration in sediment quality. This can impact upon the wildlife that live and feed on these sediments, including humans. The BGS has developed a methodology to help track human-induced (anthropogenic) environmental change in coastal and fluvial systems through the use of organic pollutants, heavy metal concentrations and isotope ratios (e.g. $Pb\text{-}^{207/206}$), as well as radioactive isotopes such as $Cs\text{-}^{137}$. Chemical analysis of these pollutants is being considered in the context of the wider environment, since changing climate conditions such as warm wet winters, hot dry summers and increased intensity of rainfall may increase the uptake by plants and animals. The scientific knowledge from this work will improve our understanding of the potential effect of pollution on wildlife and humans in the Thames catchment and is relevant to river and coastal managers as well as the water industry.

Publications

Vane, C H , Chenery, S R , Harrison, I , Kim, A W, Moss-Hayes, V, and Jones, D G. 2011. Chemical Signatures of the Anthropocene in the Clyde Estuary, UK: Sediment hosted Pb, $^{207/206}$Pb, Polyaromatic Hydrocarbon (PAH) and Polychlorinated Biphenyl (PCB) Pollution Records. Philosophical Transactions of the Royal Society (A) 369, 1085–1111.

Vane, C H, Kim, A W, McGowan, S, Leng, M J, Heaton, T H E, Coombs, P, Kendrick, C P, Yang, H, and Swann, G E A. 2010. Sedimentary record of sewage pollution using faecal marker compounds in contrasting peri-urban shallow lakes. Science of the Total Environment 409, 345–356.

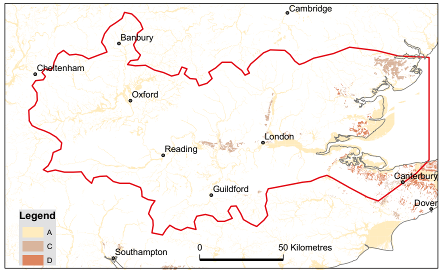
BGS data inventory — Thames Basin

The BGS holds a wealth of information and knowledge and licences a wide range of digital data. The combination of this information base and unique range of geoscience expertise gives the BGS its key core competence. Some of the data BGS produces is available to view through the BGS OpenGeoscience portal (www.bgs.ac.uk/opengeoscience.html) and can be used free of charge for non-commercial private study, research and educational activities. Other data is available to by contacting BGS directly. The following table provides an overview of some of the BGS data for the Thames Basin.

For more information about our digital data please contact the BGS Digital data team digitaldata@bgs.ac.uk or visit our web pages http://www.bgs.ac.uk.

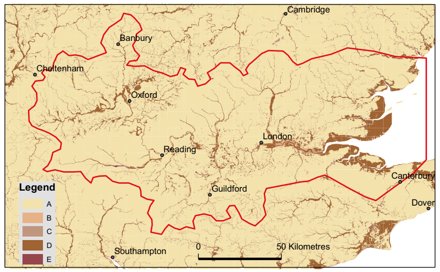
Collapsible deposits

Some kinds of natural deposit can collapse, i.e. they undergo a rapid reduction in volume, when a load (such as a building or road traffic) is placed on them, especially when they become saturated. Such collapse can cause damage to overlying property.



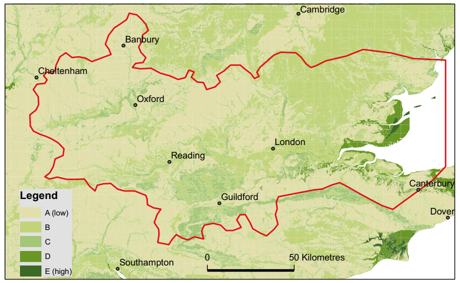
Compressible ground

Some types of ground, may contain layers of very soft materials like clay or peat. These may compress if loaded by overlying structures, or if the groundwater level changes, potentially resulting in depression of the ground and disturbance of foundations.



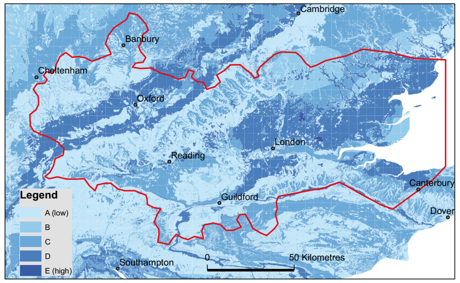
Running sand

Some rocks can contain loosely packed sandy layers that can become fluidised by water flowing through them. Such sands can 'run', removing support from overlying buildings and causing potential damage.



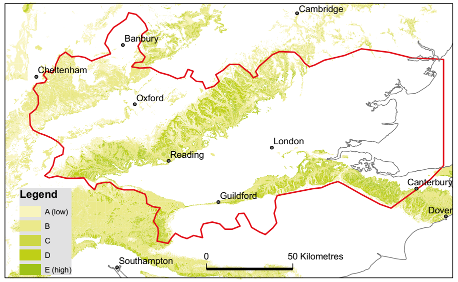
Shrink–swell

Swelling clays can change volume due to variation in moisture, this can cause ground movement, particularly in the upper two metres of the ground that may affect many foundations. Ground moisture variations may be related to a number of factors, including weather variations, vegetation effects (particularly growth or removal of trees) and man-made activity. Such changes can affect building foundations, pipes or services.



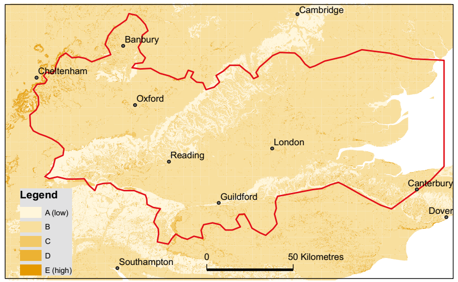
Soluble rocks (dissolution)

Ground dissolution occurs when water passing through soluble rocks produces underground cavities and cave systems. These cavities reduce support to the ground above and can cause localised collapse of the overlying rocks and deposits.



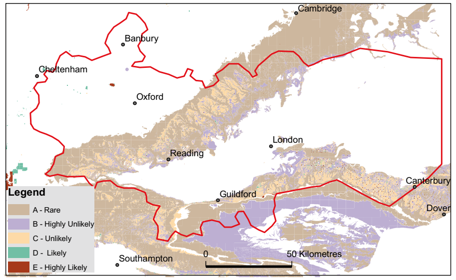
Landslides (slope instability)

Landslide hazard occurs due to particular slope characteristics (such as geology, gradient, sources of water, drainage, man-made constructions) combining to cause the slope to become unstable. Downslope movement of materials, such as a landslide or rockfall may lead to a loss of support and damage to buildings.



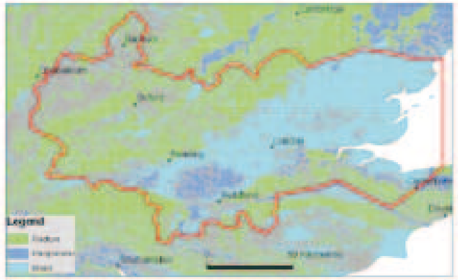
Mining hazard (not including coal)

Mining hazards may lead to financial loss for anyone involved in the ownership or management of property, including developers, householders or local government. The mining hazard (not including coal) dataset provides essential information for planners and developers building in areas of former shallow underground mine workings that may collapse.



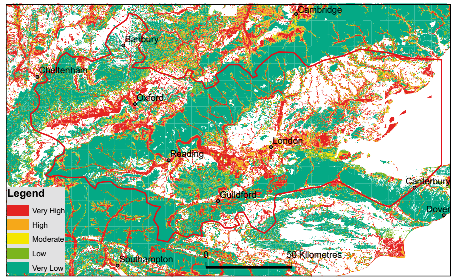
Permeability

The term permeability refers to whether and how water can flow through a rock. Permeability data is often used in studies of groundwater and in particular during investigations of pollution or aquifer contamination. The BGS has prepared permeability information based on the 1:50 000 Digital Geological Map of Great Britain (DiGMapGB). The map on the right shows bedrock permeability.



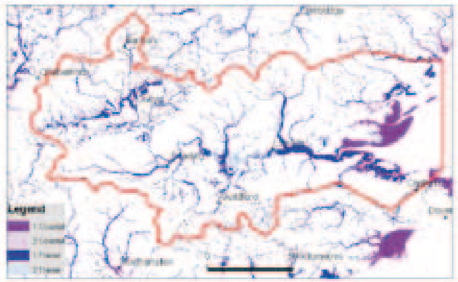
Susceptibility to groundwater flooding

Groundwater flooding is the emergence of groundwater at the ground surface. It can occur in a variety of geological settings including valleys in areas underlain by Chalk, and in river valleys with thick deposits of alluvium and river gravels. Groundwater flooding happens in response to a combination of already high groundwater levels (usually during mid or late winter) and intense or unusually lengthy storm events.



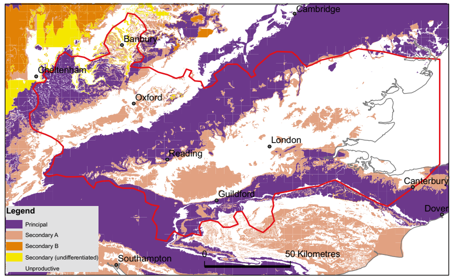
Geological indicators of flooding

Geological maps show where all the floodplains and coastal plains in Britain are and therefore the main areas at greatest risk of flooding. The map is based on observation of the types of geological deposit present and does not take into account any man-made influences such as house building or flood protection schemes.



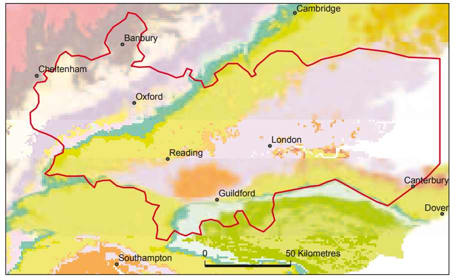
Aquifer designation data

The aquifer designation dataset has been created by the Environment Agency and British Geological Survey and identifies the various aquifers of England and Wales. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) and their role in supporting surface water flows and wetland ecosystems.



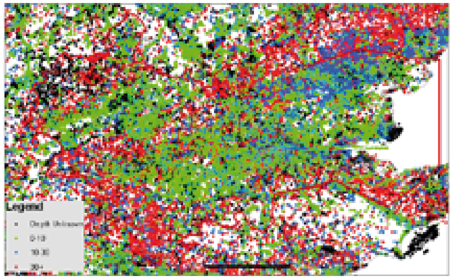
DIGMapGB

Geology maps are the foundation for many other types of earth science related maps and are of potential use to a wide range of customers. The Digital Geological Map of Great Britain project (DiGMapGB) has prepared 1:625 000, 1:250 000 and 1:50 000 scale datasets for England, Wales and Scotland. The map on the right shows bedrock geology at 1:625 000 scale.



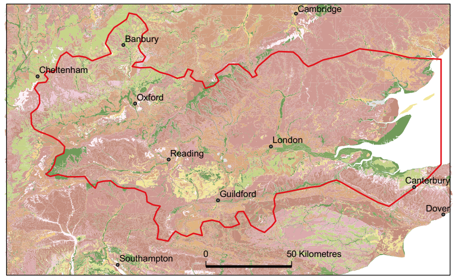
Single Onshore Boreholes Index (SOBI)

The Single Onshore Boreholes Index (SOBI) is an index of over 1 million records of boreholes, shafts and wells from all forms of drilling and site investigation work held by the BGS. The collection covers onshore and nearshore boreholes from Great Britain dating back to at least 1790 and ranging from one to several thousand metres deep. Some 50 000 new records are added each year.



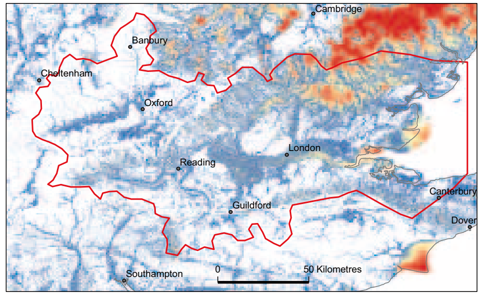
Soil parent material model

A parent material is a soil-science name for a weathered rock or deposit from, and within which, a soil has formed. Parent materials provide the basic foundations and building blocks of the soil, influencing their texture, structure, drainage and chemistry. The map on the right shows the soil parent material model displayed as estimated texture ranges.



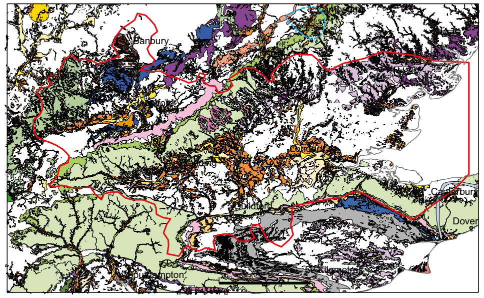
Superficial deposits thickness model

Superficial deposits are the youngest of the geological formations (less than 2 million years old). They are largely unconsolidated and cover much of the bedrock of Britain. The superficial deposits thickness models show the depth of the bedrock surface which is critical in a number of areas of work, for example, in civil engineering, the evaluation of groundwater resources and possible water pollution, and in the prediction of surface hazards such as landslides and the collapse of underlying rocks.



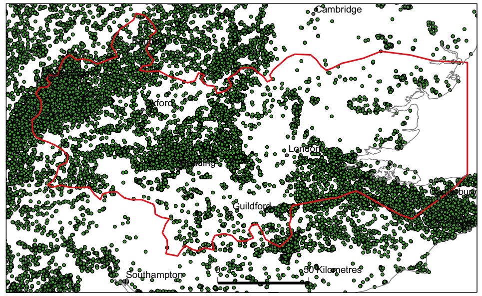
Mineral resources

Minerals are essential for the development of a modern economy, but their extraction is subject to environmental and other constraints. Bringing together minerals, environmental and other land-use information in an integrated system allows more effective and sustainable management strategies to be developed. This dataset contains the geological distribution of onshore mineral resources.



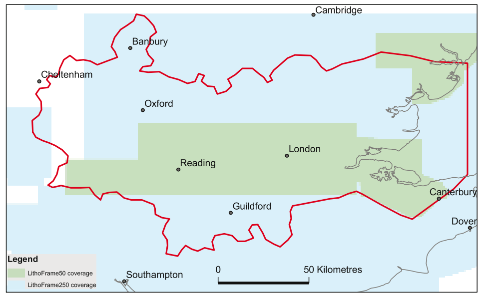
Britpits

The British Pits (Britpits) database holds information on the name of active mines and quarries, their geographical location, address, operator, mineral planning authority, geology, mineral commodities produced and end uses where known. The database, and its associated GIS, provides a valuable tool for monitoring not only resource depletion, but also the extent that mineral sites have been restored to beneficial aftercare.



3D model coverage

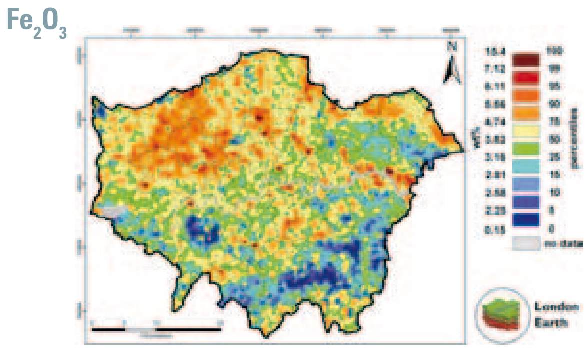
LithoFrame is an initiative to produce models of Britain's subsurface geology; the 3D equivalent of the geological map. LithoFrame models have been created at a range of scales equivalent to 1:50 000 and 1:250 000. Larger-scale modelling is available for selected urban areas. Models can be visualised and interrogated using a range of software tools. Contact Enquiries@bgs.ac.uk for more information about licensing an existing model or for commissioning custom 3D geological models.



London Earth

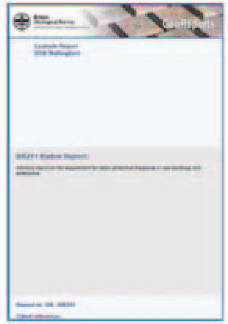
BGS is working towards providing comprehensive baseline data on the chemistry of the UK surface environment, thus improving our understanding of the sources and behaviour of chemical substances in the surface zone. The *London Earth* project provides soil geochemical data that will:

- help to assess the geochemical background concentration of over 50 determinants including potentially harmful elements
- be of direct relevance to land-use planning and development, urban regeneration, ecosystem protection and contaminated land assessment.



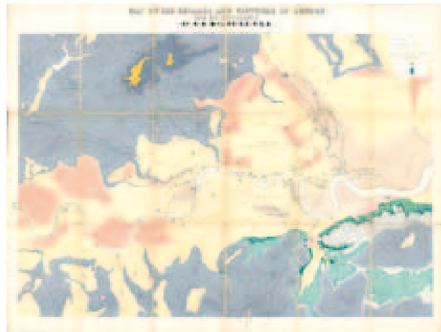
HPA-BGS radon potential

The radon potential map is the definitive map of radon affected areas in England and Wales, created jointly by the Health Protection Agency (HPA) and the BGS. If you are buying, building or extending a home, then you need to know about radon, and there are several reports that are available for you through the BGS and UKradon websites.



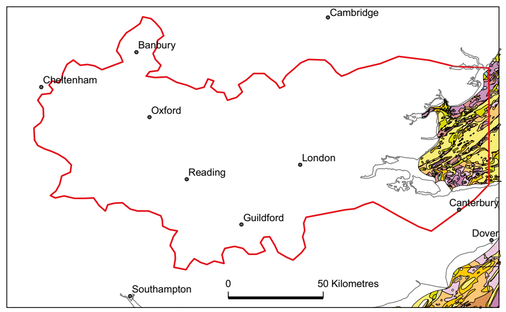
Printed geological maps

Geological maps show the nature, extent and relative stratigraphical age of the different rocks within a district. The first comprehensive geological map of London and its environs was published in 1856 by Robert Mylne. Newer and/or reproduced geological maps, such as this, are available from the BGS on a print-on-demand basis.



Offshore information and data

A wide range of offshore digital data products are available under licence. These include information on sea-bed sediments (DigSBS250 shown in the image), bathymetry (DigBath250) and offshore bedrock geology (DigRock250). Geophysical and magnetic survey data are also available.



3D capability

3D geological models

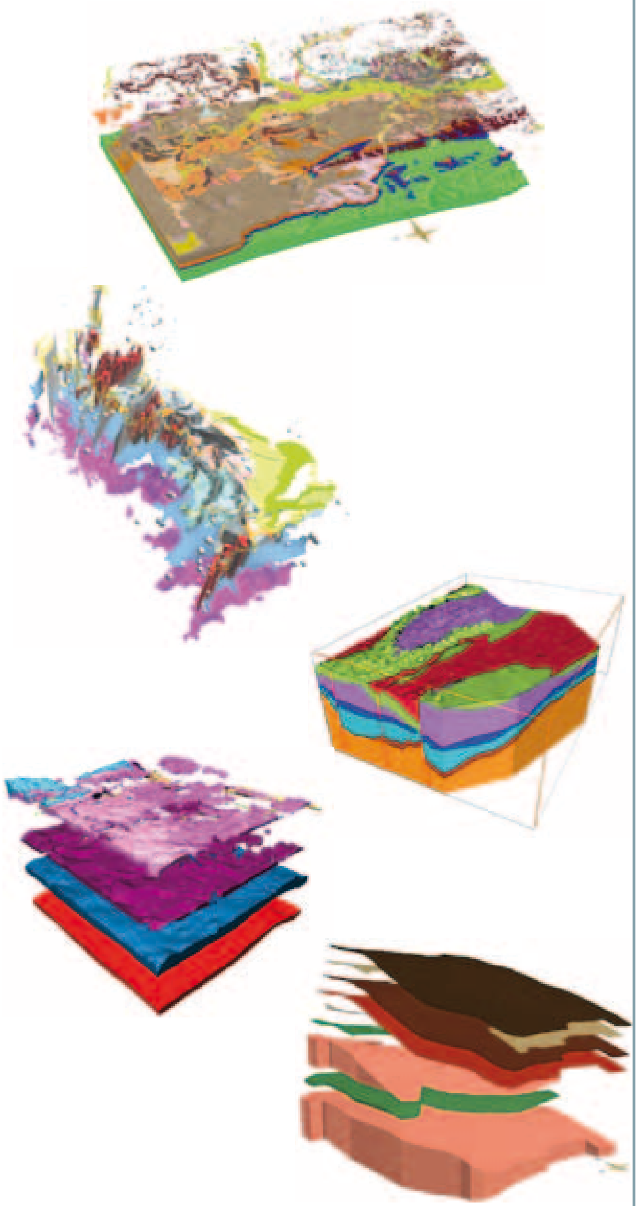
The 3D investigation and characterisation of the Earth's subsurface is the prime objective of any geological survey. With advances in computing power and technology and the availability of increasingly precise digital terrain models (DTM) it is now possible to deliver a totally new survey product: the 3D geological map, also known as LithoFrame. BGS LithoFrames are available at a range of resolutions for various parts of the UK and can be provided in a range of formats for use in GIS. LithoFrames delivered in the standalone viewer can be interrogated by synthetic boreholes, cross-sections, depth-slices and 3D visualisation.

LithoFrame 1M — for use at a scale of 1:1 000 000 for onshore Britain. It shows the most significant stratigraphical divisions (e.g. the base of the Cretaceous and the interface between the Chalk and the overlying Tertiary deposits) and major faults in a single model, down from the ground surface to the base of the Earth's crust (40 km). The model mainly serves as an educational tool to give an overview of UK geology, including major faults, and shows other features such as the magnitude and depth of earthquakes.

LithoFrame250 — shows major stratigraphical units (e.g. base Chalk Group), to a depth of around 5 km. These models provide a well-constrained structural framework for regional, strategic assessment of groundwater and energy resources, and for deep underground storage and waste repositories.

LithoFrame50 — shows stratigraphy to formation level (e.g. base London Clay Formation, base Harwich Formation) and will reach around 1 km in depth. Our detailed models concentrate on the near surface and have applications for planning and development.

LithoFrame10 — is the highest resolution, with a focus on well-characterised and relatively shallow superficial deposits including, where appropriate, the subdivision of artificial ground, flood plain, and river terrace deposits. The models have applications for archaeological investigations and site characterisation.



The British Geological Survey (BGS) is a Public Sector Research Establishment within the Natural Environment Research Council (NERC), which is the UK's main agency for funding and managing research, training, and knowledge exchange in the environmental sciences. NERC reports to the UK government's Department for Innovation, Universities and Skills.

BGS was founded in 1835 and is the world's oldest national geological survey. In addition to our work within the UK we also undertake an extensive programme of international research, surveying and monitoring, including major institutional strengthening programmes in the developing world. Our scientists have expertise across the geoscience disciplines and our work is underpinned by unrivalled geoscience collections, comprising millions of records and samples.

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British Geological Survey

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