Simon Price, **Diarmad Campbell** and **Katherine Royse** describe how geoscientists are extending our knowledge of the urban environment into the third dimension. Especially where it matters most — in our cities.

Geoscience where it matters

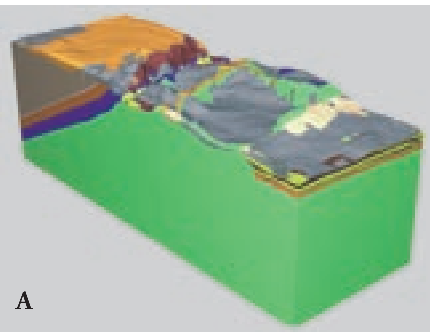
These are exciting times in our urban areas. The places where we live, work, and interact with our environment are changing. The skylines of our major cities are evolving, and regeneration is improving the quality of life for communities across the country.

Breathtaking development is taking place in Manchester and Salford, following their hosting of the Commonwealth Games and the move of the BBC to a new Media City in the former industrial docklands of Salford Quays. The Beetham (or Hilton) Tower, opened in 2006, is the tallest building in the UK outside London. In Liverpool, major regeneration is taking place being driven especially by its City of Culture status in 2008. Regeneration momentum continues to gather pace in the gateways of the Clyde and Thames. Wholesale transformation is under way in the Glasgow area, led by the Clyde Gateway and Clyde Waterfront projects. Major work has already begun in the Lea Valley area, home to the Olympic village in 2012.

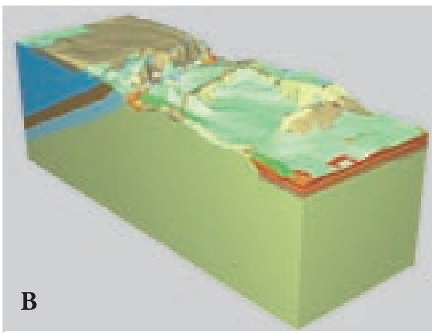
But how do we interact with our cities, and what effect do we have on the urban landscape and the ground beneath our feet? What can the subsurface reveal about the industrial expansion that has characterised the places in which we live and work? Human activities mould the landscape in very distinctive ways: from depositing colliery spoil on the

3D geological and property models built in GSI3D for West Thurrock, Thames Gateway. The models have been generated to show properties tailored to specialist users. A: Geologist, B: Civil Engineer, C: Hydrogeologist.

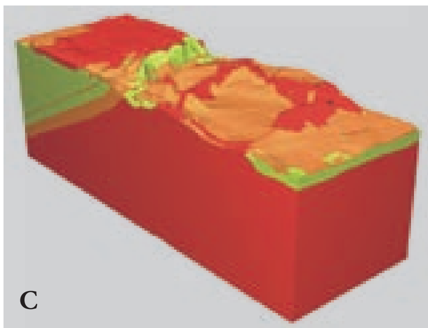
NEXTMap Britain Elevation Data



Geological model: areas of peat (brown) are revealed beneath deposits of alluvium (yellow), river terrace deposits (orange) and man-made deposits (grey). Bedrock is composed of Palaeogene deposits (orange, blue and pink), underlain by Chalk (green).



3D variations in the compressibility of geological material relevant to a specialist user assessing foundation conditions. Areas of high compressibility are coloured in orange and red, variable compressibility coloured in light brown to green and areas of low compressibility are in blue to brown.



3D variation in the hydraulic conductivity of geological materials: high conductivity in red and low conductivity in green. Relevant to a specialist user assessing the risks to groundwater.

land surface, to cutting into the ground to extract minerals, or by burying waste, we are continually changing our environment. It is the role of urban geoscientists at the BGS to characterise and monitor these changes, and most importantly, to understand how they affect the ground beneath our feet.

In all our major cities, there is a legacy from our industrial past. Today, this legacy has left us with a myriad of brownfield sites which are typified by highly variable and potentially contaminated ground conditions. To ensure the safe and sustainable redevelopment of these areas, and to reduce the subsequent risks to people and property, there is an ever-increasing demand for detailed environmental information. The BGS is working in Glasgow, London, Manchester, and Liverpool to provide geoscience information, driven by environmental legislation such as Part IIA of the Environmental Protection Act, the Environmental Assessment (Scotland) Act and the Water Framework Directive. The BGS's work in these areas of the country aims to provide the best information and research to enable planners, developers, and regulators to make informed decisions about sustainable land use and regeneration.

Traditionally, geological information has been displayed in two-dimensions on maps, with only a few cross sections and map legends to help decipher what lies beneath the surface. Recent digital advances have introduced the routine use of geographical information systems (GIS). These enable an unlimited range of spatial data to be shown as single or multiple 'layers'. Importantly, these layers can be queried. Furthermore, 'what if?' scenarios (forward modelling) may be introduced that will better inform strategies for ground investigation and remediation. By embracing new 3D technology, ground conditions in the shallow subsurface can be revealed beneath the cover of buildings and roads.

Rapid developments in 3D modelling software provide powerful tools for constructing detailed geological models of the shallow subsurface. Using this new technology (supported by our geological, geotechnical, and hydrogeological archives), we can start to predict not only the type of rocks and soils that lie beneath our feet, but also their physical properties.

This view of Glasgow's waterfront is from the Science Tower and shows redevelopment of dockland 'brownfield' sites with high-rise flats dating from the 1960s and 1970s in the background.

In urban areas, we are also able to include not only natural geological deposits but also anthropogenic (man-made or 'artificial') material too. This is important, as artificial ground is often associated with potentially contaminated material, variable engineering conditions and unstable ground. By including this, layer upon layer of industrial activity can be modelled and their physical properties predicted. 3D models are no more than digital versions of 'conceptual models' that are so fundamental in ground investigation. However, their presentation and visualisation in 3D provides, easily accessible digital data ready for use. They enable us to:

- Predict the whereabouts of chemical and physical geohazards and how they may affect people, property, or groundwater.
- Assess the variability in ground conditions that may affect future developments.
- Make better-informed decisions on the environment to help improve our lives.

In Glasgow for example, historical mine plans are being integrated to assess the potential risk from former mining activities. Glasgow City Council is already using 3D geoscientific data to help make decisions about future land use. In Manchester and Salford, the Environment Agency has incorporated a 3D geological model of superficial deposits to estimate rainfall recharge to the underlying Sherwood Sandstone aquifer, and its vulnerability to pollution. Therefore, informed decisions can be made about how much water can be can be taken out of our urban aquifers if they are to be sustained.

Our towns and cities and the cityscapes that we instantly recognise, are an integral part of our everyday lives. In digital form, and especially in 3D, environmental geoscientific data in urban areas provides a powerful tool for providing information where it directly affects our lives. Genuine improvements to our environment and quality of life can be made by providing easily accessible ground information to improve land conditions, identify hazards and reduce risk.

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