

Integrated modelling within the Thames Basin — examples of BGS work

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Background

The effects of climate change and the human exploitation of our environment pose a serious threat to the sustainability of our water resources, both for 'ecosystem services' and human consumption. To make robust projections of the future impact of these pressures they must be considered in combination. This necessitates the simulation of the feedbacks and complex interactions between different parts of the water cycle, and the development of integrated environmental models. Examples of the construction of such integrated models are presented in this poster, which focuses on the simulation of combined fluvial and groundwater flood events in both rural and urban settings: the Berkshire Downs and the city of Oxford. The NERC-funded 'Changing Water Cycle' project, which started in January 2011, is also described. This project will investigate environmental change within the Thames Basin. Finally, an approach to modelling the multi-aquifer groundwater system within the whole Thames Basin is outlined.

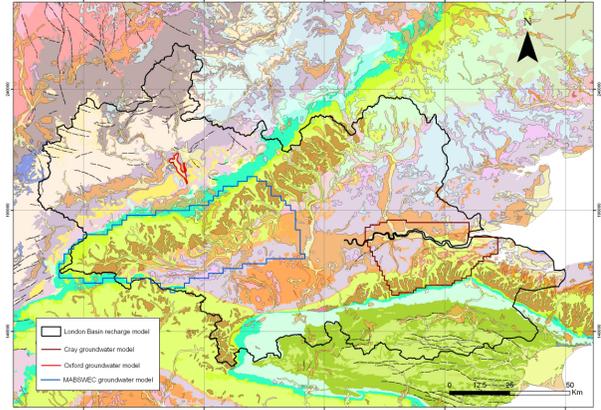


Figure 1 BGS groundwater models within the Thames catchment.

Oxford

Groundwater flooding has occurred in the Oxford floodplain during high river flows resulting from significant rainfall events, particularly in December 2000, January 2003 and July 2007. Flooding occurred due to both rising groundwater levels and overbanking of the Thames and its tributaries. Therefore, to understand and simulate the flood events, a combined appreciation of surface water and groundwater processes needs to be developed. The groundwater system has been studied by BGS and a relatively simple groundwater model of the alluvial gravels has been created. In parallel, a surface water model of the river system flowing through and around Oxford has been built by HR Wallingford. The two models have been connected using the model linking standard OpenMI (see www.openmi.org).

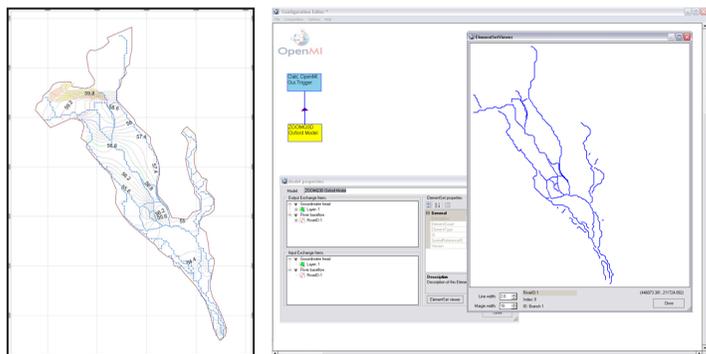


Figure 2 Groundwater model of the Oxford alluvial gravels and complex river system.

Simulation of the complex flow processes in the floodplain is ongoing. However, linking the models has provided a better simulation of the groundwater heads under flood conditions.

Berkshire Downs

Groundwater flooding on the Chalk within Rivers Pang and Lambourn catchments occurred in the winter of 2000/1, and again in 2003. The flooding was long-lasting (of the order of weeks to months) compared to surface water flooding and caused damage to housing and disruption to transport. Understanding of groundwater flooding in the Chalk requires an integrated assessment of saturated and unsaturated groundwater flows, together with surface water processes. This integrated understanding has to be reflected in the modelling system deployed to simulate groundwater flooding. A modelling approach has been developed that allows the simulation of the extent and timing of groundwater flooding. The ZOOMQ3D groundwater flow model has been enhanced to include unsaturated zone processes and overland flow. Climate change simulations are planned to see if the persistence, severity and frequency of groundwater flooding increases.



Figure 3 Groundwater flooding in the Pang and Lambourn catchment and results of modelling the groundwater flooding.



Thames Basin

The Thames Basin is underlain by geological strata of variable permeability. Frequently the permeable aquifer units are not in direct connection with each other and are linked only by the River Thames and its tributaries. To provide an integrated assessment of groundwater resources, a novel approach is required. This will answer scientific questions such as 'how might environmental change affect water resources in the whole of the Thames Basin?'. Funded internally, within the Mathematical Modelling Team, BGS is currently developing a modelling approach which can answer these questions. A groundwater model will be built using a combination of simple lumped approaches and more complex distributed models which are linked using OpenMI. These models can then be linked to models of other parts of the hydrological cycle such as hydraulic models of the River Thames or rainfall-runoff models. The groundwater part of this system is currently under development. The challenge is to incorporate the conceptual knowledge of groundwater systems at a basin-wide scale.

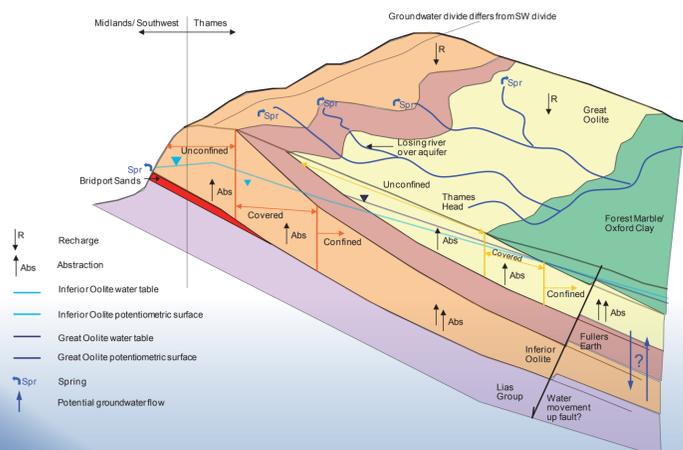


Figure 4 Conceptual model of groundwater flow in the Cotswolds limestones.

Changing water cycle – hydrological extremes and feedbacks (HyDEF)

HyDEF is a NERC funded project led by Imperial College London involving BGS, Reading University and University College London. This aims to examine how climate change will impact on the frequency of extreme events, droughts and floods, as well as examining how feedbacks occur and affect the impacts of climate change on the water environment. Two test catchments have been chosen: the River Eden, Cumbria and the River Thames. The work in the Thames catchment will focus on an understanding and simulation of groundwater droughts, with particular emphasis on the sustainability of abstraction from boreholes and on the support provided by the Cotswolds limestone aquifers to baseflow in the River Thames. Groundwater flooding will also be considered, leading on from the work undertaken in Oxford and the Pang and Lambourn catchments.

More information can be found here: www3.imperial.ac.uk/ewre/research/currentresearch/hydrology/changingwatercycles.



Figure 5 Chalk stream during low flow periods.

Contact information