science summary

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Model for investigating the impacts of groundwater abstraction

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Hydrogeologists in the Agency can now have access to a simple pilot tool based on Excel to assess applications to abstract small volumes of water, according to a new report. The tool links into a regional groundwater model to assess the impacts of proposed abstractions on river flows.

Along with developing a pilot version of a user-friendly modelling tool the project, funded by the Environment Agency and the British Geological Survey, tested the importance of including a range of aquifer features – such as catchment size, boundaries, recharge and transmissivity – in groundwater models to accurately simulate impacts on river flows. The project used a case study from the River Candover to test model simulations against observed river flow data.

Development of pilot modelling tool

To date, licensing officers have had two options for assessing abstraction impacts: simple analytical models which are quick to use but can only roughly indicate the likely impacts of an abstraction, or regional groundwater flow models which more accurately represent UK aquifers. The latter generate better estimates of river impacts, but can take months or years to develop. Furthermore, licensing officers often do not have direct access to these models and have to request a simulation to be run, which means they tend not to be used to assess small licence applications.

This study therefore developed a modelling tool for licensing officers to use with the ZOOMQ3D groundwater flow model to assess requests to abstract small volumes of water. A simple Microsoft Excel spreadsheet, ZOOM_IGARF, was designed to prepare input for, run and examine the output from ZOOMQ3D. The ZOOM_IGARF tool incorporates some of the complex features simulated by regional groundwater models, and can thus represent multiple, non-linear and dendritic river catchments.

Two further Windows applications were developed to help the user construct models of complex river catchments. The first simplifies the process of transferring river geometry and elevation data from a GIS into the ZOOM_IGARF model and the second simplifies adjustment of model river parameters such as river-bed conductances.

Modelling aquifer features

The aim of this modelling exercise was to explore whether some hydrogeological processes such as recharge could be ignored when calculating the impacts of abstraction on rivers. The report found the following:

It is important to include all rivers that could be affected by pumping and good practice to define the boundaries of a model using the physical extent of the aquifer if possible. It is not acceptable to select a stable groundwater divide between two catchments as a model boundary when assessing the impact of abstraction on river flows.

If a sub-catchment model must be developed, a better estimate of depletion rate will be derived if the average is taken of depletion rates calculated with two models: (i) the sub-catchment model in which the boundaries are defined as no-flow and (ii) the sub-catchment model in which boundaries are defined as fixed heads. By taking this average, the effect of poorly defined boundary conditions can be reduced.

The inclusion of recharge in a model used to calculate depletion rates only affects the results when (i) transmissivity depends on groundwater head (however the effects of ignoring recharge may be small), (ii) when the introduction of recharge affects the timing of when parts of the river become perched or sections of the channel become dry, or (iii) when the introduction of recharge causes another flow mechanism to exhibit non-linear behaviour.

If the length of the river being modelled changes during a simulation, the impact of an abstraction borehole on discharge will change. Care must be taken to represent the changing length of the river if depletion rates are to be calculated accurately.

The following list provides a **rough** guide as to which features of a system are the most important to represent in a numerical model. **The first two points are true for any system, however, the importance of representing the remaining features will depend on the aquifer being modelled and therefore require investigation by the hydrogeologist.**

- The full extent of the aquifer out to the physical boundaries and associated major streams which are in hydraulic contact with the aquifer being pumped must be included in the model.
- The correct geometry of the network of the rivers.
- Ephemeral sections of streams.
- Any perching or drying of streams, which may mean we have to include recharge unless we can represent seasonal variation in river length empirically.
- Heterogeneity of aquifer properties
- Significant unconfined behaviour which requires the inclusion of a reasonable initial groundwater head profile, recharge and other groundwater abstractions.
- The vertical variation of hydraulic conductivity with depth.

Candover case study

In the mid-1970s, Southern Water Authority set up a river flow augmentation scheme in the Candover catchment in Hampshire. During testing of three boreholes built as part of the scheme, groundwater abstraction rates and river flows were monitored. These data were used to compare river baseflow depletion rates simulated by models of different complexity with those observed in the catchment.

The comparison of modelled to field data proved difficult for a number of reasons. The Candover data were collected during trial pumping in the summer of 1976, in the middle of a severe drought period. Groundwater levels were very low at this time and this complicates interpretation of the impact of abstraction on river flows. However, a number of conclusions can be drawn from the Candover modelling exercise, which relate to the required complexity of a model – the features which much be included – and the confidence with which its results can be regarded.

This summary relates to information from Science Project SC030233, reported in detail in the following output(s):-

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