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title: **Groundwater-surface water interaction: insights from a lowland Chalk site in the UK**

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An understanding of the processes controlling groundwater-surface water interaction is essential for the effective management of water resources and for the protection of sensitive ecosystems. The Chalk is an important European aquifer and occurs in a number of countries around the southern North Sea. In the United Kingdom the Chalk aquifer forms the country's most important groundwater resource and in south-east England many streams and rivers are substantially supported by groundwater flow from the aquifer. It is important therefore to understand the mechanisms of groundwater-surface water interaction in Chalk-fed watercourses.

For several years the British Geological Survey has undertaken a study of groundwater-surface water interaction at a valley-bottom site situated on the Chalk aquifer on the River Lambourn in Berkshire (Allen et al., 2010). At this site the river flows over fluvial gravels underlain by Chalk and investigations of the hydraulic system have involved boreholes, riparian and river bed piezometers and have employed a combination of hydrophysical and hydrochemical techniques. The investigations have shown that the pattern of interaction between groundwater and surface water at the site is complex.

A 3-D geological model of the site was constructed, based on a combination of surface geology and borehole logging data. This model provided a framework for the ensuing conceptual hydrogeological model, which utilised physical hydraulic and hydrochemical data.

Potentiometric data from piezometers, boreholes and a stilling well indicated that the direction of groundwater flow in the Chalk at the site follows the regional trend; however Chalk groundwater apparently flows under the river with little interaction with it, and probably discharges to the river further downstream.

Hydraulic heads in the mainly gravel alluvium underlying and bordering the river indicate the presence of a complex groundwater flow system. There seems to be little hydraulic connection between the gravels and the underlying Chalk over most, though not all, of the site, while the gravels appear to be broadly in hydraulic contact with the river. The alluvial groundwaters show components of flow both parallel, and transverse, to the river, with general indications of upward flow below the river bed. The relationship between bankside gravel groundwaters and the river is complex, with both influent and effluent behaviour seen.

At the study site, three reservoirs of water with potentially different hydrochemical quality exist; the Chalk, the gravel alluvium and the river. The general chemistry of these three reservoirs is similar, because all three are effectively sourced from groundwater. However local variations in certain chemical species in the gravels have enabled the movement of alluvial groundwaters to be traced across much of the site, showing flow components both parallel to, and under, the river. This has enabled the physically based conceptual hydrogeological model of the site to be substantially refined.

The conceptual model of the site has suggested that, while the gravel aquifer has a significant influence on local surface water-groundwater interaction it has limited importance as a route for down-catchment water flow compared with the discharge of the stream.

More recently, in conjunction with the Centre for Ecology and Hydrology, the studies have been extended downstream, to include wetland areas adjacent to the river. In addition to extending the hydrological monitoring array used at the initial site, these studies involve approaches such as temperature surveys and monitoring the effects of anthropogenic changes in river level on

the groundwater system, in order to further investigate the nature of the flow systems at the enlarged site.

In conclusion, the investigations at the study site so far have indicated a complex pattern of interaction between groundwaters and surface waters. This has implications both for the way such systems are studied and for the implementation of regulations such as the European Water Framework Directive.

REFERENCES

Allen D.J., Darling W.G., Gooddy D.C., Lapworth D.J., Newell A.J., Williams A.T., Allen D., Abesser C., 2010: *Interaction between groundwater, the hyporheic zone and a Chalk stream: a case study from the River Lambourn, UK*. Hydrogeology Journal. Published online March 2010.

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