Mid River Colne & Lakes

investigating the impacts of Affinity Water's groundwater abstraction on the Mid River Colne and Lakes

by Matthew Rickard

Under the National Environment Programme (NEP) the Environment Agency are instructing water companies to undertake investigations and actions that will ensure the future prosperity of our natural environment. A number of these studies relate to restoring water company abstractions to sustainable levels in areas where they may be adversely affecting the water environment. The stretch of the River Colne between Rickmansworth and Denham, known as the Mid Colne Valley, was once home to a number of aggregate companies extracting gravel from the valley. When the majority of these extractions ceased in the middle of the 20th century, the pits were flooded to form lakes of varying sizes and depths. These lakes now make up a large network of aquadromes (lakes for recreational use) and nature reserves, a number of which comprises the Mid Colne Valley Site of Special Scientific Interest, which is designated due to its importance for breeding birds.

Undertaking lake bathymetry measurements - Courtesy of Mott MacDonald

Background

Public water supply in the area is managed by Affinity Water Limited, who use boreholes to abstract groundwater from the chalk aquifer within the catchment area of the Mid River Colne. The Environment Agency identified that flows in the Mid River Colne and water levels in the lakes could potentially be adversely affected by this public water supply abstraction, which in turn could be impacting on the local ecology.

Under the NEP, Affinity Water was instructed to carry out an investigation to quantify the impact of public water supply abstraction on the flows, levels and ecology of the River Colne and the local lakes. Mott MacDonald was commissioned to undertake the investigation which began in 2010. To quantify the impacts, the interactions between the River Colne, the lakes and groundwater in the aquifers below the river valley needed to be better understood. To achieve this, an extensive monitoring network was established to measure water levels and flows in the River Colne, groundwater levels across the catchment, water levels in the local lakes as well as ecological monitoring in the river and lakes.

Monitoring took place over a period of four years to record the responses to seasonal variations and extreme weather events. During this period a number of signal tests were carried out at a number of Affinity Water's groundwater sources.

These tests consisted of reducing or ceasing abstraction from each individual site for a number of weeks, whilst monitoring the responses in the river, groundwater and lake. The data from the whole period and the individual tests was analysed to develop a detailed conceptual understanding of the system, and subsequently to assess the impact of each local groundwater abstraction.

The River Colne - Courtesy of Mott MacDonald

High water levels on the River Colne - Courtesy of Mott MacDonald

Groundwater monitoring at one of the observation boreholes Courtesy of Mott MacDonald

Surface water

The River Colne has been subject to extensive modifications in the past. In particular, this section has various connections with the Grand Union Canal. In the upper reach of the study area, the River Colne and the Grand Union Canal are indistinguishable and flow as one. The Environment Agency has classified this section of the River Colne as a heavily modified water body (HMWB) owing to the numerous flow-altering structures along it.

The river has also had its course changed in the past owing to the gravel extraction that took place in the valley and there is a complex set of interactions with the lakes consisting of various inflow, outflow and bypass channels.

This study examined the complex hydrology through targeted regular spot flow gauging and continuous river and lake level monitoring. Using this data it was possible to identify which reaches of the river were losing or gaining water and to investigate the relationship with Affinity Water's abstraction.

The results of the analysis showed that flows generally accrete from north to south along the 12.5km length of the Mid Colne River, largely resulting from discharged treated sewage effluent from Maple Lodge STW, which constitutes approximately 34% of the river flows recorded at the downstream end of this section. Potential losing reaches were identified, but the losses are considered to be minor compared with overall flow (approximately 5% of the average flow in 2013).

No discernible impacts were observed on the flows or levels in the river due to changes in Affinity Water abstractions during planned signal tests. Generally it is very unlikely that the impact of changes in abstraction could be observed in the river flows (or levels) as Affinity Water's abstraction in the area equate to only 15-20% of the total surface water discharge from the catchment during 2013.

Groundwater

In this area the geology comprises chalk overlain by superficial deposits of alluvium, sand and gravel in the valley bottom. Groundwater flow is generally to the south east. However, towards the south of the study area groundwater flow is drawn towards the centre of the valley.

At the beginning of the study, a groundwater monitoring network was designed to provide the best spatial coverage of the groundwater regime within the study area. This network consisted of up to 27 observation boreholes.

Groundwater levels were recorded using continuous loggers in boreholes penetrating either the superficial deposits or the chalk aquifer, in parallel with continuous monitoring of lake water levels. Analysis of the continuous monitoring data (groundwater and lake level hydrographs) suggested that groundwater is in partial hydraulic connectivity with surface water in the lakes; this was indicated by broadly similar measured groundwater and lake levels.

All of the signal tests carried out at the groundwater sources were observed to have some degree of impact on local chalk groundwater levels. Our understanding of the local hydrogeology suggested that the chalk and the superficial deposits may be in partial connectivity. To test this theory, a simple model was developed using an existing theoretical method to represent a situation where the drawdown and recovery of the water level in the chalk aquifer is affected by leakage from the superficial deposits aquifer.

Abstraction and groundwater level data from the signal tests was used in this model to simulate a theoretical groundwater level recovery. The simulated groundwater levels showed good agreement with the monitoring data, thereby confirming that the chalk and superficial deposits are in partial connectivity.

Surface water and groundwater interactions

Using the results from the analysis described above and further information on geology, lake bathymetry and groundwater levels across the network, it was possible to produce conceptualised long-sections of the river valley to assess the surface/groundwater interactions.

From our conceptual understanding, the groundwater flow in the superficial deposits is likely to be down the river valley and potentially flow through some of lakes where the gravel has been excavated. It is also probable that the river is perched above the groundwater and lake water levels in some sections and is fed by the groundwater/lake system further downstream.

Temperature analysis was used to reinforce the conceptualisation of flow between the groundwater, lakes, and river. The analysis used existing data from the continuous loggers at level monitoring locations. During rainfall events, the water in the lakes rose by more than would be expected from direct rainfall. Analysis of the monitoring data showed that water levels in the gravel aquifer rise during rainfall events and this then drains laterally into the lakes.

Ecology

Ecology surveys were undertaken at four locations along the river to assess the ecological condition across the monitoring period. Surveys included macroinvertebrate, macrophyte, River Habitat Surveys (RHS) and River Corridor Surveys (RCS). Hydroecological analysis was carried out to establish any potential impacts of groundwater abstraction on the river ecology, particularly macroinvertebrates, macrophytes and bird communities.

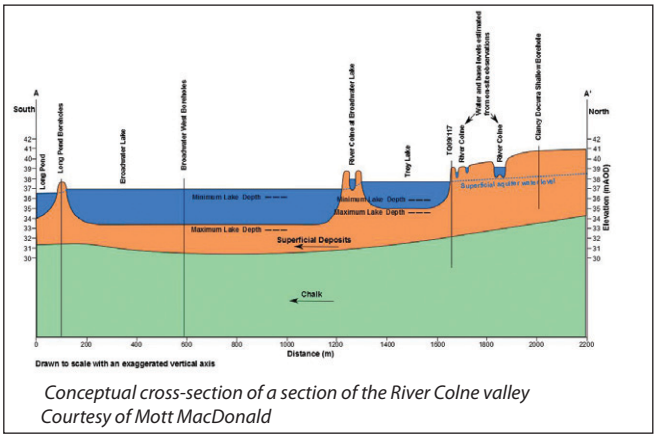
For the River Colne, results showed that the ecology is not currently that of a typical chalk river; the river channel lacks suitable morphology for key chalk stream species while the macrophyte community shows low sensitivity to changes in flow. In addition, macroinvertebrate data at the monitoring location with the longest dataset does not show evidence of impact from low flows in recent years. The ecology results agree with the hydrological study outcomes in that there is no apparent relationship between the changes in flows in the Mid Colne River and Affinity Water's groundwater abstraction.

Thirteen of the forty-five lakes in the study area were selected to be monitored for ecology. The selection was based on a previous study, in which they were identified as being potentially at risk from groundwater abstraction. Ecology monitoring included bathymetric surveys, Lake Habitat Survey (LHS), macrophyte surveys, macroinvertebrate surveys, wintering bird and breeding bird surveys.

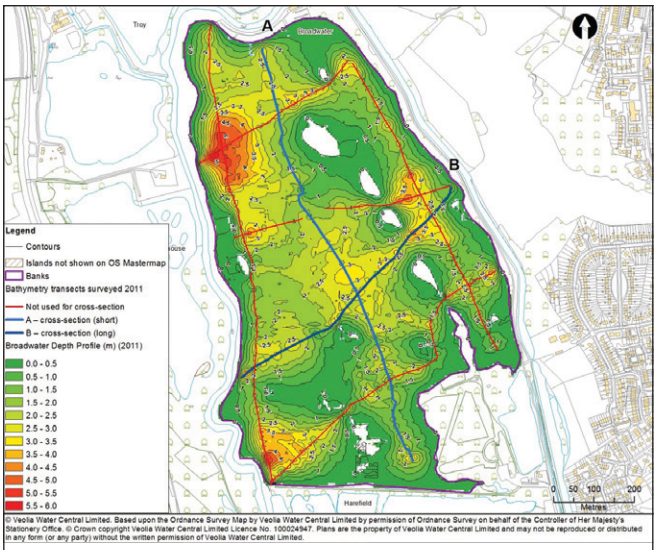
A combined approach was required to extend traditional hydroecological methods of assessment across a system containing lakes and ponds (both connected and disconnected from the stream network) which are characterised by non-linear responses to groundwater abstractions.

The results of lake bathymetric surveys, ecology data and lake water levels were analysed and compared to establish whether the ecology showed signs of being impacted by Affinity Water's groundwater abstractions.

Of the thirteen lakes studied for ecology, seven showed a water level response to a signal test. In six of these seven lakes the reduction in water levels due to abstraction did not reduce the available habitat for the resident bird populations. In one of the deepest lakes (amongst those that did not have a reduction in habitat) a decrease in water level due to abstraction was thought to have a positive effect on the bird community as higher lake levels could lead to a reduction in the photic zone and consequent limitation of macrophyte distribution.



Conceptual cross-section of a section of the River Colne valley
Courtesy of Mott MacDonald



Bathymetry map of Broadwater lake - Courtesy of Mott MacDonald

In the shallowest lake that showed a water level response to a signal test, a decrease in water level due to abstraction is thought to be having a negative effect on the lakes' ecology by accelerating their transition to terrestrial habitat. This is likely to be impacting the bird community due to habitat loss, and it was observed that dabbling and shallow water divers such as mallard and little grebe are not as common here as on the other lakes.

Conclusions

The study as a whole has helped to improve the understanding of the water environment in the River Colne valley and how the hydrological, hydrogeological and ecological systems interact to produce an ecosystem of national importance for flora, fauna and the visiting public.

Overall the study indicated that although groundwater abstraction in the area has a localised impact on groundwater and lake water levels, this does not appear to have an adverse effect on river flow or the hydroecology of the river and most of the lakes in the valley.

Going forward, it is believed that further monitoring is required on those lakes where the impact of abstraction could have an adverse effect on ecology. This would help better understand the impacts of abstraction and inform a water level management plan that would halt any transition to terrestrial habitat and ensure the survival of the lakes in their current form.

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