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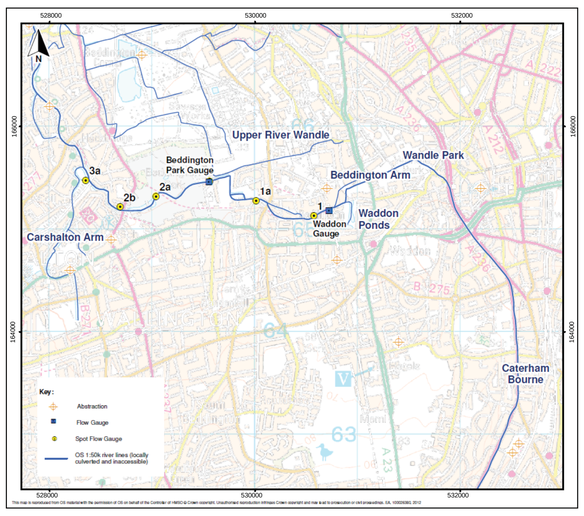
Integrated groundwater & ecological assessment of abstraction impact on an urban pond & river system in south London



Background and Drivers

Thames Water Utilities Limited (TWUL) has undertaken an investigation into the potential impact of its abstractions on the Upper River Wandle and Waddon Ponds under the National Environment Programme in AMP5.

The Upper River Wandle and Waddon Ponds is a non-designated site of local concern and the main driver for the AMP5 investigation is 'Local Priority'.

The aim of the study was to determine whether Thames Water's abstractions are having a significant adverse impact on water levels and flows in the Waddon Ponds and Upper River Wandle, and whether this gives rise to any significant adverse ecological impacts.

Study Overview

The study commenced in 2010 and is now in the final stages. It comprised:

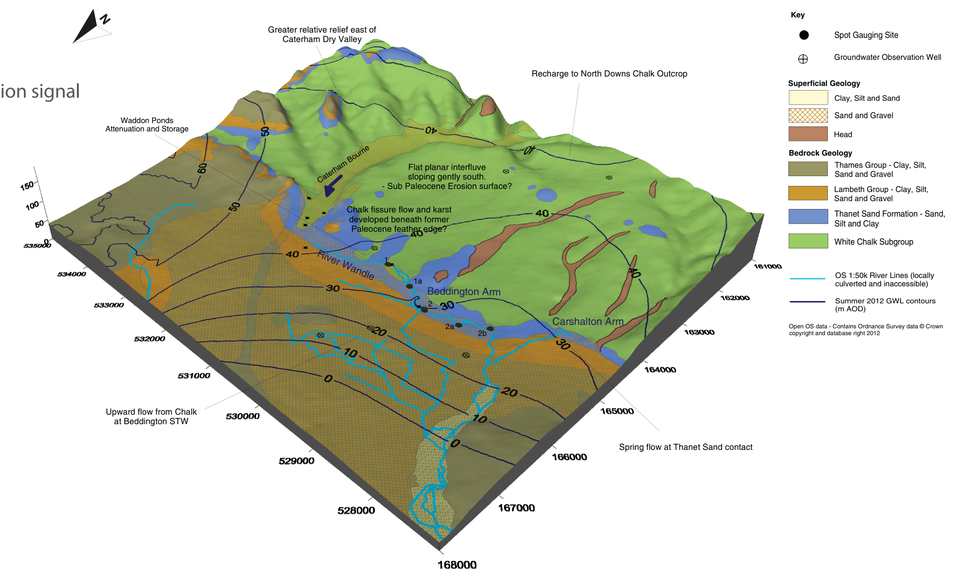
- Detailed review of historical data and development of conceptual model;
- Field monitoring, including installation of observation boreholes, abstraction signal testing and ecological monitoring;
- Detailed analysis of the field data and update to conceptual model;
- Hydrological and ecological impact assessment.

Conceptual Model

The Upper River Wandle flows within the hydrogeological transition zone between the unconfined Chalk and the confined Chalk-Thanet Sands Aquifer at the edge of the London Basin. The whole of the Upper River Wandle is underlain by the Hackney Gravels which also provide a potential source of baseflow for the river.

Groundwater levels and flow directions are influenced strongly by high transmissivity zones in the chalk, and by the elevation of spring discharges, for example at Waddon Ponds and Beddington Park, as well as groundwater abstractions. The river is well connected to the aquifer system. At higher groundwater levels groundwater to surface water discharge is expected along the majority of the river channel. Flow from Waddon Ponds is also contributing to river flows.

When groundwater levels are lower groundwater-surface water interactions are modified and the point at which groundwater levels intercept the river bed moves west.

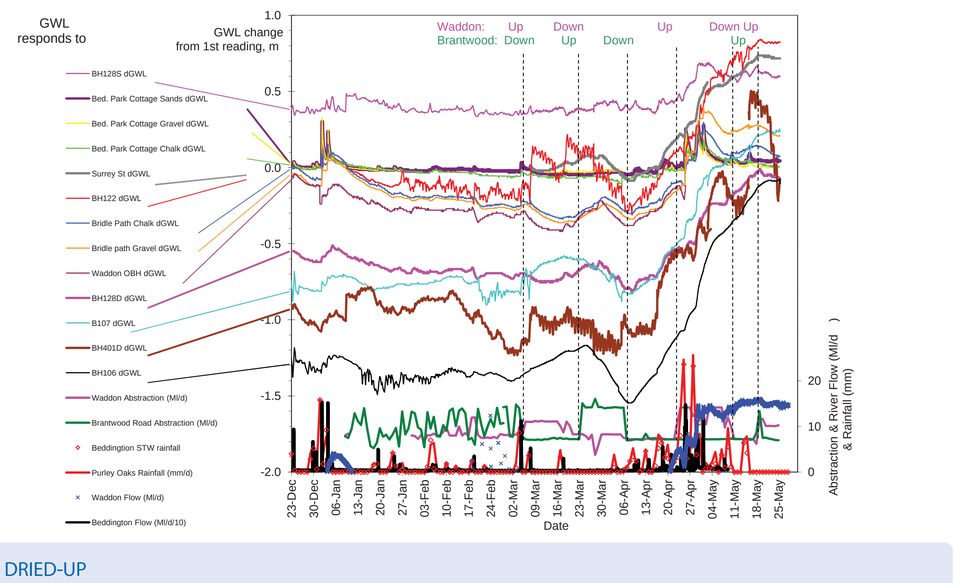


Hydrological Impact Assessment Summary

Uncertainty remains in the response of Waddon Ponds to abstraction signals from the Waddon source, but evidence from historic field data suggests that signals of approximately 7.5 Ml/d might change flows from the ponds by around 2.3 Ml/d during high/normal groundwater level periods. Under extreme low groundwater level conditions impacts at the top of the River Wandle will be limited as the groundwater system will be decoupled from river/pond system. However, additional impacts on flow will be seen further downstream.

The Brantwood Road source has only a short historical record, but data suggest that abstraction at Brantwood Road has an effect on groundwater levels below a significant dry valley, which may influence flows at the source of the River Wandle. Brantwood Road may also affect groundwater flow in to and from Waddon Ponds, but when both sources are operating this is likely to be masked by any abstraction impact from Waddon which is much closer to the ponds.

The impact assessment was supported by analysis of signal test data and initial review of model scenario outputs from the London Aquifer Model provided by the EA. However a more rigorous review of the model conceptualisation and parameterisation would be required to establish its fitness for purpose to support decision making.



Hydro-ecological Impact Assessment Summary - *Tasks:*

- Review of the Water Framework Directive ecological status of the based on macroinvertebrate data (**ASPT** and **NTAXA**);
- Hydro-ecological validation - review of river flows and a range of biotic indices (**LIFE**, **ASPT**, **NTAXA** and **PSI**) calculated from the macroinvertebrate data. Observed scores compared with expected scores to derive an **EQR** which, if below 1, can indicate stress;
- Waddon Ponds - assessment of the quality of the habitat using the Lake Habitat Survey Method (SNIFFER, 2008) and nature conservation value assessed using the Predictive SYstem for Multimetrics (PSYM) approach (Pond Conservation, 2008);
- Regression of **LIFE** scores against statistics derived for a range of antecedent flows;
- Analysis of the flow velocities present at ecological monitoring locations in the Upper River Wandle against accepted flow criteria for certain invertebrate taxa and water crowfoot (Ranunculus);
- Assessment of the level of channel modification and habitat quality using River Habitat Surveys (RHS) at biological sampling locations;
- Modelling, using the DRIED-UP suite of models (Dunbar et al, 2006, 2008, 2010a, 2010b – see Box 2). The effects of existing and reduced levels of channel modification on LIFE scores were predicted. Additionally, the amount of additional water that would be required to improve LIFE scores to the same degree as reduced habitat modification was also predicted. Six sets of modelled LIFE scores were generated based on combinations of observed flows/scenario flows and actual, halved, and zero RHS channel re-sectioning scores (to simulate various states of channel modification).

Box 1 Definitions for Biotic Indices

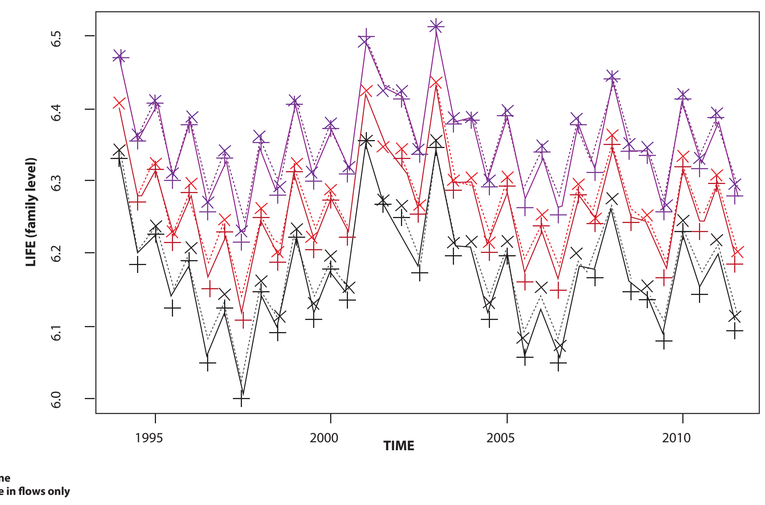
LIFE - Lotic Invertebrate Index for Flow Evaluation (Extence et al., 1999). Scores can be used to indicate the flow sensitivity of invertebrate communities.

ASPT - Average Score Per Taxon. Used to indicate the biological quality of river water and is designed to provide an indication of the presence of organic pollution. Used as part of the assessment of Ecological Status for Water Framework Directive.

NTAXA - Number of taxa. Used in the derivation of ASPT. Used as part of the assessment of Ecological Status for Water Framework Directive.

PSI - Proportion of Sediment-sensitive Invertebrates (Extence at al., 2011). Index based on the sensitivity of invertebrates to the presence of sediment and can therefore be used as a proxy to describe temporal and spatial impacts of sedimentation.

EQR - Environmental Quality Ratio. Biological assessment results expressed as a ratio. An EQR value of 1 represents (type-specific) reference conditions and values close to zero indicate significant biological stress.



Box 2 DRIED-UP

The DRIED-UP approach models riverine macro-invertebrate community response to antecedent flows and physical habitat conditions, as represented by RHS habitat modification score (HMS) resectioning values (Dunbar et al., 2010a, 2010b).

DRIED-UP is a useful tool for dissecting macroinvertebrate monitoring data, accompanied by flow and physical habitat data, with a view to informing the development of target flow regimes and other river rehabilitation options for a river under scrutiny.

DRIED-UP allows the following tasks to be undertaken (although not all were undertaken for this study):

- Prediction of LIFE scores under alternative flow and habitat scenarios;
- Assessment of the relative impact of flow alteration versus habitat modification on the macroinvertebrate community via LIFE score;
- Extrapolation of LIFE-flow relationships to any sites within the sub-catchment of interest which have River Habitat Survey (RHS) data, hence assessment of the spatial variability of LIFE-flow relationships within the catchment;
- Reduction in uncertainty associated with impact assessments based on macroinvertebrate sample data from few years or even a single year, for example the biological monitoring data collected already by APEM Ltd;
- Infilling/interpolation of LIFE scores for dates (year and season) where samples not taken;
- Derivation of a target LIFE score from running the models using naturalised flows and zero habitat modification.

Hydro-ecological Impact Assessment Summary - *Results:*

- All the biotic indices indicated that the invertebrate communities were stressed. The ASPT and NTAXA EQRs indicate that the river generally does not meet good ecological status as defined for the Water Framework Directive;
- The ASPT and NTAXA EQRs appear to increase during periods of high flow and decrease during periods of low flow. There is an indication at the site with an extended dataset that the EQRs are improving. A Thames Water's abstraction close to the study area ceased operation in 2007 and it is possible that this has had some effect although cause and effect has not been proven within this study;
- Regression of LIFE scores against antecedent flows failed to identify any significant relationships. On this basis it is suggested that factors other than low flows (i.e. flooding, water quality or channel structure – which is generally 'severely modified') are the significant controls on the macroinvertebrate community;
- Flow velocity analysis indicated that velocities are significantly below those required to support communities that expected to be present in a chalk river such as the Upper River Wandle. The river is sedimented which is exacerbated by low flows and over-widening of the channel that results in low water velocities. Narrower sections have higher flow velocities;
- DRIED-UP indicated that the highest gain in LIFE score would be obtained by setting the HMS Resectioning sub-score to zero, followed by setting it to half its value (a potentially realistic scenario). LIFE scores increased only by limited amounts when 2.3 Ml/d was added to the river flows;
- The increases in flow required to achieve similar LIFE score gains to those obtained from changing RHS Resectioning values were estimated. Although only approximate, the effect of halved HMS Resectioning would require an additional flow of 5 Ml/d and matching zero HMS Resectioning would require 9 M/d;
- Waddon Ponds have limited biodiversity value as a result of low habitat diversity and high nutrient content. It is unclear what contribution to these scores results from abstraction related effects although reduced water levels resulting from abstraction may be a minor contributory factor.

Conclusions

The DRIED-UP modelling has significantly influenced the conclusions of the study. Based on the above it is considered that options to reduce Thames Water's abstractions in isolation would not realise significant ecological benefits.

In summary:

- There is no clear case for implementing a flow Sustainability Reduction in isolation; and
- The analyses undertaken during this study suggest that river restoration should be the primary measure for improving the ecology of the River Wandle to realise tangible hydro-ecology benefits.

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