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Groundwater Dependent Ecosystems

Wednesday 27th February 2013
Birmingham and Midland Institute,
Birmingham



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Foreword

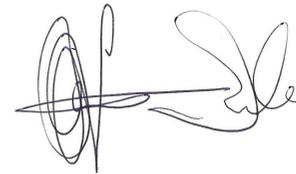
I'd like to take this opportunity to welcome you to the Birmingham and Midland Institute and to The Geological Society's 'Groundwater Dependent Ecosystems' conference.

Groundwater dependent ecosystems face multiple pressures related to public water supply, intensive agricultural land-use and land management practices, and pollution from industrial and household waste.

Since the implementation of the Water Framework Directive significant effort has been put into characterising groundwater dependent ecosystems and assessing the threats to them. However, these threats may change under future environmental change.

The meeting here today gives us all an opportunity to share our current understanding of the form and functioning of a range of groundwater dependent ecosystems, to discuss current research, highlight progress since the implementation of the WFD, and address present and future challenges facing these habitats.

Thank you for attending.

A handwritten signature in black ink, appearing to read 'Simon Neale', with a stylized, circular flourish on the left side.

Simon Neale

Chairman

Geological Society Hydrogeological Group

Programme

		14:40pm	Decadal changes in shallow groundwater regime leading to biodiversity loss in a lowland floodplain meadow <i>David Macdonald, (British Geological Survey)</i>
09:30am	Registration and light refreshments		
10:00am	Welcome address	15:00pm	Simulating the impact of regional groundwater changes on raised bog eco-hydrology <i>Dr Ray Flynn, (Queen's University Belfast)</i>
10:10am	Protecting groundwater dependent wetlands from significant damage; recent experience and new threshold values Invited Speaker Dr Johan Schutten (<i>Scottish Environmental Protection Agency</i>)	15:20pm	Coffee
10:40am	The WFD wetland chemical test - what have we learnt from last time around? <i>Mark Whiteman (Environment Agency)</i>	15:50pm	Coastal dune wetlands in England and Wales: Understanding rainfed groundwater dependent ecosystems to underpin conservation management <i>Dr Nick Robins, (British Geological Survey)</i>
11:00am	Determination of nutrient threshold values relevant to groundwater-dependent terrestrial ecosystems (GWDTEs) in Ireland: progress and challenges <i>Dr Sarah Kimberley, (Trinity College Dublin)</i>	16:10pm	Mega-scale restoration of alkaline and calcareous groundwater-dependent fen communities, Cors Erddreiniog, Anglesey. <i>Rhoswen Leonard, (Countryside Council for Wales)</i>
11:20am	Coffee	16:30pm	Groundwater: the hidden groundwater dependent ecosystem <i>Tim Johns, (Environment Agency)</i>
11:50 am	Integrating hydrogeology, hydrology and ecology to assess the impact of abstractions on groundwater dependent ecosystems <i>Megan Durrant, (Mott MacDonald)</i>	16:50pm	Closing remarks
12:10pm	Groundwater Dependent Ecosystems in Karst: An Assessment of Pant y Llyn, Wales' only turlough and comparison to Irish sites <i>Gareth Farr (BGS) & Dr Owen Naughton (Trinity College Dublin)</i>		
12:30pm	Devils and Details: hydrology and conservation ecology in small, calcareous, groundwater-fed fens <i>Dr Bryan Wheeler, (University of Sheffield)</i>		
12:50pm	Newham Fen NNR, Northumberland – an example of GDE complexities <i>Anna Wetherell, (Natural England)</i>		
13:10pm	Lunch (Hydrogeological Group AGM 13:10–13:20)		
14:10pm	Projecting uncertain impacts of climate change on wetlands: a risk-based web tool for England and Wales Invited Speaker – Dr James Blake , (<i>Centre for Ecology and Hydrology</i>)		

Protecting groundwater dependent wetlands from significant damage; recent experience and new threshold values

Johan Schutten

Scottish Environmental Protection Agency, Stirling, Scotland

Groundwater dependent terrestrial ecosystems (GWDTEs) are protected from significant damage through the Water Framework Directive. A recent (2012) technical report by the EU Working Group C (Groundwater) has clarified what GWDTEs are and how they need to be considered during River Basin Planning.

I will show how the UK developed new nitrate threshold values for GWDTEs on basis of best available scientific knowledge and will share our experience during the first River Basin Planning cycle and highlight areas that need further development.

The WFD wetland chemical test - what have we learnt from last time around?

Natalie Phillips¹, Mark Whiteman¹, Andrew Brooks²

¹ Environment Agency, ² Amec

The UK Technical Advisory Group (UKTAG) on the Water Framework Directive has published a working paper on the use of water quality threshold values to determine what groundwater concentrations of chemicals, if exceeded, could be (or actually is) causing damage to a groundwater dependent terrestrial ecosystem (GWDTE). The new approach uses empirically based nitrate trigger values, corresponding to different wetland types and altitudes, which if exceeded in the GWDTE may cause significant damage to the plant communities on the site.

This is a significant departure from the previous methodology which grouped phosphate pressure into categories of high, medium and low, based upon relatively arbitrary thresholds and relied upon the UK's National Vegetation Classification (NVC) to infer the sensitivity of the plant communities to nutrients. This paper compares the results from application of the two approaches for GWDTEs across England and Wales and investigates the implications at the site level using two case studies.

Determination of nutrient threshold values relevant to groundwater-dependent terrestrial ecosystems (GWDTEs) in Ireland: progress and challenges

S Kimberley¹, C Coxon¹, M Craig² and J Schutten³

¹ School of Natural Sciences, Trinity College Dublin

² Environmental Protection Agency, Richview, Dublin

³ Scottish Environmental Protection Agency, Stirling

Groundwater-dependent terrestrial ecosystems (GWDTEs) are wetlands that depend directly on groundwater contributions. The EU Water Framework Directive (2000/60/EC) requires assessment of the effects of groundwater pressures on GWDTEs as part of groundwater body (GWB) classification. Groundwater chemical threshold values (TVs) are a component of chemical status assessment and are concentrations of nitrate and/or phosphate within a groundwater body that when exceeded in conjunction with evidence of significant damage to a wetland triggers further site investigation.

In Ireland, there are currently no proposed threshold values for GWDTEs and this paper focuses on on-going attempts to determine chemical threshold values for calcareous fens in Ireland. An approach developed by the UK Technical Advisory Group on the WFD to determine threshold values was applied to Irish calcareous fens. This approach involved establishing hydrogeological connections between calcareous fens and the drinking water and groundwater quality monitoring network.

A lack of reliable information on the ecological condition of sites prevented the further step of grouping fens into 'good' and 'poor' ecological condition categories in order to examine the associated ranges of groundwater nutrients. Recently completed basic surveys of 44 fens with hydrogeologically connected groundwater monitoring points provide information on the dominant water inputs and the presence and extent of Annex I habitat types under the Habitats Directive.

Integrating hydrogeology, hydrology and ecology to assess the impact of abstractions on groundwater dependent ecosystems

Megan Durrant¹, Celia Figueira¹, Simon Starling², Jamie Riches² and Steve Tuck²

¹ Mott MacDonald, Demeter House, Station Road, Cambridge

² Thames Water Utilities Limited, Clearwater Court, Vastern Road, Reading

As part of the National Environmental Programme, investigations have been carried out into the impacts of Thames Water groundwater abstractions on the River Wye and Letcombe Brook in the Chalk of the Berkshire Downs and south west Chilterns.

A summary is presented of the analyses carried out to establish any potential impacts on the stream ecology, particularly macroinvertebrate and fish populations. In order to assess the magnitude and significance of these impacts, the investigations looked at mesohabitats, macroinvertebrate and fish data. A microscale assessment on the changes in water velocity and water depth imposed by abstraction and its relation with fish species' habitat requirements was carried out to estimate the potential for abstraction to impact fish populations present in the stream. To integrate these assessments, conceptual hydrogeological models were developed to enable an evaluation of a range of abstraction scenarios and consequential impacts on river flows.

A critical review of the constraints of the methods employed is also presented, with proposed changes to the field methods to enable a more efficient integration of ecological and hydrological data.

Groundwater Dependent Ecosystems in Karst: An Assessment of Pant y Llyn, Wales' only turlough and comparison to Irish sites

Gareth Farr¹, Owen Naughton², Tristan Hatton-Ellis³, and Jamie Bevan⁴

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² Department of Civil, Structural and Environmental Engineering, University of Dublin Trinity College

³ Countryside Council for Wales, Maes-y-Ffynnon, FforddPenrhos, Bangor, Gwynedd

⁴ Countryside Council for Wales, MaesNewydd, Llandarcy, Neath

Turloughs are ephemeral karst lakes resulting from high rainfall and, accordingly, high groundwater levels in topographic depressions in karstified limestone terrain. The ephemeral nature of turlough hydrology gives rise to a characteristic ecology as such turloughs have been designated as a Priority Habitat in the EU Habitats Directive (92/43/EEC). While there are recorded turloughs in the Republic of Ireland Pant-y Llyn is Wales' and mainland Britain's only recorded turlough; it is a key feature of Cernydd Carmel SSSI and SAC.

A collaborative investigation was carried out between Environment Agency Wales and Countryside Council for Wales (soon to be Natural Resources Wales). The main aims of this investigation were to:

- Improve the hydrogeological conceptual understanding.
- Review the water chemistry of Pant-y-Llyn and the surrounding groundwater.
- Compare the hydrology of Pant-y-Llyn with that of recorded Irish turloughs.
- Use existing data back model the turlough hydrograph.
- Provide evidence to confirm its status for the Habitats Directive.

The investigation has shown that Pant y Llyn has both a water quality and hydrological cycle. For the first time comparisons with Irish turloughs allow us to put Pant y Llyn into a wider turlough typology.

Devils and Details: hydrology and conservation ecology in small, calcareous, groundwater-fed fens

Bryan D. Wheeler

Department of Animal & Plant Sciences, University of Sheffield

An examination will be made of some difficulties inherent in relating the hydrogeology of small, calcareous, groundwater-fed fens to the occurrence and conservation of patches of internationally important mire vegetation. Particular attention will be given to some examples from East Anglia and to the relevance of patchiness and appropriate scale in investigations.

Newham Fen NNR, Northumberland – an example of GDE complexities?

Anna Wetherell, Senior Specialist - Hydrology & Hydrogeology, Natural England

GDEs are often complex features set in wider wetland landscapes, with multiple factors to be taken into account when trying to characterise them, manage them, or assign any impacts back to the associated groundwater body. Often the groundwater related interest only forms one part of the system.

Newham Fen NNR is one such example of a GDE. The NNR contains an alkaline fen, a classic groundwater fed habitat, set in the wider Embletons Bog which contains agricultural land which floods regularly, despite multiple attempts to drain it over the years. However, while research has been carried out on the site over the last 20 years, there are still questions about what the key groundwater source for the fen might be. Recent datalogger data has allowed water level responses to hydrological events to be analysed in more detail, and highlights the very different characteristics of the groundwater fed parts of the site compared with precipitation / surface water dominated areas. Combined with geological and vegetation data, more detailed characterisation of the site has become possible, providing an example of the analysis this type of site often requires.

Projecting uncertain impacts of climate change on wetlands: a risk-based web tool for England and Wales

J. R. Blake, M.C. Acreman
Centre for Ecology and Hydrology, Wallingford, Oxon

The UK climate is projected to continue changing over coming decades. Estimates produced in 2002 predicted wetter winters and drier summers, with the greatest changes in the south and east where, in summer, soils are likely to become drier for longer (UK Climate Impacts Programme, UKCIP02). These projections have been updated (UKCP09) and although the general pattern of change is broadly similar, the projections are now probabilistic in nature, allowing climate change impact uncertainty to be evaluated. Such changes will have significant implications for wetlands, which require periodic saturation or inundation. Changes to the hydrological regime of wetlands are likely to impact on the ecosystems services they provide including flood management, water quality improvement, provision of wildlife habitats and carbon sequestration. Future management, restoration and adaptation of wetlands, particularly delivery of the Wetland Vision in England, will thus require tools to help understand the potential impacts of climate change so that appropriate adaptation plans can be developed.

We have developed an open-access, web-based tool that quantifies the potential impacts of climate change on wetland hydro-ecology at the regional scale. The conceptual framework for the tool includes regional differences in climate change and different water supply mechanisms to wetlands (i.e. rain-fed, river-fed and groundwater-fed). New improved reduced-complexity models for these three end-member mechanisms have been developed that balance sufficient process representation with simplicity to make them fit for purpose. The models are computationally efficiency, enabling assessment of the 10,000 possible climate realisations available for each of the twelve Water Framework Directive river basin regions of England and Wales for the selected climate change time period and emissions scenario. For groundwater-fed wetlands, the new model is driven by projected groundwater levels produced by the Future Flows project. Results are presented in a risk-based framework and provide wetland managers, consultants and researchers with an initial assessment of the probable impacts of climate change on a variety of interest features including wetland water levels, plant communities, birds and the historic environment.

Decadal changes in shallow groundwater regime leading to biodiversity loss in a lowland floodplain meadow

David Macdonald¹, Ann Williams¹, Majdi Mansour¹, Andy Dixon², David Gowing³, Irina Tatarenko³, Paul Morris⁴, Anne Verhoef⁴

¹ British Geological Survey, Groundwater Science Programme

² Groundwater Monitoring and Drilling Ltd

³ Open University, Department of Environment, Earth & Ecosystems

⁴ University of Reading, Department of Geography and Environmental Science

Floodplain meadows are dependent on hydrological conditions characterised by regular fluvial flooding and shallow groundwater. The area occupied by these meadows within the UK has decreased significantly since the early 20th Century, primarily due to intensified agriculture. Although much of this habitat is now protected, threats remain due to changing land use, climate and river management.

A case study site from the River Thames floodplain in the Oxford Meadows Special Area of Conservation is used to examine the range of factors affecting the hydrological regime and in turn the meadows' plant communities. The site is well characterised as a result of surveying and monitoring required by the environmental regulators to assess the impact of gravel extraction which began in the locality in the late 1980s and through the dedication of local botanists. Water-level monitoring has shown an overall decrease in the depth to groundwater over the past three decades, and botanical surveys show a trend towards meadow plant species that prefer wetter conditions. Model simulations have been used to assess the potential underlying causes of this trend including: the sealing of the nearby gravel pits which reduces the volume of gravel through which the groundwater can flow; an increasing trend in summer rainfall coinciding with the period of gravel extraction; and a lack of maintenance of the drainage system. Environmental management implications are considered, which have broad applicability to floodplain meadow sites.

Simulating the impact of regional groundwater changes on raised bog eco-hydrology

Raymond Flynn¹ and Shane Regan²

¹ School of Planning, Architecture and Civil Engineering, The Queen's University of Belfast

² School of Civil Engineering, Trinity College Dublin, College Green, Dublin

A conventional geotechnical view of Irish raised bogs considers them as sequences of compressible peat underlain by low permeability deposits. Consequently the effects of changes in groundwater head in underlying units are considered to have a negligible effect on peatland ecohydrology, with the impact of drainage is assumed to be restricted to peat. A widely-used rule-of-thumb assumes the effects of marginal drainage to extend less than 15m into uncut peatland. Work completed in Clara Bog, Co. Offaly (Clara), where widespread differential subsidence has occurred over large areas during the past 20 years, challenges this view.

A programme of coring on the south western side of Clara has revealed layers of calcareous sand and till/clay underlying the peat to form a northerly sloping substrate, while electrical conductivity measurements, coupled with piezometric data, suggest mineralised groundwater discharges from the peat substrate to marginal drains. Bog topographical simulations, generated using a one dimensional groundwater flow model, coupled to peat compressibility, indicate that substrate geometry plays an important role in determining the subsidence-related topography. Moreover, the model explains the recent development of lakes on the bog, explaining the paradox that marginal drainage can make some areas of the bog wetter.

Coastal dune wetlands in England and Wales: Understanding rainfed groundwater dependent ecosystems to underpin conservation management

N.S. Robins¹ and C.J. Stratford²

¹ British Geological Survey, Wallingford, Oxon

² Centre for Ecology and Hydrology, Wallingford, Oxon

Coastal dune wetlands are fragile ecological pockets that sit within larger and often very dynamic dune systems. The hydrological regime within the wetland, and in turn the flora and fauna that inhabit it, is influenced by combinations of natural and anthropogenic processes occurring throughout the dune system. A conceptual understanding of the processes controlling the hydrological regime both now and in the future is fundamental in underpinning effective conservation management at these sites. Management issues include felling tree plantations to revert to natural warren, mobilisation of dunes by vegetation control, scraping the upper organic layers in slack floors and grazing. However, conservation management also has to cope with coastal erosion and accretion which impact groundwater base levels, change in rainfall and other natural and sometimes overriding impacts.

A number of initiatives are being carried out collaboratively between BGS, CEH and University of Southampton, Natural England, Sefton Council, Countryside Council for Wales and University of Groningen. These include predictive modelling of climate change scenarios at Ainsdale in Lancashire, quantitative analysis of change, groundwater flow modelling (Zoom), water profile monitoring and analysis (MIKE SHE) in the unsaturated zone in dune slacks at both Braunton Burrows in Devon and Whiteford Burrows on Gower, physical property, chemical and isotope profiling beneath high dunes in the unsaturated zone at Braunton Burrows, salinity monitoring of an embryo slack at Whiteford Burrows and high frequency water level monitoring at Braunton, Whiteford, Ainsdale, Newborough Warren in Anglesey and Sandscale in Furness. These investigations are carried out alongside detailed vegetation survey monitoring which has also required conceptual groundwater flow models to be developed at three additional east coast UK sites.

Mega-scale restoration of alkaline and calcareous groundwater-dependent fen communities, Cors Erddreiniog, Anglesey

Rhoswen Leonard¹, Justin Hanson¹, Janine Guest¹, Peter Jones¹, Rob Low²

¹ Prosiect LIFE& Corsydd Môn a Llŷn / Anglesey and Llŷn Fens LIFE+ Project, Countryside Council for Wales

² Rigare Ltd

Cae Gwyn, the 'White Field', is located on the eastern flank of Cors Erddreiniog, a large rich-fen site on Anglesey. Before restoration a large proportion of the site was dry, with a 20-40 cm covering of mineral soil, of undetermined origin, over extensive peat and white marl deposits. The latter suggested that the site had been a location of active groundwater discharge (from the Carboniferous Limestone) and peat formation prior to extensive drainage, re-routing of spring discharge and agricultural improvement.

Under the 'Restoration of Anglesey and Llŷn Fens' EU-LIFE project, during early 2012, a peat and marl surface was exposed by removal of an average of 350 mm of topsoil over the 4.5 ha site; 20,000 m³ of material was excavated and hauled from the site over a 12 week period. Springflows from the Carboniferous Limestone were re-routed to the upslope margin of the site, via a reedbed which is designed to reduce the high nitrate content of the incoming water. Water table drawdown within the site, by an adjacent deep ditch, has also been significantly reduced by installation of a plastic sheet-pile curtain.

The revised profile and hydrological functioning of the site was carefully designed, through consideration of the small-scale hydrogeology of the site, referring to the WETMECs scheme, to foster the complex hydrological supporting conditions for alkaline and calcareous fen communities. There are very encouraging signs that this restoration project, which is amongst the largest nature restoration projects attempted in the UK, will be successful in restoring a significant area of rare groundwater-dependent alkaline and calcareous fen communities to this area of Cors Erddreiniog.

Groundwater: the hidden groundwater dependent ecosystem

Tim Johns¹, Lou Maurice², Anne Robertson³, Lee Knight⁵, Debbie Allen², James Sorensen², Damiano Weitowitz⁴, Gareth Farr²

¹ Environment Agency

² British Geological Survey

³ Roehampton University

⁴ British Geological Survey / Roehampton University

⁵ Hypogean Crustacea Recording Scheme

Britain's aquifers support a range of microbial and invertebrate fauna, many of which are only found in groundwater. They provide a unique and important contribution to biodiversity, and help in the delivery of ecosystem services. Invertebrates only found in groundwater are called stygobites, the majority being small crustaceans, adapted to survive in the subsurface where there is no light and limited resources.

There are eight stygobitic macro-invertebrate species known from England and Wales, one *Niphargus glenniei* being endemic to Devon and Cornwall. However, the spatial distributions and ecological function of our groundwater fauna remains poorly understood.

Recent British studies aimed at improving this knowledge include:

(1) Investigating stygobites presence in different geological and chemical environments in southwest England.

(2) Investigating regional variability in Chalk groundwater ecosystems and packer testing studies of groundwater fauna at different depths.

(3) Genetic investigations into the different stygobitic Crustacea.

These studies show that although Britain has a relatively low diversity of groundwater fauna, compared to other parts of the world, those present occur relatively frequently and in a range of geological environments. The presentation will introduce groundwater ecosystems, present results of recent studies, and discuss the importance of this hidden, often overlooked groundwater dependent ecosystem.

Posters

Refining conceptual and numerical models of groundwater-surface water interactions in areas of complex superficial geology: A case study from the Upper Colne Catchment, Hertfordshire

Matthew Ascott, Affinity Water

Waun Fawr- an investigation into high nutrients in a groundwater dependent ecosystem

Rachel Breen¹ & Jon Hudson²

¹ Environment Agency Wales, ² Countryside Council for Wales

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

Ellie Creer¹, Andrew Brooks¹, Heather Williams¹, Cedric Laize², Simon Starling³ and Steve Tuck³

¹ AMEC, ² Centre for Ecology and Hydrology, ³ Thames Water Utilities Limited

An integrated hydro-ecological approach to the identification of sensitive groundwater dependent terrestrial ecosystems within wind farm Environmental Impact Assessment

Helen Culshaw and Andrew Halcro-Johnston, Golder Associates (UK) Ltd

Calcareous, groundwater-fed fens in England: distribution, ecology and conservation

Iain Diack¹, Phil Eades², Mark Parnell², Sue Shaw², Ros Tratt², Bryan Wheeler³

¹ Natural England, ² Independent Consultants, ³ University of Sheffield

Subterranean biodiversity: ecology of a Chalk aquifer

Jessica Durkota (PhD student), University College London

Rusland Valley mosses restoration: hydrogeology, hydro-ecology and landscape visualisation

Alex Jones¹, Sam Bishop¹, Steve Rose¹, Nick Allin¹ and Matt Powell²

¹ JBA Consulting, ² Natural England

Groundwater abstraction impact and long-term vegetation community survival in Greywell Fen, Hampshire

Rob Low¹, Adrian Hutchings², Sue Morris², Helen Harfoot², Emma Goddard³

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