No. 61 May 1999

THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

Circulation

Contents

Plynlimon: still active after all these years, but changing

Plynlimon soils report reissued

Modelling surface-groundwater interaction: lowflows, ecology & wetlands
BHS/Geol Soc meeting, 22 Feb. 1999

President's piece by Frank Law

Successful postgrad symposium
Held at Bristol, 29-30 March 1999, plus a PhD student's view of the event

Source control
Report of BHS Pennines meeting, Leeds

Innovative flood investigation: the Galway experience
Report of the Southern Section Meeting on St Patrick's Day at Imperial College

Royal Met Soc Group news

UNESCO publications received

Regional groundwater modelling
Report of a Midlands Section Meeting

Committee nominations please!

Catchment management
Report of a two-day MLURI workshop

New members

Recent NERC research grants

Book reviews
Encyclopaedia of Hydrology
Water in the Netherlands

News from members and others

Gauging mountain torrents

BHS South West: new web site

Forthcoming meetings
MTBE groundwater pollution — London
Water in the Celtic world — Aberystwyth
Accuracy in spatial data — Amsterdam
Extraordinary floods — Rejkjavík
Hydroinformatics 2000 — Iowa, USA
Groundwater quality 2001 — Sheffield

BHS AGM: changed date & venue

Programme of National Meetings

Diary of BHS and other events

Circulation is published quarterly. It is free to members of the British Hydrological Society; £20 to nonmembers on annual subscription.

- Membership enquiries: Helen Sismey, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA. *Tel 0171 665 2239, E-mail sismey_h@ice.org.uk.*
- Editor: John Griffin, Institute of Hydrology, Wallingford, OX10 8BB. *Tel 01491 692427. Fax 01491 692424. E-mail b.h.s@mail.nwl.ac.uk.*
- Internet: http://www.salford.ac.uk/civils/BHS

Circulation is produced by the Institute of Hydrology and indexed in *Geosystems' Hydrotitles* & *GeoArchive* and *NISC HydroROM.*

Plynlimon — still active after all these years

Changes are under way at the Plynlimon catchments, but measurements continue.

There can be few members of the Society who have not heard of the Institute of Hydrology's Plynlimon catchments in mid-Wales. Many perhaps had the opportunity to visit them as undergraduates, but might not have been back since, and may wonder if they are still being operated — others are now learned Professors and keep returning, year after year, either to conduct research or to bring their own group of fresh-faced undergraduates.

This year is a milestone, marking 30 years of catchment operation. Back in the 1960s everything we take for granted in environmental instrumentation was either new, or did not exist and had to be invented. This was a time of developments: the 'Wallingford' neutron soil water probe, early Automatic Weather Stations, as well as the work by the Hydraulics Research Station on steep stream flumes capable of measuring flows in channels with



One of Plynlimon's steep stream flumes

Froude numbers well in excess of unity. Other challenges were the large sediment loads, the high proportion of winter precipitation occurring as snow, and the absence of reliable data loggers, with which to record all these important environmental variables!

The story of Plynlimon parallels the story of the development of British hydrology in many ways. The early years were spent ensuring accurate measurements as a sound foundation for the later work. The hydrological studies were originally concerned solely with water quantity, the question being put simply as ' do trees use more water than grass?' (The answer was "Yes", not so much because of higher transpiration, but rather because of higher interception losses). In time this work widened considerably to tackle other issues, as the catchments, their hydrometric network and the accumulated data provided an ideal base for other studies of upland water quality and freshwater ecology. Thus, whilst the 1960s were concerned largely with developments of measurement techniques, the 1970s focused on water quantity and the 1980s saw new work into surface water acidification, as well as systematic routine monitoring of water quality, which is now providing potentially really valuable information on long-term water chemistry trends.

Through the 1990s there has been increasing recognition of the importance of ecology and 'integrated' or holistic catchment studies. This is providing potentially valuable information on climate change and rapid changes in land use (e.g. forest clear felling and moorland set-aside). The responses of managers of water resources and forests are also changing, as a result of scientific advances and increased public awareness of the problems — and some of the potential solutions.

It is only by adapting to these changing needs and issues that the Plynlimon catchments have continued to operate so successfully beyond their original (ten-year!) lifespan. Nowadays there has been a national shift in emphasis from upland water issues to the lowlands, where there is pressing need for better understanding of a wide range of topics, including agricultural pollution, aquifer recharge and floodplain restoration.

As a consequence, although the basic catchment data collection will continue, there is to be a reduction in the work at Plynlimon, including the closure of the staffed office at Staylittle later this year. In future IH staff based at its sister organisation within the Centre for Ecology and Hydrology — the Institute of Terrestrial Ecology in Bangor — will conduct the hydrometry. The long-term collection of water quantity and quality data will carry on, at a somewhat reduced level, and the catchments will continue to appear in the National Surface Water Archive. The main database is at present being transferred to the Institute of Hydrology at Wallingford, where **David Biggin** will service requests for data.

The most noticeable feature to our visitors is that unfortunately guided study tours of the catchments will be more difficult to organise, because there will be no staff on site. Visits will have to be planned well in advance, since IH/CEH staff will have to make a special trip from Bangor or Wallingford. Unguided tours are still possible for those familiar with the catchments, but visitors will be required to take responsibility for their own safety arrangements and to contact the landowners themselves to arrange access.

Nevertheless upland hydrology remains important, and there are many challenging and important aspects to be studied to implement the best integrated management of catchments. These include, for example, knowledge of the changing pattern of evaporation losses over the lifespan of a commercial forest plantation, as well as the question of why some acidic forest catchments can sustain trout populations, whilst other have become devoid of this valuable and environmentally-indicative game fish.

Much of the recent and current research has been published in a special issue of *Hydrology and Earth System Sciences**. The Institute of Hydrology welcomes new collaboration with researchers in these and other topics, and the catchments themselves will continue to operate as outdoor laboratories. As the IH Director **Prof. Jim Wallace** said, "IH commitment to catchment research continues". Anyone interested in conducting field research in the catchments should contact either **Mark Robinson** or **Jim Wallace** at IH Wallingford.

Mark Robinson and Jim Hudson

* *Hydrology and Earth System Sciences* 1 (3), 381-764 (September 1997)

New edition of Plynlimon soils report

As part of the continual programme of maintaining and updating the Institute of Hydrology's Plynlimon database it has been decided to publish the detailed soil survey (John Bell's IH Report No. 8, "Soils of the Plynlimon catchments") in a new colour edition.

This study is the definitive work on Plynlimon's extensively studied soils, and as one of the earliest attempts to directly link soil distributions with hydrological processes will be of interest and use to a wide audience of environmental scientists.

Modelling surface-groundwater interaction — lowflows, ecology & wetlands

BHS and Geological Society (Hydrogeological Group) Institution of Civil Engineers, London 22 February 1999

This joint meeting, with eight technical presentations, was attended by over 145 people, from the Environment Agency, water companies, non-governmental organisations, research institutions, universities, consultants and others. Unfortunately, because of the size of the meeting room, not all applicants could attend.

Brian Adams (BGS Hydrogeology Group) welcomed the participants. The meeting was part of the follow-up to a study entitled *Low flows, Groundwater and Wetland Interactions*, funded by the Environment Agency, UKWIR and NERC. The report of the study included a framework for achieving the sustainable management of groundwater-fed catchments (Acreman & Adams, 1998).

The first step in this framework, "objective setting", was discussed at a *Groundwater Forum* seminar in November 1998. A complementary meeting was required to discuss the techniques and models available to achieve river flow and wetland water level objectives. **Mike Acreman** (IH) contended that the various methods could be divided into four areas: *1* groundwater, *2* surface-groundwater interactions, *3* river flows and wetland water levels, and *4* water needs of fish, plants and invertebrates.

Depletion of rivers and springs by groundwater pumping

David Burgess and **Stuart Kirk** gave an Environment Agency overview of depletion of rivers and springs by groundwater pumping. Dave explained that successive Water Resources Acts had required the effects of groundwater pumping on surface waters to be assessed. However, the methods used had varied, depending on the knowledge and myths of the catchment and aquifers in question. The Agency was moving towards a more considered and consistent approach — he gave examples from the Rivers Little Ouse and Wissey. Delay could occur between pumping and its impact on rivers and wetlands, which might persist for months after abstraction had ended.

Stuart described a current Agency project, called "The impact of groundwater abstractions on river flows: an investigation into methodologies". Its aim was to achieve consistency across the Agency and to identify best practice in analytical techniques. Steps included a literature search, a survey of current practice, evaluation of selected methods, recommendations and production of a user guide.

Methods were of three types: fully penetrating riverbed (e.g. Theis), fully penetrating river with semi-permeable riverbed sediments (Handtush), and partially penetrating river with semi-permeable bed sediments (Stang)†. A particular issue was the compound impacts of abstraction year after year, as the aquifer may not fully recover from previous years' pumping. More data were needed on spring flow, wetlands and valley bottom hydrogeology. A manual of techniques and better models linking surface and groundwater systems were also required.

Pumping near wetlands: improving on Theis

John Barker (University College London) argued that the protection of wetlands from increasing groundwater abstraction cannot wait for detailed site-specific investigation and characterisation. He described a simple mathematical model, developed in 1994 with funding from the NRA Anglian Region, to estimate the reduction in groundwater flow into a wetland caused by pumping. This had been tested in East Anglia, including at Lopham and Redgrave Fen. The tool was based on a new well function, which incorporates leakage between the aquifer and the wetland and is a generalisation of the Theis equation. When pumping is for a limited period, the maximum induced drawdown and flow reduction may occur a significant time after the end of pumping and can be much greater than at that time. Professor Barker stressed that this was "quick and dirty": significant improvements on such stopgap approaches must await detailed long-term monitoring of wetland fluxes and groundwater heads.

Integrated studies in Cumbria

Paul Younger and **Geoff Parkin** (Water Resource Systems Research Laboratory, University of Newcastle) presented 'Integrated field and modelling studies of natural groundwater discharge in West Cumbria'.

Paul reported that (with funds from NIREX) a small catchment draining the St Bees Sandstone on the western flank of the Lake District had been instrumented at multiple levels for piezometric head measurements, equipped with weather stations and spring and stream gauging stations. Portable capacitance probes were used to measure wetness in soils. Soils mapping and shallow RESCAN surveys were also undertaken to complete site characterisation. Surface water surveys during dry periods provided a valuable insight in the groundwater system. Hydrochemical analysis showed that, at low flows, the rivers were fed by groundwater.

Geoff explained that alongside these efforts the VSS component of the SHETRAN catchment model was used to develop a detailed model of stream-aquifer and aquifer-wetland interactions. This process-based distributed finite-difference catchment model enabled quantification of stream/aquifer/wetland interactions and led to a comprehensive understanding of groundwater discharge processes. The greatest single component of groundwater discharge was up-flow into the streambed, followed by spring discharges. Old boreholes also provided an important outlet for groundwater. They concluded that considerable data and a complex model were required to understand the nature of hydrological processes in the catchment.

River lining permeabilities

'River lining permeabilities and their implications for low flow determination' was presented by **Ann Calver** and **Andy Young** (Institute of Hydrology).

Ann presented values of river lining permeabilities from various methods of determination as a basis for considering whether generalisation was possible. A number of site specific determinations (of varying quality) exist, but overall knowledge of the behaviour of the two-way transfer of water between rivers and aquifers is spatially and temporally sketchy. Many reports and published papers use lining permeabilities, but do not explicitly state permeability figures. In the UK and Europe, riverbed hydraulic conductivities ranged from 10^{-8} to 10^{-2} m s^{-1} and were being classified according to sediment type, method and quality of determination. Studies from the Danube, which produced time series of permeability, suggested that values temporarily increased with river bed scour. They also depended on numerical model discretisation. Ann Calver asked for any data on bed permeabilities to be brought to her attention, in order to enlarge the data sample.

Andy Young explained the potential value of riverbed permeability data in river flow estimation. He described the MicroLow-Flows software, which produced flow statistics at ungauged sites for natural and artificially influenced catchments. He presented the multivariate model for estimating a Q95 flow standardised by the mean flow. This showed some large positive and negative residuals on catchments underlain by unconfined chalk — a consequence of the lack of national spatial mapping of aquifer properties at 1 km^2 resolution, which would describe the hydrogeological variability of the chalk better than the HOST classification of soils could. MicroLow-Flows used an analytical solution to determine the influence of groundwater abstractions on low flows. Various models were evaluated: generally those including a streambed resistance term were more effective than the Theis solution. However, because information on *a priori* parameters to characterise streambed resistance was lacking, the Theis solution was incorporated into MicroLow-Flows. Andy stressed the need to map spring flow in groundwater-fed catchments and to collect further data and map data on bed permeabilities and aquifer properties.

Discussion

Mike Packman (Southern Water) asked if the results of the Environment Agency review would be made available to water companies to assess the impacts of existing abstractions: Stuart Kirk said that a decision on dissemination had not yet been made.

Ken Rushton (University of Birmingham) argued that recharge had not been mentioned in the first paper. John Barker recognised that this criticism also applied to his model, but it was intended as a screening technique to help with the choice of more detailed models where appropriate.

† *NRA R&D Note 274*

Dave Burgess re-emphasised the paucity of peizometric data near rivers. Ann Calver added that there were a few examples in Europe and North America, but more data collection was needed. **Angela McMahon** asked whether data collection would be a legal requirement as part of future licensing agreements — some groundwater licences were already linked to groundwater level monitoring.

Modelling groundwater in wetlands

Kevin Gilman presented 'Modelling the groundwater component of the wetland water budget'. Many wetland sites discharge groundwater to the surface, through localised springs or diffuse seepage. Groundwater's role in the water budget of a wetland varies from total dominance to a minor sustaining influence. Seasonal changes in groundwater levels in wetland soils and in underlying or adjacent aquifers can produce a complex pattern of water movement and storage. The groundwater component may be highly significant to the wetland's survival, and changes in springflow and seepage caused by increasing groundwater abstraction have often added to the impacts of drainage and river management on wetland sites.

A simple modelling approach could quantify the groundwater component and the influence of abstraction. The model MIROS (Mires in receipt of seepage) had been used on several wetlands, including Morton Pool in Shropshire, underlain by 5 m of fen peat and sandstone, separated from the wetland by fluvial-glacial deposits (clay to gravels). Piezometric data showed a connection between the peat and the sandstone, through the gravels. The model, based on a relationship between upward seepage and the difference in water levels between the peat and the sandstone, could be used to simulate natural water levels in past drought conditions, and to set the impact of groundwater abstraction in context with natural fluctuations. Consequential changes to plants and animals were complicated by competition and historical management.

Flow requirements of ecosystems

'The use of habitat survey and modelling in setting river flow objectives' was the paper by **Conor Linstead**, **Mike Dunbar** and **Mike Acreman** (Institute of Hydrology).

Conor Linstead pointed out that the overall management objectives of most UK rivers include maintaining a healthy aquatic ecosystem, indexed by fish, invertebrates or plant species. To meet these objectives the flow requirements need to be determined. A range of approaches existed for setting flows: River Habitat Survey, River Corridor Survey, SERCON, HABSCORE, RIVPACS and PHABSIM. RIVPACS and HABSCORE used multiple regression analysis between the characteristics of the river and catchment and in-stream species (invertebrates in the case of RIVPACS and salmonids in the case of HABSCORE). Neither these models, nor the survey techniques (including SERCON) could predict the impacts of abstraction on ecological health. PHABSIM was the only truly predictive model, but was too expensive for strategic assessment because of its high data needs. Conor reported that the Institute of Hydrology was developing a hierarchical approach, containing a set of methods. The most appropriate method depends upon the type of river, the management objectives and the available data. Survey techniques could be used for broad-scale screening. When combined with flow estimation models, like MicroLow-Flows and a digital terrain model, a middle level method could result. For very detailed analysis of highly contentious abstractions, a detailed method like PHABSIM would be recommended.

Hydroecology and flow objectives in groundwater-fed systems

Chris Extence and **David Balbi** (Environment Agency) presented their paper: 'Hydroecological relationships and objective setting in groundwater-fed systems'.

Chris described the recently-developed LIFE method. This summarises the qualitative and semi-quantitative response to flow variation by a macroinvertebrate community. LIFE scores were related to combinations of flow parameters using different statistics, durations and periods. In many cases the flow parameter producing the strongest correlation explained 80-90% of the variation in LIFE scores. Key flow parameters varied between rivers, but showed some consistency between river types. Results from chalk and limestone streams in England, including Waithe Beck and the Rivers Lark and Kennet, showed the method's potential. Flow parameters of critical importance in determining invertebrate community structure in groundwater fed systems could be readily identified. This should ultimately enable relevant hydro-ecological objectives to be set.

David Balbi described the use of the LIFE method to set flow objectives. Outliers, relating to periods of drought, were used to identify hydrological and ecological thresholds. He discussed the use of these thresholds and a potential method for including them in the Agency's water resource strategy.

Impact of water-table behaviour on grassland plant communities

David Gowing (Silsoe College) described the impact of water-table behaviour on plant community composition in wet grasslands. Water regime is a dominant environmental factor controlling competition between plant species. An apparently small perturbation in soil water regime can trigger a significant change in the plant community, because a plant can only persist where the water regime gives it a competitive edge over its neighbours and they can only take up nutrients effectively over a restricted range of soil moisture conditions.

A ten-year MAFF-funded research project had tried to quantify this plant-soil-water relationship. This included studies of wet grasslands across lowland England, in collaboration with the Institute for Terrestrial Ecology. Relationships between species and hydrological statistics (e.g. mean water table depth during the growing season) were derived from the field data. A more complex water-status statistic, the Sum Exceedence Value (SEV), was determined: this is the cumulative time that the water table exceeds a given threshold. This gave potentially the best explanation, as it combined the effects of aeration and drought stresses on the vegetation. It provided a tool to design the water management regime for wet grasslands. However, to achieve particular conservation targets, other aspects such as vegetation management, nutrient availability and propagule distribution, must be considered.

Dr Gowing emphasised the importance of modelling in applying this information to real situations in the field. An improved eco-hydrology model was required to extend the technique, especially where there was a delay in the system between hydrological changes and their impacts.

Discussion

The focus of the meeting was water quantity, but in reply to Paul Younger, Conor Linstead said that some techniques (e.g. RIVPACS) were used to model water quality impacts. Chris Extence explained to James Dodds that his aim was to define the relationship between the natural regime and in-stream species, however only some invertebrates sampling sites had flow records, so artificially influenced catchments were used. Mike Acreman welcomed the new LIFE technique, but recommended rigorous statistical analysis to ensure that none of the relationships could have arisen by chance.

Jerry Sheriff (Environment Agency) was undertaking a review of methods to assess the impact of abstractions on ecology. In particular, a cheaper method than PHABSIM was required for many of the 2000 abstraction licensing applications received by the Agency each year. Paul Younger argued that there was no such thing as 'no impact', and so it is essential to

quantify tolerable levels of impact. This would involve a combination of hydrological, ecological, economic and social models. **Tim Jolly** (a farmer) asked if abstraction would be permitted from a site between an SSSI and a river. A specific response could not be given, as each licence application needed separate assessment. **Brian Connorton** reminded participants that, as part of the current Periodic Review, the Environment Agency was evaluating the costs and benefits of restoring over-abstracted rivers and aquifers and assessing their value to society.

It was difficult to predict abstraction impacts accurately, but **James Dodds** hoped that modelling developments would allow licensing authorities to make good judgements, rather than just applying the precautionary principle. He added that many impacts were reversible, so development could continue, provided that monitoring was undertaken. David Gowing said that it was simple to monitor vegetation, but long time series were needed, as there was a long lag time in many systems. Furthermore, many species could not naturally re-colonise if lost. Dave Burgess reported that some licences have cessation clauses to allow flexibility if impacts are discovered. **Mr Cameron** contended that there was still a gap between applying technical methods and making decisions: methods provide guidance but not foolproof answers.

Rob McInnes suggested that a method similar to LIFE could be developed for other species, including those living in terrestrial habitats. Mike Acreman reported that the Institute of Freshwater Ecology had sought direct relationships between flow and fish, but few data were available and no simple relationships equivalent to LIFE had been found.

Summary

In summarising the meeting, Mike Acreman hoped that participants agreed that the presentation had provided an excellent review of the state-of-the-art of methods for setting flow and wetland water level objectives in groundwater-fed catchments. He suggested that some areas of hydro-ecological science had moved forward, which should be an inspiration to researchers, whilst some areas of hydrogeological aspects of surface-water interaction had not advanced, which should guide research funders.

He felt that two of the most important messages were: *1* the need to collect data for model development and to determine impacts of specific abstractions and 2 the existence of long lag times between abstraction and hydro-ecological impacts.

Mike Acreman, IH
Brian Adams, BGS

President's piece

In the last issue of *Circulation* we only had time to squeeze in a bare notice of our delight that **Dr John Sutcliffe** had accepted Honorary Membership of BHS. This seems a fitting year for it to be awarded, because 1999 sees the publication of the *Flood Estimation Handbook*, thus emphasising how long-lived and effective has been the *Flood Studies Report* for which he was team leader and editor. The FSR saw the official light of day in 1975 and remains unsurpassed for its clarity of investigation and methodology. He was brave enough to ensure that the assumptions were evident, tested and published. The entire text was founded on a mass of quality-controlled data, which was also put into print for the good of all. The FSR volumes never sat easily in a briefcase, but the weight they carry is still of real value, spanning subjects from meteorology to hydro-dynamics. The team he fostered went on to achieve much in hydrological analysis more generally, and were often consulted overseas.

This year sees the publication of Dr Sutcliffe's tour-de-force on the hydrology of the Nile, marking his other strong sphere of knowledge. To be so productive in 'retirement' is an example to those of us who are also heading in that direction. *The Hydrology of the Nile*, by J. V. Sutcliffe & Y. P. Parks, is IAHS Special Publication No. 5 (1999), £34, available from IAHS Press, Wallingford (ISBN 1-901502-75-9) — *see page 14.*

John has never played the academic citations game, leaving the FSR simply to be described as 'NERC (1975)' in many a bibliography. It is a small compensation that BHS has given by marking his contribution to hydrology for the care of the communities along UK floodplains.

BHS Main Committee continues to be active on your behalf and will be seeking to ensure that overseas hydrologists coming to the IAHS programme within IUGG99 at Birmingham University (19-29 July) have maximum opportunity to benefit. We will co-host, with the NERC Centre for Ecology and Hydrology, a reception for all visiting hydrologists. There will also be a new Occasional Paper to enable every hydrology research grouping in the country to display its specialities, and DFID has agreed to sponsor a short BHS course for ten visiting hydrologists from the developing world.

F. M. Law
President, BHS

Successful BHS postgraduate symposium at Bristol

29-30 March 1999

The ninth BHS Postgraduate Symposium was held at the University of Bristol on 29th/30th March 1999. It provided an opportunity for current and recent postgraduate students to present their work and discuss it with their peers in an informal and friendly environment.

Over 37 postgraduates attended, from 22 institutions, representing a broad spectrum of the hydrological community in Britain; 23 made technical presentations covering an extremely wide range of topics, illustrating to good effect the inter-disciplinary nature of hydrology.

The presentations were grouped into six sessions: floods, water management, environmental hydrology, hydrological modelling, sediments and hydrological processes. The first evening session featured presentations from two guest speakers, **Prof. Howard Wheater** (Imperial College) and **Dr Owen Wedgwood** (Environment Agency). Howard Wheater's talk was about Danube dams — Hungary *v* Slovakia at the International Court of Justice. Owen Wedgwood's paper described the Environment Agency's monitoring, forecasting and response to extreme hydrological events. Both talks were especially well received and promoted an interesting discussion.

In general, the quality of the student presentations was exceptionally high. Multimedia facilities were widely used, which in some sense caused more work for the Symposium

organisers. Delegates requested nearly everything one could imagine: OHP, computer with ZIP drive and CD-ROM drive, a high resolution computer projector, 35mm slide projector, video player, television, flipchart, ... !

The Symposium was sponsored by BHS, Bristol Water, the Environment Agency, Halcrow Group Limited, Mott MacDonald and WEMRC. Each presentation was assessed by a judging panel comprising Owen Wedgwood, Howard Wheater and Prof. Ian Cluckie (University of Bristol).

The three best presentations were chosen and the winners were presented with certificates and cheques by **Frank Law** (President of BHS). The first prize (£50) went to **Jenny Thorne** (Centre for Water Systems, School of Engineering & Computer Science, University of Exeter) for her presentation on 'Development of optimised conjunctive control rules for a system of water supply sources'.

Second prize (£30) went to **Gary Beasley** (School of Geography, University of Leeds) for 'Urban non-point-source pollution: its impact on macroinvertebrate assemblages'. The third prize (£20) went to **Matthew Heywood** (Department of Geography, University of Exeter) for 'The siltation of salmonid spawning beds: an investigation of associated fluvial sediment dynamics in the Hampshire Avon catchment'.

Badock Hall provided excellent accommodation and catering services and the feedback from participating students was very satisfactory. Gratitude is expressed to the following people who provided valuable help for the Symposium: Frank Law (Institute of Hydrology), Dr Peter Walsh (Consultant), Prof. Howard Wheater, Dr Owen Wedgwood, Dr Kevin Tilford (University of Salford), Dr Paul Webster (Birmingham University) and my colleagues in Bristol: Dr Andrew Lane, Dr John Loveless, Dr Richard Griffith, John Bracy and Denise Lomasney.

The abstracts for each of the presentations and a list of delegates are available at the web site: http://www.fen.bris.ac.uk/civil/wmrc/BHS/bhs.htm, which also has photographs from the Symposium.

Dawei Han and Lisa Collett
WEMRC (Water and Environmental Management Research Centre), University of Bristol

A PhD student's view

I was fortunate enough to attend the BHS Postgraduate Symposium for the second year running, thanks to a BHS travel grant. I was keen to return, anticipating a relaxed atmosphere in which postgraduates from every spectrum of the UK and abroad could present their research and discuss it within their peer group in an informal and friendly environment.

The Water Management session had most relevance to me, and I contributed a research paper on optimised conjunctive control rules for water supply sources, sponsored by the Environment Agency. The paper by **Sherryl Bellfield**, a PhD student from the University of Leeds, spurred an acute professional interest: her case study highlighted factors affecting short-term domestic water demand and the importance of seasonality on public water demand. Both areas are relevant to me: the continuation of my research into the optimisation of conjunctive-use water supply sources will incorporate different demand levels and identify how different demand projections will affect the supply rate from the existing conjunctive-use scheme.

Of particular personal interest was Dr Owen Wedgwood's presentation on extreme hydrological events. This gave an invaluable insight into the Environment Agency's current flood warning system and showed the potential destructive powers of extreme flood events.

I am extremely grateful to the organisers for coordinating such a professional and enjoyable conference: I would recommend it to all postgraduates. It certainly helped me gain confidence and experience in presenting — winning first prize for my presentation was encouraging — and it has given me the chance to meet some leading hydrological professionals.

Jenny Thorne
University of Exeter

Source control

BHS Pennines Hydrological Group meeting Environment Agency, Leeds 4 November 1998

This discussion meeting heard presentations from SEPA, the Environment Agency and Bryant Homes: 48 people attended.

The Scottish experience: leading the way

Bob Sargent (Scottish Environment Protection Agency) said that SEPA had been at the forefront of promoting surface water drainage best management practices (BMPs) in the UK since 1994. This had been driven by a water quality agenda, although BMPs can also help to reduce flood runoff and promote sustained low flow characteristics. Most surface water in Scotland is in the highest quality classes, but over 4600 km of watercourses are still regarded as downgraded, 11% of them from the effects of urban runoff. The enormity of the task was not properly appreciated at first, but it was recognised that SEPA was asking dischargers to install systems with unknown performance. SEPA, therefore, shares the risk of poor performance with the discharger by issuing a qualitative consent: if the system does not produce a good quality effluent SEPA and the discharger are both stuck with it. A working party (comprising SEPA, water authorities, local authorities, developers and the Highway Agency) is developing a reputable design manual under contract by CIRIA, for publication this year. Next year CIRIA will produce a manual for England and Wales and DETR guidance for building regulations, to give consistent design guidelines for the whole of the UK and gain the confidence of developers. The working party will provide a forum for discussion about BMP implementation.

The increased rates of urban runoff directly affect the rate of permeation, replenishment of the water table, flooding within the receiving watercourses and base flows during dry weather.

The sources of water pollution within the urban catchment include paved urban areas, highways and industry. Contaminants, including oils, antifreeze, detergents and zinc, can originate from surface water drainage from paved urban, from everyday activities such as car washing, wheelie bin cleaning and general surface runoff.

Oils, chemicals and heavy metals can all originate from highway drainage, as can large quantities of sediments conveyed into the receiving watercourse during storm events.

Industrial spills, discharges and cleaning processes can all contaminate surface water drainage, eventually reaching rivers and streams.

The use of porous blocks within car parks would provide several advantages: filtration of suspended materials, settling of suspended solids, bacterial breakdown of hydrocarbons and

additional storage. Certain porous road surfaces can also produce a quieter running surface and reduce spray, with environmental and safety advantages.

Using grassed swales next to roads would help to eliminate the need for oil interceptors and rain gullies, saving developers money. Swales would also provide further areas for flood storage, bacterial processes, settlement and permeation. These simple treatment processes can go some way towards satisfying the SEPA legislation that treatment is provided prior to discharge into watercourses.

SEPA consider that the use of BMPs can only be beneficial to the environment, but it is important that parties from all sectors of the industry come together to understand and develop the way forward.

In the discussion **John Turner** (Leeds City Council) asked how SEPA proposed to meet the local authorities' maintenance costs for public open spaces and green land, but Bob Sargent replied that SEPA were not asking them to take on a great deal of expense.

Another question was about the relative cost of ponds and swales, including the costs of associated safety measures. Bob replied that the developer on one-owner sites covered some of this initial cost, although multi-owner sites were more problematic.

Constructing a wetland to treat contaminated surface runoff

Anthony Parsons (Environment Agency, North West Region) described the Tue Brook reed bed scheme. The Tue Brook is grossly polluted by wrong connections, industrial estate drainage and unsatisfactory combined sewer overflows. As a result the receiving watercourse, Fazakerley Brook, is designated grossly polluted. Much of the Tue Brook catchment is a dense urban area with the watercourse culverted for more than 5 km.

Traditional pollution investigation and prevention methods have failed to improve the quality of the brook significantly. This scheme will divert the last 400 m of the culverted brook onto land owned by NorthWest Water Ltd, which will allow the wetland area created to treat the contaminated flows prior to discharge into Fazakerley Brook.

The wetland site will incorporate a small river channel with oxygenating riffles, a series of settling ponds to remove suspended solids and two reed beds. The reed beds will remove some of the remaining heavy metals and provide a medium for bacterial breakdown of other contaminants such as hydrocarbons. Retrofitting a wetland treatment area at the lower end of Tue Brook is more economic than tracing each discharger. The total costs will exceed £0.6 M and finance is being sought.

A diversion chamber was required to divert the flow through the wetland. It was initially thought that a flow control device would be needed to limit discharge into the wetland area, but it was found that the total flow through the culvert could be diverted into the wetland while still meeting the 2.5 $m^3 s^{-1}$ flow constraint.

Through the consultation an opinion arose that the wetland area should be increased, since wetland habitat is in short supply within the Liverpool area. Enlargement of the wetland would reduce the area of other habitats, such as the existing grassland meadow, and proposed woodland areas surrounding the site, as well as affecting the cut and fill exercise.

The Agency is seeking finance for the scheme via a Heritage Lottery bid and a LIFE bid.

It is predicted that the maintenance costs for the wetland for the first ten years will be in the region of £200,000. It is envisaged that the local community will support the Agency in the project by undertaking some of the less technical maintenance tasks.

The wetland project should be complete some time next year, coinciding with improvement in the quality of discharge from Fazakerley wastewater treatment works. Once these two objectives have been reached it is predicted that the Fazakerley Brook will be able to support fish stocks.

James Lancaster (Ove Arup and Partners) asked whether the wetland would provide ecological habitats, if it was designed to trap contaminants, or just look as if it did. Anthony Parsons replied that the wetland would remove contaminants from the water as well as providing environmental enhancements.

Brian Abraham (Lancaster City Council) asked if Mr Parsons believed that the local community would take care of the watercourse because of this wetland? Through the consultation exercise it became evident that some groups were very interested in contributing to the project. It is the hope that involvement with simple maintenance will lead to a sense of community ownership.

Andrew Grimes (Westwood Services) wondered if the local community might be more concerned with their children's safety than with the water quality problems. The safety issue was very important and an effort would be made to satisfy all parties. The advantage of a wetland was that it was a sustainable method of water treatment, unlike the current alternatives.

Sustainable runoff control: a regulator's perspective

Philip Marshall (Environment Agency, North East region) said that seven years after the UNCED Earth Summit advocated the concept, sustainable development still needs to be addressed, particularly at the local level. The continuing pressure for building land highlights the 'conflict' between development and environmental protection.

The watercourse system is particularly susceptible to changes in drainage patterns and diffuse pollution. The 'traditional' use of this network to accommodate urban runoff is highly wasteful, and can devastate the river ecosystem, causing degradation of riparian habitats, lower water quality, flooding and seasonally dry watercourses as consequences of poor water drainage management.

Systems that mimic the 'natural' response to rainfall events would be sustainable, and environmental regulators are challenged to ensure their uptake through regulation and persuasion, but also fairly and reasonably. The Northern Development Area, a major 'green belt' development on the edge of Tyneside, offers an opportunity for a new approach to urban runoff, but it will require full cooperation from all involved.

Alterations to natural drainage regimes cause faster runoff in the urban catchment and much larger peak flows in the watercourse, increasing the flood risk areas. There is also a direct affect on permeation into the ground, which decreases the rate of underlying aquifer recharge and decreases base flows.

Sustainability in watercourse management aims to maintain or improve current water quality, prevent increases in flood risk, prevent compromise on future developments, and protect conservation interests and safety. The Agency believes that source control meets these aims.

Government agencies, water companies, developers and planners have to work together to agree the way forward on sustainable urban drainage systems (SUDS). The Environment Agency has a regulatory role in this procedure, providing an objective review of proposals and promoting best practice. It has adopted initiatives including Section 105 flood studies, flood plain policy, culvert policies and Local Environment Agency Plans (LEAPs). Its approach is to advise, object and use its flood defence powers to promote SUDS. The culvert policy is aimed to promote alternatives to culvertisation, which causes destruction of wildlife habitat and the potential for blockage of watercourses. The LEAPs identify targets that must be reached and promote development partnerships in source control.

In the Northern Development Area, the potential effects were identified as reduction of water quality, increase in flood risk and damage to wildlife corridors. All interested parties were

brought together for discussion to decide on a way forward with regard to site drainage policies. It was agreed that all areas of development should be outside the 1:100 year floodplain. It was also agreed that the watercourses within a site should be made into a feature, and that where possible surface water control wetlands should be used.

These surface water control wetlands are of complex design, with restricted discharge, but they should accommodate a 1-in-30-year storm flow. The design should also help to reduce pollution within the surface water, control outfall velocities and create wildlife and recreation areas.

Sustainable runoff control: a developer's perspective

Ian Tallentire (Bryant Homes North-East) discussed the problems of implementing new and untested approaches to sustainable runoff control. The building industry is slow to embrace change, and the conventional approach to urban and highway drainage has served the house builder well: known costs, known limitations, and known reactions of the authorities and customers. The way to establish the required change is either regulation or providing cost savings. Regulation is not the issue at this time, but cost saving could give the push required. It has resulted in Bryants appointing a consultant to formulate a Best Management Practice strategy for a large 1000-acre development north of Newcastle.

The strategy document describes the way it has allowed Bryants to carry out feasibility costing on those methods evaluated and then to test the water with the agencies concerned, to ensure their future adoption. The problems already encountered both with the agencies and from our own sales teams are discussed. Also comment is made regarding the difference between locations and size of developments and the effect this has on any future implementation of the BMPs.

Traditionally it has been viewed that the quicker that water is removed to watercourses the better. However since privatisation, in many cases developers have been told that there is no more capacity within public sewers and that on site attenuation is required for surface water drainage. The methods for providing this are either online or offline tanks, or storage ponds.

One of the main problems developers face is quantifying the costs. Depending on the allowable discharge from the site, the developer must assess the cost of providing on site storage. Unfortunately water authorities do not respond quickly enough and there is a tendency to price assuming traditional methods, i.e. storage tanks. They are then tied to this cost when designing the system, and any increase in cost for BMPs will make them an unfeasible option.

Developers must be made aware of the potential costs of using BMPs, and change will only occur through regulation or monetary aid. There is a common misconception that BMPs are cheaper than conventional drainage. This is not always the case: the use of grassed swales may not require kerbstones and pipework, but will need extra tarmac at the side of the road and excavation of the swale itself.

The underlying problem is that there is very little information about the costs of implementing BMP techniques. Developers will always be wary of accepting a financial variable within their project budget when they know of proven alternatives.

Discussion

Brian Abraham (Lancaster City Council) stated that highway engineers must be involved in BMPs if anything is to be achieved; Bryant Homes had found local authorities receptive if they had the money to adopt the schemes, but water authorities were more difficult to get on board. There were moves within SEPA and CIRIA to produce alternative methods of drainage to those currently adopted. A questioner asked whether the Agency had reviewed its policy on development within floodplains since the Easter floods of 1998. Mr Tallentire replied that the Easter floods were a 1:150 year event, and the agency had no plans to change their current policy. Brian Abraham, wondering why Local Authorities should take on the costs when the Environment Agency had pushed for their adoption, was told that the Agency needed to see benefits before they considered financial aid. Decreasing flooding could reduce the demand upon flood defence budgets, leaving room for future contributions.

Jonathan Cooper
W S Atkins

Innovative techniques for flood investigation: the Galway experience

BHS Southern Section Meeting
Imperial College, London
17 March 1999

This meeting was chaired by *Professor Howard Wheater* (BHS President-Elect and Head of Environmental and Water Resources Engineering at Imperial College), who began with a short overview of the history of flooding in the Galway region.

Denis Peach (Head of Hydrogeology Group, BGS) introduced the Galway study. The Irish Office of Public Works initiated the project two years ago, following extreme flooding during the winter 1994-95, which followed two earlier flood events in 1989/90 and 1993/94. Flooding occurs as a result of high water levels in a karstic groundwater system that leads to a number of turloughs expanding to cover extensive areas, inundating housing, cutting off roads and stranding livestock.

He explained the objectives of the study: to investigate the causes of the flooding, and find possible engineering solutions. Denis also emphasised the philosophy of an integrated, multi-disciplinary approach used in this study. He showed slides from the project region, illustrating the karstic hydrogeology and the extent of the flooding, concluding with an overview of the tasks performed during the project.

Richard Chandler (Statistical Science Department, UCL) outlined the rainfall simulation modelling study. The three aims of his work were: to discover whether the flooding was caused by abnormal rainfall; if so, to find out whether climate change is to blame, and finally to provide a rainfall simulation model to calculate input to the rainfall-runoff and hydrogeological models. The answer to the first two questions was "yes". Richard then gave a detailed explanation of the data available for the study and the problems of the large amount of noise present in these data. Examination of the rainfall time-series reveals that historical flooding years coincide with extremely high December to February

rainfall events. The General Linear Modelling method of time-series analysis was used to produce the stochastic simulation model, and to investigate if trends can be identified from the historical rainfall data. Statistically significant linear and cyclical trends were identified, suggesting that climate change is affecting rainfall in this region.

Matthew Lees (Dept. of Civil and Environmental Eng., Imperial College) described the rainfall-runoff modelling component of the work, which was required to simulate the surface water flow into the groundwater system. A continuous-simulation model that could accurately predict long-term flow volumes was required. In this case, a hybrid conceptual metric model (HYCOM) was used, consisting of an antecedent precipitation-based loss function and general transfer function routing component. This configuration was selected because of the lack of PE data, which precluded the use of a soil-moisture-based loss component. Good calibration and validation results were achieved, particularly when assessed in terms of correct prediction of long-term flow volumes. Afforestation sensitivity analysis was performed, which concluded that afforestation effects are not an important contributory factor to the flooding.

Sally Watson (Jackson Environment Institute, UCL) summarised the fieldwork undertaken to investigate the hydrogeological system of the Galway region. She described the system characteristics in detail, e.g. caves, swallow holes, estevelles and dolines, as well as the lithology and structure of the area's limestone and sandstone geological units, and their influence on the hydrological and hydrogeological response of the area. The study area was divided into three different categories of groundwater flow system: a shallow epikarstic system; a deep karst system, and a distributed flow system. This conceptual hydrogeological model could then be translated into a numerical system.

Denis Peach gave the final talk, describing the modelling framework developed for the Galway region in general terms, and the hydrogeological model in more detail. The modelling tasks performed can be split into rainfall modelling; runoff modelling; direct recharge modelling (using a simple soil moisture balance approach), and groundwater flow and storage modelling. The resultant model components were combined in an integrated framework that produces simulated groundwater levels. The groundwater model used is the HYDROWORKS hydraulic event based model that is more commonly used to model pipe flow in urban water systems. The model was altered so that it could be used in a continuous mode with six-month simulation runs. It performed well both in calibration and in validation, where simulated 1994/5 levels fitted observed levels remarkably well.

Discussion

Tim Davie (Queen Mary Westfield) asked if the rainfall simulation climate change conclusions were unduly influenced by the large dip in the data during the 1960s. Richard Chandler answered that the methodology enabled him to distinguish objectively between genuine and chance effects, and the evidence for genuine trends is overwhelming.

Frank Law (Institute of Hydrology) wondered whether extremely high groundwater levels, similar to those caused by the extreme flooding in the winter 1994-95, had been recorded in previous years. Denis Peach said that nothing comparable had been recorded, although there was anecdotal evidence of large floods in the 1920s and 1950s.

Duncan Reed (Institute of Hydrology) was interested in the current situation in the Galway area. Denis Peach explained that floods have occurred this year. He added that flooding damage is now low in financial terms, since residents of previously flooded buildings have moved. Current concern is primarily related to problems of blocked roads and difficulties in reaching livestock.

Bob Moore (Institute of Hydrology) wanted to know how afforestation was included in the loss function of the runoff model used. Matthew Lees explained that afforestation effects were not included in the loss function, but in the routing module of the model. This seemed appropriate, given results from the Coalburn study that indicate increases in runoff volumes and reduction in response time.

Cedo Maksimovic (Dept. of Civil and Environmental Eng., Imperial College) asked whether research into the Galway flooding problem was still continuing, since no measures to stop or decrease the affects of flooding were implemented. Denis Peach said the group would like to continue the work but it was constrained by a lack of funding. A cost-benefit analysis has shown that the benefit of engineering measures would be very low. Therefore, only continued hydrometric monitoring is being funded at the moment. Cedo, drawing on his experience of complex karst systems in other countries, also suggested that identifying more parts of the system and adding more pipes could increase the performance of the groundwater model. Denis thought that the developed model was adequate for its purpose and that a small increase in performance would not justify further investigation.

Duncan Reed asked if the influence of tipping on the system's capacity to drain large volumes of water during flooding was significant (Denis had mentioned in his talk that some swallow holes had abandoned cars in them!). Denis Peach said that the dynamic character of the karst system is much more important than potential blockages by cars and plastic bags. Blockages within the groundwater flow system are more likely to be caused by sediment deposition, which could be affected by changes in forest cover.

Howard Wheater thanked the speakers and they and members of the audience moved to the bar to continue the discussion.

The paper below, presented at the Exeter conference last year, gives more details of the rainfall-simulation work. Details can also be found in two UCL reports (see www.ucl.ac.uk/stats/research/).

Thorsten Wagener and Matthew Lees
Imperial College

Lees, M.J., Price, N., Wheater, H.S. & Peach, D. (1998) A flood simulation model for the South Galway region of Ireland, In: *Hydrology in a Changing Environment*, Proc. BHS International Conference, Vol. III, 93-104, John Wiley & Sons, Chichester.

Royal Met Soc Group news

The Royal Met. Soc.'s Meteorological Observing Systems Group has a new chairman (**Dr Ian Strangeways**) and a new Treasurer (**Mike Brettle** of Vaisala). They are holding a meeting on *30 June 1999* at the British Antarctic Survey, Cambridge, on "Measuring climatic temperature change".

For details of this meeting, and of membership, please contact the group's secretary, **Catherine Rowbottom** (cmrowbottom@meto.gov.uk).

Publications received

Two IHP documents received from UNESCO are now in the Institute of Hydrology library:

Basic river water quality models, by Dr Géza Jolánkai: a computer-aided learning programme on water quality modelling (WQMCAL version 1.1 is included on disk), IHP-V Technical document in hydrology No. 13;

Ecohydrological processes in small basins (Proc. Strasbourg conf., 1996), IHP-V Technical document No. 14.

Regional groundwater modelling

BHS Midlands Section Meeting
University of Birmingham
24 February 1999

The Midlands Section opened its account for 1999 with an afternoon meeting, attended by some 25 people, with three papers on various aspects of regional groundwater modelling. The venue was fitting, considering the significant contribution made to groundwater modelling in the UK by workers from the Schools of Civil Engineering and Earth Sciences at Birmingham University.

Rob Soley (Entec UK Ltd) kicked off the meeting. His experience includes VSO in Nepal and working for *Save The Children* in Malawi, but focusing on an area a little closer to home, he conducted a whistle-stop tour around the West Midlands, describing a water resources study that Entec are undertaking on behalf of the Environment Agency.

This is a large-scale study of the Permo-Triassic water resources that extend from Droitwich Spa in the south to Wolverhampton and Telford in the north and comprise the catchments of the Rivers Worfe and Stour.

The hydrology and hydrogeology surprisingly included the region's extensive canal network, because of its role as a major receptor of Sewage Treatment Works (STW) effluent.

There was a critical need to recognise and take account of anthropogenic influences on the local hydrological cycle. This is all relatively recent: in 1860 there was effectively zero abstraction, while in 1998 abstraction from the ten groundwater management units totalled 250 Ml/d.

Because of the high storage capacity of the sandstone aquifer, large-scale changes only occur over long time periods. In order for the modelling of recent years to be accurate, it was essential to start with representative antecedent conditions. With this in mind the model was run on an annual basis for the last 100 years in order to take account of the intense urban development which has taken place over this period.

The model has been calibrated against groundwater levels on an annual basis for the period 1880-1970 and on a monthly basis from 1970 to 1997. The study is now moving into its final stages and looks as though it will provide the Environment Agency with a useful resource management tool.

Next up was **Dr John Tellam** (School of Earth Sciences, Birmingham University) who described the early stages of a three-year study by him and **Richard Gresswell**, which might give some pointers to solving future water shortages, with a possible solution being surprisingly close to home!

The study is being conducted on three spatial and temporal scales (aquifer-wide/long-term; sub-aquifer/medium term; single borehole/short term). It is part of the NERC-funded Urban Regeneration programme (URGENT), which is being undertaken in collaboration with other Schools at Birmingham and other UK universities.

He put the potential for abstracting good quality water from urban aquifers on a sustainable basis in the context of rising groundwater levels under major UK cities, a result of the decline in urban industrial abstractions.

Using Birmingham and the underlying Permo-Triassic sandstone aquifer as a case study, the pattern of historical groundwater usage (Figure 1) shows the post-war decline in abstraction and the commensurate rise in groundwater levels from the 1960s to the present.

The study aims to deliver a number of products, including new data on water quality, a database of contaminated land, a GIS model, a borehole model for use in a layered aquifer and regional solute models. Together these constitute a suite of approaches to assess urban groundwater.

Groundwater chemistry samples were taken from boreholes, mainly on former industrial sites, representing a negatively biased sample in terms of water quality. Even so, most samples were below European Union Maximum Allowable Concentrations for major ions, though contamination by organic solvents was widespread. For example Trichloroethylene (TCE) was detected in 78% of boreholes.

Vertical mixing in the aquifer was limited: good quality water could exist at the base of the aquifer with poorer quality water at shallow depths above.

To test this relationship, pore water was collected from cored boreholes. Down to 25 m below ground the water was acidic (pH 3 to 5); below 25 m the pH was around 7. A conceptual model of possible pH conditions was put forward (Figure 2), which explained the pattern on the basis of the presence of calcite at depth in the sandstone, which could buffer pH levels, while near surface the absence of calcite and input of low pH metal-rich wastes led to acidic groundwater conditions. The third scenario has serious implications for the River Tame, which may receive discharges of acidic groundwater in the future.

Solute transport modelling forms an important component of the study and the use of tracers can assist in understanding the governing processes. Five new boreholes have been drilled next to the School of Earth Sciences, and tracer testing in these holes showed complex

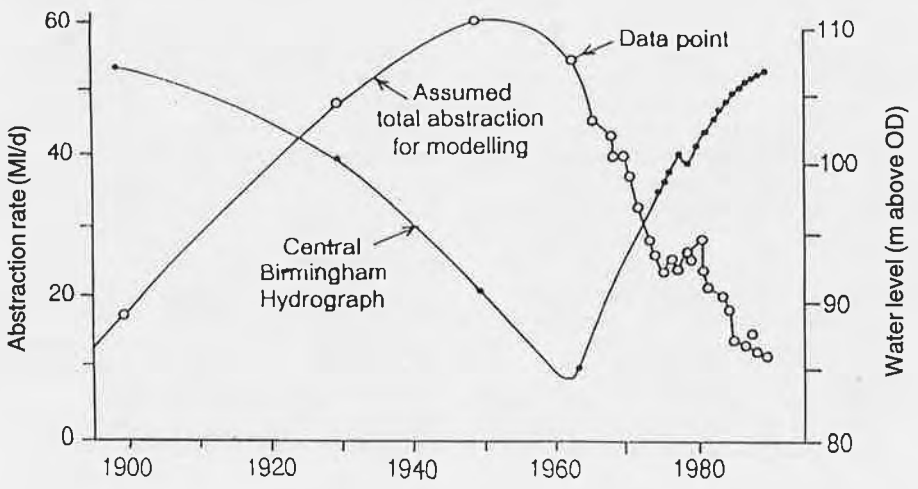


Figure 1 *Hydrograph and abstraction records from Birmingham (Gresswell, 1992)*

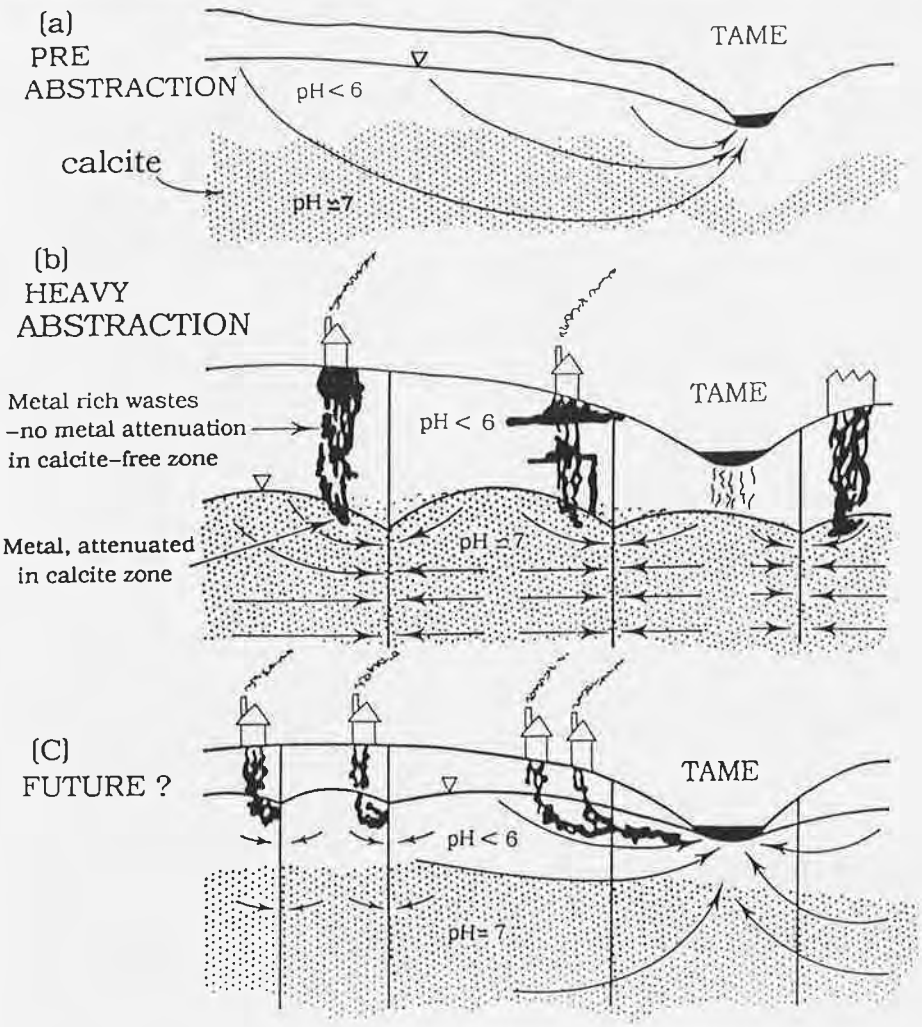


Figure 2 *Schematic sections across the Birmingham aquifer and River Tame*

breakthrough patterns, with up to four different routes identified.

The study is at a relatively early stage, but already seems to be producing some promising results, which may lead to the use of urban groundwater for public water supply in the future. We watch developments with interest.

Moving far away from the West Midlands, **Andrew Hughes** (Water Management Consultants, Shrewsbury) described variable density flow modelling in South America under the intriguing title 'Dead Men, flamingos and brine'.

Brine (groundwater with very high levels of dissolved solids) is a considerable nuisance in water resources studies, but may have economic value if the salts it contains (e.g. potassium and lithium salts) can be extracted. This is done by abstracting the brine and then evaporating the water in solar ponds. A local example of this is Droitwich Spa, where salt has been mined by extracting brines from Triassic halite deposits since mediaeval times. Coincidentally Droitwich marks the southern boundary of the modelling study described by the first speaker.

Most brine-related modelling in the past has been related to the siting of nuclear waste repositories near salt domes and has looked at deep systems. However, the brine modelling by WMC has related to shallow systems (less than 100 m below ground level) in closed basins. These fall into two broad groups: unconfined salars (salt lakes) in the high Andes up to 3000 m altitude, and confined salt pans in Africa at around 800 to 1000 m.

The presentation concentrated on the Andes group, but some features were common to both. One of these was the requirement to modify 'normal' groundwater thinking for this specialised domain, for example the need to use intrinsic permeability rather than hydraulic conductivity, because of the variable viscosity of the liquid.

This revealed that describing these systems as 'variable density' was a misnomer: between 'normal' groundwater and saturated brine there is 20% increase in density, whereas the viscosity increases by around 70% and these systems would be better described as *variable viscosity*.

The modelling work in the Andean salars served two purposes: resource estimation and evaluation of environmental impact. The latter related to the populations of flamingos that inhabit the salars and depend upon the water around their nest mounds to protect their eggs from predators: a novel form of groundwater protection zone!

The criteria for the choice of code by WMC for brine modelling are just as applicable for choosing normal groundwater modelling software:

- Manageable run time;
- Good documentation;
- Good support;
- Inclusion of relevant mechanisms (specifically evaporation, specified concentration);
- Ability to reproduce test problems from the literature.

The final outcome was that some codes (SWIFT, HST3D, DSTRAM) were given approval, while others (3DFEMFAT, FEFLOW) were found wanting.

The session ended with questions for each of the speakers on a number of technical (and less technical!) points.

The last speaker finally let us in on the source of the 'dead men' in the title of his presentation. Apparently one of the sites modelled in the Andes was known as 'the Salar of the dead man' (Salar del Hombre Muerto), so named because a grave (complete with headstone) was located there. Photographic evidence was shown that proved it!

On behalf of the BHS Midlands Section, **Richard Boak** (WMC, Shrewsbury) concluded the meeting by thanking the speakers for an interesting and entertaining afternoon.

Tim Grapes (PhD student)
School of Geography and Environmental Sciences
University of Birmingham

Nominations please!

The following committee members will retire at the AGM in September:

Frank Law, who has been President for two years. He will be succeeded by President-Elect **Howard Wheater**.

Terry Evans is coming to the end of his term as Hon. Treasurer, but is able and willing to continue for another two-year term.

Chris Soulsby, who has served on the committee for the maximum three years, is standing down, and there is another vacancy, created when Peter Walsh became Hon. Secretary last year.

Nominations are therefore sought for the post of Hon Treasurer (Terry has agreed to stand for a second term) and two Ordinary Members. Please read the form enclosed and consider whether you, or a colleague, could serve the Society for the next few years as a member of the Committee.

New members

We welcome the following members to the Society:

Khalid Salman Al-Sehli ..... Madinah, Saudi Arabia
Rodney C Bridle ..... Rodney Bridle Ltd, Amersham
Andrew Clay ..... School of Civil Engineering, University of Birmingham
Philippa Clegg ..... Environment Agency (South West)
Stephen F Dangerfield ..... Halcrow Group Ltd
Charles I Essery ..... Sydney, Australia
Hayley J Fowler ..... Dept of Civil Engineering, University of Newcastle
Tim R Grapes ..... School of Geography, University of Birmingham
Alasdair M Hardie ..... Institute of Ecology and Resource Management, University of Edinburgh
Nigel T H Holmes ..... Alconbury Environmental Consultants
Donald W Knight ..... School of Civil Engineering, University of Birmingham
Robert J Moore ..... Institute of Hydrology
Gareth H Old ..... School of Geography, University of Birmingham
Olufemi Osidele ..... Warnell School of Forest Resources, University of Georgia, USA
Matthew J Roberts ..... Division of Geography, Staffordshire University
Jon Robinson ..... Hyder Consulting
Jason L Small ..... Symonds Group
Michael Stokes ..... Environment Agency
Joly Tremelling ..... SEPA East Region
Lorna J Wadwell ..... School of Civil Engineering, University of Birmingham
Anna Wesselink ..... Environment Agency

Catchment management — the scientific challenges

Workshop held at the Macaulay Land Use Research Institute, Aberdeen 29 September to 1 October 1998

This is a summary of a report from the workshop on catchment management held at MLURI last year, funded by the Scottish Office Agriculture, Environment and Fisheries Department. A full report of the workshop is available on the world-wide web at http://www.mluri.sari.ac.uk/cmreport.htm

Catchment management is an essential procedure for environmental agencies, and with new European legislation the nature of the management process will need to become more proactive. The EU Water Framework Directive (WFD) (COM(97)49) will establish a new set of demands for catchment management, aimed at protecting and enhancing the quality and quantity of aquatic ecosystems within the context of sustainable development. The production of river basin management plans will also become mandatory, and other forms of legislation and restrictions on land use (such as the nitrates directive and protected areas) also have an impact on catchment management.

Against this background, the Land Use Research Co-ordination Committee (LURCC) arranged this workshop on the scientific challenges involved in the process of implementing catchment management.

The aim was to provide a forum for information exchange between representatives of regulatory authorities, those with operational interests, and scientists. The workshop was structured around discussion of how catchment management has been tackled, and how it might need to adapt to meet the requirements of the WFD. In particular, it was felt there was a need to consider the increased importance of land-use-related processes compared to simple point source regulatory controls on water resources.

Other important foci for discussion at the meeting included how to develop appropriate tools for achieving catchment management and how to expand consultation to provide a mechanism for integrating scientific knowledge.

The Workshop was formulated around three key sessions:

- *Catchment Policy* — where discussion was focused on defining the requirements for implementation of legislation under differing Institutional structures.
- *Catchment Evaluation* — where the key issues were whether we know enough about potential catchment responses from our existing data and process based understanding; how physical and chemical changes can be linked to biological impact, and how "good ecological status" can be defined.
- *Catchment Integration* — where appropriate methods for translating science into practice were discussed. Other considerations included the level of complexity which we should operate at, and whether there are new approaches that will help to integrate social and economic factors into the decision-making process.

The workshop was intended as a forum to bridge the gap between the research and the requirements of resource managers and policy makers. A key objective was feedback into research planning through highlighting areas of uncertainty. It also aimed to encourage appropriate information exchange between different communities, to "talk the same language" and to develop strong collaborative links between diverse groups.

Dr Sarah Dunn
Macaulay Land Use Research Institute
Craigiebuckler, Aberdeen

Recent grants for research in hydrology

Identification of physically based design criteria for riffle pool sequences in river rehabilitation — £186 000 from NERC to **Dr N. Clifford** (University College London) and **Prof Geoff Petts** and **Prof Angela Gurnell** (University of Birmingham).

Laboratory validation of slope channel coupling models for catchment hydrological response — £100 000 from NERC to **Dr J. Wainwright** (King's College London).

Ice dynamics and runoff in high arctic glaciers and response to climate change — £82 000 from NERC under the ARCICE programme to **Dr P. Nienow** (Glasgow University).

Multi-annual dynamics and mass balance of Svalbard glaciers — £54 000 from NERC under the ARCICE programme to four universities led by **Dr T. Murray** (Leeds University).

Numerical simulation of bank erosion and channel migration for wandering rivers — £51 000 from EPSRC to **Dr S. Darby** (Southampton University).

BOOKS

Encyclopaedia of Hydrology

Encyclopaedia of Hydrology and Water Resources, edited by Herschy and Fairbridge, 1999, 500 pp. Price £180. ISBN 0 948540 85 0.

The *Encyclopaedia of Hydrology and Water Resources* edited by Herschy and Fairbridge is a magnum opus. Given the requirement for sustainable methods of planning, design and management of water resources and the urgent need to improve the availability of a safe water supply and the provision of adequate sanitation for the majority of the world's population, an emphasis on hydrology and water resources will dominate many of the decisions politicians will face over the next fifty years. The editors and their team of contributors will have made an important input to the needs of hydrologists, hydrogeologists, water engineers and politicians in solving these problems in the years ahead.

The subject index consists of three columns on each of seven pages and it is difficult to think of many topics of importance to hydrologists that are not covered in one or other section of the encyclopaedia. The subject matter ranges from the and lands of Africa through the Colebrook-White formula, lysimeters, the River Seine, thermal water and water divining to zooplankton, The book is divided into sections dealing with a cognate group of subjects, i.e. Drought, Drought in Western Europe 1988-92; Drought Management and Droughts - each subject is treated by a specialist. Whilst many of the subjects have been covered by Herschy, the editors have assembled an impressive list of contributors, which is itself a "mini Who's Who" in hydrology.

One of the impressive features of the encyclopaedia is the bibliography included at the end of each subject, together with cross-references to other sections of the book. Thus a reader interested in a particular topic not only finds a succinct précis of the subject but can supplement the information in the encyclopaedia by further reading of the references listed in the bibliography.

Although the quality of the entries varies, the overall impression is of a significant piece of work, which will be of great interest to those concerned with hydrology and water resources. Whether these be the retired or semi-retired who will have many interesting hours of browsing, senior and practising professionals who require an authoritative reference source, or younger scientists and students who want to broaden their hydrological knowledge, all of them will find something informative, stimulating and challenging.

Because of its price the encyclopaedia will be beyond the reach of most personal buyers, but no professional firm working in this area should be without a copy in the office.

The book is an essential reference work for all major civic, university and research establishment libraries.

M. J. Hamlin
Birmingham University

Water in the Netherlands

Huisman, P., Cramer, W., van Ee, G., Hooghart, J. C., Salz, H., and Zuidema, F. C. (1998), *Water in The Netherlands*, Netherlands Hydrological Society (NHV), Delft, 186 pp. (in English). Price 45 Guilders.

Although the vast majority of people are aware of the exponential increase in the World's population, relatively few stop to think where these new inhabitants will be living in the future. The answer is predominantly in the deltaic areas of the world, previously regarded as too flood-prone to inhabit or too expensive to reclaim.

Nevertheless, a classical example of a densely-populated and highly-developed country situated in a deltaic area can be found in The Netherlands. With a land area of some 34,000 km^2 situated at the downstream end of the rivers Rhine, Meuse and Scheldt, about one quarter of The Netherlands is below sea level, and without the coastal dunes and the dikes, some 65 per cent of the country would flood regularly at high tides and river levels.

The present systems of water management and control are the result of successive cycles of inundation and reclamation over several centuries, perhaps the most famous structures being the Delta works, initiated after the storm surge in the North Sea in February, 1953. The expertise gained during the design and construction of such major hydraulic works has been found highly marketable in other countries (as Chapter 10 of this book elaborates — for example, Vermuyden and the drainage of the English Fens in the 1600s). This transfer of knowledge continues to this day, and this book has been produced specifically to enlighten foreigners about the management of water in what is predominantly a man-made environment.

The book contains 13 chapters. Following a short synopsis, Chapters 2 to 6 deal with the geography, climate and hydrology, the genesis of the man-made environment, water-related interests, and the impact on and improvement of water systems. Chapter 7 then turns to water as an international issue, and Chapter 8 continues with discussions on integrated water management and sustainability.

Institutional and legal aspects are dealt with in Chapter 9, and (as noted above) Chapter 10 treats activities abroad. Chapters 11 and 12 describe education and research organisations and provide an analysis of trends in research respectively. The final chapter provides brief summaries of 15 research topics, touching upon management-related research, ecosystems research, decision support tools and climate and soil-vegetation-atmosphere topics.

With contributions from some 30 individual authors, the reader has to contend with regular changes in style and presentation. Editorially, there are a number of anomalies. The mysterious process of "verdroging" is encountered first in section 5.3, but is not fully defined until section 6.5. The tables and figures in Chapter 3 are not always internally consistent. Table 3.3 gives the average precipitation and evapotranspiration for The Netherlands as 750 and 550 mm respectively. However, the mean annual rainfall map of Figure 3.1 appears to indicate an areally-weighted total in excess of 800 mm. Figure 3.3 shows a mean annual runoff (excluding the major rivers) of some 320 mm, rather more than the 200 mm implied by Table 3.3. However, these small inconsistencies should not be allowed to detract from the wealth of information that the book provides on a wide range of water-related topics.

Particular mention should be made of the treatment of trans-boundary river problems in Chapter 7. The improvement in the water quality of the Rhine — which has resulted from the efforts of the International Commission formed in 1950 by the Rhine States — is surely a lesson in what can be achieved for the similar, but more moribund, international river commissions around the World.

Another point of interest is the legislative framework, described in Chapter 9. However, this catalogue of structures and acts is set in clearer context by the history of the water boards given previously in section 4.7. The water boards are said to be the oldest democratic institutions in The Netherlands, and even today, residents may vote for their representatives on the local water board (OFWAT please note!).

The book is well produced, and extensive use is made of colour in the many diagrams, maps and illustrations. In providing an authoritative introduction to the many facets of water management in The Netherlands, the presentation succeeds admirably. However, those readers who wish to pursue specific topics in more detail (especially those of Chapter 13) are perhaps less well served. A list of names and addresses of relevant

organisations is included as an appendix, along with fax and telephone numbers, but not web-site addresses. However, e-mail addresses are included for data bases on ongoing research and water-related literature.

M. J. Hall
IHE-Delft, The Netherlands

News from members

Congratulations to our President-Elect, **Professor Howard Wheater**, who has been elected a Fellow of the Institution of Civil Engineers.

—

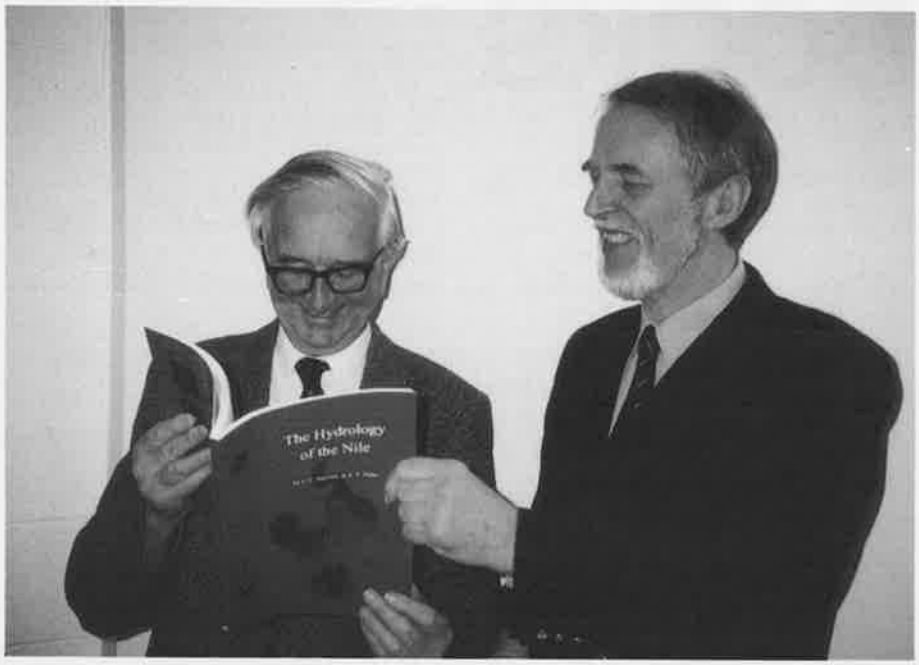
James Ramsay (of James Ramsay Associates) is a BHS member living in British Columbia. He has been appointed as Environmental Management and Quality Control Advisor to the Ministry of Public Works and Water Resources in Cairo, for construction of the new Naga Hammadi Barrage across the River Nile in Upper Egypt (see the picture of the old one opposite, which in James's opinion should have been rehabilitated).

—

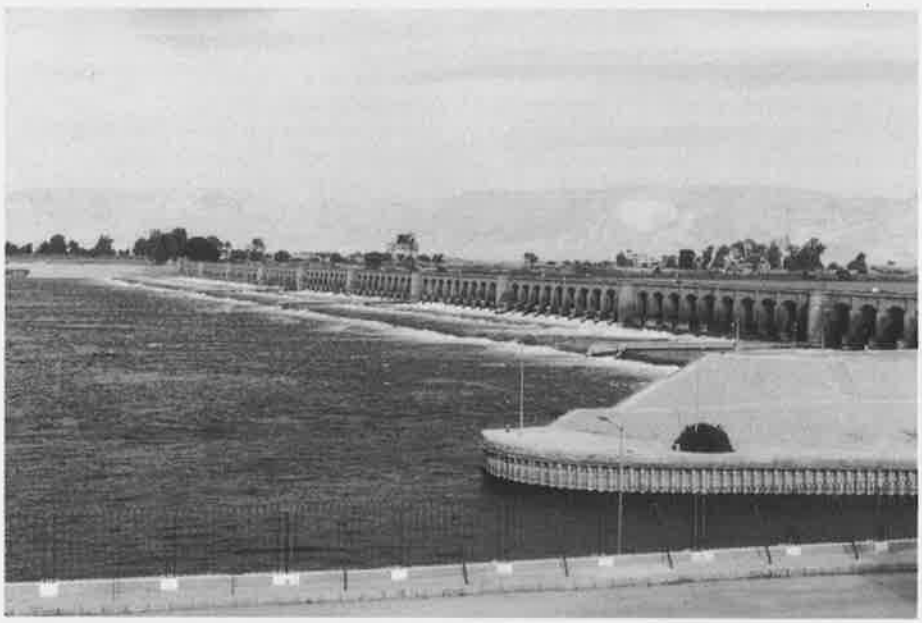
Michael Law has recently left the Environment Agency's York office, where he was Hydrology Team Leader, to work as an independent consultant contracted to Weetwood Services. He will still be based in York (tel *01904 672259*, email *lawmc@aol.com*).

—

Andrew Folkard, Hon. Secretary of the Scottish Hydrological Group, is moving from the Department of Civil Engineering at Strathclyde University. On *1st August* he will take up a lectureship in physical geography in the Hydrodynamics and Sedimentology (Hysed) Group in the Geography Department at Lancaster University. The new SHG Hon. Secretary is **Tim Jolley** (SEPA), and **Kate Heal** (Edinburgh University) is now the Membership Secretary.



John Sutcliffe and IAHS President John Rodda enjoying "The Hydrology of the Nile" by John Sutcliffe and Yvonne Parks (Photo: Penny Kisby)



The old Naga Hammadi barrage, River Nile, Egypt, built 1927-1930 with 100 limestone arches. Between 2001 and 2008 it is to be replaced by a new structure 3 km downstream (Photo: James Ramsay)

Farewell to Richard Howard

The Committee would like to thank **Richard Howard**, who has acted as our Secretary at the Institution of Civil Engineers for over three years. He left the ICE on 7th May to take up a post as policy administrator at the Chartered Institution of Building Services Engineers (CIBSE) in London: we wish him well in his new job.

Gauging mountain torrents

A well-proven technology is being adapted in a novel way to infer continuously the flow in a mountain torrent in North Wales. Signals have been measured from a sensor kindly loaned by the Institute of Hydrology.

It has been found from research that these signals have varied with flow over a wide range. Theoretically, a near-linear relationship is expected, which could enable a simple calibration to be applied.

Calibration tests are now in progress, with the kind help of the Environment Agency. The gauge needs to be optimised, engineered and more

calibration tests carried out to establish its operational validity and its limitations. There is currently no approved method for continuous gauging of this type of stream.

We believe that this new method could be a useful link in flood warning systems, but for commercial reasons we are unable to disclose at present the type of measurement being used.

John D. Newman
Dolgellau, Gwynedd, LL40 2TU
(tel/fax 01341 430620)
Reg Herschy
CNS, Reading RG1 4JW (tel 0118 958 7666)

BHS South West Section web site

A web site has now been set up for the BHS South Western Section: http://www.fen.bris.ac.uk/civil/wmrc/BHS/

FORTHCOMING EVENTS

Meetings

Seminar
MTBE AS A POLLUTANT: IMPLICATIONS FOR GROUNDWATER RESOURCES
Imperial College, London
8 June 1999

Methyl tertiary-butyl ether (MTBE) has been added to motor fuels since the early 1980s and recent legislation on air quality has led to increased use.

However there are increasing concerns about possible health risks associated with MTBE in drinking water. It is extremely mobile in groundwater and releases of MTBE from underground tanks and other point sources could pose a threat of groundwater contamination.

In collaboration with Komex International and sponsored by the Environment Agency, this one-day seminar will highlight some of the current issues. The objectives are to:

- define the potential threat;
- assess methods of remediation;
- identify research needs.

This seminar will be of wide interest and is expected to attract a broad spectrum of participants.

For the seminar brochure or further details, please contact Sally Verkaik, Centre for Continuing Education, Imperial College, Room 526 Sherfield Building, Exhibition Road, London SW7 2AZ (*tel* 0171 594 6882, *fax* 0171 594 6883, *email* s.verkaik@ic.ac.uk).

Call for papers for the
2nd Inter-Celtic Colloquium
WATER IN THE CELTIC WORLD: MANAGING RESOURCES FOR THE 21ST CENTURY
Aberystwyth, Wales
3-7 July, 2000

Following the success of the first Inter-Celtic Colloquium in Rennes in 1996, the second will be held next year in the coastal university town of Aberystwyth.

A programme of field trips is being planned, plus events for accompanying persons, a conference dinner and a concert.

Papers (to be peer-reviewed and published) are invited on environmental and hydrological themes including the social history of water use in the Celtic lands. They may be in English or French — or a Celtic language plus an extended summary in English or French.

Expressions of interest and requests for information should be sent (by email if possible) to Dr J.A.A. Jones, Institute of Geography and Earth Sciences, University of Wales, Aberystwyth SY23 3DB (*tel 01970 622595, fax 01970 622659, email jaj@aber.ac.uk*)

ACCURACY 2000
4th International Symposium on SPATIAL ACCURACY ASSESSMENT IN ENVIRONMENTAL SCIENCES
Amsterdam, The Netherlands
12-14 July, 2000

The environmental sciences (hydrology, soil science, geomorphology, ecology, climatology) make much use of spatially distributed data, frequently stored as maps in a spatial data base or a Geographical Information System (GIS). These are rarely, if ever, free of error, and the data are often used as inputs to models of environmental processes, which are themselves subject to uncertainty. Spatial statistics and stochastic systems theory offer methodologies to handle these uncertainties, but their successful application requires the joint efforts of scientists from various disciplines.

This symposium aims to bring together experts from environmental science, spatial statistics and geographic information science to develop theory and practical applications of methods for handling spatial uncertainty in the environmental sciences.

Topics include development of error-sensitive GIS, theory and application of uncertainty propagation in spatial modelling, stochastic spatial simulation, spatial uncertainty modelling, effect of aggregation and generalisation on spatial uncertainty assessment, discretisation and up-scaling effects for global environmental models, model validation with imperfect ground truth data.

An extended abstract (500-600 words, including keywords) should be received by **1 October 1999**. Authors will be informed about acceptance for oral or poster presentation by 1 December 1999. Papers based on these extended abstracts should be received by 15 March 2000 and will be pre-published in book form for all delegates.

Further information from Dr Gerard B.M. Heuvelink, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Nieuwe Prinsengracht 130, NL 1018 VZ Amsterdam (*tel* +31 20 525 7448, *fax* +31 20 525 7431, *email* accuracy@frw.uva.nl, *web* http://www.gis.wau.nl/Accuracy2000).

CALL FOR PAPERS
International Symposium on Extraordinary Floods
THE EXTREMES OF THE EXTREMES
Reykjavík, Iceland
17-19 July, 2000

The theme of this symposium is extreme and extraordinary floods, with particular reference to mountainous regions and extreme climatic zones. It will focus on the role of snow and ice, extraordinary combinations of hydrological and climatic conditions, failure of natural dams, volcanism and landslides.

Papers are invited on this theme, including the physical processes,

predictability of extreme floods, short-term forecasting, frequency estimation, case studies and environmental consequences. Selected papers will be published in the IAHS "Red book" series after the meeting.

Abstracts (300-400 words) should be submitted by **31 October 1999** to Extremes2000 Secretariat, Helga P Finnsdottir, Hydrological Service, National Energy Authority, Grensasvegi 9, IS-108 Reykjavík, Iceland (email extremes2000@os.is).

There will be a social programme and a field trip, as well as one-day and three-day excursions after the symposium. Reykjavík is European City of Culture in 2000 and this symposium is on the official calendar of events.

The web site is www.os.is/vatnam/extremes2000 and the meeting is supported by UNESCO/IHP, WMO/OHP and IAHS.

Call for papers
HYDROINFORMATICS 2000
Iowa City, USA
23-27 July 2000

The fourth international conference on hydroinformatics — the application of modern information technologies to problems in hydrology, hydraulics and environmental engineering — is to be held in Iowa, USA.

Founded in hydraulic and hydrological modelling, these new methodologies are offering novel solutions and tools for managing challenges in our aquatic environment.

Sponsored by IAHR, the conference will cover GIS, decision support and management systems, data mining, numerical engines, neural networks, ecology and water quality modelling and many other topics.

Workshops will be held on 23rd July; conference sessions begin on 24th.

Abstracts for consideration must be submitted by **15 September 1999**. They must be in English, no more than 500 words (or two pages), and electronic submission is encouraged. Papers will be published in a proceedings volume.

Registration fees will be about $500, including visits and the proceedings.

Further details are available from *Hydroinformatics 2000*, Iowa Institute of Hydraulic Research, University of Iowa, 404 Hydraulics Laboratory, Iowa City IA 52242-1585 *(tel +1319 335 5239, fax +1319 335 52389, email iihr@uiowa.edu)*.

IAHS Conference
GROUNDWATER QUALITY 2001
Sheffield, UK
18-21 June 2001

This is advance notice of an IAHS conference on natural and enhanced restoration of groundwater. There are no details available, but if you want to know more please contact Professor David Lerner, Groundwater Protection and Restoration Group, University of Sheffield (*tel* 0114 222 5743, *fax* 0114 222 5701, *email* d.n.lerner@sheffield.ac.uk, http://www.shef.ac.uk/~gprg/).

BHS AGM changes

The Annual General Meeting of the Society will be held at *Imperial College*, South Kensington, London on *22nd September 1999* at *3.45 p.m.*: this is a week later and a few miles further west than originally announced, but it should enable more members (and particularly the incoming President) to attend.

The preceding technical meeting on "Water quality modelling" will start at 10.00 a.m. For further details please contact **Matthew Lees** *(tel 0171 594 6019, fax 0171 594 6124, email m.lees@ic.ac.uk)*.

Programme of National Meetings

At its April meeting the BHS Committee considered proposals from the Meetings Sub-committee (Peter Walsh, Howard Wheater and Steve Parsons) for the future programme of meetings. Detailed planning has still to take place, but the outline programme of national meetings was agreed (see below). Anyone willing to help to organise or contribute to any of these meetings should contact Peter Walsh (*tel 01228 710510, fax 01228 710510, email peter_d_walsh@compuserve.com*).

• November 1999	*Flood Estimation Handbook*	ICE, London
• February 2000	Water resources plans	*venue to be decided*
• April 2000	Flood forecasting	Bristol
• June 2000	Catchment & process studies	*venue to be decided*
• September 2000	Seventh National Symposium	Newcastle

Diary

8th June 1999
Seminar on MTBE in groundwater
Venue: Imperial College, London SW7
Contact: Sally Verkaik (*see Meetings*)

19th–30th July 1999
IUGG Assembly + BHS/IAHS meetings
Venue: Birmingham, UK
Contact: Dr Gordon Young *(Fax +1 519 8460968, email 44iahs@mach1.wlu.ca, web http://www.wlu.ca/~wwwiahs/index.html)*

7th September 1999
BHS Pennines Hydrological Group
Field visit
Venue: Tophill Low water treatment works and nature reserve, Hull
Time: 13.00
Contact: Dr Kevin Tilford, Dept of Civil & Environ. Engineering, University of Salford, Manchester M5 4WT *(Tel 0161 295 3458, Fax 0161 295 5060, e-mail k.a.tilford@civils.salford.ac.uk)*

22nd September 1999 [new date & venue]
BHS Annual General Meeting *(15.45)*
+ meeting on "Water quality modelling" starting at 10 a.m.
Venue: Imperial College, London SW7
Contact: Dr Matthew Lees *(tel 0171 594 6019, fax 0171 594 6124, email m.lees@ic.ac.uk)*

3rd November 1999
BHS National Meeting
"The Flood Estimation Handbook"
Venue: Telford Theatre, ICE, London
Contact: Prof Howard Wheater *(tel 0171 594 6066, fax 0171 823 9401, email h.wheater@ic.ac.uk)*

22nd–23rd March 2000
Scottish Hydrological Group Conference
"Hydrology in Scotland 2000"
Venue: University of Dundee
Contact: Dr Andrew Black *(tel 01382 344433, fax 01382 344434, email a.z.black@dundee.ac.uk)*

3rd–7th July 2000
IAHS/BHS 2nd Inter-Celtic Colloquium
"Water in the Celtic world: managing resources for the 21st Century"
Venue: University of Wales, Aberystwyth
Contact: Dr J.A.A. Jones, *(tel 01970 622595, fax 01970 622659, email jaj@aber.ac.uk)*

Copy deadline for *Circulation* No. 62
4th July 1999