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THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

Circulation

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Drought management – South Africa

Diary of BHS and other events

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President's notes

International programmes are as inevitable as World Cup soccer, but less well supported! However, Paris in June also saw the gathering of the IHP Intergovernmental Council, where most of the time was spent deliberating on the form of IHP-VI, the phase of cooperative international research and training activity that will run from 2002-2007. The heart-searching associated with it relates to the relatively low funding (say US$ 3 million) and the very great length of time that is taken to ensure consensus is reached on the topic themes. On this occasion, the form that is emerging relates to "Water Interactions: Systems at Risk and Social Challenges". The five themes within that are:

1: Global change and water resources
2: Integrated watershed dynamics
3: Regional perspectives
4: Water and society
5: Knowledge, information and technology transfer.

You can find the full text about the proposed programme at the following web address:
http://www.pangea.org/orgs/unesco/13Council/10cov.html

Should any member have a particular project related to that theme which they wish to put forward — and for which they could find their own funding — then please make it known to the UNESCO Division of Water Sciences through the UK IHP Committee (c/o myself).

It was interesting to learn that the World Meteorological Organisation Panel of Experts on Education and Training have come up this year with a definition for hydrological personnel:

"Hydrologist — a person who holds a University degree or equivalent and has completed a basic instruction package on hydrology; and

Hydrological technician — a person who has successfully completed the basic instruction package for hydrological technicians."

The document concerned states that WMO is consulting with UNESCO on any further refinement of that pair of definitions and of establishment of curricula for the two instruction packages. That reminds me to mention the work of **Terry Marsh** in conjunction with Reading teachers in providing, over the Web, material on hydrology for the national curriculum in A-level geography, which can be found at http://www.highdown.berks.sch.uk/hydrology/

From 8th-12th February 1999 the 5th joint UNESCO/WMO International Conference on Hydrology will take place in Geneva at the new WMO Headquarters. This relatively rare event is an attempt to coordinate the respective hydrological programmes of the two organisations and is largely taken up with looking at the complementarity

and occasional duplication of their separate activities. Again, there may be those within BHS who are interested in possibly attending as part of a United Kingdom delegation on their own organisation's funding. If so, please contact **Professor Angela Gurnell** (Birmingham University Geography Department) in the early Autumn when further details will be available: Angela is the BHS representative on the Inter-departmental Committee for Hydrology, which will seek formal approval of the small UK delegation.

I very much hope to see a wide cross-section of the membership of BHS among the 250+ attendees at the Exeter '98 conference. We are greatly indebted to the organising committees under the leadership of **Professor Des Walling** and **Dr Bruce Webb** at Exeter University's Geography Department. They and their many colleagues within South West England have done a sterling job on all of the practical matters concerned with such a major activity.

I am delighted for them that there has been a wide international response to the chosen topics. I am also grateful to **Prof Howard Wheater** for his coordination of the scientific programme committee. Through the hard work of the theme convenors, aided by **Celia Kirby, Hilary Arnell** and **John Griffin**, we have three refereed volumes of worthy hydrological papers available to the conference, and for sale through John Wiley & Son thereafter. It only remains now to make the most of the networking opportunities that so rarely occur on this scale within hydrology in Britain.

Frank Law

Honour for BHS past president

Professor Susan Walker, President of BHS from 1993-1995, was awarded the OBE in the New Year Honours List.



Sue is well known for her active participation and leadership in the society and particularly for her support and campaigning for education, training and professional recognition of hydrologists. She is visiting professor in Civil and Offshore Engineering at Heriot-Watt University, as well as a Freeman of the City of London and a Liveryman of the Worshipful Company of Engineers and the Company of Water Conservators.

Born and brought up in Bolton, Sue took a first class degree in geography at Durham, and a PhD at UMIST — her thesis was entitled "Interactive display of water demands and resources".

Sue joined the North West Water Authority as a hydrologist in 1980, remained with the privatised North West Water for two years and then became Regional Water Resources Manager for the NRA.

She is now Regional Water Manager for the Environment Agency, based in Warrington, leading the development of a sustainable water resources strategy for the North West, as well as contributing to national policy developments on flood defence and water resources.

WMO publications

The following publications have recently been received from WMO. They are available to members for consultation or loan through the Institute of Hydrology Library (Tel. 01491 692450).

WMO Regional Office for Africa 1998. Newsletter No. 26 (17pp)

Barry, R.G. (ed.) 1998. Arctic Climate System Study — Proceedings of a meeting of experts on cryosphere and climate: Cambridge 1997. World Climate Research Programme doc. 102, WMO/TD No 867 (~60 pp).

Gadgil, S. *et al.* 1998. Atmospheric Model Intercomparison Project — Monsoon precipitation in AMIP runs. World Climate Research Programme doc. 100 WMO/TD No 837 (~50 pp).

Obituary

Tony Edwards, 1939-1998

Dr K A Edwards, hydrologist, environmentalist and diplomat, died suddenly in Geneva on 23rd April. After graduating in Geography and Geology at Birmingham University, he served for two years with the British Antarctic Survey, returning to Birmingham to take a PhD in hydrology (estimating soil moisture deficits from climate data).

Tony Edwards worked at the Institute of Hydrology in the 1970s on catchment area research and modelling in the UK and East Africa. His later career was in the UN Department of Technical Cooperation for Development and UN Environment Programme, and in international water resources negotiations, in association with the Centre for Environmental Studies and Resource Management in Norway.

Tony was active in founding the Water Academy in Oslo this year. A Scholarship fund is being set up in his memory for research in "resolution of environmental conflicts". Contributions may be sent to The Water Academy, Tony Edwards Scholarship, PO Box 1089, Blindern, N-0317 Oslo, Norway. A full obituary by Jim McCulloch and Tor Wennesland will appear in *Hydrology & Earth Systems Science.*

Member on the move

Doug Wilson, formerly of the University of Huddersfield, has moved from Southern Water in Sussex to work for Thames Water in Reading.

Surface water aspects of the recent DoE yield review

BHS seminar (National / Southern Section) Institution of Civil Engineers, London 4th March 1998

This seminar brought together over 60 delegates involved or interested in the recent surface water yield reassessments. The morning session comprised formal presentations by representatives from the water companies, the Environment Agency and the auditors. They discussed their work and their viewpoints, concentrating on the more interesting or unusual aspects of the review. The afternoon session was given over to more informal presentations and a lively discussion.

Morning presentations

Chairman **Frank Law** (Institute of Hydrology) opened the meeting, reminding the audience that the DoE 1996 *Agenda For Action Report* was the driver behind the recent yield review.

Glenn Watts (Environment Agency, Bristol HQ) set the scene with an overview of the yield review: its history, organisation, scale and future. Previous yield statistics were not based on consistent assumptions and methods, and were not therefore comparable. Furthermore, recent changes to supply sources and systems, and the availability of recent data needed to be taken into account.

Provisional results suggest that, on average, yields over England and Wales have fallen by around 5%, but this figure masks considerable variability between water companies, with some showing a small increase. Some explanations for this overall reduction are given below:

- Assessment based on worst historic drought in (derived) record back to the 1920s — not, say, a 1-in-50-year drought;
- Assessment included emergency storage allowance;
- Assessment allowed for system constraints, e.g. treatment capacity;
- Assessment based on higher water company Level of Service assumptions.

Peter Mitchell queried whether the new yield statistics represented the environmentally acceptable yield. Glenn (and others) replied that the abstraction licences should take care of the environment, however, where voluntary agreements are currently in place to reduce abstractions for environmental reasons, these have generally been included in the yield review.

Richard Harpin (Halcrow) gave an overview of their role as appointed auditors of the yield review process, for both surface and groundwater sources. Their principal objectives were to review company work plans and audit a sample of sources *during* the process using a feedback scoring system, to ensure consistent quality application, then to collate and report the deployable output results for the three scenarios (ongoing). They were concerned primarily with the data sources, the technical approach and the audit trail, not the calculations themselves.

The main issues arising were:

- Some records were not available or not extended back to the 1920s — could miss a critical drought;
- Some companies did not differentiate all three required Level of Service scenarios as they claimed the 'no restriction' scenario was also the 'company policy' scenario;
- There was a variable approach to outage evaluation — Halcrow's own method was seen to be too complex or data hungry; similarly process water was inconsistently accounted for;
- The approaches to developing inflow sequences (rainfall runoff, disaggregation etc.) and allowing for gains in yield through conjunctive use systems were inconsistent;
- Agency and water company models of the same system sometimes gave different results.

Rachel Spence (Environment Agency, Solihull) asked whether the auditors were confident that the non-sampled source yields had been calculated with the same degree of care and attention. Richard was confident that they were, since the water companies were not told the sources until a significant way through the process, and used the same models for multiple sources.

Frank Law wondered whether the results were affected by the 1995 drought: would the answers have been different if the analysis had been done after the 1989-91 drought? Richard replied he would prefer the reassessment to be based on probability, not on the worst historic drought.

Glenn Watts commented that probabilities are more difficult to understand and prove — but at least the worst historic drought cannot be debated.

Local accounts of yield review experiences

David Crookall (Severn Trent Water) concentrated on the East Midlands Resource Zone, a multiple reservoir, river and groundwater conjunctive use scheme. David emphasised the averaging of results masks important local effects.

The complex River Severn Resource Zone has been modelled by the Environment Agency, but Severn Trent Water are currently developing a new model (for consistency with their East Midlands model) which will include travel time elements.

John Mawdsley (Environment Agency, North East Region) enquired how Severn Trent had interpreted the 'no restriction' scenario: was the yield was calculated by just touching the control curve, or were control curves removed allowing drawdown to emergency storage? David replied the former was the case, but control rules were included for the Level of Service reference scenario.

Frank Law enquired how the model dealt with operational inefficiencies. The model does not work to the *exact* prescribed flow, but includes an efficiency algorithm to generate a range of errors.

David noted that climate change modelling gives results varying from a large reduction to a small rise in yield, with the critical period at different places and times, depending on the scenario chosen. This uncertainty, he argued,

needs to be addressed in water company plans.

In response to **Paul Webster** (University of Birmingham), David explained that the climate change modelling was carried out by applying the monthly change factors to the whole HYSIM rainfall-runoff derived flow record, although rainfall and evaporation data were adjusted in the case of reservoirs.

John Curtin (Environment Agency, Solihull) discussed the yield review of the River Severn System. The Agency was responsible for this reassessment as the system supplies three water companies and other abstractors, and the day to day operation is managed by the Agency. The River Severn regulation system is supported by two reservoirs and a series of groundwater boreholes, with a *conditionally* maintained flow at a control point half way down the river. Once the support sources are releasing at their *maximum* sustained capacity, the system acts as a 'put and take' system.

John highlighted some of the more interesting parts of the review — particularly the methodology for the correction applied to the existing disaggregated 'naturalised' flow series (1932 onwards) which did not allow for the significant spray irrigation demands in the catchment. This consisted of defining an overall spray irrigation monthly demand profile (based on crop type, demands and seasonality), assessing percentage abstraction compared to licensed maxima from 1995 returns, and applying this percentage to each years licensed quantity with a climatic adjustment to reflect how dry the year was.

The Severn System is not designed to cope with a severe drought, so the 'no restrictions' scenario inevitably led to a reduction in yield of 24%. A six-month Drought Order was modelled for the critical 1975/76 drought, which included abstraction restrictions (5% PWS and 50% SI). The Agency plan to review the control rules in the future.

In reply to **Frank Law**, John said leakage draining back into the catchment (particularly where sewage returns are out of the catchment) is not included in the model.

Paul Hodge (Bristol Water) asked whether there were plans to recharge the supporting aquifer artificially (Shropshire Groundwater Scheme) but John was not aware of any such plans.

Meyrick Gough (Southern Water) focused on the flow record modelling to determine the yield of unsupported river abstractions. They had begun by naturalising a short flow record by disaggregation. Local water companies were sensitive about the release of actual abstraction data, so the Agency was only able to release monthly catchment aggregate abstraction returns for each use type. Groundwater abstractions therefore had to be treated as 100% immediate impact on river flows. ADAS attempted to split the monthly irrigation data into shorter periods, but with little success, so a uniform irrigation profile was assumed throughout each month. Assumptions about consumption (net rather than gross abstractions) were made for each use.

With help from ADAS, they then used rainfall and PE data to generate natural flow sequences back to 1920 using a transfer function catchment model, applying the split record calibration / validation technique.

For the yield modelling itself, the 1995 uptake rates were applied to the full record for non-public water supply abstractions. Previous yield estimates had been based on a 1-in-50-year drought; the reassessment showed 1976 was the worst historic drought with a return period in excess of 100 years, hence there was a resulting significant drop in yield of all unsupported abstractions.

Neil Whiter (South West Water) ended the morning session with a description of the modelling of the south-west's resources systems. Their demand pattern is extremely seasonal because of the massive summer influx of tourists — in fact Neil joked that other water companies send their customers to the south-west as a demand management measure! However, local customer focus group surveys revealed that 30% of customers believed there was a hose pipe ban in force, when none had been imposed for several years!

Although they have synthesised rainfall/runoff data back to the 1920s, the early results are dubious, so only the data from 1956 onwards were used for the yield analysis, giving a worst historic drought in 1976 or 1991.

Neil elaborated on their 'realistic' outage assumptions, ignoring outages that mean a different (maybe more expensive) source is temporarily used and including only those outages which have a genuine impact on deployable output. Infrastructure constraints were found to cause a huge reduction in yield so the scenarios were modelled both with and without these constraints. They departed from the review methodology guidelines by considering it unacceptable for a reservoir to not refill for more than five years (~8% difference).

Neil stressed that his interpretation of the term deployable output is the annual average yield, not the peak four-week yield.

Afternoon discussion

With **Peter Walsh** (Chairman, Pennines Hydrological Group) in the chair, the afternoon session was given over to a series of more informal presentations and open theatre discussion.

Kunle Akunde (Halcrow) elaborated on issues highlighted by the auditing process, particularly regarding outage calculation inconsistencies.

John Mawdsley discussed the methodology behind the yield review and Yorkshire anomalies. Yorkshire Water's interpretation of the 'No Restriction' scenario, normally resulting in the lowest yield, was to remove all control lines and operate down to the emergency storage, thereby giving the highest yield. Their 1-in-40-year drought order interpretation allowed two drought orders *per customer*, but four in total over the interlinked Yorkshire grid.

Susannah Moss (North West Water) illustrated the sensitivity of deployable output calculations to the emergency storage assumptions. A reduction from a 30-day to a 20-day emergency storage at Ennerdale, for example, would increase deployable yield by 25%. As sources become more integrated there is less risk in reducing the emergency storage at each, thereby increasing overall yield.

Tim Wyatt (Water System Consultants Ltd) discussed the pros and cons of different yield assessment methodologies, concluding that demand based simulation models were most appropriate, such as the MOSPA package developed by him and used by North West Water. However, economic yield as well as maximum yield must be considered.

A lively discussion followed, covering a wide range of yield related topics: the consistency of interpretation of the yield review guidelines, the purpose and implications of emergency storage, the environmental consequences of no risk scenarios, the 'power' of water companies to meet proposed 'no restriction' policies in the face of Ofwat and Agency objections, and indeed whether a no restriction policy is what the public really want, the reasonableness of planning to meet the demands of the worst historic drought and its additional cost, stochastic modelling and the effect of different storage starting positions.

John Mawdsley commented that the yield review move away from probabilistic to historic drought analysis was expected to be criticised, but was a practical solution given the sheer size of the task.

The afternoon culminated in Frank Law taking a poll on the motion that future yield reviews should consider probability-based analysis. Although no-one present voted against the motion, a considerable number abstained. Clearly further thought and discussion is required before the next review.

Overall, it was a lively seminar, with considerable interest shown in both the experiences of the water companies carrying out the surface water review, and in the methodology itself. A similar groundwater yield reassessment seminar will follow later in the year.

Rachel Spence
(Environment Agency, Solihull)
Hilary Smithers
(Environment Agency, Warrington)

Groundwater protection and management

Pennines Hydrological Group Annual General Meeting University of Central Lancashire, Preston 20th May 1998

Peter Walsh (Chairman of the Pennines Hydrological Group) presided over the AGM and Frank Law (BHS President) began with a short talk on the forthcoming BHS International Conference on *Hydrology in a Changing Environment* from 6 to 10 July 1998 at Exeter University (http://www.nwl.ac.uk/ih/www/server/bbhs.html). Frank mentioned that travel grants might still be available through the BHS Hon. Treasurer, Terry Evans.

Tony Peacock (Environment Agency, Warrington) started the presentations with one on *"The Need for Groundwater Protection"*, introducing the importance of groundwater resources and threats to groundwater supplies (such as landfill, industry, agriculture, contaminated land, spillages, salt, herbicide applications and graveyards!).

Recent improvements in groundwater mapping (such as groundwater protection/ vulnerability maps) have developed as a result of continuing changes in groundwater protection legislation. It is planned that a new EC Directive integrating surface waters and groundwater will be only a few years away.

Concluding remarks highlighted:

- The benefits of groundwater maps;
- Such groundwater maps are complex to both produce and keep up to date;
- Groundwater protection zones may be inaccurate, since zoning is based on arbitrary definitions, often with poor data availability and subjective cost benefits;
- Groundwater protection zoning is a "screening tool".

No questions were raised.

Groundwater protection in the Hull area of East Yorkshire by **Dr John Aldrick** (Environment Agency, Ridings Area, Leeds) introduced the impacts of urban development upon groundwater resources in the Hull area from an historical perspective, with the use of several hundred-metre-long adits feeding Victorian groundwater pumping stations.

Potential pollution of groundwater resources in the Hull area include market gardening, septic tanks and leakage of sewage. Tracer tests highlight the vulnerability of the Chalk aquifer in areas of thin clay / alluvium cover: such tests have helped in the delineation of Groundwater Protection Zone (GPZ) maps using the steady-state 'FLOWPATH' groundwater model.

As the statutory consultee for planning issues involving 'water', Dr Aldrick clarified the Environment Agency's role as bound by the Town and Country Planning Act of 1990. Improved groundwater source protection via integration of GPZs, Groundwater Vulnerability maps with Local Authority Unitary Development Plans are envisaged as the 'way ahead' for the growing urban area of Hull.

John Turner (Leeds City Council) asked about the significance of surface runoff seeping into groundwater resources and how this runoff could be detained. John Aldrick said that surface seepage infiltrating to groundwater was not usually a problem. However, contaminant 'flushing' (for example, of heavy metals and hydrocarbons) following dry spells was acknowledged as a more serious problem to surface hydrology *rather* than to groundwater resources. "Interceptors", adjacent to road systems, are being used to collect accidentally-released hydrocarbons before they can enter surface river courses, hence reducing pollution risks.

Andrew Binley (Lancaster University) asked both Tony Peacock and John Aldrick which areas academic resources should be directed towards to assist the Environment Agency. Tony Peacock, in explaining that the mechanisms for the delineation of Groundwater Vulnerability and Protection 'zoning' is over-simplistic as present, suggested that a more precautionary approach should be adopted, using more sophisticated methods, and further, that a risk assessment of how pollutants migrate and retard, along with cation exchange processes, would help in this zoning delineation.

Steve Wilde (University of Central Lancashire, Preston) raised the question of responsibility for policy concerning landfill and contaminated land remediation. Tony Peacock suggested:

- The need to seek guidance on contaminated land, and that such land need be cleaned-up "fit for pragmatic use";
- Using risk assessments to consider conditions around the site and the future use of groundwater from beneath the site would assist in demarcating the level of remediation, adding that such a process would be very expensive.

Tony added that the Environment Agency has the power, and the *choice* to apply that power, should the money and interest be available, for such remediation.

John Aldrick added a comment regarding the lack of information demonstrating the level of risk to groundwater from landfills, exposing the need to investigate such sites and to quantify the pollution.

In a presentation on *The role of the unsaturated zone in aquifer vulnerability*, **Dr Jared West** (Department of Earth Sciences, Leeds University) highlighted the role of aquifers' unsaturated zones, and of 'Drift' or overlying deposits to aquifer vulnerability. Groundwater recharge source and recharge time-delay (surface infiltration to phreatic zone impact) issues were illustrated. The first example was from the Sherwood sandstone near Selby, Yorkshire, where a 'recharge window' within the Drift deposits is being investigated using soil physics to compare recharge through this to that through the Drift cover, to understand the overall hydrology of the system.

The second example, an unsaturated Chalk interfluve at Kilham, Yorkshire, demonstrated the importance of solute monitoring using solute profiling with direct and geophysical monitoring within the vadose zone: a vertical travel-time for the solute of 12 m in two days was reported.

In summarising Dr West made these points:

- The unsaturated zone controls the source of recharge plus recharge travel times;
- Tracer testing integrated with geophysical monitoring is useful;
- Bypass flow (within the vadose zone) is dependent on the antecedent conditions and on the hydraulic loading rate of the tracer.

Vic Over (Bolton Institute) asked if there was a geological reason for defining the uppermost five metres of the Kilham Chalk as a 'storage' buffer: Jared West pointed out that changes in moisture content caused by winter rains destroying late-summer moisture deficits, were observed with neutron probe/ tensiometric methods in this uppermost zone.

Charlie Hedges (Yorkshire Water) commented that Drift is greatly over-

simplified, highly variable and needs further investigation: Dr West agreed that Drift characterisation was insufficient.

Adrian Butler (Imperial College, London) raised the question of the resolution of the geophysical methods to detect changes in tracer concentration. Dr West responded by introducing the notion of variable flow processes of tracer diffusion and dilution within the dual-permeability (fractured and matrix) Chalk at the field-scale, which do not show up at the laboratory scale. The suggestion was that tracer 'backs up' on marl layers within the chalk, draining away later in time.

Adrian Butler (with **Matthij van Leeuwen**, Imperial College, London) then presented a talk entitled *Determination of well capture zones: source protection* on modelling groundwater flow, discussing the problems of contaminant transport and the scale-dependency of dispersion, and spatial heterogeneity constrained by limited data.

Modelling thus needs to include better physical structure, include fluid advection with dispersion, incorporate 'uncertainty' methods and quantify such small-scale variations of properties such as flow velocity. Adrian described the geo-statistical methodology culminating in zones mapping the Probabilistic Well Capture Zone, to be incorporated alongside Risk Assessment techniques.

An example for the Netherlands illustrated the method, and the talk concluded with the need for:

- Spatial, or 'flagship' data;
- Revised studies for controversial sites;
- Discussion amongst the user community;
- More studies to consider other sources of uncertainty.

Andrew Binley asked how much usable data is required for such a modelling method. Adrian replied, saying that each problem is 'material dependent'. However, geostatistics from 'tens of boreholes' should be aimed for. He added that Dr West's presentation had illustrated such Drift uncertainties that could be assisted with a geostatistical approach.

Jon Naylor (GPRG, Sheffield University) asked how Adrian Butler could have confidence in such random geostatistical fields: the response was that such 'confidence' was never achievable, as so little sub-surface information is available, since the material presented is a statistical field of properties.

Matthij van Leeuwen suggested that no data are needed: with fewer data, the greater is the importance to carry out the uncertainty analysis. He added that data are needed to assess the structure, and that combined with values of hydraulic conductivity from literature could thus show the uncertainty in the model.

Andrew Binley pointed out that the uncertainty modelling shows levels of uncertainty or levels of sensitivity, rather than levels of confidence. Adrian replied that levels of confidence can be determined from such levels of uncertainty.

Frank Law asked if this model could introduce the concept of 'drought' into its parameters: Adrian Butler's response was that recharge conditions could be built into the model, but he asked Frank Law in return where the line should be drawn in the future, as many extra variables can be incorporated, especially with contaminant pollution.

Beiyan Zhang (University of Sheffield) discussed *Protection and restoration of adit systems*, describing delineation of Groundwater Source Protection Zones using the USGS BRANCH and MODFLOW, integrated into MODBRNCH, in order to incorporate the hydraulic effects of groundwater adits in two examples of Chalk aquifers, in south-east London and in Humberside. Such adits are modelled as fully-saturated, pressurised flow systems, with hydraulic 'adit parameters' constructed from adit width = 1.5 m, height = 2m, at depth 20 below ground level, planar and horizontal, many hundreds of metres long, of defined conductance and permeability.

Tony Peacock asked if her output model boundaries could incorporate true (or real) values, or if hypothetical values were used: hypothetical fixed-head boundaries were used for the London example, and constant head upper- and lower-boundaries for the Humberside example.

Adrian Butler asked about the 'adit parameters' and how their values were determined: real-case values were used. He also asked if it was possible to address the problem of adit leakage within this adit parameter. Beiyan Zhang replied that initially this problem was addressed by 'forcing' conductance, but then was changed to calibrate the model.

Paul Hulme (Environment Agency) asked if the adit fluid velocity was calibrated with real data, and enquired if any tracer studies had been carried out within adits. Beiyan Zhang replied that water velocities in adits were nearly the same as real-case velocities, and to her knowledge no tracer studies in adits had been investigated.

Roy Middleton
Lancaster University

Plynlimon water quality findings

The latest crop of results from the Institute of Hydrology's Plynlimon catchment programme has recently been published as a Special Issue of the European Geophysical Society's journal *Hydrology and Earth Systems Sciences*.

The Special Issue contains 31 papers, mostly relating to water quality in the uplands, in particular the impact of forestry and land-use change. **Dr Jim McCulloch**, who was Director of the Institute when the Plynlimon experiment started 30 years ago, has written a historical foreword on strategic research in hydrology.

The final paper is a 300-item bibliography that demonstrates the breadth and depth of research associated with the Plynlimon experiment.

Contents pages and abstracts of this and other issues of the journal are available on the HESS Web Site at http://www.copernicus.org/EGS/hess/hess.html

Kevin Gilman
http://www.wetlands.demon.co.uk

New Members

We welcome the following members to the Society:

Bayliffe, M. D.	BHR Group Ltd
Hasan, M. K.	University College, London
Homann, S.	Environment Agency
Huband, M.	WS Atkins
Longfield, S. A.	University of Leeds
Markwell, K.	Anglian Water Services
Mosugu, M. E.	University of Birmingham
Peters, R. S.	Tetbury, Gloucestershire
Samuels, H. J.	Kennedy & Donkin Consulting Engineers
Sheffield, P.	Institute of Hydrology
Shotbolt, L.	Salford University
Steel, M. E.	University of Dundee
Thorne, J. M.	University of Exeter
Vetere Arellano, A. L.	University of Birmingham

River, estuarine and coastal research on water quality, biology and sediment transport: the land-ocean interaction study (LOIS)

Announcement of a BHS / Challenger Society Joint Meeting, to be held on 25 September 1998, from 10.30 a.m. to 4.30 p.m. at the Institution of Civil Engineers

Organisers: Graham Leeks (Institute of Hydrology), Prof. David Huntley (University of Plymouth) and Prof. Des Walling (University of Exeter)

The Land-Ocean Interaction Study (LOIS) is a very large scale NERC thematic science research programme. The programme includes marine, geological, rivers and terrestrial science, involving many research institutes and universities. LOIS began in 1992 and is concerned with the physical, biological and chemical fluxes to the marine environment from river basins and the atmosphere and the modelling of future fluxes under a range of scenarios. LOIS has integrated rivers science with coastal research more than has ever been possible before. The science includes the operation of large-scale monitoring networks in the rivers, estuaries and North Sea along the eastern coast of England and Scotland. There is measurement and analytical science in hydrology, sediment transport, water chemistry and biology. Remote sensing, GIS database and integrated model development are also included. There has been close collaboration with the EA, SEPA, Yorkshire Water and supporting work for DETR and MAFF.

Rivers research in LOIS

The core study catchments cover an area of more than 59 000 km^2 extending from the Tweed to the Trent, including more than 20% of the UK population and a significant part of its energy, industrial and agricultural production. Monitoring of a wide range of substances from many non-point and point sources through river basins, moving down to the estuaries and coast, has been carried out on an intensive basis using large scale networks.

Integrated instrumentation including automatic bulk samplers, pressure transducers, turbidity monitors and multiprobe systems (covering pH, conductivity, temperature, dissolved oxygen depth and salinity) provide high temporal resolution data on river conditions and fluxes, in close collaboration with the EA and SEPA. Routine weekly and flow-related sediment and water chemistry sampling has been carried out. The contrast between the more highly urbanised and industrialised catchments (e.g. Trent, Don, Aire, Calder) and more rural rivers (e.g. Ouse, Wharfe, Nidd, Tweed) is very apparent. These observations also led to additional intensive studies on the Swale-Ouse and Aire systems for nutrients and micro-contaminants process studies and the development of the integrated river models. Compact Airborne Spectrographic Imaging (CASI) took place and full stereo colour vertical imagery was taken during the flood events. It is possible to routinely link hydrological, sediment and pollution events. Similarly, detailed data collection is enabling scientists to develop a range of hydrological models to determine flux and how flux will alter with changes in land use, industrial inputs or climate. There has also been research effort in the estuarine / fluvial boundary zone, in tidal reaches of the Ouse, Trent and Tweed.

Large integrated marine, river and geological data archives have been developed. The data from the EA, SEPA and LOIS have been combined to provide new spatial and temporal visualisations of majors, metals and organics data. A suite of CD-ROMS is currently being produced for dissemination of the LOIS data.

The purpose of the meeting will be to present summaries of the science of the LOIS programme to an audience with both academic and operational interests. The presentations, posters and demonstrations will cover scientific results, descriptions of technological, database and model development in the river component (briefly described above), in addition to the estuaries and coastal component of the LOIS study.

Speakers

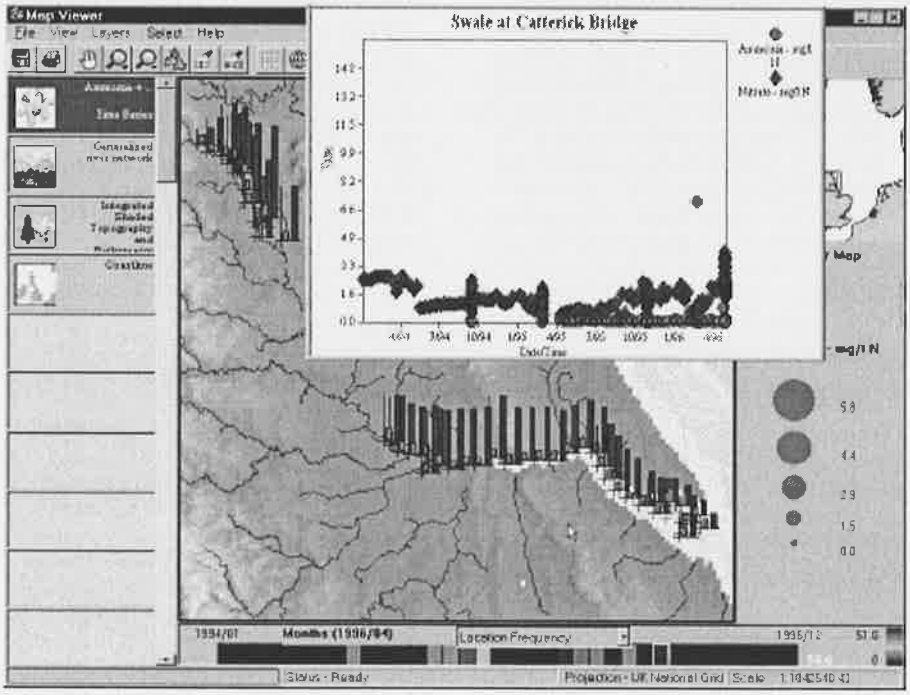
Prof David Huntley (Univ. of Plymouth), Graham Leeks (Inst. of Hydrology) and Dr Tony Stebbing (Plymouth Marine Lab) — Background to LOIS

Dr A.M.C. Edwards (Ridings Area Manager, Environment Agency) — Catchment and estuary management issues in the Humber.

LOIS River Basins science

Sediment Dynamics — Prof Des Walling (University of Exeter)

River Chemistry — Dr Colin Neal (Institute of Hydrology)



Preview screen shot from the LOIS overview CD-ROM (LOIS Data Committee)

Nutrients and micro-contaminants in LOIS rivers — Dr A. House (Institute of Freshwater Ecology)

Modelling of large-scale river basins — Dr Pam Naden (Institute of Hydrology)

LOIS Estuaries and Coasts science

Sediments — Prof K. Dyer (Univ. of Plymouth)

The Intertidal Zone — Dr. J. Widdows (Plymouth Marine Lab.)

Chemistry — Prof G.E. Millward (University of Plymouth)

Biology — Dr D. Purdie (University of Southampton)

Chaired by:

Prof. W.B. Wilkinson, Director NERC Centre for Ecology and Hydrology

Prof. F. Mantoura, Director, Plymouth Marine Laboratory, NERC Centre for Coastal and Marine Studies

The cost of the meeting will be £25 (incl. lunchtime buffet). Please book (using flyer enclosed) with Richard Howard, ICE (e-mail: howard_r@ice.org.uk).

The Flood Studies Report rainfall-runoff method – a final word

__David Archer__'s article about the FSR rainfall-runoff method [Circulation 56] prompted replies from __Mike Lowing__, __Duncan Reed__ and __Helen Houghton-Carr__ [Circulation 57] and now we have one from __Max Beran__. I hope that Max's will be the last word for the present, but if there is any further discussion of this topic, it might be conducted through the BHS mailbase — Ed.

Now that the authorship of the article "The Flood Studies rainfall runoff method — a fundamental flaw" has been revealed, I feel more motivated to put in my own twopenceworth, especially as Mike Lowing and Duncan Reed have done much of the heavy work.

I write as the member of the Floods Study team at the Institute of Hydrology who was responsible for the methodology for linking the event-based unit hydrograph approach to the statistical approach. At the time this was groundbreaking stuff, there being no previous formal attempt at such a linkage. The state of the art as matters stood in the late 1960s went something like this: a 50-year rainfall probably causes something close to a 50-year flood, if you associate it with middling severe values of the other variables responsible for causing the flood. The Floods Team wanted to go one better.

My sense is that David Archer (for it is he) would like to take us right back to those days (and possibly earlier, as he seems to have it in for rainfall-runoff as a free-standing approach to flood design). Certainly, in what is now nearly a quarter century of sniping at the *FSR* approach, I have never had the sense that David fully grasped what is meant by a derived distribution. I may have to share the blame as I probably did not make a particularly good fist of explaining it in Chapter 6.7 of the *FSR*.

The hydrologist of the 1990s has, I am sure, a much stronger feel for these statistical niceties and so nowadays one may discuss it more succinctly. A variable Y is a function of several causative factors, Y=f(X1, X2, X3 etc). We know the function, f, and we know the statistical distributions of all the Xi; so how does one derive the frequency distribution of Y? That is the gist of the first part of the problem, in which Y is hydrograph peak (or any other aspect of its geometry such as a volume) and the X's are variables to do with depth, duration and temporal rainfall distribution and catchment wetness (controlling how much of the rain reappears under the flood wave). The function f is the event model.

The aspect of the procedure that has always seemed the hardest to grasp is the requirement that one must work in terms of event probabilities, not exceedance probabilities — what the statistics books call density rather than cumulative distributions. Any given value of Y is the outcome of an infinity of combinations ranging from high rain with low wetness to low rain with high wetness (see *FSR* Figure 6.48). It is only when one has completed the reconstruction of the entire distribution of Y that one discovers the value corresponding to a given quantile.

I have called this the first part of the problem and for good reason. We judged that the *FSR* users would not want to be bothered with this derivation every time they wanted to use the unit hydrograph approach. So we had to provide a procedure akin to what was current — in other words a recipe for selecting single points for the X's that would on average, and with reasonable assurance, home in on the flood of the right return period. However the two parts are inextricably linked as that selection came about after exhaustive explorations, summarised in *FSR* Sections 6.7.5 and 6.7.6. The task was made easier by the discovery that the duration and temporal pattern of rainfall were of low impact compared with total depth and catchment wetness. This was already quite a hurdle, as the received wisdom of the day was that duration was a key quantity (possibly conditioned on the industry's half century of immersion in the rational formula).

Mike Lowing (in *Circulation 57*) has described the issues surrounding the particular decision. However I think he underestimates the difficulty of identifying a CWI that would permit equal return periods of rainfall and peak runoff. A few words on this as I think it also reinforces the folly of David Archer's expectation that simple ratios can hold true across climatic and hydrological situations. The key idea here is to consider the series of individual rainfall maxima (annual or exceedance). Of these only a very few will contribute floods of sufficient importance to contribute to the equivalent flood series. The reason hardly needs to be spelled out – that for most situations heavy storms occur in the summer, while most floods occur during the winter. This disjunction means (a) second guessing return period relationships is on a hiding to nothing, and (b) one is more likely to have to look towards the right-hand end of the rainfall distribution for stable relationships. This reasoning has a lot to do with why equality of return periods could be accommodated for urbanised catchments and on all catchments for the most severe rainfalls.

Having said this, the world must look different now with 40-year-long flood records a commonplace, compared with the situation 25 years ago, when they were a rarity. Now, as then, what the data say is what should determine techniques. But what do David Archer's data say? Take the statement "Thus for example in Region 3 or 10 with soil Type 4 or 5.... the average error at Q30 will be of the order of 23% and at Q100 will be 31%". Powerful stuff if these really are data. But is that so, or is it surmise based on supposed internal relations? — a table of data comparisons is needed so that we can judge.

A final word, if I may be permitted, on Duncan Reed's expectation that simulation will consign all this bickering to history. I am with Mike Lowing on this, and not holding my breath! Remember too that there is more than one way of simulating: I assume that Duncan refers to simulation in the time domain — basically reconstructing the total hydrograph as an output from a time series of inputs and an input-output model. If the future is to be simulation-shaped, then let it at least be the other type of simulation that takes place in the frequency domain. This was the type used to obtain the derived distributions discussed above, where sampling was from across the frequency distributions

of the flood forming factors and only the flood forming factors. Modelling the entire time series structure of these key quantities just to pad out the space between the peaks with useless information cannot be efficient, and that's putting it nicely!

Max Beran
East Hagbourne
e-mail: max@oldboot.demon.co.uk

Continuous flow simulation using unit hydrographs characteristic of total streamflow

Recent articles on aspects of the *Flood Studies Report* rainfall-runoff method (see *Circulation* **56**, *12-13* & **57**, *13-15*) prompted this short article. The purpose here is not to address directly the various points made in those articles, but to bring to the attention of a wider audience one strand of progress in unit hydrograph identification and application. This has been documented in the scientific literature over the past ten years and is now available in PC-package form. The IHACRES unit hydrograph (identification of unit hydrographs and component flows from rainfall, evaporation and streamflow data) is different in some important ways from the more traditional unit hydrograph exemplified by the *FSR* case.

The *FSR* unit hydrograph characterises *direct* flow only (whatever *direct* may be taken to mean physically in this context) and is derived from runoff *events*. The IHACRES unit hydrograph is characteristic of *total* streamflow, and may be derived from either event or time series (*continuous*) datasets; the latter option, especially, leads to efficient continuous streamflow simulation, with many possible applications. Last year (February 1997), a version of the IHACRES methodology was released as PC-IHACRES (Version 1.0) — further details are available from the author.

Because IHACRES identifies a unit hydrograph characteristic of total streamflow it circumvents the requirement for the *prior* baseflow separation necessary in the traditional method. In common with the traditional method, however, statistical relationships between IHACRES model parameters and catchment physical attributes — area, slope, stream density, etc. — can be sought, leading to application of synthetic IHACRES unit hydrographs at ungauged (flow) sites. The mathematical representation of the IHACRES unit hydrograph leads easily to 'quick flow' and 'slow flow' sub-unit hydrographs, each defined by its peak flow and its exponential decay time constant (i.e. just two parameters). A simple loss module to derive effective rainfall is applied in IHACRES before the unit hydrograph module.

Convolution of effective rainfall with the 'quick' and 'slow' sub-unit hydrographs leads to continuous separation of modelled streamflow into dominant quick flow and slow flow components *as an integral part* of the IHACRES schema rather than as a separate, and highly subjective, prior exercise to derive direct flow as in the traditional method.

Figure 1 shows an example from the PC-IHACRES User Guide that demonstrates the capability for continuous flow simulation (for the 894 km² Teifi at Glan Teifi). In *calibration* mode over the period 27 July 1982 to 31 July 1985 (Figure 1b) the model accounts for about 86% of the initial variance in streamflow. In *simulation* mode over the preceding three years from 23 July 1979 to 27 July 1982 (Figure 1d) the same model still accounts for about 82% of the initial variance in streamflow.

The IHACRES methodology has been demonstrated to be generic in the sense that it has been applied successfully to catchments in many hydroclimatic zones of the world, using data timesteps from six minutes to one month corresponding to catchment areas of less than 1 ha to nearly 10 000 km² (published accounts are available). It should not be expected to perform well in all cases, however. Different loss modules may be required to deal with different data timesteps, hydroclimatologies and applications. Nevertheless, IHACRES arguably marks an advance in the application of unit hydrograph theory that may be of interest to a wide range of *Circulation* readers. PC-IHACRES makes a version of the methodology available for general use.

It is hoped to continue to improve both the IHACRES methodology (e.g. different loss modules for UK applications) and PC-IHACRES.

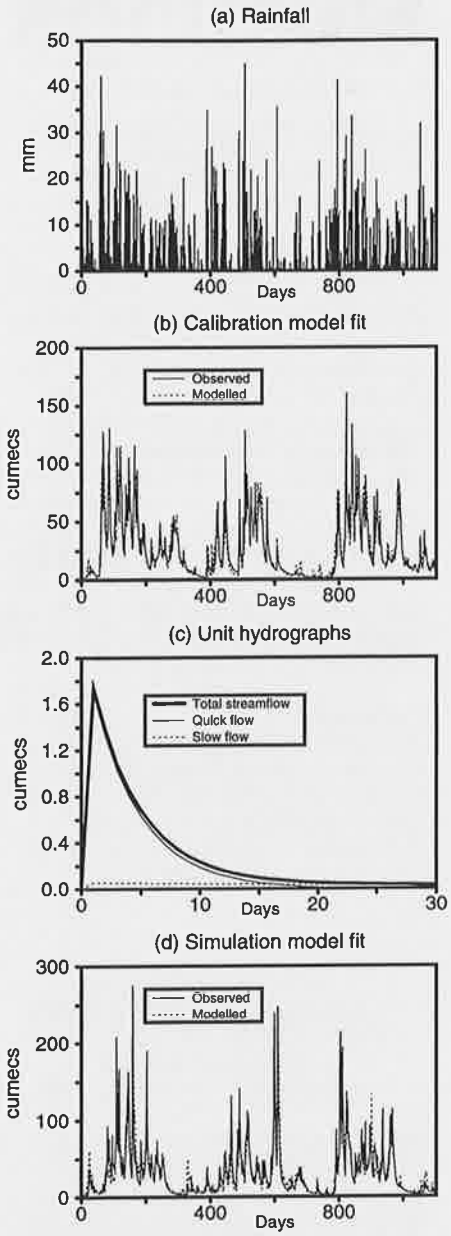


Figure 1 *Teifi at Glan Teifi: (a), (b) and (c) 27 July 1982 to 31 July 1985; (d) 23 July 1979 to 27 July 1982*

Bibliography

Jakeman, A.J., Littlewood, I.G. and Whitehead, P.G. (1990). Computation of the instantaneous unit hydrograph and identifiable component flows with application to two small upland catchments. *J. Hydrol.* **117**, 275-300.

Littlewood, I.G., Down, K., Parker, J.R. and Post, D.A. (1997). IHACRES: Catchment-scale rainfall-streamflow modelling (PC Version 1.0 User Guide). Institute of Hydrology, Wallingford.

Ian Littlewood
Institute of Hydrology

Copy deadline for *Circulation* No. 59 24th July 1998

Meetings

UDM '98: Fourth International Conference on DEVELOPMENTS IN URBAN DRAINAGE MODELLING London 21-24 September 1998

Organised by Imperial College and the International Research and Training Centre on Urban Drainage (IRTCUD), the provisional programme includes quantity and quality of rainfall, runoff and sewer processes, urban pollution management and hydroinformatics.

A special edition of *Water Science & Technology* will contain selected papers. Fees are £350 for members of IAWQ or IAHR (£400 for non-members) — to be received by **31 August 1998**. There will be space for individuals or companies to display their products/services.

Contact for further information: Dr David Butler, Environmental & Water Resources Engineering Section, Dept of Civil Engineering, Imperial College, London, SW7 2BU, UK. Tel: 0171 594 6099, Fax: 0171 225 2716, e-mail: d.butler@ic.ac.uk, URL: http://ewre-www.cv.ic.ac.uk/udm98.htm

Two-day workshop on CATCHMENT MANAGEMENT: THE SCIENTIFIC CHALLENGES Aberdeen, Scotland 30 September - 1 October, 1998

This workshop at the Macaulay Land Use Research Institute, Aberdeen, is organised on behalf of the Land Use Research Coordination Committee by MLURI and the Institute of Hydrology, and supported by the Scottish Office Agriculture Environment & Fisheries Department.

Catchment management is essential for environmental agencies: with new European legislation management it will have to become more proactive. This workshop will be a forum to bridge the gap between research scientists and resource managers and policy makers.

To register or for full details, please contact Sarah Dunn, Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen, AB15 8QH, Scotland, e-mail s.dunn@mluri.sari.ac.uk

First announcement WMO/IOC/ICSU CONFERENCE ON THE WCRP CLIVAR STUDY Paris 1-4 December 1998

The WCRP sponsors (WMO, ICSU and IOC) will hold a major international conference on CLIVAR at UNESCO Headquarters in Paris. Dr D. Carson from the Hadley Centre, UK, chairs the international Conference Organising Committee.

Responding to scientific challenges from the successful TOGA (Tropical Ocean Global Atmosphere) programme and WOCE (World Ocean Circulation Experiment), CLIVAR, the Climate Variability and Predictability project, is the primary atmosphere-ocean research component of the World Climate Research Programme (WCRP).

The outcome of the Conference will guide the CLIVAR Scientific Steering Group and national funding agencies on priorities in implementing CLIVAR.

Further information can be obtained by returning the pre-registration form (pdf-version at http://www.dkrz.de/clivar/hp.html) or from the CLIVAR Conference Secretariat, c/o Max Planck Institut für Meteorologie, Bundesstr. 55, D-20146 Hamburg, Germany, Tel. +49 40 41173 412, Fax. +49 40 41173 413, e-mail: clivar@clivar.dkrz.de

Call for papers / posters WATER 99 – JOINT CONGRESS Brisbane, Australia 6-8 July 1999

Water 99 combines the 25th Hydrology & Water Resources Symposium (run by the Institution of Engineers, Australia) and the 2nd International Conference on Water Resources & Environmental Research. The themes are *"Building on 100 years of Australian water engineering for the new millennium"* and *"International achievements in water resources"*.

There will be hydrological games at the dinner. The trade exhibition is an integral part of the congress: exhibitors should contact the organisers at once.

Papers and posters are invited on a wide range of hydrological themes. Abstracts (300 words – 4 copies) must be submitted (by post) by **15th August**, and full papers by 1st February 1999.

For further information please contact the congress secretariat (tel +617 3369 0477, fax +617 3369 1512, e-mail: hyd99@im.com.au).

FIRST ANNOUNCEMENT & CALL FOR PAPERS Interdisciplinary international conference on INTEGRATED DROUGHT MANAGEMENT — LESSONS FOR SUB-SAHARAN AFRICA Pretoria, South Africa 20 - 22 September, 1999

This conference, convened by the South African National Committee of the UNESCO IHP, contributes to the UN's IDNDR Climate Programme 1990-2000.

The aim is to understand the factors that predispose people and landscapes to drought vulnerability, to find strategies to reduce that vulnerability and to move towards sustainable development.

Papers and posters are invited: two-page extended abstracts must be submitted by **30 October 1998**. Registration fees will be about R 1000. For further details and the enrolment form, please write to Conference Planners, P.O. Box 82, Irene, 0062, South Africa.

Diary

1st-3rd July 1998
33rd MAFF Conference of River and Coastal Engineers
Venue: University of Keele, Staffs
Contact: R. Purnell, MAFF *(Tel. 0171 238 6742, e-mail e.c.webb@fcd.maff.gov.uk)*

6th-10th July 1998
BHS International Conference
"Hydrology in a Changing Environment"
Venue: University of Exeter
Contact: Dr Bruce Webb *(Tel. 01392 263342, e-mail B.W.Webb@exeter.ac.uk)*

6th July 1998
"Land drainage and flood defence"
Venue: Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA
Time: 09.30 a.m.
Contact: C. Chin *(Tel. 0171 665 2316, Fax 0171 233 1743, e-mail chin_c@ice.org.uk)*

9th-15th August 1998
Freshwater Biological Association
"Sustainability of the hydrological cycle"
Venue: Dublin, Ireland
Contact: FBA, The Ferry House, Ambleside, Cumbria, LA22 0LP

17th-20th August 1998
Second International Conference on Climate and Water, Espoo, Finland
Contact: Ms Nea Helenius, Tietotie 1, 02150 Espoo, Finland *(Fax +358 9 451 38 27, e-mail nheleniu@ahti.hut.fi)*

24th-26th August 1998
Hydroinformatics '98
Venue: Copenhagen, Denmark
Contact: Asger Kej, DHI *(Tel +45 457 69555, Fax +45 457 62567)*

25th September 1998
BHS / Challenger Society joint meeting
Estuaries (LOIS project) – *see page 7*
Venue: ICE, London
Contact: Graham Leeks, *Tel 01491 692203*

early October 1998
BHS AGM – *details to be announced*
"Recent flooding in England and Wales"

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