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Circulation

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Circulation on the Internet

This is the first issue of *Circulation* to be put on the Internet for the world to see. This front page (and the *Exeter '98* circular) may now be found at the BHS world wide web address — http://www.salford.ac.uk/civils/BHS

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Sixth National Hydrology Symposium

University of Salford, Manchester
15-18 September 1997

In a week when weather experts and environmental agencies had been bracing themselves for severe flooding along Britain's coastline as a result of unusually high tides combined with high winds, it was apt that the BHS was convening its Sixth National Hydrology Symposium.

The symposium was formally opened by **Ian Cluckie**, Professor of Water Resources at the University of Salford, who welcomed over 100 delegates to the first BHS national meeting to be held in the north-west of England. His enthusiastic introduction set the scene for the following four days, in which the management, monitoring and prediction of water resources were explored through a diverse range of technical papers and active discussion.

The first session was on *Hydrometry and water resources management* and

Matthew Lees (Imperial College, London) set a high standard for the conference with the first paper, describing a new methodology for river flow regulation using real-time flow forecasting models and associated automatic controllers. The predictive theme was continued by **Professor Mike Hall** (IHE, Delft) who outlined the successful application of Artificial Neural Networks (ANNs) to rainfall-runoff modelling, but also highlighted some of the problems associated with this technique, which currently preclude its widespread acceptance as a modelling tool. Two such problems were considered in depth in the paper: the transferability of networks between hydrologically-similar catchments and the capability of ANNs to extrapolate beyond their training data sets. **Tony Bennett** (Scotia Water Services) reported on the progress of a national R&D project aimed at identifying the key users of hydrometric monitoring data, and the development of a Cost-Benefit Analysis method for assessing the quantifiable benefits of collecting hydrometric data. The environmental and socio-economic impacts of declining water quality in upland catchments was addressed by **Matthew Johns** in a paper that examined the potential links between sheep overgrazing, accelerated erosion and increased runoff rates. Concluding Session 1, **Hugh Goldsmith** used rainfall-based drought severity indices to show that recent drought episodes in the north-east of England are normal when placed in a historical context.

In Session 2, four papers were presented on *Water quality in upland catchments*. **Julie McNish** described the successful development of a GIS model for predicting the relative sensitivity of upland rivers in Yorkshire to acidification, based on the buffering capacity of soils and geology, and calibrated using biological data (macro-invertebrate and fish populations). **Chris Soulsby** (Aberdeen University) also emphasised the important influence of geology on the hydrology and hydrochemistry of upland streams: he presented groundwater data collected over two years in the Allt a' Mharcaidh catchment in the western Cairngorms, Scotland. **Gareth Thornton** continued the hydrochemistry theme, describing the effects of geology and land use on the major-ion chemistry of streams in the English Lake District, and the development of a simple model to predict the response in stream-water quality to acid deposition and land-use changes.

The importance of sediment transfer to water resources management in upland areas was considered by **Jim Walker** (Environment Agency) using the results from an ongoing research project in the Shelf Brook (Derbyshire) to demonstrate the development of a typology to quantify bedload transfer under any given hydrological scenario.

A rather sedate start to the second day of the symposium resulted from the previous night's festivities. Those who made it to Session 3 were in for a diverse set of papers on *Water quality modelling*. **Steve Wallis** had the challenging task of bringing the audience into the land-of-the-living: he did so successfully with a technical paper outlining DISCUS, an advection-dispersion model to simulate contaminant transport in rivers. Its advantages were stability, accuracy and computational efficiency compared to more traditional Eulerian schemes.

Paul Whitehead (Reading University) discussed a new process-based model, INCA (Integrated Nitrogen Catchment model), which can predict the fate of nitrogen in terrestrial and aquatic environments on a daily time-scale, and has been designed to include alternative scenarios, for example changes in land use, hydrological flow pathways and atmospheric deposition rates. Turning to environmentally hazardous organic micropollutants, **Frederick Mwanuzi** (Vrijie Universiteit, Brussels) showed how incorporating the effects of dissolved organic matter (a binding agent) improved predictions made by the SCALDIS model about the fate of PCBs in aquatic environments.

Following a lively discussion and a much needed refreshment break, **Professor Uri Shamir** of the Water Resources Institute in Israel delivered the Penman Lecture: *Hydrological basis for sound management of water resources* (printed on pages 3-7, and also on the BHS web pages). He addressed first the sociological, environmental and political issues associated with the provision of water in Israel, Jordan and Palestine, and then went on to examine the roles of hydrology and technical feasibility, which are secondary factors in such a politically volatile area.

After the AGM and a break for lunch, the *Water quality modelling* theme was resumed, starting with a paper by **Doug Wilson** (Southern Water) demonstrating a mathematical procedure for predicting the dispersion of conservative, soluble pollutant spillages in non-tidal rivers. Turning to more diffuse sources of pollution, **Rachael Dils** reported new results suggesting that hydrological status is a key control on the size and composition of the phosphorus load delivered in agricultural runoff. **Chris Soulsby** and **M Chen** addressed the application of the geochemical model NEPATH to predict surface water contamination following the closure of mines in central Scotland. Moving to southern Zimbabwe, where water resources are a major constraint on sustainable development, **Celia Kirby** suggested that the bacteriological quality of well water in rural areas was related to the hydrological behaviour of catchments as well as to anthropogenic activities. To close Session 4, **Gill Litton** gave a paper of local significance on remediation measures for long-term improvements in water quality in the Manchester Ship Canal.

That evening saw a buffet reception at Manchester Town Hall. All those who managed to find their way safely back to Salford were rewarded with two remote sensing sessions the next day. The first concerned *Satellite observations*, and started with **Neil Fox** using surface water and radiation balance measurements to calculate the sensible heat flux. **Chris Collier** then described how such estimates may be used with temperature, albedo and net radiation data to model the occurrence and magnitude of convective rainfall. On a different note, **Tim Davie** considered the resolution of SAR imagery, determining that within-field variation could be detected, and suggesting one hectare as the optimum spatial resolution for interpretation. Looking at a site a *little* further away than a field in Essex, **David Collins** described work on glaciated basins in the Karakoram mountains, where remote sensing of the changing snow covered area was used to record the position of the snowline relative to basin hypsometry, which along with energy input influences the seasonal pattern of runoff formation.

The sixth session moved down to earth with *Ground-based radar observations*. It began with **Paul Hardaker** outlining the future impacts of both Doppler and polarisation-diversity weather radar on hydrology: the former improved quantitative rainfall estimates and the latter was able to distinguish between types of precipitation and therefore identify the melting layer. Developments in conventional reflectivity radar were covered by **Ewan Archibald**, including opportunities to improve data quality further and provide information more carefully tailored to specific operational requirements. Data quality was then studied in greater depth, firstly by **Dawn Harrison** who discussed how the Meteorological Office Nimrod system corrects radar estimates of precipitation by relating reflectivity measurements to precipitation rates on the ground, and then by **Andrew Lane,** who focused on using vertical reflectivity measurements and verification raingauges to reduce bright band errors and hence improve data accuracy and reliability.

The only drawback of the Symposium so far had been that delegates were missing out on the beautiful weather outside. So — after **Steven Crow**, the Environment Agency's Project Manager of the River Irwell Flood Defence Scheme, had outlined the reasoning for the choice of project, design and present status of construction — delegates spent an interesting and enjoyable afternoon in the sun: firstly at Salford Quays and then at the aforementioned Irwell flood defence project. This was followed in the evening by the Symposium Dinner in the magnificent surroundings of Tatton Hall in Tatton Park in the

Cheshire countryside.

The final day began with Session 8, *Aspects of climate change*. Its first paper was **Duncan Faulkner**'s comparison of three daily rainfall generators, designed to scale down monthly climate change scenarios. Hydroclimatic variability was then the focus as **Miranda Foster** described the nature, causes and impacts of recent variability in Scotland and Northern Ireland, postulating an unequivocal link between the flood generating mechanism (in terms of Lamb's synoptic weather types) and the growth curve of the resulting flood frequency distribution. Turning back to General Circulation Models, **Rob Wilby** compared several downscaling models based on airflow (vorticity) indices with two GCM simulations. Precipitation scenarios produced by downscaling were then compared with area average precipitation generated by HadCM2 for present (1980-99) and future (2080-99) climate scenarios. **Chris Hughes** looked at potential impacts of climate change on water resources: his paper assessed how specific scenarios are likely to affect the resource yield in supply networks and evaluated alternative operational strategies or investments to manage the impacts of climate change. Finally in this session, **Chris Kilsby**'s paper linked Hadley Centre GCM output with impacts on flood frequency, low flows and flow duration curves, using a chain of climate scenarios, downscaling methods for precipitation and validated hydrological models.

Session 9, *Aspects of hydrological modelling*, concentrated on the modelling that had been an integral part of many preceding presentations. **Mark Brown** described a summer flow estimation method based on a relationship between summer and annual flows, designed to be applicable elsewhere in a catchment. A method of incorporating information from annual flow duration type curves was used for validation. **Joanne Cheesman** used GIS and remote sensing to model upland catchment yield, noting substantial errors in evapotranspiration in both GIS-based and conventional methods, with overestimation in mountainous areas and underestimation in upland areas. **Keith Beven** then delivered two papers. The first showed that by using remotely-sensed, multi-temporal single frequency microwave (ERS-1 SAR) imagery in combination with a topographic index and limited ground truth data, the range of feasible model parameter sets could be constrained relative to calibration on discharge data alone. The second considered the variability of surface fluxes at the landscape scale, this time using LANDSAT-TM images to derive uncertain estimates of the land surface-atmosphere sensible and latent fluxes over a period of time, and then used a fuzzy disaggregation approach to examine these image estimates.

Neural network rainfall-runoff modelling was covered by **Robert Abrahart**, beginning with the training of the model on 1985 (normal climatic regime) data and then moving on to test its forecasting abilities which were then compared with TOPMODEL results. Finally, the use and development of a real-time flood forecasting system developed by the Water Resources Research Group at Salford University was described by **Owen Wedgwood** of EA North West, where it is in operation. The system's flood forecasts are produced via the use of rainfall runoff and flow routing models fed by radar and raingauge rainfall measurements and telemetered river flow data. Future possibilities were also covered such as the potential for the dissemination of WRIP information through internal WWW networks.

The new BHS President, **Frank Law**, closed the Symposium just as everyone's brain was about to overflow, with the award of prizes for best papers to Chris Soulsby for his paper 'Groundwater influence on the hydrology and hydrochemistry of upland streams in Scotland' and Rachael Dils for 'Hydrological controls on phosphorus loss from agricultural systems'. All the technical papers are published in the Symposium Proceedings. Copies may be ordered from **Jenny Reddaway** using the publications form enclosed.

The authors of this synopsis were both grateful recipients of travel grants from the BHS97 Organising Committee.

Rachael Dils and Michael Steel

The Penman lecture

"Hydrological basis for sound management of water resources"

by **Professor Uri Shamir** (Director, Water Research Institute, Technion–Israel Institute of Technology; President of IAHS 1991-95; Vice-President of IUGG 1995-99; Fellow of the American Geophysical Union & the American Society of Civil Engineers; Member of Board of Governors, World Water Council)

Incoming President Frank Law, outgoing President Mike Hamlin, fellow hydrologists, members of the British Hydrological Society, ladies and gentlemen: I am greatly honoured by you and your Society to have been asked to deliver this year's Penman Lecture.

My experience is largely in analysis, planning and management of water resources systems. This work is anchored in the physical world of hydrology and hydraulic engineering, but encompasses also economics, the environment, social aspects, as well as the institutional and political dimensions.

My work has included preparation of regional and national water plans, and of water policies, in Israel and in other countries, and participation in the negotiations on water between Israel and its neighbours — Jordan and the Palestinians. It was this last duty which kept me from giving the Penman Lecture two years ago, when I was first invited. I am delighted and grateful that you have given me another chance.

This series of lectures is named after Howard Penman, who developed basic and seminal contributions to our understanding of the hydrological cycle. The water which is available for terrestrial processes is a relatively small difference between two large quantities — rainfall and evaporation. Small changes in these quantities can make a significant difference in runoff, and in the amount of water available for beneficial uses. It is therefore important to have a good grasp of the processes of precipitation, evaporation, transpiration, infiltration and runoff, in various settings, if one is to propose means for managing the physical environment with the objective of achieving a more beneficial division of the precipitation into the different components of the hydrological cycle.

Penman's contributions to the theory and practice of computing evaporation have therefore enhanced our ability to manage water resources more effectively.

Hydrology has two aspects — scientific and applied — which are closely intertwined. Scientific hydrology seeks to understand and explain the hydrosphere as part of the physical world we live in. People like Walter Langbein, Jim Dooge, Howard Penman and Pete Eagleson — this year's recipient of the Stockholm Water Prize — have helped make hydrology a science with both a local and a global perspective.

Applied hydrology responds to our need to manipulate the natural environment for the benefit of humanity, and of the species that share this earth with us. The need to manage water resources focuses our attention on those issues of scientific hydrology in which there are still knowledge gaps, where better understanding and tools are required.

In planning, designing and operating well-defined and relatively simple water resources systems, the



Professor Uri Shamir at Salford

hydrological, engineering and economic aspects seem to be dominant. As one progresses to larger and more integrated systems — at the municipal, regional, national and international scales — it becomes obvious that the non-technical dimensions — political, institutional and even bureaucratic — acquire a much greater significance, often overshadowing the technical ones. But even in the seemingly simple cases, the role of applied hydrology is actually to support decisions and policies.

While water management is shaped in the political arena, hydrology is important as a basis for decision making. An inadequate or inaccurate picture of the hydrology steers the deliberations into wrong directions. Hydrologists and water resources specialists must, as the saying goes, "speak wisdom to power". It is from this perspective — a combination of the scientific basis with experience in the decision making domain — that I offer you my reflections, relating to the hydrological basis for sound management of water resources.

I would like to dwell on only two of the areas of hydrology which relate to sound management of water resource systems. The first is *uncertainty*, the other the *spatial scale and variability of hydrological phenomena.* I shall illustrate by projects in which I have been involved over the years.

Uncertainty poses a continuing challenge in analysis, and even more so in bringing about implementation of decisions and policies. Most of the parameters we deal with are uncertain: discharges and water volumes, watershed and aquifer parameters, future demands, potential new technologies, emerging economic conditions, costs and prices. The question is how to take uncertainty into consideration in developing policies and plans and in proposing them for decision making.

To illustrate, let us examine the operation of reservoirs, used for water supply, hydroelectric power generation, streamflow augmentation, navigation on waterways or flood control. A great variety of approaches and models have been developed and applied over the years, and yet forecasting inflows into reservoirs, and the use of forecasts in making management decisions remain challenges in both study and application.

For reservoir operation, inflow forecasts have to be generated for two spans of the time horizon. The first is the short-term, which lasts between several hours and a few days, depending on the time constant of the watershed, and the second is everything beyond that. For the short term, inflows are simulated with a watershed model, starting with the current conditions on the watershed — soil moisture, snow cover, and volume in the various storages — and using the short-term weather forecast to compute a deterministic sequence of inflows.

Since the watershed conditions are never adequately measured, the initial conditions for this simulation are provided by continuously running the watershed model, which tracks past events up to time "now". The short-term forecast should also use measured upstream flows, when available, routed hydraulically down the river and into the reservoir. This short-term forecast is essentially deterministic, although some perturbations may be imposed. It can typically extend over no more than a few days.

Beyond that, only probabilistic forecasts are possible, which can be computed in several ways. The first is to take the historical flows, consider each year as one realisation from the population of all possible annual inflow sequences, and rank these in some probabilistic order.

Another way, which can be very useful if there are only few years of streamflow data but many more years of weather records, is to use the watershed model and generate annual sequences of flows with the weather as input, starting from the condition of the watershed at the end of the short-term forecast mentioned above.

A third method is to develop a time-series model, from the measured or computed past streamflows, and use it to produce synthetic sequences. This, however, amounts to the same as the probabilistic forecast mentioned above, since the information content of the time-series model can be no more than that in the streamflow records themselves.

Assigning probability measures to whole sequences of inflows is not a trivial matter, but, more importantly, it is very difficult to bring such probabilities across into the decision making arena. Experience with real-time operators and also with managers of reservoirs shows that they are typically conservative. This may be for a good reason from their personal perspective: there is no reward for rationally based risk taking, even if the expected value of outcomes is improved by the risky action, while there is a severe penalty for any short-term failure, even if the action can be justified on the basis of a rational long-term view.

Several cases of hydropower systems operation illustrate this. For daily and weekly operation, the objective is to maximise the monetary value of the energy generated, by determining reservoir releases and turbine loadings. For annual and multi-year operation, the objective is to recommend monthly or weekly reservoir operation, target reservoir levels at the end of the planning horizon and suggest contract arrangements with adjacent utilities for the purchase or sale of energy.

Operators and managers were initially quite reluctant to accept the operating plans computed by the optimising model, even though it included consideration of inflow uncertainty. It took them sometimes several years to adjust and accept the results. Ex-post comparison of what the operators actually did with what the decision support system recommended convinced them to follow the optimised operating plans.

The same decision support system switches to a different mode when the reservoirs are full and flooding is imminent: the objective then is to minimise flood damage around the reservoirs and in the downstream rivers.

In another case a city was seeking a licence to increase its water withdrawals from a river, while the department of fisheries objected. The variability of river flows was a major issue. Fisheries declared that the flow must never drop below a specified value, and was not willing to adjust this value to hydrological conditions.

Analysis of the hydrology and the river hydraulics, with multi-objective optimisation of reservoir operation for fish flows and for city water supply, combined with a scheme for counting the arrivals of spawning fish in real-time, resulted in the granting of the licence. And while a greater annual amount of water from the river is being diverted to the city, the number of fish spawning in the river was increased substantially over the original claim by fisheries. Here hydrological variability was used to advantage, in an analysis which also recognised uncertainty.

In the Jordan-Israel Treaty, the waters of the Yarmouk and the Jordan Rivers are allocated between the parties. The river flows are naturally uncertain, which had to be recognised in the Treaty. Israel's allocation from the Yarmouk was given priority (12 Mm^3 in 154 days of the "summer" period, and 13 Mm^3 in 211 days of the "winter"

period), while the Hashemite Kingdom of Jordan gets the rest. In addition, "Jordan concedes to Israel pumping an additional 20 Mm^3 from the Yarmouk in winter in return for Israel conceding to transfer to Jordan during the summer period the quantity specified in paragraph (2.a) below from the Jordan River" (Annex II, Article I-1b).

In return, "...Israel concedes to transfer to Jordan in the summer period 20 Mm^3 from the Jordan River directly upstream from Deganya gates on the river. Jordan shall pay the operation and maintenance cost of such transfer through existing systems (not including capital cost) and shall bear the total cost of any new transmission system" (Annex II, Article I-2a).

The dam on the Yarmouk River, which is yet to be built, close to the existing diversion to the Jordanian King Abdallah Canal, is being designed to enable Israel to take its allocations with priority, under all hydrological conditions, while at the same time allowing Jordan to take as much of the remaining water as it deems technically feasible and economically desirable. It must also provide for taking the 20 Mm^3 which Israel stores in its system for Jordan. On the Jordan River, the arrangement is reversed: Jordan has priority allocations and Israel can take all the rest.

The spirit of confidence and co-operation in the Jordan-Israel Treaty is revealed by the fact that Jordan has constructed the pipeline from the Jordan River to its system, partly in Israeli territory, and operates it, while in the Arava Valley Israel continues to operate wells and to explore for additional groundwater in Jordanian territory.

In the discussions that led to the agreement, the hydrology of the Yarmouk River and its temporal variability played a significant role. Jordan wished to ascertain how much water it is going to get from the Yarmouk. To secure political and public approval of their achievements, the Jordanian negotiators had to present the quantities which Jordan is and will be getting under the Treaty. The public at large, the politicians, and even many professionals, have great difficulty in relating to the hydrological variability of the quantities, and many arguments ensued.

It is not possible to conduct a political discussion in which probabilities appear. Averages are used, even though the effects of variability are critically important. So the Treaty is constructed in a way which recognises hydrological variability, but is expressed in deterministic terms.

It is worthwhile noting that the term which appears in the Jordan-Israel Treaty for these quantities is "water allocations", not "water rights". The parties agreed to stay away from a legalistic framework and base the agreement on a pragmatic approach — specified quantities, with prescribed qualities, at certain locations and times. Article 6 of the Treaty states that Jordan and Israel have reached "... a comprehensive settlement of all water problems between them." and that they "... mutually recognise the rightful allocations of both of them in the Jordan River and the Yarmouk River waters and the Arava/Araba groundwater, in accordance with agreed acceptable principles, quantities and quality as set out in Annex II".

This must be regarded as a sign of maturity in the relations between the two parties. International water law does not provide hard-and-fast rules for allocating water among parties: it lists a set of criteria that should be considered, but prescribes no specific priority among them. The parties concluded that relying on "water rights" defined according to international law would not provide a specific resolution of their water issues.

The Palestinians, on the other hand, demanded firmly that their water rights should be recognised. The difference is probably due to the fact that Jordan is an established state and places less importance on declarative statements, while the Palestinian Authority is a nascent entity, which seeks to declare its rights. Thus, Article 1 of the interim agreement between Israel and the Palestinian Authority, the Oslo II Agreement, states that "Israel recognises the Palestinian water rights in the West Bank. These will be negotiated in the permanent status negotiations and settled in the Permanent Status Agreement relating to the various water resources".

The main water resource of interest between Israel and the Palestinian Authority is the Mountain Aquifer. It lies underneath the mountains of the West Bank, and has three sub-basins, which flow to the west, the north-east, and the east respectively.

The largest sub-basin is the western one, which continues underneath Israel's coastal aquifer towards the sea. Israel has been using most of the waters of this aquifer since before the 1967 war, initially from springs and then through wells drilled within its territory into this deeper aquifer. The north-east basin feeds water sources within Israel, in the valleys of Yizrael and Beit-Shean. The eastern basin is not yet fully developed.

The Oslo II Agreement deals in Article 40 with water and sewage. It recognises hydrological variability and the need to manage the aquifers accordingly. The Agreement contains data on the three sub-basins: existing extractions (at the time of the Agreement) by each of the two parties, and the hydrological potential of each sub-basin. The quoted potential is an estimate of the average recharge. To deal with variability and uncertainty, the Agreement requires the Joint Water Committee to adjust the extractions: "When conditions, such as climatological or hydrological variability, dictate a reduction or enable an increase in the extraction from a resource, the JWC shall determine the changes in the extractions and the resultant supply. These changes will be allocated between the two sides by the JWC in accordance with methods and procedures determined by it" (Schedule 5, 1(d)).

The uncertainty associated with the aquifers themselves, not only the variability of the recharge, is also reflected in the agreements. Israel continues to operate wells it drilled in the Arava Valley, north of Eilat and Aqaba, which are now in Jordanian territory as a result of border adjustments. The agreement states that, in addition, "Israel may increase the abstractions from wells and systems in Jordan by up to 10 Mm^3/y above the yields referred to in paragraph 1 above [the existing wells], subject to determination by the Joint Water Committee that this undertaking is hydrogeologically feasible and does not harm existing Jordanian uses" (Article IV(3) of Annex II to the Treaty). Since the Treaty was signed, in October 1994, this has not yet been implemented. Some of the delay has been due to hydrological uncertainty, or at least the absence of an agreement on the hydrological information, but most of is due to the political atmosphere.

Both water agreements — with Jordan and with the Palestinians — should be viewed in the context of the overall agreements, not in isolation. The Israel-Jordan Treaty is a final settlement of all issues between the parties, including, among others, borders, security, refugees, water, energy, environment, trade and tourism. The Oslo II Agreement between Israel and the Palestinian Authority is an interim agreement: according to the Madrid process, the final settlement is to be concluded by 1999. And here too, the agreement covers a wide spectrum of issues.

Thus, in both cases, the water chapter cannot be separated from the other components of the agreements. The politicians who led the negotiations had a much broader scope to consider than water alone. They may have decided to concede in one area in return for some achievement in another. Some of the published analyses of these agreements fail to recognise this, and judge or criticise the water agreement without reference to the broader context.

In both cases the agreement establishes a Joint Water Committee, with equal membership of the two parties, a joint chair and no casting vote. There is no mention of arbitration, so the parties have to work out their differences. The Joint Water Committee, in each case, is charged with implementation of the agreement and any additional issues which may arise. In the Palestinian case, the JWC is largely

concerned with water supply and operation of the water distribution systems. Hydrology of the Mountain Aquifer is, however, an important issue.

In the case of Jordan, much of the work has been concerned with hydrology. This includes:

- Selecting the size of the reservoir on the Yarmouk River and the details of the dam structure and outlets. The streamflow data used will determine the amounts which each side can expect to get, for a given reservoir size and dam design.
- The same hydrological data will also figure in the evaluation of downstream effects on environmental habitat, including erosion and deposition.
- The PMF for the dam has to be estimated, for dam stability and for prevention of the flooding of the town of Al Hamma upstream.
- The hydrological balance of the Jordan River, from the outlet of the Sea of Galilee, through the confluence of the Yarmouk River, and down to Wadi Yabis/Tirat Zvi — the point along the Jordan where the old border of the West Bank began — has to be agreed.
- Geohydrology of the Arava Valley, continued operation of existing wells, replacement of failed wells, and locating wells for the additional water to Israel.

The second area of hydrology which is important to water resources management is *spatial scale and variability*. We often think of this as relating to the connection between GCMs and terrestrial hydrology, while I wish to discuss this in relation to scaling up from point processes.

Processes at the point scale are examined with idealised models — a vertical column of the atmosphere, down to the land surface, and then below it into the soil — using specific values of the parameters. Two- and three-dimensional models (of the atmosphere and the rainfall field, of the surface, and of the soil below) can be conceptualised, but the assignment of parameter values throughout these spaces poses problems.

Spatial variability can exceed by orders of magnitude the range of values measured in the laboratory or at a number of points in the field. Also, the spatial correlation structures of the values — of parameters and of the hydrological phenomenon itself — are difficult to ascertain. The solutions of real world problems are therefore not sufficiently reliable. Scaling up from point to plot, then to a field, to the watershed, to a whole region and beyond remains an open challenge.

Water resources management is usually thought of as dealing with quantities at scales of the watershed and beyond. But there is much to be accomplished at the micro-scale, as a contribution to better management of our water resources.

Agriculture is the heaviest user of water: about two thirds of total use worldwide, and even more in certain countries. As population rises, more food will have to be produced. The greatest contribution towards meeting future food needs of the world is through more effective utilisation of water for crop production, in both rainfed and irrigated fields. Work by **Batchelor**, **Butterworth** and **Wallace** at the Institute of Hydrology (and by others) is demonstrating how agro-technology can manipulate the physical environment above ground, at the land surface, and below it, in ways which improve the efficiency of rainfall in producing crop yield. In parallel, irrigation techniques are designed to make as much of the water available directly for the productive process of the plant, minimising losses by evaporation, deep infiltration and runoff. There are experimental results for the plot level, while scaling up to a watershed and region is still not reliable.

There is a claim that some of the water which runs off from the individual field may not be lost at the watershed scale, because it shows up in the water course as return flow. This may be the case in certain places, but not in others. In any case, it is better to use rainfall and irrigated water on the field itself, rather than depending on a second chance to capture it. This water may escape from the controlled domain, and, even if it doesn't, it requires additional pumping and conveyance back to the field, and it will be of lower quality after having gone through the cycle once.

In urban areas, conventional development practices increase runoff and reduce infiltration. Work conducted in the last decade, in Japan, Australia, Yugoslavia, Israel, the USA and here in the UK, shows that this can be changed, that water-sensitive urban planning can mitigate the undesired effects. This is done by on-site infiltration, which enhances groundwater resources, reduces runoff and loads on the drainage systems and can decrease damage in downstream areas due to flooding.

This is achieved by proper spatial distribution of pervious and impervious areas, by directing runoff from roofs and other impervious surfaces so it enters the soil in open spaces and through simply constructed infiltration facilities. The key is at the micro-scale: the individual house, its yard and garden, the city block and neighbourhood. And again, as in agriculture, scaling up from the micro results is still an open challenge.

We have conducted a modelling study of a typical new neighbourhood in Israel's coastal plain, where most of the population is concentrated, and evaluated the potential for additional infiltration that can be achieved by connecting roof drains to pervious areas in the yard. The results show that a third of the water which would be lost as runoff due to conventional urban development can be infiltrated. It is not feasible to allocate space for large retention and infiltration basins in the urban area.

The proposed policy is to concentrate at the micro-scale, to institute land use practices and incorporate facilities which accomplish the desired changes in the hydrological cycle. This includes requirement for a minimum of impervious areas, properly spaced in the yard, and for directing roof and yard runoff to open spaces and to simple infiltration structures — buried horizontal ditches and vertical infiltration wells.

Before recommending a policy of water-sensitive urban planning, we must project these findings to the coastal aquifer, Israel's largest reservoir, which underlies 1900 km^2 in the coastal plain. One third of this area is already built, and it is projected that by the year 2020 another third will be urbanised. We have estimated that implementing the means mentioned earlier can increase infiltration by some 30 Mm^3/y, in the areas yet to be developed. If the same can be done in the already existing urban areas, then the total saving may double. This is a first estimate, and we still have to substantiate the scaling up from the micro scale to the entire coastal plain. Precipitation fields, micro climate, topography, properties of soils at the land surface, zoning and building practices, stratigraphy, groundwater location and quality — all vary spatially.

Thus in both cases (agricultural fields and urban areas) scaling up is needed, from the micro catchment to a whole agricultural farm or an entire city, and from there to the relevant watershed and region, taking proper account of spatial variability at all scales.

Before concluding, I would like to mention two coupled topics, which in my view should receive more attention, since they are important in hydrology itself and for water resources management. These are *hydrochemistry* and *hydrobiology*.

Hydrologists are traditionally educated with little attention to the quality of water, and are concerned primarily with its quantity. More should be done to integrate water chemistry and biology into a common framework with water quantity.

Models that cover water quality — in rivers, lakes, reservoirs, groundwater, and also in water supply systems — are more difficult to construct, validate and run than those which describe flows and volumes only. On the other hand, if a combined quantity-quality model is able to predict flows as well as concentrations of tracers and contaminants, then the probability that it is a valid description of the real world is increased.

Combined models are based on

continuity equations for water and for constituents, together with equations which describe the interactions between the various species. Quality data are then used in the calibration of the model, in verifying its structure and determining parameter values. For example, the hydrological model of the lower Jordan River, below the Sea of Galilee, covers flows and salinity. Matching the spatial and temporal variations of flow and of salinity to field measurements (of which there are not enough) results in a model more reliable than would be with water quantities alone.

The Jordan-Israel Agreement calls for restoration of the lower Jordan River, preventing disposal of saline waters and of wastewaters. Israel has been diverting about 20 Mm^3/y of saline waters, from springs and wells on the north-west shores of the Lake, through a canal, into the lower Jordan. The Agreement requires Israel to desalinate about 20 Mm^3/y of these waters, and deliver to The Hashemite Kingdom of Jordan 10 Mm^3/y of desalinated water. The brine is not to be discharged into the Jordan, and may have to be piped to the Dead Sea, over 100 km away. Wastewaters can not be discharged into the Jordan and Yarmouk, unless they are treated to a quality suitable for unrestricted agricultural use.

The bacteriological quality of surface and ground waters is similarly an important factor. Combined analysis of quantity with chemical and bacteriological quality can yield a more robust model, and serve to track water quality in the sources and the supply systems.

Ladies and gentlemen, it may seem that after many years of work in hydrology there is little left to accomplish, that most of the interesting and challenging work has already been done. There is nothing further from the truth.

It is an exciting and challenging time to be a hydrologist. The world we live in is becoming more difficult to manage, due to the pressures of increasing populations, to stress on the resources and to environmental concerns. Hydrologists must continue to develop knowledge and put it at the disposal of society, so we can make sound decisions in managing our precious water resources.

Uri Shamir

BHS Annual General Meeting

Held at Salford University 16 September 1997

Present

Mike Hamlin (President), Frank Law (President-elect) and 53 other members.

President's introduction

In his introductory speech, **Mike Hamlin** reminded us how much BHS has to give hydrologists. We hold higher quality meetings than many other institutions, at lower cost, in a very friendly atmosphere. Mike Hamlin's particular initiatives had been to expand the membership, and to raise funds for young people to attend the Exeter Conference next year. So far ten donations had been received, raising more than £500: more would be very welcome. Looking to the future, BHS was poised to make a significant contribution as a Society, with the UK rejoining UNESCO and the regrouping of the UK Hydrological Committee, contributed to by BHS and academics.

Mike said it gave him great pleasure to hand over to **Frank Law**, whom he held in great respect for his fund of knowledge, and felt he would bring a great deal to the post.

Frank acknowledged the welcome, and hoped he could indeed make a beneficial impact. There was a tradition of committed committee members and an appropriate mixture of legality and informality. He encouraged all members from whatever background, especially younger ones, to contribute freely.

Minutes of the previous AGM

The minutes of the previous AGM were taken as read.

Hon. Secretary's report

by Hilary Smithers

It is my privilege as the Hon. Secretary to give you a report of the Society's activities over the last 12 months. I will aim to give a personal yet balanced picture of what has been a year of solid progress.

We continue to organise the best, and certainly the cheapest, technical meetings in hydrology on a wide range of topics. Since the last AGM we have held six National meetings, in locations ranging from Exeter to Stirling. These included the annual post-graduate symposium at Imperial College. We have continued collaboration with other Societies, including the Welsh and Scottish Hydrology Groups, British Dam Society, and the Soil Water Physics Group. Our Regional Groups continue to provide an extensive programme of stimulating meetings somewhat closer to members' homes and a useful talking shop.

On behalf of Society members I would like to extend my thanks to **Kevin Tilford** and his backing team here in Salford, who have risen magnificently to the challenge and the high standards set by previous symposia. We have had a stimulating start and I look forward to the rest of the week. The BHS Symposium is always an opportunity to broaden one's viewpoint and find new ideas from other areas of hydrology, which I think is one of its strengths.

We have come to expect high standards of the proceedings, and once again **Celia Kirby** and **John Griffin** and the team at IH have produced an excellent volume to a very tight schedule. I would also like to thank the team of reviewers who have given the document an extra layer of authority.

Looking ahead, we have three National meetings scheduled:

- A BHS workshop on ecohydrology, on 18-19 October in Sheffield, jointly with the British Ecological Society;
- We are planning a meeting with the Challenger Society in February to discuss the results of the LOIS project;
- In March there will be an opportunity to learn more about the current review of water company yields, and to discuss the methods employed.

There will also be the usual programme of regional meetings.

However the major event of the year will be the first BHS International Conference, entitled *Hydrology in a Changing Environment*, to be held in Exeter next July. Plans for this are progressing well, with 290 abstracts accepted for oral or poster presentation. Oral papers will be published in three volumes by John Wiley; posters in a separate volume by BHS. Substantial funds have been donated by UNESCO to subsidise attendance by author delegates from developing countries, with further support from the UK Department for International Develop-

ment and also WMO. This promises to be an exciting event and I urge you all to put it in your diaries now.

Plans are also well advanced for the publication of a BHS book, *The Changing Hydrology of the UK*, edited by **Mike Acreman**. An impressive range of contributors has been signed up, who are now producing the material.

The Society continues to liaise with other institutions and societies, both in the interests of hydrology in Britain, and also with a view to the long-term viability of BHS itself.

On a less happy note, we have been unable to convince the Millennium Commission to support our project to produce a time capsule of hydrological data on CD-ROM. It is possible that this will re-emerge in another form in due course, but I would like to thank **Max Beran** and the rest of his committee for all their efforts.

This is also the place to express my thanks to all the Main Committee members for their often unseen efforts on behalf of BHS through the year. **Richard Davis**, **Angela Gurnell** and **Laura Baird**, who are retiring, have made significant contributions to the work of the Committee. We also lose **Richard Harpin** as Hon. Treasurer, and of course Michael Hamlin as President: I have greatly enjoyed working with both of them, and they also smoothed my path when I became Hon. Secretary. We are, as always, very ably supported by the administrative team at ICE, and my personal thanks go to **Richard Howard** as Secretary.

I would like to formally welcome the new members of the Committee, starting with **Frank Law**, who we are delighted to have as our President. I only hope I can keep up with his tireless enthusiasm and commitment to hydrology! **Terry Evans** has agreed to serve as Hon. Treasurer, and I look forward to meeting him on his return from Khazakstan. As ordinary committee members we welcome **Andrew Black** (University of Dundee), **Peter Walsh** (independent consultant) and **Rob Scarrott** (Halcrow).

I see it as very important to maintain a balance on the Committee between practitioners and academics; industry and regulator. The new members bear this out and I am sure they will make an excellent contribution, but (to echo one of my predecessors) it would be encouraging to have more elections! I know how busy everyone is these days, but next time nominations papers are issued, please all give some thought as to whether you could serve on the Committee.

On a similar note, this year we have made some efforts to sound out members' views, with very little response on the whole. The Committee has tried hard to do what members want, but this is hard if you don't contact us. So please let us have more dialogue on what you see as the most important issues facing the profession and how you would like BHS to be run. My e-mail address is in the Committee list!

I don't want to end on a gloomy or hectoring note, because many positive things are happening in British hydrology and in the Society, and I look forward to the future with optimism. It has been both a challenge to my time-management skills and a privilege to serve the Society as Hon. Secretary so far and I look forward to my continuing term of office.

Hon. Treasurer's report

Copies of the Society's accounts were circulated, in a much extended form to previous years. Richard Harpin explained that this was due to new and onerous requirements by the Charities Commission, designed to cut down fraud. There was also a need to change the Constitution, which the Hon. Secretary would investigate.

It was difficult (as always) to assess the membership figures, because of a variety of reporting dates and deadlines for late subscriptions. He believed there was some long-term growth, but not quite up to target. However the financial position was better because we had fewer student members. Finances were healthy and there was no need to increase subscriptions.

Mike Hamlin proposed that we should consider paying half the Exeter registration costs of student researchers with no access to other funds, and this needed good advance publicity. The Committee would consider it further.

Anthony Tollow proposed that the accounts be accepted, which was agreed by the members present.

Report of Editor of *Circulation*

John Griffin echoed thanks to Kevin Tilford and the Symposium organisers. He also thanked members for their articles, meeting reports, book reviews, news, pictures, diary entries and many other contributions to *Circulation*.

The President's Piece had been a regular feature, one that he was sure Frank Law would continue. Book reviews had been revived and new reviewers were always welcome. It would be good to have more news from members and the regions. Meeting organisers were asked to send the programme to the editor, since the information collated by the Hon. Secretary is only in outline. A new poster of meetings would be produced following the next issue of *Circulation*. Please tell the editor if you can display one in your department.

John concluded by thanking the Committee for their support, as well as Celia Kirby and colleagues at IH and Richard Howard at the ICE.

Matthew Lees asked whether there were any plans to publish *Circulation* on the Internet. This was technically feasible, but as *Circulation* was one of the main benefits of paid membership, the Committee would consider how to proceed without harming membership numbers.

Changes to BHS Committee

The Committee list appears on page 10.

Other business

Angela Gurnell was relinquishing her role as publications officer, and Frank Law thanked her for her hard work. Her replacement is **Jenny Reddaway** at Salford University.

Frank extended his warm thanks to Mike Hamlin for his two year's Presidency, coming at the end of his period as a Vice-Chancellor. He had promoted the Society in many circles and was now busy helping to organise the IUGG Birmingham meeting in 1999. He had also been able to lobby for the Society in the highly influential Royal Academy of Engineering. Finally Frank hoped that Mike would very much enjoy the next period of his life.

Referees and sponsors

Thanks are expressed to the referees who reviewed the papers for the Salford Symposium proceedings before publication: Dr Peter Walsh, Dr Richard Griffith, Dr David Collins, Dr Dawei Han, Dr Kevin Tilford, Mr Neil Fox and Dr Geoff Shepherd.

The Symposium's success was due also to its sponsors: the Institute of Hydrology, NISC Information Services, United Utilities (North West Water), Yorkshire Water and the Mersey Basin Business Foundation — their support is gratefully acknowledged.

Visiting professor

Professor Steve Chapra of the University of Colorado, Boulder, USA is visiting the Civil Engineering Department at Imperial College for a two-year period from October.

Steve is well-known for his McGraw Hill textbooks on *Surface Water-Quality Modelling* and *Numerical Methods for Engineers* and his two-volume book on *Lake Management*.

There will be an opportunity to hear of his recent work on lake water quality management, including carbon cycling and the drinking water implications of trihalomethane production, at the BHS Southern Section meeting on *10 December* at Imperial College.

Howard Wheater

President's piece

BHS is one of those bodies where much of the satisfaction comes simply from being thoroughly involved. It is a pleasure to try and make my Presidential years useful to the profession and to the wider society which we serve. Once people know what hydrologists do, it is clear that we rank reasonably high in their value judgement of jobs. It also helps when 'one of us' goes on to senior management elsewhere.

Professor Mike Hamlin did that and then returned! Hence the gratitude that I expressed at the AGM in Salford for his presidency, which followed immediately on his retirement from a Vice-Chancellor's office.

When your committee met in October it looked both backwards and forward. We thanked **Kevin Tilford** for his organisation of the Salford Symposium, ably supported by a Telford Institute team from post-grads through to Professors Ian Cluckie and Chris Collier. The volume of papers is good value, and the sponsorship ensured a modest profit for future re-investment. Watch out for two new initiatives, and let me know if you want to contribute in detail at national or local level:

- *National Floodmark Project: 1999-2000:* To place a modern mark at sites experiencing a 50 plus year flood in those millennial years.
- *A World Wide Web Hydrological Diary of Britain up to 1929:* To put searchable text of hydrological facts in chronological order into the public domain as a resource revealing variability and extremes of our rivers and groundwater.

Over 100 hydrologists (some overseas and some outside BHS) have now registered with the BHS-hydrology mailbase and so are able to share their news by e-mail. This is doubly valuable when a regional meeting programme has to be changed or a rapid response is needed to a query that is dogging your work. If you haven't tried its value then e-mail me (f.law@ioh.ac.uk) and I will forward to you the exceedingly easy way to join in.

Frank M Law

Toolbox — plea for new editor!

Most of the work of compiling the *BHS Hydrologist's Toolbox* has already been done. What remains to be done is the job of assembling the contributions into a form ready for publication.

The proposal is for a concise source-book of methods, formulae, typical parameter values, nomograms and summary figures, combined with expert commentary, that a practising hydrologist — that Jack of all trades — can refer to in the office or in the field. It will represent the "knowledgebase" of experience of British hydrologists and will contain key references on each topic as a starting point for "digging deeper". It is not a textbook, but a set of tools to be used in practical situations.

There has been considerable interest in this project, which has had input from several members, but **Hilary Smithers** has had to relinquish the editorship because of pressure of work — and her duties and Hon. Secretary. If there is a volunteer willing to carry the *Toolbox* forward to completion, please contact Hilary (see Committee list) for more information.

7th BHS Postgraduate Symposium

Imperial College London
15-17 April 1997

Nineteen students from ten universities and colleges throughout England and Scotland attended the 7th BHS Postgraduate Symposium at Imperial College in April. There were twelve presentations by research students working in the field of hydrology. This year's meeting had prominent biological and ecological themes, which were reflected in sessions on hydro-biological processes and wetland hydrology.

A keynote address entitled *"Environmental history — has it a future?"* was given by BHS President-elect **Frank Law** on the historical development of hydrology. During his address, Frank shared some of the reasons for his own personal passion for the subject. He spoke of past heroes, such as Beardmore, who had helped to compile hydrological tables for both Great Britain and Europe, and reminded his audience that their work was building upon the foundations of data and insight of these Victorian pioneers.

A visit to the Thames Barrier on the Wednesday afternoon provided an opportunity to see the inner workings of London's tidal flood defence system.

As well as the president-elect, we were delighted to have BHS President **Prof. Mike Hamlin** attend the final day of the meeting. **Prof. Howard Wheater** concluded the symposium with a presentation on the hydrological and environmental issues associated with the construction of the Gabcikovo canal on the river Danube, which he had recently presented to the International Court in The Hague. It was a fitting end to this symposium, which had shown the wide range of social and ecological issues that hydrology now embraces.

A prize of £50 in book tokens, kindly donated by Thames Water Utilities, was awarded to **Rob Malcolm** (Aberdeen University) for his talk entitled *Hydrological processes in a restored coastal wetland, St Fergus, north-east Scotland*, which was voted best presentation of the symposium. All those who attended valued the opportunity to meet others working in similar areas and to obtain a flavour of research work being undertaken elsewhere in Britain's universities.

Adrian Butler
Imperial College

BHS Committee 1997/9

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New members of the Committee

Andrew Black is a physical hydrologist with research interests principally in flooding. He has been a lecturer in Geography at the University of Dundee since 1995, where he teaches courses in hydrology and analytical methods.

His research activities include studying the links between climatic variations and flood risk and assessing the economic damages of major floods. His earlier hydrological career began with a PhD at St Andrews on flood seasonality, and he then worked at the Institute of Hydrology's Stirling Office.

Rob Scarrott is a young Hydrologist working for Sir William Halcrow and Partners. His background is in water resources and he has been heavily involved in the modelling and audit work required for the Environment Agency's Reassessment of Water Company Yields.

Rob previously worked at the Institute of Hydrology. He hopes to bring new ideas to the Society so that it meets the expectations both of the research sector and of the consultant community.

Peter Walsh has specialised in hydrology and water resources for over 30 years, having held senior positions with North West Water Authority and the NRA. He is now an independent consultant and Chairman of the Pennines Hydrological Group.

Peter was actively involved in the formation of BHS and served on the committee during its early years. His main interests are in catchment management, the operation of water resource systems, flood warning systems and the use of weather radar.

Terry Evans has returned to the BHS Committee (after a break of eight years) — this time as Hon. Treasurer. In the meantime he has retired from consultants Mott MacDonald, where he was responsible for hydrological work, including water resources, flood control and hydraulic modelling.

However, his long interest in major river basin hydrology and climate change continues with his involvement in the Aral sea basin. Although Terry feels he should have more time available to devote to Society affairs, he admits to facing a struggle to keep Parkinson's Law at bay and fitting in all the other activities, which seem to mushroom with more free time.

Groundwater in the urban environment

International Association of Hydrogeologists XXVII Congress, Nottingham 21-27 September 1997

The annual congress of the International Association of Hydrogeologists (IAH) returned to the UK for the third time when the 27th congress was held in Nottingham in September. There were about 300 delegates, representing about 40 different countries, comprising a blend of academics, regulators, consultants and government bodies. Nottingham was an appropriate venue for the conference, since the city lies above a major UK aquifer.

The theme of the congress "Groundwater in the urban environment" was focused on an important problem: how groundwater-related processes and problems are being tackled in urban areas, given that by the year 2000 they will contain about half the world's population. There were six main topics:

- Urban groundwater processes;
- Geotechnical construction problems;
- Water supply experiences;
- Groundwater pollution hazards;
- Environmental management and planning;
- City case surveys and studies.

The congress was held over five days, with optional field trips over the subsequent weekend. The Monday began with workshops, before the official opening in the afternoon. A plenary session was held on the Tuesday morning and then parallel sessions — up to three running at any one time — continued throughout the remainder of the congress. There were three breaks: one for a field trip on Wednesday afternoon, the others for poster sessions on Thursday and Friday.

The plenary keynote presentations set the scene well and touched briefly upon several areas that were later examined in greater detail. **Chris Barber** (CSIRO, Australia) warned that in Western Australia the effects of urbanisation on groundwater often did not show for about 20-30 years. This highlighted the need for proper planning and management as urban areas grow, especially where groundwater is an important resource.

Several interesting points were presented and discussed, including the effect of urbanisation on the recharge to aquifers. **Mike Barrett** (Bradford University) estimated that the equivalent of 10 mm per annum of recharge could arise from leaking sewers in Nottingham. When coupling this with leakage from water supply pipes and the numerous soakaways present in urban areas, then the potential for urban recharge may prove significant. This will be contributing to the problem for cities with rising groundwater tables such as Barcelona and Cairo, and (closer to home) Birmingham and London. Some of the problems associated with rising water tables are adverse effects on foundations, and mobilisation of contaminants present in the unsaturated zone.

David Watkins (Exeter University) presented an overview of current European approaches to infiltration as a means to deal with stormwater runoff. **Bryan Ellis** (NERC) questioned the sustainability of such infiltration systems due to the lack of attenuation of contaminants, and warned that a more cautious approach should be taken with pre-treatment being considered.

Several interesting papers were presented on the topic of groundwater pollution hazards, including the development of an expert system, to assist in decision making processes for non experts. Also the construction and implementation of a GIS based tool for contaminated land assessment was presented by **Coran Kelly** (Newcastle University). There were papers illustrating how varying approaches to the assessment of groundwater resources and possible effects of contamination were implemented in various countries, including Lithuania, Romania, and Chile, giving an interesting comparison of the different approaches.

The threat of contamination was an underlying theme, which carried through most of the topics discussed, either directly by its presence and subsequent problems, or predicting where and how it may occur. Several papers examined the characteristics of contamination plumes and again stressed the importance of adequate monitoring to ensure that plumes are detected if they are present.

Various interesting field trips were organised for the Wednesday afternoon. One was to an opencast mine which aimed to yield 1.7 million tonnes of coal. The area formerly had a small river flowing on the surface, which had to be diverted while mining operations proceeded. However, because this river happened to form the border between Derbyshire and Nottinghamshire, stringent restoration has been required.

I would like to express my sincere thanks to the British Hydrological Society for the travel grant which contributed towards my attendance at this congress.

Kenneth A. MacDougall
University of Strathclyde

Hydrometric monitoring in the new millennium

Some thoughts from Andrew Black

I am currently working (with others) on an Environment Agency/SNIFFER commission looking at methods for economically quantifying the benefits accruing from hydrometric monitoring activities. It's a difficult area — there are no easy answers — but an important one too (as has been recognised in the literature over some decades).

The commission arises from an awareness (amongst our sponsors) of the desirability of being able to demonstrate the value-for-money of operating the monitoring networks — public expenditure must be justifiable. We do not yet have our final results: even when we do, it will be for our sponsors to disseminate them as they see fit.

Meanwhile, I would be interested in the views of someone who has been involved with hydrometric monitoring in Britain over a long period. The scale of activity has increased hugely since the 1950s, and there has been a commensurate increase in our knowledge of British streamflow characteristics and behaviour. Progress in rainfall monitoring has perhaps been less dramatic: the history there is longer and the evolution less dramatic. It could be argued that many of the initial objectives of establishing the national flow

monitoring network have now been met. But there has also been a large increase in the uses to which data are now put, not least as a result of the opportunities afforded by telemetry.

Some economic analyses (e.g. studies in Australia dealing with the design of structures) have shown benefits far greater than the costs of data generation; elsewhere, benefits may not withstand economic analyses, yet might warrant the support of local hydrometric agencies. The matter begins to get complicated, since the costs of data collection are borne by the tax payer, while the benefits may accrue to specific communities or contractors working on their behalf: the idea of selling hydrometric data to finance the networks just doesn't work (apparently).

So, why not let's stand back and take a measured look at this? At what level should we be considering the maintenance of our monitoring networks — to use a buzzword: what is sustainable? There will always be scope to install more monitoring instruments until the ground is entirely covered by them, but what is sensible? To what extent should we be able to rely on modelling or information transfer approaches, rather than supporting the costs of instrumentation and its associated servicing?

I think that a wide range of answers might arise from different perspectives, and there may be a danger of 'not being able to see the wood for the trees'. So I would value the opinions of an experienced hydrologist — I'm sure others involved with hydrometry would too — but, more importantly, we should think of the wider hydrological community who use the resulting data.

To take things one step further, I should like to volunteer **David Archer**. He has many years experience in hydrometry, and is able to take a more detached view of this subject since he left his position with the NRA (now the Environment Agency).

David is also no stranger to the pages of *Circulation* [see below - Ed.] and, in my opinion, he could be relied on to give some lively insights. The title above could be a starting point.

Andrew Black

The Flood Studies rainfall-runoff method— a fundamental flaw?

With the latest reorganisation of the water industry, the Environment Agency has set out with renewed vigour in assessing boundaries of potential flooded areas on rivers throughout England and Wales. Section 105 requires the delineation of the boundary of the flooded area in a 100-year return period flood. Such assessment, of course, requires both hydrological analysis to determine the discharge at both ungauged and gauged sites for the required return periods, and hydraulic analysis to assess the water level resulting from such a discharge.

Sophisticated models have been programmed such that they can be run and operated by staff with little professional understanding of the powerful tools they are using and their inherent assumptions and limitations. This is particularly the case with respect to flood estimation where MicroFSR embodying the procedures laid down in the *Flood Studies Report* and supplements is almost universally used in the estimation of both the instantaneous maximum and a flood hydrograph and volume. In some instances hydraulic modelling is based on raw flood estimates for ungauged locations using the rainfall runoff method which have not been adjusted for observed information at adjacent gauged catchments of time to peak (Tp) of the unit hydrograph or of percentage runoff (PR) which can make radical differences to such estimates. Differences of more than ±50% are not uncommon and resulting errors in the design flood level can be more than a metre.

However, even when such adjustments have been made, the rainfall runoff method is subject to inherent weaknesses which seriously limit its ability to reproduce observed flood frequency curves over the greater part of the UK. Errors of 50% in the 100-year return period flood are still possible. The reasons for the poor performance of the rainfall runoff method have been outlined in Archer and Kelway (1987) but this paper seems to have fallen into a black hole and its results have not been adequately recognised. In view of the extensive work currently in progress and the practical consequences both in terms of the level and cost of protection, it seems essential that these limitations should again be drawn to the attention of hydrologists, engineers and managers in the Environment Agency and consulting engineers.

Flood Studies rainfall runoff method outline

The rainfall runoff method is the only standard method in use in Britain to provide a flood hydrograph as well as peak discharge of specified return period. The intention of the method is to simulate a flood peak and design hydrograph of given return period by combining:

- a rainfall of given return period for a design duration,
- a percentage runoff derived from soil and climatic characteristics of the catchment,
- a defined time distribution (or profile) of rainfall over the design duration,
- a unit hydrograph response function to convert the effective rainfall to a flood runoff hydrograph,
- a standard baseflow to add to the flood hydrograph.

Assumptions and simplifications are involved in each of these components and the extent to which these assumptions are fulfilled, either in general or with respect to particular catchments, limits the accuracy of the resulting estimates. The complexity and apparent sophistication of the method has obscured its weaknesses.

The storm rainfall frequency

The most fundamental limitation arises from the specification of storm rainfall for different return periods and effects on flood growth. Using the rainfall runoff method, the growth curve (or slope of the flood frequency curve) depends primarily on the growth rate of rainfall — and only to a small extent on the growth rate of percentage runoff.

The growth rate of rainfall is a function of the Rf_5(M5)(5-year rainfall) for the selected duration for the catchment as defined in FSR Volume I Table 2.7. Typically Rf_5 lies in the range from 20 to 75 mm and is higher for larger catchments with longer design duration or for wetter catchments.

In order to compare the growth rate of rainfall with the resulting growth rate of flow, one can examine the standard ratio of Q_{30}/QBAR and Q_{100}/QBAR. Q_{30} is chosen as a return period which may be assessed with reasonable reliability from the typical amounts of data available and Q_{100} as the principal design return period.

Although there have been criticisms of the regionalisation element of the FSR statistical method (and revisions are under way), it still gives a reasonable indication of the average flood growth curve within the ten specified regions of the UK. Clearly some catchments will display values well below or well above the average. Average regional flood growth factors for the ten regions defined in FSR are shown in Table 1.

For rural catchments, the rainfall and runoff return periods are not the same; the recommended transformation is shown in FSR Volume II Fig 6.61. From this it may be seen that a rainfall

Table 1

	Region									
	1	2	3	4	5	6	7	8	9	10
Q_{30}/QBAR	1.89	1.90	1.75	1.96	2.40	2.27	2.27	1.91	1.77	1.69
Q_{100}/QBAR	2.48	2.63	2.08	2.57	3.56	3.19	3.19	2.42	2.18	2.08

of 2-year return period is associated with a mean annual flood (2.33-year return period) and a rainfall return period of 50 years is associated with a flood return period of 30 years. Hence the equivalent rainfall ratio to give a Q_{30}/QBAR is Rf_{50}/Rf_2. This figure and similarly the equivalent rainfall ratios for the 100-year flood may be extracted from FSR I Table 2.7 (below).

Conclusions concerning the operation of the rainfall runoff model can be drawn by comparing Tables 1 and 2.7.

Comparing average regional flood growth with rainfall growth factors, it can be seen that on rural catchments (URB < 20%), the rainfall growth rate is greater (and sometimes much greater) than the flood growth rate for both the 30-year (Col 5) and the 100-year (Col 7) events for all except Regions 5, 6 and 7 for M5 up to 50 mm. This is without taking into consideration any further growth arising from percentage runoff. The differences are greatest in the wetter regions (3, 9 and 10) and for small catchments with short design duration (and M5).

For urban catchments (URB > 20%) FSSR 5 recommends equality of rainfall and flood growth, but even here rainfall growth rates (Col 6 for 30-year return period and Col 8 for 100-year return period), rainfall growth rates still exceed the regional flood growth rate for several regions.

Percentage runoff growth

At an ungauged site the percentage runoff PR is calculated using FSR methods by using the equation:

$$PR = 95.5\,SOIL + 12.0\,URBAN + 0.22\,(CWI - 125) + 0.1\,(P - 10)$$

The first two terms of this equation are fixed and define the standard percentage runoff (SPR) for a catchment or station. The last two terms are said to be dynamic, but in fact for prediction the CWI (catchment wetness index) is also fixed, irrespective of return period leaving only the P term (storm total precipitation) as the dynamic term to influence PR with changing return period. This typically results in an increase (above a mean annual flood) of 3% in PR for a 30-year return period and 5% for a 100-year return period flood.

Since the increase is above a static percentage runoff (first three terms) the effect of the increase differs with the initial PR which is primarily dependent on SOIL. Typically for Soil Types 4 and 5, the percentage increase in percentage runoff is 6% for a 30-year and 10% for a 100-year flood. (i.e. PR growth rates of 1.06 and 1.10) and on Soil Type 1 the percentage increase in PR is 20% and 35% for 30 and 100-year return period floods respectively (PR growth factors of 1.20 and 1.35).

Combining FSR storm rainfall and PR growth

The effects of storm rainfall and percentage runoff growth on flood growth are approximately multiplicative. Hence on a catchment with an M5 rainfall of 50 mm for the design duration and Soil Type 4 or 5 the flood growth rate will be

2.03 x 1.06 = 2.12 (30-year return period)
2.48 x 1.10 = 2.73 (100-year return period)

and for Soil Type 1

2.00 x 1.20 = 2.40 (30-year return period)
2.48 x 1.35 = 3.35 (100-year return period)

Thus for example in Region 3 or 10 with soil Type 4 or 5, where QBAR is estimated accurately, the average error at Q_{30} will be of the order of 23% and at Q_{100} will be 31%. Actual errors on individual catchments can be much greater. More typically QBAR is underestimated and Q_{100} is overestimated and the FSR and data estimates coincide somewhere in the middle. The agreement is more in the nature of the clock which is correct twice a day than an indication of success in fitting.

Conclusions

Unless the rainfall runoff model was to produce a declining percentage runoff for increasing rainfall (which it does not), the fixed rainfall frequency table acts as a constraint on the ability of the model to reproduce observed flood growth. Over the greater part of the country the 100-year return period flood is seriously overestimated by the FSR rainfall runoff method. Underestimation is possible in Regions 5, 6 and 7.

The use of local data to redefine values of time to peak of the unit hydrograph (Tp) or of SPR as recommended in Flood Studies Supplementary Report No 13 does not alleviate the problem. The unit hydrograph component of the model has no effect on flood growth as the response is assumed to be linear. Locally derived SPR has limited effect and may even be counter productive (e.g. reduction in SPR will increase PR growth and resulting estimated flood growth).

The Flood Studies rainfall runoff method *cannot* be satisfactorily calibrated, as required in some current EA contracts.

The original problem in development and calibration of the rainfall runoff model arose primarily from the use or rainfall data sets for the meteorological and hydrological components of the analysis which did not match. Meteorological analysis carried out at the Met Office and described in Volume II, included all short period rainfall data; hydrological analysis carried out at the Institute of Hydrology and described in Volume I, used only those rainfall events which resulted in floods. Therefore the rainfall series for hydrological analysis was truncated and excluded all events with low percentage runoff where no flood resulted. The attempt then to reproduce the flood series from the complete rainfall series, has resulted in unrealistic combination of parameters and poor fit.

In spite of its simplicity the statistical procedure usually gives results which are much closer to those obtained from data. Adjustment in relation to surrounding gauged data is much more straightforward and reliable. The rainfall-runoff method can still be used to estimate a flood volume and hydrograph but with the ordinates rescaled by the ratio of the adjusted statistical and rainfall runoff method peaks, as outlined in Archer and Kelway (1987)

References

Archer, D. R. and Kelway, P. S. (1987) A computer system for flood estimation and its use in evaluating the Flood Studies rainfall runoff method. *Proc. Instn. Civ. Engrs.* Pt 2, 83, 601-612.

Institute of Hydrology (1979) Design flood estimation in catchments subject to urbanisation. *Flood Studies Supplementary Report No. 5.*

Institute of Hydrology (1983) Some suggestions for the use of local data in flood estimation. *Flood Studies Supplementary Report No. 13*

NERC (1975) *Flood Studies Report.* National Environment Research Council, London. Reprinted 1993, Institute of Hydrology, Wallingford.

FSR Volume I, Table 2.7

Rf_5 (M5)	Growth factors in relation to Rf_5					Ratios		
mm	Rf_2	$Rf_{2.33}$	Rf_{30}	Rf_{50}	Rf_{50}/Rf_2	$Rf_{30}/Rf_{2.33}$	Rf_{140}/Rf_2	$Rf_{100}/Rf_{2.33}$
	1	2	3	4	5	6	7	8
15	0.70	0.75	1.56	1.70	2.43	2.08	3.11	2.65
20	0.72	0.77	1.57	1.73	2.40	2.04	3.10	2.64
25	0.73	0.78	1.56	1.72	2.36	2.00	3.02	2.58
30	0.75	0.79	1.54	1.70	2.27	1.95	2.88	2.49
40	0.77	0.81	1.49	1.66	2.13	1.84	2.68	2.33
50	0.79	0.82	1.44	1.58	2.00	1.76	2.48	2.21
75	0.81	0.84	1.36	1.47	1.81	1.62	2.16	1.95
100	0.82	0.87	1.31	1.40	1.69	1.51	1.98	1.77

Dealing with drought — current issues

BHS National Meeting
Institution of Civil Engineers, London
10 July 1997

This topical one-day meeting was chaired in the morning by **Michael Hamlin**, BHS President and in the afternoon by **Howard Wheater**.

The first paper was by **Martin Lees** (Institute of Hydrology) on "Spatial and temporal characteristics of the 1995-? drought". The data used to characterise droughts have limitations. Rainfall data in the IH 'Water Resources Summary of Great Britain' come from Morecs and comprise provisional figures from a small number of gauges. Since the late 18th century the five-year rolling average rainfall for Oxford has shown a slight downward trend. From the 1940s onwards the winter half-years become progressively wetter and the summer half-years drier.

During the winter 1994/95 there was a succession of rain-bearing systems, followed by extreme rainfall deficiencies in summer 1995. April to August 1995 was the driest on record for England and Wales, but most areas were still within 10% of their annual average rainfall. The ratio between the winter and summer half-years is the largest in the 229-year rainfall series. During 1995, summer temperatures were 0.5-1° above average and potential evaporation was 15-20% above average. These figures are similar to those for 1990; rainfall deficiencies were also similar to the 1989/90 drought, but occurred over a shorter period. Cumulative rainfall departures from average show particularly steep slopes for the Yorkshire and North West Regions. The winter of 1995/96 was colder and drier than the winter of 1989/90.

The 1996/97 figures show the south-east suffering the most. Thames was the only Region for which rainfall between December 1996 and June 1997 was substantially below average. Groundwater levels are exceptionally low throughout the Chalk. Six to eight weeks of average rainfall is needed to satisfy SMDs, but this is more or less within the average range.

Mike Eggboro (Environment Agency NW) presented the next paper: "Managing drought: an Environment Agency perspective from the North West". In that Region 1995/96 was the driest, longest-lasting drought, with the widest geographic spread.

Mike highlighted the problem of defining a drought and deciding when it has started. The Water Resources Act 1991 gives powers for Drought Orders (DOs) and Permits if an exceptional shortage of rain threatens a serious deficiency of supply. Much of the Environment Agency's work during 1995/96 centred around defining "exceptional shortage". The Agency needed to strike a balance between protecting the environment and safeguarding supplies.

During the drought North West Water invested in new sources and brought old sources back into use, which produced 160Ml/d extra water. NWW have also undertaken to reduce leakage by 250Ml/d between 1995 and 2000. The advertising campaign suffered from NWW's "fat cat" image, which is a separate issue, but people were less willing to cooperate than in 1976. NWW had a hosepipe ban and drought orders, including a prescribed uses order, which does not necessarily save much water, although inspectors at public enquiries expect them to be in place when other DOs are applied for.

The Drought Orders gave NWW 200 Ml/d extra water and NWW agreed with the Agency that they would revert to the normal compensation levels if any of the rivers suffered from environmental stress as a result of the DOs. This is not as strong legally as a section 20 agreement, but more flexible, so it was important that NWW and the Agency trusted each other. The first DO was on the Derwent, an unsupported source. A hosepipe ban was not required for this DO, unlike all the others. After that, the Agency relied on a "tit-for-tat" exchange: NWW introduced a hosepipe ban and in return the Agency supported DO applications. The Agency had to persuade its own staff that DOs were necessary and had to pacify the green lobby, who thought that it was too lenient — while NWW thought that it was at times too harsh.

NWW applied for a DO for the River Lune. The Agency showed that better use could have been made of the original licence. At the public hearing an objector said a genetically unique spring salmon would be detrimentally affected. The DO was not granted, but NWW did make changes that allowed them to make fuller use of the River Lune licence when flows improved.

As an objective way of taking some of the heat out of the debate, a group control curve was agreed for determining HPB and PUO operation.

Ben Piper (GUP) asked how the Agency decided when the drought had ended. Mike Eggboro said that there had been a programme for the lifting of restrictions. The Agency had wanted restrictions to be lifted as soon as possible, so that reservoirs would not spill. Ben thought it was much harder to define the end of a groundwater drought.

Ian Stevens (Yorkshire Water) said that to obtain a DO it must be proved that a shortage of rainfall has led to a shortage of water. However, because it took 6 to 8 weeks to get a DO, they had to apply for one as a precaution.

The final paper of the morning was from **David Turnbull** (Thames Water Utilities) on "Managing drought: a water company perspective from the south-east". TWU is different from other water companies because: (1) it has the lowest combined water and sewage charges in the country, (2) it has had no Drought Orders since 1990, and (3) it is the worst in the leakage league table. TWU plans to keep reasons 1 and 2, but improve on 3.

TWU meets 75% of its overall demand (and 90% of London's) from surface water. The present drought was slow to start, and demand was low in June 1995, but increased during July and August. September had above average rainfall and TWU thought that the drought had ended, but then came a dry, cold winter. During 1996 demand was very high during June and decreased during July and August. Peak demand in 1996 broke the record set in 1995. In October 1996 reservoirs were only 50% full and TWU started to plan for summer 1997. They brought forward work on the new intake on the Thames at Surbiton, stepped up their leakage campaign and brought in Hippos. They also looked at longer-term plans, such as shipping in water from Norway or Scotland, increasing reuse of effluent, and desalination. None of these has been used, but research has been done in case they become necessary. Communication was important, and TWU worked closely with IH, which helped to convince the public of the drought. Like NWW, TWU found the public less willing to cooperate than in 1976.

TWU have a control diagram of the lower Thames, which shows restriction levels. The diagram has been discussed with the Environment Agency, who wanted restrictions to be imposed before TWU did. As a compromise,

broader trigger "bands" were used instead of lines, to allow flexibility. At the moment reservoirs are 90% full, but groundwater levels are the same as in 1976. River flows are temporarily high and TWU expected supplies to be maintained this summer, but if there is another dry winter there could be problems next summer.

The morning was rounded off with a general discussion. **Terry Marsh** (IH) said that using rainfall patterns to define droughts in groundwater areas is problematic, and he asked if any other criteria could be used as a basis for DO applications. Mike Eggboro did not think so, but Martin Lees thought that runoff could be used in groundwater areas. David Turnbull reiterated the problem of applying for DOs in advance. He wanted to see predictions used as a basis for applications. **Jasper Tomlinson** asked whether compensation discharges were larger than necessary in rivers where DOs appeared not to have caused environmental stress. Mike Eggboro replied that many compensation flows had been set for mill owners rather than for the environment. **Peter Walsh** asked what research had been done on the severity and frequency of droughts. Martin Lees said that there were problems in looking at longer drought events, for which IH still uses ranking as a method. Peter also thought that companies were losing credibility by going back for the same Drought Orders as in previous droughts.

David MacDonald (Binnie, Black and Veitch) showed two overheads. The first showed that East Chilterns runoff since April 1995 was only the 4th driest period since 1921. The second showed the England and Wales rainfall series departure from average. This showed that the later 19th century was much drier than the late 20th century so far. Terry Marsh replied that the England and Wales rainfall series is only annual and the problems have been caused by increased seasonal variability in the rainfall. The problem is that 1940-1985 was a quiescent period in terms of variability, but the water industry now needs to take account of increased variability.

Chris Binnie asked if long-term climate change had happened: Martin Lees did not know yet. **Hilary Smithers** said that, whether or not it had happened, the water industry has to manage the present situation and look at what might happen in the future. **Riaz Hasan** (Independent consultant) wondered if water industry staff got media training. Mike Eggboro said that Environment Agency staff do, but that the media have a hidden agenda and will try to create a debate. David Turnbull said that TWU had been trained by journalists and that the safest interview to do is a live one. **David Rodda** (independent consultant) said that the 1991/92 drought was the first one during which water companies had a contractual commitment to supply water. He asked about new licences in areas of population explosion. Mike Eggboro said that there was a need to distinguish between water resources planning and drought issues. David Turnbull said that TWU does have areas of population growth where they need to look at new resources.

The first paper of the afternoon was "Managing water quality in a drought", presented by **Graham Tate** from the Environment Agency (Northeast Region). He outlined a project using the experience of 1995/96 to develop a set of tools for managing droughts. These include drought orders, time-limited licences, emergency responses and longer-term planning for financing, drought team management and environmental assessment. Using environmental action plans, the significance of any damage could be identified, along with actions to avoid, choice of monitoring sites and best monitoring practice. Data collection and analysis are crucial for drought management. Graham highlighted some of the problems associated with a long drought: lack of baseline data, difficulties with pacing resources (i.e. limited monitoring equipment) and the need for a consistent approach to each DO application. In the North East, monitoring was agreed between the Environment Agency and Yorkshire Water, with resources targeted where low flows were most critical. Important water quality issues included cuts in compensation flows, particularly in rivers with a high proportion of STW effluent. The River Don was an example where temporary changes in STW operation were implemented to protect downstream water quality. Drought Orders can specify mitigation measures, for example temporary increases in compensation flows (freshets), fish rescues, aeration and weed cutting (this was particularly effective). Finally, communication with river users, dischargers and the farming community was important.

Howard Wheater (Imperial College) asked about the range of information covered by these management tools; Graham said that they tried to measure everything possible, even if only for a short time. Water quality and flow modelling tools were already in place, but ecological modelling is more difficult, and often can only identify that changes have occurred. **Geoff Bell** (Environment Agency Thames Region) asked about using volunteers: again the importance of communication and consultation was stressed.

Brian Hemsley-Flint (Environment Agency Northeast Region) described the ecological aspects of the Environment Agency Northeast Region drought management project. The relationship between river flow and biology is complex and poorly understood. River ecosystems are delicate and the ecology of standing waters, upland and lowland rivers are all different. He identified two types of drought: a natural drought is a prolonged lack of rainfall leading to a decrease in groundwater, river flows and runoff, while an artificial drought is a consequence of abstractions or reduced compensation and, unlike a natural drought, can be controlled. Ecological effects of a drought differ in upland and lowland rivers because of their different flow regime. For example, upland streams show a decrease in wetted area, reduced habitat and may dry out completely. In contrast, low flows in lowland rivers may lead to increased retention time and water quality problems. Short-term effects of drought include death of organisms and habitat destruction; longer-term effects may be a change in community structure or habitat type.

As part of the 1995/96 drought management in the north-east, a data collection programme was set up. It was quickly realised that procedures had to be standardised, and a two-volume document was produced, covering scoping, environmental assessment and monitoring methodologies for water resources projects. Water quality and quantity, habitat, plants, macroinvertebrates, fish, birds and mammals, recreation, aesthetics, archaeology and heritage were all included. Data analysis is in its early stages but suggests some movement of fish populations: for example larger fish stayed further downstream, leading to decreased predation of smaller organisms in their usual habitat upstream. Lessons for the future were identified, including recognising the need for appropriate data, resources to collect it and consultation with ecologists in the early stages of a project to identify the information required.

Sir Charles Pereira asked about progress in interpreting biological results: this was in its early stages, hampered by a lack of background data and the difficulty of attributing ecological changes to any particular event. Howard Wheater asked about other research (for example by the Institute of Freshwater Ecology), which might provide background data: much of the relevant research has concentrated on chalk rivers but there is some ongoing work. Algal problems that have occurred are difficult to attribute to a particular event. Geoff Bell was told that there was liaison with other organisations (e.g. English Nature over wetland issues). **Andrew Kelvell** (Gibb Ltd) asked about the prospect of changes to two-stage channels: it was necessary to consider the aims of protection, i.e. whether just the fish or the whole system is to be protected. Finally Mike Hamlin reminded the audience of a recent BHS low flows meeting where habitat simulation work

was presented: there questions were raised about what we are trying to preserve and the need to take action at different times of year for different species.

The final paper, by **Simon Bamford** (Southern Water Technology Group), was "Dealing with drought — the farmer's response". Simon began by outlining demands for irrigation water (increasing by 2% per year), fuelled by modern farming practices and the supermarkets' demands for perfect vegetables through quality-dependent contracts. It is now difficult for farmers to obtain a summer abstraction licence. Solutions include winter storage reservoirs (with a 55% increase in total storage capacity between 1992 and 1995); trickle irrigation, which does not require a licence but is limited by the need for expensive filtration of surface water; flood irrigation (also unlicensed); boom irrigation, which produces a fine mist of water and is 10% more efficient; prioritisation of crops, and irrigation scheduling.

A more recent solution is water sharing schemes, which are common in other countries. The remainder of the paper considered the technical options, management and abstraction licensing issues raised. Three case studies were described. Water Transfer Ltd in Lincolnshire (a scheme managed by the NFU) abstracts water from the River Witham into drainage ditches, from which 70 local shareholders then have licences to abstract. The transfer allows the farmer to abstract from the ditches where previously there was insufficient water. The capital costs are comparable to building a reservoir. An example of farmers cooperating to manage a limited resource is Lark Abstractors, a group formed after a ban on irrigation due to low flows in the River Lark. The farmers negotiated a 50% decrease in their licensed quantity provided they could irrigate throughout the season. Similarly the Rother Valley abstraction group in Hampshire meet to discuss the river condition, their abstraction requirements and how best to maintain supplies. Southern Water is involved with this group, supplying river recession data and other management tools. The development of shared resources requires careful negotiation on issues such as who pays for the capital investment (e.g. the Environment Agency, the farmer on whose land the reservoir is, or the water users) and licensing (whether farmers can have a licence to supply surplus irrigation water to a neighbour or to apply irrigation water to crops on land owned by someone else).

There were several questions in response to this paper. Howard Wheater asked whether farmers are trying to create a risk-free system. Farmers are designing systems to cope with 1976 conditions. They are very possessive about water falling on their land and do not consider water as a commodity that must be bought (like fertilisers and machinery). Geoff Bell asked whether farmers were prepared to consider reservoirs to allow other companies to abstract from rivers. He was informed that farm reservoirs require no planning permission and can only be objected to on aesthetic grounds. Sir Charles Pereira asked about farmers abstracting during droughts: Geoff said river flows may be decreased, but below a certain level farmers are not allowed to abstract.

A panel discussion with the three afternoon speakers considered some of the issues raised by their papers. **Hilary Smithers** (Environment Agency North West Region) and **David MacDonald** (Binnie, Black and Veitch) commented on winter storage reservoirs that are built and then do not fill in a single winter season; Howard Wheater questioned whether farmers carry out sufficient analysis. Simon Bamford responded that farmers are becoming more professional (particularly the larger businesses), although often at the insistence of the Environment Agency.

Neil MacKenzie (South West Water) wondered whether it was cheaper to buy farmers out than to monitor water use: Simon Bamford felt that this might be the case, but there is still more scope for cooperation. Mike Hamlin questioned people's right to abstract water and whether resources could be better optimised. He was told that many licences are not time limited.

Ian Stevens commented that applications for supply licences required a statement of need, but he was told that for irrigation licences all that was required was information about the crop type and area, with no economic assessment. Geoff Bell commented that efficiency of water use was considered in licence applications, but in the longer term a review of licences was needed, since many licences of right are not sustainable.

Howard Wheater commented on the north-east drought project and suggested that we know very little about the resilience of natural systems; he also queried whether short-term improvements in STWs could be maintained after the drought. Graham Tate responded that improvements in STW performance during a drought were due to some extent to natural processes (e.g. increased temperatures), but in the longer term it was necessary to be reasonable with companies running STWs. Ben Piper commented on the need to set baseline levels and asked how they are defined, whether for stream type or geology or other factors. He was told that there are objective ways of looking at rivers (e.g. RIVPACS) but generally targets are set for water quality and the aim is to preserve the system as it currently exists. Andrew Kelvell suggested augmenting streams with effluent. Graham Tate said that this already happens in some places and although there is a public perception problem it is often regarded as better than no water.

Hilary Smithers (Environment Agency North West Region) closed the meeting by identifying common threads that ran through all the papers. These included the difficulty of identifying a drought, the exceptional conditions in 1995/96 and the need to be pragmatic. Communication is important, within and between organisations and crucially with the public, who may have little understanding of the hydrological cycle and may not understand how much rainfall is required to sustain resources. The lack of baseline data is also a problem, making it difficult to quantify variations in the system.

She also highlighted the problems for farmers, the need for sustainability and the need to take a long-term view. Because is not possible to control the natural components of droughts, we need to set up flexible structures for drought management that must include the ability to analyse and present information. To a certain extent drought management is risk analysis and our attitude to risk varies according to our position.

Susannah Moss (North West Water) & Judith Stunell (Environment Agency)

McClean's hydrometric publications

The archive of McClean's hydrometric records has recently been moved to new accommodation in the University of Dundee. In re-cataloguing and re-organisating the archive, large numbers of duplicate publications have been identified, which are now being made available to interested parties.

The pioneering work of **Capt W N McClean** in the Scottish Highlands, dating from 1913, is well known to many hydrologists. From private funds, he established a rainfall and river flow monitoring network centred on the Ness basin. High standards of precision were applied throughout his operations, and summary data were published in series of pamphlets from McClean's Westminster headquarters.

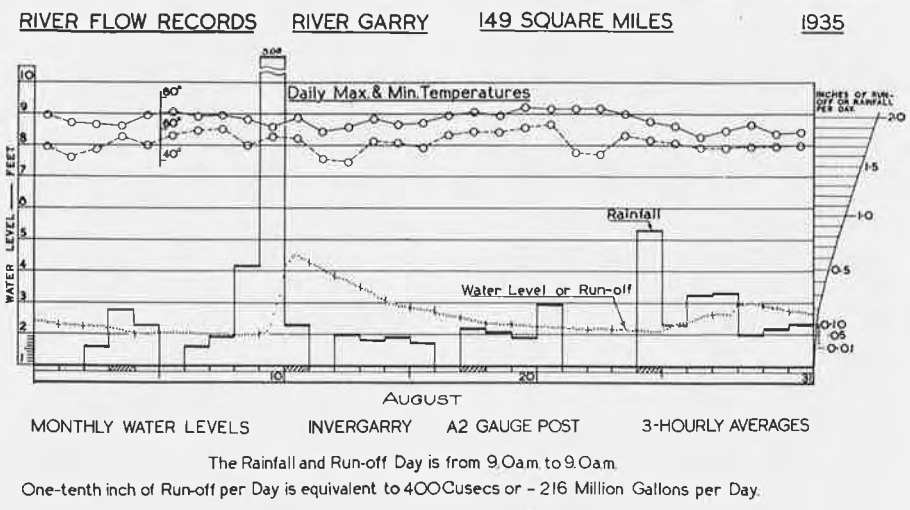
A summary of the records produced by McClean's organisation, *River Flow Records*, written by **Prof Alan Werritty**, appeared in the Institute of Hydrology *Hydrological data UK: 1988 Yearbook*.

The duplicate materials now available comprise mainly tables of daily and monthly runoff and rainfall, but there are also graphical records of rainfall,

runoff and storage for some periods (see figure). Tables are accompanied by notes addressing issues such as computational methods and data quality. The high-quality records are generally continuous or near-continuous over the period 1930-1942. The rivers covered are the Ness, Foyers, Garry, Moriston, Lochy, Spey and Dee.

Readers interested in this archive material are invited to contact Dr Andrew Black (e-mail a.z.black@dundee.ac.uk) or Prof Alan Werritty (a.werritty@dundee.ac.uk). The records may be of particular value for research or teaching. A programme of digitising both summary and raw data is under way, supported by Scottish Hydro-Electric and the Scottish Environment Protection Agency, and these data will be made available to the wider hydrological community. All original records (charts, postcards, etc.) and copies of all McClean's publications will remain archived in Dundee University.

Andrew Black
University of Dundee



McClean's meticulous pen-work, illustrating stage/runoff hydrograph, daily rainfall and maximum/minimum temperatures, for the Garry catchment, August 1935.

Hydrology on the front line

Paul Garrad has been to Sierra Leone to undertake an EIA/Audit of a wet mine and rutile processing plant.

This plant involves flooding fairly flat river valleys with laterite embankments, and using a 60' × 60' dredge to mine the material. There was therefore a certain amount of hydrology involved — the valleys fill in one wet season and emptying them after ten years can cause drawdown in village wells developed in the interim — causing water shortages.

The surface and groundwater quality measurements at the processing plant may also be of interest. The pH of surface waters (a 1.2 Mm^3 lake) surrounding the plant fell from 5.5 to 2.9 during the two years the mine site was unoccupied during the civil war, when it was looted by both the RUF rebels and the Army. Using a simple water quality model and sampling, I determined that the low pH was due to:

(i) acid mine drainage: as the plant wasn't occupied for two years the tailings (with a high pyrites content) were exposed to air and water each season, rather than being constantly submerged (pH 1.3 in tailings ponds), and

(ii) the emptying of 560 drums (300 litres each) of concentrated hydrochloric and sulphuric acids into surface waters. It transpires that the rebels used the empty drums to transport water and oil from transformers to other bases, presumably for use in vehicles. (Unfortunately the transformers also included PCBs, so I hope they didn't use it for cooking!)

Using the same model I devised control and remediation options. This really was hydrology on the front line, with our heavily armed Angolan/South African security guards carrying AK47s and the environmental team in front of a jeep with a sub-machine gun mounted on the rear, not to mention children swimming in pH 2.9!

Paul Garrad
Guildford

Channel-aquifer transfer parameters

We are compiling a sample of the numerical values of parameters that control the transfer of water between rivers and surrounding materials. The determinations can be made using field, analytical or modelling methods from a variety of standpoints: hydrological, hydrogeological, hydraulic or sedimentological.

Do you have any information you would be willing to add to the sample? Primarily, the parameter of concern is the hydraulic conductivity of bed (and/or bank) lining material, together with precise definition of the conditions of determination. It is also helpful to know spatial and temporal outcomes of the effect of these conductivity values in terms of quantified water transfers in and out of channels. The ultimate aim is to see if generalisations are possible based on physical characteristics or whether scale and method of determination play dominant roles.

If you are able to contribute some information and would like to know more details, please contact **Ann Calver** at the Institute of Hydrology *(tel 01491 692261 / 838800, fax 01491 692424, e-mail anc@ua.nwl.ac.uk).*

BOOKS

WMO hydrometric reference work

INFOHYDRO Manual — WMO Operational Hydrology Report No. 28. '1995 edition', WMO-No 683. xxxiv + 440 pp. Geneva: World Meteorological Organization, 1994 (sic).

This global directory of hydrometric monitoring serves as an excellent reference book for anyone wishing to become acquainted with the scale and nature of monitoring and archiving in unfamiliar countries. It consists mostly of tabular material, with explanatory tables in four languages: English, French, Russian and Spanish. It updates and extends the scope of the first edition, published in 1987. There are six sections:

I International organisations dealing with hydrology and water resources;
II Principal river and lake basins;
III National agencies dealing with hydrology and water resources;
IV Hydrological observing stations;
V National hydrological data banks;
VI International data banks related to hydrology and water resources.

Sections I and II are truly international in scope: Section I lists committees and institutions (often with links to United Nations, World Bank, etc.) dealing with water in an international/transfrontier context; Section II describes the disposition of major basins across national boundaries. Suddenly, one must appreciate the true scale of British rivers.

Section III could be very useful for the roaming hydrologist, giving addresses of national organisations and an indication of their functions and types of stations, e.g. hydrometric, climate, ice thickness. Section IV then

expands on this, with numbers of stations in national precipitation, evaporation, discharge, stage, sediment/water quality and groundwater networks. A breakdown of numbers is given in each table, e.g. differentiating storage from recording raingauges; availability of telemetry, etc.

Section V gives some details of the data processing and storage arrangements made for individual countries, while Section VI is devoted primarily to describing briefly the Global Runoff Data Centre, holding in 1993 of runoff records from 3070 stations in 140 countries. The centre receives data updates from time to time, and the report gives details of the data retrievals available. It must be anticipated that data held by the Centre will not be as up-to-date as those in national or regional offices, but it does offer the advantage of a central, systematic point of access. This could offer considerable potential for researchers working on large-scale projects requiring data from several nations.

For any hydrologist working internationally, this is a useful reference book. However, it should be stressed that no sub-national information is given, and users requiring gauge locations or time series will need to contact the national centres listed.

Readers may be interested to note that a complete catalogue of all WMO publications currently in print may be downloaded over the internet from the WMO site at: http://www.wmo.ch/

Andrew Black
University of Dundee

Water quality modelling revised

An Introduction to Water Quality Modelling, 2nd Edition. Ed. A. James.

This second edition of Sam James's book provides an introduction to the principles of water quality modelling and applications for the aquatic environment. Although aimed at the beginner, and intended as an introduction for engineers and scientists involved in water pollution control, it includes sufficient detail to be of interest to anyone involved in water quality issues, modelling and management. The second edition has been modified to reflect the increase in the use of mathematical models, particularly in the control of pollution in rivers and estuaries, and has been expanded and updated.

The first six chapters outline the basic principles of simulation modelling, BASIC computing, numerical methods, time series analyses and statistics. Each chapter covers the principles and details subjects such as finite difference approximations and methods of solution, principles of advection, diffusion and dispersion, kinetics of physical and chemical processes and problems of parameter estimation for linear and non-linear systems. These sections have been revised and are presented in a far more coherent fashion than the first edition. A new chapter on time series analyses is a useful addition.

The remaining five chapters deal with the principles of modelling rivers, estuaries, lakes/reservoirs, groundwater and the marine environment. Each has been updated and expanded from the first edition; in some cases quite significantly. River modelling now includes a section on stochastic methods whilst modelling of groundwaters and marine outfalls have also been significantly rewritten and expanded. To accommodate these revisions, several chapters from the first edition — modelling waste water treatment, activated sludge models, fixed film reactors, anaerobic processes and waste water treatment — have been removed.

These five chapters include model codes in both BASIC and FORTRAN are included so the reader can understand the principles of setting up a water quality model. However, it might have been useful to have included examples of input and output data. There are 22 pages of FORTRAN code for a finite difference estuary water quality model but without example data or output files it is not possible to check the code and obtain an understanding of the principles. Surely if the codes are included in the book they are there to be used and thus why not include example data? Unfortunately there are typographical errors in the codes, and one subroutine (p. 181) ends rather abruptly. Spreadsheets are often preferred to high level programming languages and whilst spreadsheet formulae have been provided for the sewage outfall model, the equations require some interpolation. Perhaps it would have been useful to have included all codes on diskette?

With the introduction and growth in the number of off-the-shelf water quality models in recent years, perhaps this text no longer reaches the wide audience it deserves. This book is an ideal introduction for those wishing to learn about the basics of water quality modelling and its application to the water environment, as well as those who might use such models without fully understanding the principles and dynamics of water quality modelling — recommended bedtime reading.

Paul Garrad
Guildford

New Members

We welcome the following members to the Society:

Al Nassar, K.T.	Sir Alexander Gibb Ltd
Armitage, J.M.	Sir Alexander Gibb Ltd
Barrett, A.P.	Division of Geography, University of Derby
Brown, P.	HR Wallingford
Cameron, D.S.	Environmental Science Dept, University of Lancaster
Daly, D.J.	Sir William Halcrow & Partners
Day, R.	Hydro-Logic Ltd
Dunn, P.	Ashford, Kent
Elgy, J.	Dept of Civil Engineering, Aston University
Gibbs, B.R.	School of Environmental Sciences, University of East Anglia
Griffiths, J.A.	London
Lowe, A.T.	Dept of Geography, University of Manchester
Lukey, B.T.	Flynn & Rothwell
McNish, J.H.	Freshwater Fisheries Laboratory
McVey, R.A.	Dept of Geography, University of Hull
Moriarty, P.B.	Lowveld Research Station, Zimbabwe
Okoronkwo, C.N.	Dept of Civil Engineering, University of Strathclyde
Rayner, G.	Southern Water
Reynolds, J.A.	North Surrey Water Ltd
Thompson, I.	ELE Group
Thornton, G.J.P.	Dept of Earth Science, The Open University
Williams, A.	Environment Agency

US perspective on wildlands

Wildland Watershed Management by D.R. Satterland and P.W. Adams, John Wiley & Sons, ISBN 0-471-81154-8

Having just returned from the Reading University Okstinden hut in a wild catchment on the Norwegian Arctic Circle, I thought this book would enlighten me on the nature of wildlands around the world (and perhaps in Norway). Alas the book is derived very much from the experience of managing remote watersheds in the USA and there is very little mention of watersheds elsewhere in the world.

Indeed there are minimal references

to any watershed studies outside the USA. After a basic introduction to hydrology and processes, it moves on to discuss management issues. The major components of the hydrological cycle are described, and the book has some value as an introductory text for newcomers to hydrology.

The chapters on managing wildland watersheds covers flood protection, snow management and runoff control using land management as a means of control. Why one would want to control runoff in wildland watersheds I am not sure! The water quality section is strong on erosion and sediment but extremely weak on other aspects.

There is very little mention of acidification problems in upland systems or the potential problems from increasing nitrogen deposition. Stream temperature changes are mentioned but there is little reference to the techniques of hydro-ecology as tools for watershed management. All in all the book is an interesting introduction to hydrology and watershed management from a US perspective.

Paul Whitehead
Reading

News from members

Aquatic Environments Research Centre, Reading

Paul Whitehead left IH in 1995 to take up a Professorship at the University of Reading. Since then he has established the Aquatic Environments Research Centre (AERC) at Reading, which is becoming a major centre of excellence in the Thames Valley.

New Projects have been initiated, such as the INCA (Integrated Nitrogen in catchments) model developed in collaboration with **Dr Emma Wilson** at National Power and funded by National Power and NERC. Together with **Penny Johnes** and **Alan Howard**, new projects have been started on a UK lakes classification system (funded by the Environment Agency) and a neural network approach to modelling algal growth in rivers (funded by the Natural Environment Research Council).

Joint projects have been established with IH and IFE investigating phosphorus dynamics in rivers, and the AERC has been involved in a major way with the Axford public enquiry on the hydrology, water quality and ecological modelling of the River Kennet. All in all the AERC has had an exciting and busy first year.

Hydrological colleagues are very welcome to visit Paul in Reading. The AERC is looking for collaborative research to provide new techniques, software and skills for the hydrological community.

Vice-Presidency for Ian Reid

Professor Ian Reid, Head of the Department of Geography at Loughborough University, has been elected a Vice-President of the Royal Geographical Society, which has 13 000 fellows. Ian will chair the RGS Annual Conference in January 1998, assessing problems facing the planet: his address will be entitled "Understanding the environment".

Chris Collier is new director of Telford Institute, Salford

Chris Collier, Professor of Environmental Remote Sensing at the University of Salford, is the new Director of the Telford Research Institute. He supersedes Professor Ian Cluckie who has moved to the University of Bristol.

The Telford Institute is a multidisciplinary grouping of over 75 active researchers from different academic departments, undertaking research into civil and environmental engineering in its broadest sense.

The Telford Institute of Environmental Systems, the largest division of the Institute, is active in environmental remote sensing (including the use of a Doppler pulsed lidar for boundary layer studies — one of only two such systems in the World); hydrological modelling (especially river flow modelling, flood forecasting and the use of weather radars and satellites for hydrology and meteorological applications), and the development of geographical information systems (GIS) for a range of applications. The Research Institute is further strengthening its research in urban sustainability with a new Professorial research post funded by a United Utilities (North West Water) endowment.

Further information on hydrological and meteorological research at Salford will be published in a future issue of *Circulation*. Until then, more details can be obtained from Dr Kevin Tilford (tel. 0161 295 3458, fax. 0161 295 5060, Email k.a.tilford@civils.salford.ac.uk) or from the Telford Institute Web pages: http://www.salford.ac.uk/telford

New groundwater group

Professor David Lerner is to lead the new Groundwater Protection and Restoration Group in the Department of Civil and Structural Engineering at Sheffield University. The group is based at Mappin Street, Sheffiield S1 3JD (tel 0114 222 5743, fax 0114 222 5701) and includes Professor Bob Watkinson, Dr Steve Banwart and Dr Steve Thornton.

Travel grants

Up to £1100 has been allocated in the Society's budget for grants towards the cost of attending meetings.

Applications are invited, to be sent to the Hon. Treasurer to arrive by *14 January 1998*. Please provide details of the meeting, whether you are presenting a paper, why you want to attend, the costs of attending and other sources of finance. Successful applicants will be expected to produce a short report for *Circulation*.

Enquiries to the Hon. Treasurer, **Terry Evans** *(tel/fax 01353 862723)*.

BHS international conference: Exeter 1998

The first BHS International Conference, "Hydrology in a changing environment" is to be held next July in Exeter.

Hydrologists are key contributors to the interdisciplinary examination of the environment during periods of change.

This major event will contribute to UNESCO's International Hydrological Programme Phase V and WMO's Operational Hydrology Programme, and will be a major input to IHP-VI.

The papers will be pre-published in three volumes by John Wiley & Sons and the poster presentations will be a BHS Occasional Paper.

Two exhibitions will present the most up-to-date hydrological instrumentation and software.

Good accommodation is available on the University campus, within easy walking distance of the lecture theatres, conference office and city centre.

Social events include a reception, Conference Banquet and evening visits.

A mixture of technical and 'sightseeing' visits is planned for 8 July.

The registration fee is £275 if paid before **1 February 1998** (£310 after that). There is no reduction for attending only part of the conference. All authors presenting papers or posters at the conference must register by **1 February 1998**. Papers will **not** be included in the Proceedings unless at least one author is

registered by then. There is a full programme for accompanying persons.

The registration fee for *bona fide* full-time postgraduate students is £150. There is also some cheaper accommodation for postgraduates, but only 20 places (see the registration form).

Accommodation on the University of Exeter campus is charged separately and must be booked by no later than **1 February 1998**.

Full details and registration form are on the Internet: http://www.nwl.ac.uk/ih/www/server/bbhs.html

Course

CONTAMINATED LAND AND GROUNDWATER: RISK ASSESSMENT AND MANAGEMENT
Sheffield
14-15 January, 1998

This course looks at risks to human health and the environment from exposure to pollutants, in the context of legislation for control and management of contaminated land and groundwater under the 1990 Environment Act.

The course starts with buffet lunch on Wednesday, includes dinner and an evening session of case studies/ exercises, and finishes at tea time on Thursday. The fee is £295 including (£190 for students); overnight bed and breakfast accommodation costs £30.

To book, please contact Sarah Murton, Dept of Civil and Structural Engineering, University of Sheffield, Mappin Street, Sheffiield, S1 3JD *(tel 0114 222 5712, fax 0114 222 5700).*

Meetings

International Conference on WORLD WATER RESOURCES at the beginning of the 21st Century
UNESCO, Paris
3-6 June, 1998

Headlined *Water: a looming crisis?* this conference replaces the 4th IAHS/IHP Kovacs Colloquium. It starts with the presentation and discussion of the UNESCO IHP monograph *World water resources at the beginning of the 21st Century* and other related papers.

The objectives are to take stock of our knowledge of the world's water resources (considering quality and quantity), to identify problems to be faced in the next century arising from increased demand, and to make recommendations to the international scientific community to deal with future challenges.

Conclusions from the five parallel workshops on the second and third days will be submitted to a plenary session on the final day.

If you are interested in attending this meeting, please contact UNESCO Division of Water Sciences, 1 Rue Miollis, 75732 Paris Cedex 15, France *(Fax +33 1 45 68 58 11).*

CIWEM/ICE One-day conference
MAINTAINING THE FLOW
and *Water Environment '98* exhibition
ICE, London
26 March, 1998

Deputy Prime Minister **John Prescott** will be a keynote speaker at the third biennial *Water Environment* conference, now to be a one-day meeting *(see diary).*

Papers will be presented on general source yields, groundwater protection and recovery, and waste water reuse.

To receive further details, please contact Jenny Eele, Thomas Telford Conferences, 1 Great George Street, London SW1P 3AA (Fax 0171 233 1743).

***Call for papers:* ERB Conference on CATCHMENT HYDROLOGICAL & BIOGEOCHEMICAL PROCESSES IN A CHANGING ENVIRONMENT**
Liblice, Czech Republic
22-24 September, 1998

This is the seventh general assembly of the European Network of Experimental and Representative Basins. It will focus on hydrological & biogeochemical monitoring and modelling, effects of land-use change on catchment processes, runoff generation and water pathways, evapotranspiration, energy and water balances.

In the ERB tradition of exchanging new ideas and experience, there will also be an open session for papers on any other themes.

Extended abstracts or poster descriptions (including diagrams; not more than 3000 words; hard copy plus Word file) should be sent before **1 February 1998** to M. Tesar, Institute of Hydrodynamics ASCR, Pod Pat'ankou 5, CZ 166 12 Prague 6, Czech Republic.

IAHS Symposia and Workshops at the XXII IUGG GENERAL ASSEMBLY
Birmingham
19-30 July, 1999

This is an early announcement, because IAHS pre-publishes its proceedings: extended abstracts are required by the end of **March 1998.**

Contributions are invited for five symposia and three workshops that make up the hydrological programme.

The first circular may be obtained from IUGG99, School of Earth Sciences, University of Birmingham, B15 2TT *(Fax 0121 414 4942, e-mail iugg99@bham.ac.uk)*

Diary

1st December 1997
Land drainage & flood defence seminar
Venue: ICE, London
Contact: Thomas Telford Conferences *(Tel 0171 665 2323)*

10th December 1997
BHS Southern Section half-day meeting
"River water quality and ecology modelling"
Venue: Imperial College, London
Contact: Prof. Howard Wheater, Dept of Civil Engineering, Imperial College, London SW7 2BU *(Tel 0171 594 6066, Fax 0171 594 6053)*

11th-12th December 1997
"Water Resources Management"
Venue: London Time: 09.00
Contact: IBC Conferences *(Tel 0171 453 2702)*

14th January 1998
Scottish Hydrological Group & SHSG
"Postgraduate research in Scotland: hydrology and hydraulics"
Venue: Dept of Civil and Offshore Engineering, Heriot Watt University
Time: 1800
Contact: Dr Andrew Black, Dept of Geography, University of Dundee *(Tel 01382 344433, fax 01382 344434, e-mail a.z.Black@dundee.ac.uk, internet http://www.dundee.ac.uk/geography/shg/)*

21st January 1998
BHS Southern Section meeting
"Water management for drought conditions"
Venue: Imperial College, London
Contact: Professor Howard Wheater *(Tel 0171 594 6066, Fax 0171 594 6053)*

11th February 1998
Welsh Hydrological Group
"Local implications of global climate change"
Venue: Chepstow
Time: 1730 for 1800
Contact: Terry Newman *(Tel 01222 666234, Fax 01222 666180)*

18th February 1998
Pennines Hydrological Group
"Urban Hydrology"
Venue: Sheffield Hallam University
Contact: Dawn Taylor *(Tel 01904 692296, Fax 01904 693748)*

19th February 1998
Scottish Hydrological Group & SHSG
"Hydrology and water quality of lochs"
Venue: Strathclyde University, 1800
Contact: Dr Andrew Black *(see above)*

26th March 1998
CIWEM / ICE one-day conference
"Maintaining the flow" *(see meetings)*
and *Water Environment '98* exhibition
Venue: ICE, London
Contact: Jenny Eele *(Fax 0171 233 1743)*