THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

# Circulation

No. 11 August 1986

# MORE ABOUT PRIVATISATION

**Members will recall that in the previous edition of *Circulation* we published my letter to the DoE, MAFF and the Welsh Office. I subsequently received a request for comment on the Government's Green Paper "*Environmental control: the next steps*" and my reply is printed below for your interest. You will note that I refer to another publication by the Government which contains proposals for changes to water resources law. These proposals are in several respects as important to environmental control as are the issues of water quality control outlined in the Green Paper. I have therefore sought HMSO approval for reproduction also of the proposals on water resources law.**

**Members will of course know that the Government's intention to privatise the English and Welsh water industry has been delayed until after the next general election. I feel, nevertheless, that the several important and interesting issues raised in the government publications linked with privatisation and also with proposals to rationalise the administration and financing of land drainage, flood control and coast protection will continue to be debated and developed. It will serve us well to maintain an interest in these developments for the foreseeable future.**

*P. Johnson*

Mr. L. Pavelin,
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Dear Mr. Pavelin,

The Water Environment: The Next Step

I welcome the opportunity to comment on the consultation paper and in response to the letter of invitation dated 29th April 1986 I have sought the views of members of the British Hydrological Society. Our general observation is that the paper chiefly relates to the matters of water quality and pollution control which are on the whole outside the expertise and direct experiences of Society members.

There is however one important matter implied throughout the paper; it is the tacit assumption that hydrological data of sufficient integrity will be available to fulfill all requirements for information analysis and interpretation. An ongoing concern of Society members is the decline of legal consideration for the maintenance of hydrometric networks and the valuable data they provide. Regional water authorities currently manage regional networks to monitor rainfall, streamflow and groundwaters. They do so to meet their own and by and large immediate needs and they utilise mostly the gauging networks developed under the 1963 Water Resources Act. These networks were established principally to assess availability of water; water quality control was rarely if at all considered and I feel we do not know the extent to which the networks will meet future demands for that purpose.

Water quality environment is highly dependant upon water volumes and rates of discharge. Interpretation of water quality sampling should therefore always make reference to a hydrological base. Rigorous reference demands sophisticated analysis and for routine measures the water industry has sought rule of thumb expedients to explain significance. We have to ask if rule of thumb measures will continue to be accepted as performance indicators but whatever the answer it should be admitted that scientific knowledge and methods currently outstrip our practical ability to provide sufficient information to use them to maximum advantage. I see monitoring as a continuing difficulty for the industry associated as much with hydrology as it is with water quality and I believe, with privatisation imminent, the adequacy of networks for environmental objectives should be reviewed. I also believe and recommend that in the interest of providing a sound scientific base for future water management legal requirement for regional and national hydrometric networks should be renewed.

I have no other comments to make on the consultation paper save to record support for the proposal to create Water Source Protection Zones especially in groundwater areas where waste disposal activities are prevalent and along rivers, regulated or not, from which water supply abstractions occur. Industrial experience in recent years has revealed pressing need for further water quality safeguards to avoid risks to water supply and the whole river environment.

Other features of water resources control also have bearing on river environment. They are not referred to in the consultation paper but they are alluded to in the Government's recent proposals on Water and Sewerage Law (March 1986) and in particular Chapter 3 on Water Resources Law. I agree entirely with the general principle that future control of water abstraction from inland waters should be the proper use of water resources. Removal of exemptions from licensing control by virtue of land ownership or types of use has long been overdue. The new proposals are directed mostly to reducing administrative effort

by the licensing authority but it is necessary to ensure that at all times abstraction should not cause environmental damage. Indeed WSPLCs may be expected in the future to so manage rivers in conjunction with abstraction licence conditions as to improve the environment. Government proposals to exempt from licensing, continuous abstractions from inland waters less than $20m^3/d$, will doubtless reduce administrative effort but it is relevant to ask if there will be a likelihood of one or more such abstractions from minor watercourses or ponds, especially during dry periods, imposing unacceptable environmental stress. I have no information at hand to offer a simple answer to this question but I recommend that it should be considered before a de-minimus exemption rate of abstraction is given legal status.

A second feature of Water Resources proposals was the intention to repeal formal requirement for Minimum Acceptable Flows. It was always imagined that these would have been established in consideration of environmental criteria and it is pleasing to note that the Government expects WSPLCs to have regard for the same consideration in river management. Currently, and in the future, this means prescribing and operating Compensation Water releases from reservoirs, Minimum Acceptable Flows or Hands-Off Flows for abstraction from unregulated rivers, and Minimum Maintained Flows for regulated rivers. The water industry will clearly be concerned to prescribe appropriate levels of flow; too high a prescription will lead to expensive and even profligate use of resources, too low a prescription may lead to environmental damage. Empirical evidence in the past has led to present levels of prescription in the industry but we do need guidelines to better understand all environmental needs. I recommend research on this issue. The proposed inspectorate within the Department of the Environment and the Welsh Office will doubtless be interested in the environmental impact of water resource and river management.

The same inspectorate will also I believe be particularly interested in WSPLC proposals for resource management before and during periods of very dry weather — drought controls. Within a region in which developed water resources are insufficient to meet demands for water during droughts, the tactical use of water and depletion of water storage is on the whole designed to allow for reductions in non-essential uses. Part of the strategy may also be the reduction of compensation water discharges from reservoirs and of prescribed minimum flows downstream of major abstractions to safeguard essential uses in the long term. Strategic control may imply a degree of "environmental sacrifice" and it would seem reasonable that pre-planning and agreement on this issue would be useful if drought emergencies are to be handled efficiently, especially in a privatised water industry. (An extract of a paper recently published by three members of the Society is attached to emphasise this point.)

*P. Johnson*

# GRASS ROOTS HYDROLOGY!



NERC's Chairman **Hugh Fish** and **Michael Heseltine, MP**, discuss with **Jim McCulloch**, Director IH, some of the more esoteric aspects of hydrological research at a celebration on 10th June to mark the Institute of Hydrology's 21st anniversary. Invited guests to Wallingford saw exhibits of selected items of the Institute's work, witnessed the commissioning of the latest IBM addition to NERC's central computer facilities and joined in a seminar called "The First 21 Years" which considered the past, present and future of hydrological research.

# Process Studies and Their Application

**BHS National Meeting/Welsh Hydrological Group**
**17 April 1986**

**As *Dr. D.E. Walling*, (University of Exeter) pointed out in his introduction to the meeting, there is an increasing need to show that the results of pure scientific research in hydrology will aid those who are involved in managing the hydrological environment. This provided a context for this meeting which addressed the interface between hydrological process research and its applications.**

In all, five papers were presented on process research and they covered many aspects of hydrology and applications of hydrological research to water quality and quantity management in both rural and urban drainage basins. In spite of the enormous variety in the nature of the research that was presented, several themes recurred throughout the day and as an introduction to this account of the proceedings, two of these themes can be stressed. The first theme is the continuity of the research that has been undertaken. The majority of the presentations related to research work which had extended over 10 or 20 years and which had incorporated contributions from many researchers of diverse expertise. This continuity of research not only provides British hydrologists with invaluable long runs of hydrological data but also allows identification of a second theme, the way in which research targets and technology have evolved. They have continued to adjust and the accompanying spatial and temporal scales of the components of research programmes have changed as the complexity of the hydrological system has been unravelled. Thus essentially 'black box' catchment studies have given way to increasingly detailed process studies within the catchment and the results of these studies have in turn required continuous modification of the models which are utilised for deriving hydrological process estimates at ungauged sites.

The first paper, presented by **Drs J.C. Rodda, R.L. Hall** and **J.A. Hudson** (Institute of Hydrology), illustrated these themes particularly well. The paper described the evolution and results of the Institute of Hydrology's paired catchment study at Plynlimon. This long-term study commenced in 1967 and was initially designed to answer the question "Do trees use more water than grass?". The results of the initial part of the study, which supplied a very convincing "Yes" answer, set in motion numerous process studies within the catchments which, in the first instance, attempted to explain "Why?" and "How?" the forested Upper Severn catchment exhibited losses of approximately 27% of annual rainfall through evaporation and transpiration in comparison with only 15% losses from the adjacent moorland catchment of the Upper Wye. Process research which addressed itself to answering these questions provided information on the mechanisms of the whole hydrological system and associated sediment transport in these upland catchments and, in achieving this, spawned research on instrumentation which could provide reliable data in this rigorous environment. Although the Plynlimon study has yielded convincing answers to many of our questions concerning water balance and water routing in upland catchments, the study continues with new research targets. In particular, questions relating to the nature of water quality as well as quantity, their links with upland land management and their ecological implications are now central to research at Plynlimon and new process studies are accordingly being developed. Process studies have been found to be essential in unravelling why differences occur at the catchment scale at Plynlimon and they have made the transfer of the Plynlimon results to other catchments feasible.

There are close links between the water quality research being undertaken at Plynlimon and the Llyn Brianne land management studies which were described by **Dr. D.J. Stoner** (Welsh Water). The Llyn Brianne land management studies are based upon a multiple catchment research design and have evolved in response to the drastic decline in fisheries which was observed in many Welsh rivers during the 1960s. The Welsh Water Authority surveyed the extent and possible causes of this decline in fisheries and, in particular, its association with the occurrence of acid river waters in Wales. Studies of both average levels and temporal variability of a range of water quality parameters showed that decreasing concentrations of calcium, decreasing pH and increasing aluminium concentrations were closely correlated with increasing afforestation, declining fisheries and declining species diversity. The aim of the current Department of Environment and Welsh Office sponsored, multi-disciplinary, multi-catchment research programme is to uncover the processes underlying these correlations so that the implications of land management practices can be assessed. A range of land management techniques are being applied to the study catchments, including standard moorland improvement, moorland liming, bankside liming in moorland catchments, clearance of 10 m bankside strips in established conifer forests, the application of lime to the cleared banksides, liming of conifer plantations from helicopters without bankside clearance, planting of moorland catchments with conifers with limited ploughing and drainage work, ploughing and drainage of moorland catchments without planting trees. Field and laboratory process studies are being undertaken to help to explain differences in catchment response. This is a very large scale three year project which is being co-ordinated by Welsh Water but which involves co-operative research from the Institute of Hydrology, Institute of Terrestrial Ecology, University Colleges of Aberystwyth, Bangor, Lampeter and Swansea, University of Wales Institute of Science and Technology, the Forestry Commission and Economic Forestry Group Ltd. The results of both of these major research programmes in the Welsh uplands are going to enhance land management practices and increase their sympathy with the environment.

Subsurface research reported by **Dr. P. Smart** (University of Bristol) on recharge and storage processes in the Carboniferous limestone aquifer of the Mendip Hills, is also yielding results of great significance in water quality management and pollution control. Research undertaken by various researchers at Bristol University on the hydrology of the Mendips has a history which extends back over 20 years, beginning with an emphasis on geomorphology, developing into research on hydrology and now incorporating aspects of broader water resource significance. Dr. Smart's paper described process studies which involved fascinating detective work on the routing of drainage in this limestone aquifer. Drainage in the aquifer is strongly influenced by a zone of enhanced solutional porosity, termed the epikarst aquifer, which occurs in the upper 10 m of the limestone and which influences both the routing and storage of groundwaters. This epikarst aquifer permits considerable lateral dispersion of water (Figure 1) and also controls the routing and rate of arrival of waters in underground conduit and cave systems. Under conditions of high recharge of the epikarst aquifer, a perched water table develops and lateral drainage within the epikarst feeds major shafts which rapidly transfer the water to underlying conduit systems. Under conditions of low recharge, vertical water movements predominate and water reaches underlying cave systems predominantly via large numbers of slow seepages. Two management implications of this process research were suggested. First, although flow in solutionally enlarged conduits and cave systems in the aquifer is very rapid and point pollutant

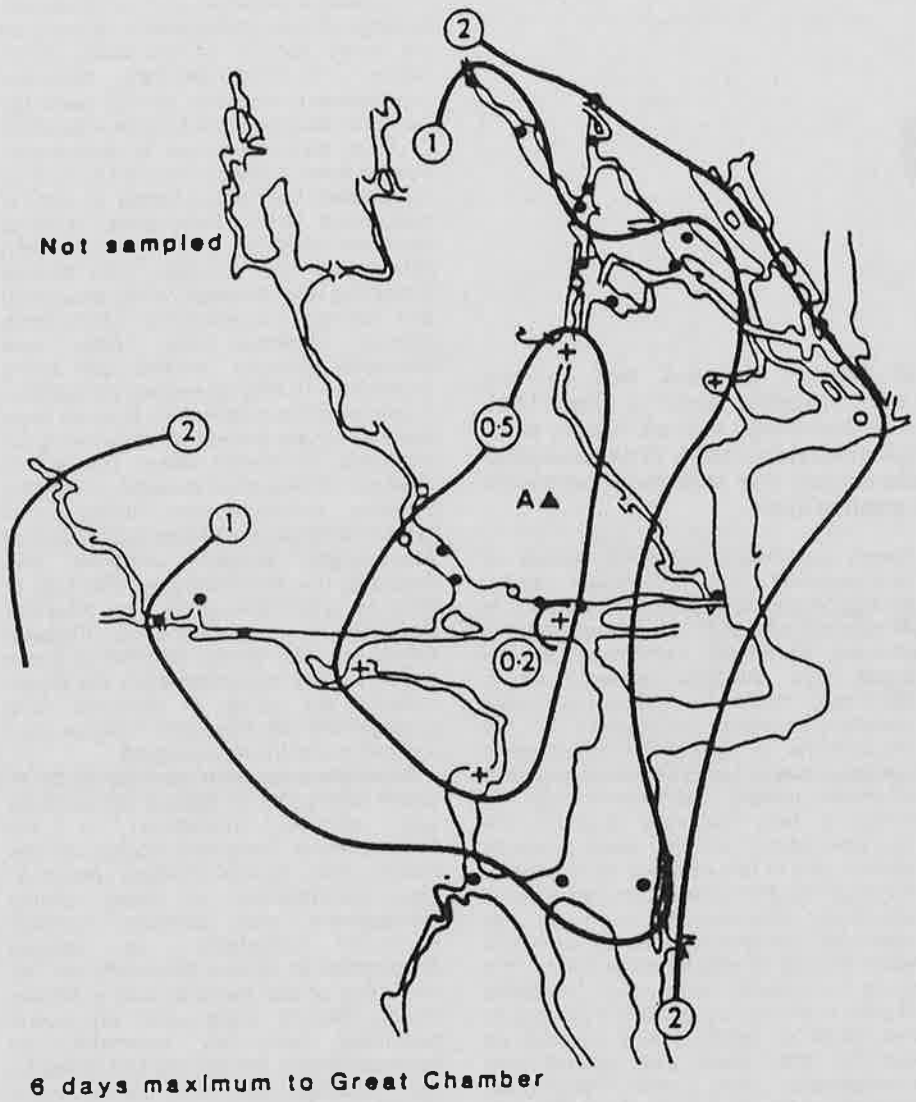



*Figure 1. First arrival times in days from injection for recharge at site A (fluorescein).*

disposal to the aquifer, particularly near surface depressions, has a very high pollution risk; dispersed pollutant inputs at low recharge rates may not be associated with a high pollution risk because of the long residence time in the epikarst and seepages prior to delivery to the conduit systems within the aquifer. Second, since quarrying activity removes the epikarst zone and disrupts the natural organisation of the drainage system within the aquifer's saturated zone, quarry sites may also be potentially good disposal sites. Nevertheless Dr. Smart stressed that this latter implication of his research results requires further verification and is as yet only a tentative conclusion from interpretation of limited data.

The remaining two papers concentrated upon the implications of hydrological process research in the urban environment. **Dr. C.J. Pratt** (Trent Polytechnic) described far-reaching changes which have occurred over the last 15 years in urban drainage design and analysis. These changes have occurred in response to the results of detailed process studies in urban catchments and to the related, increasingly complex urban runoff models and their requirement for detailed input data for design purposes. Small urban catchment studies have illustrated the complexity of urban runoff processes and have shown how percentage runoff can vary enormously from different storms for the same catchment. Process studies have led to the consideration of many properties of urban catchments including the nature of surface materials, the variations in the depression storage and infiltration characteristics of these different surfaces, the influence of initial wetness of surfaces, and the direction and character of precipitation on storm runoff. These properties have been incorporated in the surface phase of many urban runoff simulation models but, during the application of these models, it has become apparent that the subsurface characteristics of basins is not as clearly defined as was previously thought. In relation to future prospects for studying storm runoff in urban catchments, Dr. Pratt contended that there were three areas which required consideration. First, to what extent do we need to blend the detailed results of process studies into simulation models for design purposes? Second, how variable is the below-ground phase and do we need to turn our attention to below-ground process studies? Third, what is the tolerance level of existing simulation models and how accurate are results likely to be for different frequency events and for calibrated and uncalibrated simulations?

The final paper, presented by **Dr. J.B. Ellis** (Middlesex Polytechnic), considered water quality in urban catchments. Dr. Ellis stressed the unsatisfactory standard of many storm overflows and the fact that at a time of increasing public awareness of the problem there were increasing economic constraints on rectification measures. He also noted that whereas there are well-developed methods for estimating and modelling components and routing of urban runoff quantity, such methods are not well developed in relation to urban runoff quality, although the proposal to extend the WASSP model to incorporate quality aspects of urban runoff and to assess the impact of sewer discharges on receiving waters will be a great help in this respect. Dr. Ellis described the results of process studies of urban water quality which have revealed details of the mode and rate of accumulation of pollutants on different urban surfaces, the surface wash-off of the accumulated pollutants, the role of gully pots in storing and releasing pollutants, the potential importance of infiltration schemes, storages and soakaways in the regulation and improvement of urban runoff and the significance of sewer deposits and their residence time in affecting the quality of current storm runoff. Dr. Ellis noted the potential problems that may be faced in sewer design by differences in the attenuation that is most effective in regulating runoff quantity and quality but he concluded that substantial improvements in water quality could probably be achieved by a modest increase in sewer maintenance.

These five stimulating papers combined to make a most interesting and varied programme. They showed how the process studies much loved by academics can make genuine and major contributions to the management process. A recurring theme of the day's proceedings, of which we must continually be aware, is the enormous amount of time required to rigorously reveal the nature of the processes upon which our management models should be based. The papers served to underline our great and continuing need for long-term monitoring and research programmes if we are to continue to refine the management of the hydrological environment.

*Angela M. Gurnell*

# Overseas Research and Development in Surface Water Resources

## Current Research and Future Needs

**BHS Southern Section Meeting**
**28 April 1986**

**Against a background of increasingly competitive overseas markets for British consultants and an awakened public concern about famine in Africa this half-day meeting at Hydraulics Research provoked considerable interest amongst a wide spectrum of the BHS membership. The 75 participants heard descriptions of two major bodies of research in surface water resources currently being funded by the Overseas Development Administration as well as presentations by two consultants of what they considered to be the practising engineer's principal research needs. The opportunity for BHS members to discuss these issues under the chairmanship of *Terry Pike*, the Principal Engineering Advisor of the ODA, gave particular significance to the meeting.**

Terry Pike began the afternoon by outlining the ODA's policies with regard to research in surface water resources. Unlike aid organisations in several other European countries, the ODA does not channel resources into one or two priority sectors, such as water resources. Rather, it directs most of its £1.2 $\times 10^9$ annual budget either through multilateral agencies or into the geographical allocations which allow client governments a major say in defining priority sectors. An important exception is the ODA's sector allocation to research which is split between various divisions one of which is the Engineering Division. However, research in surface water resources falls between the Engineering and Natural Resources Divisions. It is commissioned in a variety of ways through research organisations, universities and individual consultants.

**Dr. Sanmuganathan**, of the Overseas Development Unit at Hydraulics Research described the research funded by the ODA for which he is responsible. Concentrating on particular aspects of the Unit's work he spoke mainly about current research into soil erosion and sedimentation. The problems created by sediment in both reservoirs and canal systems are widely known. Examples from different parts of Asia indicate that an important feature of such effects is that erosion and sedimentation rates are increasing; possibly by as much as 50% per decade. Against this background the ODU is currently engaged in research aimed at improving methods of measuring erosion rates from both large and small catchments, improving methods for predicting sediment yield and developing suitable remedial measures.

Equipment for the measurement of soil loss from small catchments (5-20 ha) was developed and has been in use in a study in Malawi for four years. This study, whose primary aim was to assess the effectiveness of control measures advocated by the Land Husbandry Division in Malawi, has also demonstrated the advantages of using small catchments as opposed to the more conventional field plots for studying soil erosion effects. The actual results obtained by this study are of considerable interest to engineers and agriculturalists alike. The cultivated catchment containing full biological and physical soil conservation measures was shown to have similar characteristics to those of a comparable wooded catchment with a dense canopy. By contrast an unmanaged catchment with traditional maize cultivation suffered severe soil and water loss: run-off increased by a factor of approximately 10 whilst soil lost increased by a factor of 100 over the well conserved catchment.

Other areas of the ODU's research programme include saline intrusion in estuaries as well as many facets of irrigation and drainage.

**Frank Farquharson** presented a succinct summary of the Institute of Hydrology's projects which are currently being funded by the ODA. Two themes underlie much of this work: first, that much of IH's overseas research is a development of projects



*One of the ODU's experimental catchments at Bvumbwe, Malawi, showing soil conservation by contour bunding and crop ridging.*

initially directed towards solving questions of UK hydrology; and secondly, that many projects have focussed on the development of suitable instruments and equipment. A recent example of the first is a proposed multidisciplinary study of water use by Eucalyptus trees in India which is a development of the Plynlimon experimental catchment studies. An example of the second is the HYDRA equipment capable of providing estimates of evaporative flux, over any surface, from measurements of vertical wind flux, humidity and temperature. The HYDRA has been successfully tested over dryland crops in Syria and Niger and over the tropical rainforest to Brazil (where the structural problem of providing a sufficiently high tower was paramount).

IH is involved in the third year of a project in Mauritius in which drip irrigation of sugar cane has been introduced to conserve water resources. Detailed studies of soil physics and plant physiology have been undertaken to optimise crop yields. One might question whether sugar cane as a crop justifies such research at present. Nevertheless valuable information is being collected on how design of the irrigation system affects root developoment and hence the ability of the crop to use such natural rainfall as occurs.

Having developed and marketed various measuring instruments principally for overseas use, such as its neutron probe, tipping bucket raingauge and automatic weather station, IH has now identified data transmission as an important area for development with regard to overseas projects. Meteosat was put forward as a useful and greatly underused facility allowing researchers reliable and rapid access to data collection devices located anywhere in the world.

The development of reliable methods for estimating flood frequencies remains an important area of IH's work with the inception of the "World Flood Study". To date the records from 1,200 stations in 71 countries have been processed. Questions from the floor highlighted the difficulties inherent in such a project: for the practising engineer, priority should be given to producing regional flood frequency curves for the tropical regions in which most developing countries lie yet gaining access to, and validating data from such regions presents a major problem to hydrologists.

As to future needs, Frank saw the following as important: development of methods to predict the mean annual flood of ungauged sites from catchment and climatic parameters; and an interdisciplinary approach to the study of drought in sub-saharan Africa. In addition he called for a shift towards the publication of more accounts of practical applied studies in the hydrological literature.

**Mike Hall** (Halcrow Water) noted the changed circumstances in which a consultant working overseas ("at the sharp end") has to operate before listing his research priorities. Typically, nowadays, a project team is made up of expatriates and local counterparts and is located wholly in the host country away from head office facilities having to meet training or "technical transfer" objectives along with engineering tasks. Moreover, it has a much shorter time-scale in which to complete the work than hitherto. The consequences for the consultant are that much greater use of on-site micro-computers is demanded and that the more senior staff tend to be seconded to such jobs leaving fewer opportunities for the training of junior staff. For water research projects there is the additional consequence that there is little opportunity to install instrument networks and, as a result, greater reliance must be placed on existing information (with spot checks) and on the use of climatic analogues and regionalisation.

The following list of research topics was presented:

1. Climatic (largely drawing together existing work):
   (a) generalised short-duration rainfall data;
   (b) estimation of "dependable" rainfall;
   (c) estimation of crop water requirements.
2. Surface Water Resources:
   (a) regionalised estimation of floods;
   (b) regionalised estimation of low flows;
   (c) compact conceptual models with well-documented calibation procedures (for on-site micros).
3. Estimation of sediment flows (although Mike questioned the extent to which sediment transport could be treated deterministically).
4. Development of simple portable instruments, for example, for:
   (a) estimation of small flows;
   (b) estimation of infiltration rates.

In conclusion, the need for improved training methods to aid "technology transfer" was stressed. Tutored Video Instruction (TVI), where the study of a recording of a lecture by an expert is assisted by a non-expert tutor, was put forward as one means.

**Terry Evans** (Sir M. McDonald) began the final presentation with a revealing aside on the difficulty a consultant faces in providing practical illustrations of areas he considers require research: to put forward a project as one in which the outcome could have been improved through increased knowledge may be taken as an admission of failure (allowable only if it is the project of a competitor)! A number of specific research topics were discussed:

- rainfall distribution in arid regions (possible use of Landsat to locate rain clouds);
- estimation of channel losses in arid regions;
- effects of soil erosion and realistic assessment of control measures over large catchments;
- adaption of the Flood Studies Report for tropical and arid regions;
- causes and effects of persistance in hydrological records especially in the Sahel;

Nevertheless, the main focus of the presentation was the question of inadequate data. In many developing countries the data are not only poor but deteriorating whilst water resources projects are becoming more complex and expensive. Researchers may assist in overcoming some of the problems through the development of foolproof automatic equipment; and by putting greater emphasis on standardisation and on methods of regionalisation.

In addition training is seen as vital both for data collection and for the management of water resources systems. For the former, the secondment of a qualified hydrologist to introduce a micro-based system is advocated. For the latter, training games, such as that developed by McDonald's for operation of a barrage on the Indus, should be used more widely.

As for the future Terry called for closer collaboration between consultants and research workers bringing benefits to the consultants who have little scope for undertaking fundamental research within their normal paying jobs and to research workers who can benefit from the skills of consultants in marketing and in meeting deadlines.

In the *General Discussion Session* which concluded the meeting a major portion of the time was devoted to considering how hydrologists, whether consultants or researchers, can obtain reliable overseas data. Although it was agreed that wider publication of data and results from overseas work is desirable, few clients will readily authorise such publication, particularly where quality checks have made reprocessing of the data necessary, unless the publication is made a precondition of the funding. Nevertheless, for regionalisation work to progress, collaboration between consultants and researchers in the informal exchange of quality-checked data is necessary. Many consultants have large potential data banks which they do not have time to put in order but may be prepared to make available.

The concern expressed by Mike Hall about the difficulty of obtaining overseas experience for junior engineers prompted a question to Terry Pike as to why the ODA's "Associate Experts" scheme had fallen into disuse. The reason given was that client governments have not been keen because they have plenty of junior staff of their own requiring training. However, there have been exceptions: the Indonesian Government accepted junior staff on the basis that they prove more efficient as a training aid for their own youngsters.

Overall this was a very useful meeting. The need for further consultation and collaboration between consultants and researchers in tackling future surface water resources problems overseas was identified by many as a priority.

*Peter Bolton*

# Design and Operation of Water Resources Systems

**BHS National Meeting**
**14 May 1986**

**With the slower growth in demand since the early 1970s, emphasis has shifted from the planning and design of new resources to the operation of existing ones. The four papers at this meeting were largely concerned with the theory and practice of operating existing resources.**

**Alan Lambert** (Welsh Water) opened with a discussion of "Operational Control Rules in Critical Droughts" based primarily on his experience in the Northern Division of Welsh Water. In this area numerous small resources together form a significant proportion of the total resources. The large and sophisticated Dee Regulation System serves 2 million population; 78 other sources serve 5 million population. It was on these smaller sources that he concentrated his discussion.

Many of these sources were without control rules during the drought of 1984 (and presumably 1976). Particular problems arose in 1984 because of the shift in the water industry towards reduction of operating costs which meant taking greater risks with resources — overdrawing the cheaper upland sources early in spring. Without control rules the consequences of these early decisions were unclear. Even with control rules, it is at this point that the operator recognises the distinction between the "hydrological" yield based on past data with built-in knowledge of the progress of the drought and the "operational" drought with no such prophetic vision. The view was expressed that the critical time for drought management is from February to May before the drought has effects evident to the public.

Unanticipated shortfalls cause major upset to water supply operations — in obtaining and implementing emergency powers for conservation measures. They also interfere with other legitimate water-based interests who are obliged to accept the restrictions placed on them in droughts. Since they bear the brunt, such interests can reasonably expect a high standard of resource management.

After the 1984 drought, Welsh Water set about reviewing yields and developing control rules for all resources. They found considerable difficulty arising from unreliable or non-existent data, on rainfall inflow, reservoir level, and demand. Reservoir surveys were carried out and new stage storage tables provided for all reservoirs (for £35,000). Allan Lambert then listed nine components, in some instances techniques, such as recession analysis, water refill and successive drawdown curves which could potentially be used in the formulation of decision support systems.

A result of this study is the consideration of resources in terms of those operated to maximise security of supply (near to operational yield). Others are run at minimum operating cost or shifting between states through the year depending on current storage.

Three speakers referred to methods of planning and operation of water resources at North West Water. **Peter Walsh** (NWW) traced the historical development of techniques starting with Rippl and cumulative minimum inflow diagrams through Frank Law's pioneering work on Stocks Reservoir using a critical period approach. This method identifies storage required at the beginning of a month to protect the source against a repeat of the design (usually historic) inflow sequence. This approach was extended to most direct supply reservoirs in NWW. The result is a set of control rules which can be used in planning and design (yield storage curves) or in operation. For the latter the control rules can be used to determine when a cheap source can be overdrawn at a rate in excess of the nominal yield rather than from a more expensive source, and the levels at which caution is required. Around 200 impounding reservoirs were grouped into operational areas. Many, as in North Wales, had very limited data and in these instances a non-dimensional regional presentation of the control rules is used.

He then looked in more detail at the development of operational control of the Lake District and Lancashire Conjunctive Use Scheme, a principal objective being the minimisation of pumping costs. In the early 1970s two Lake District subsystems were operated independently, each with a series of multiple control rules. Pumping at Windermere was controlled by the state of Thirlmere and pumping at Ullswater dependent on the state of Haweswater.

Simulation showed that the two systems could be integrated with a single control rule to determine the pumping regime and tariff combination which minimised costs at an acceptable risk level. Savings of 18% in pumping costs were identified. The approach was extended to the Lancashire Conjunctive Use Scheme.

The drought of 1984 also provided further stimulus to development of operating rules with emphasis in restrictions of overdrawing to improve the probability of winter refill. It was also recognised that a considerable amount of pumped water was subsequently lost over the spillway. A new (no-spill) control curve was derived to minimise spilled water whilst maintaining the reliability of the system.

**Susan Walker** (NWW) followed up with an explanation of recent developments and results of the use of a dynamic programming (DP) method to approach closer to optimality in Lake District pumping regimes. (The study was actually carried out by our next speaker Tim Wyatt.) The DP system — unlike its predecessors — was sufficiently flexible to allow for different combinations of pumps operating, rather than a simple on/off rule for all pumps at each site. A further annual average saving of £46,000 (6%) was identified, the savings being in normal, not drought years.

The presentation of **Tim Wyatt** (Power and Water Systems Consultants) was concerned more generally with the development of mathematical programming techniques (especially DP) for optimising operation of water resources systems, with examples leading up to the Lake District study.

To the uninitiated there is a bewildering array of proposed mathematical programming methodologies described in the literature. Many of these, however, describe simplified representations of actual systems which are not directly applicable to the real system and were not (or could not be) tested against the existing operating system. In the early 1970s DP algorithms also suffered a number of drawbacks:

1. The large amount of computer memory and CPU time required.
2. Insufficient generality which required reprogramming to apply to a specific system.
3. Lack of documentation and explanation.

Developments since then in computer capabilities and the drive to reduce operating costs, coupled with increased energy costs, has brought about a reappraisal of DP techniques especially where concerned with conjunctive use of differing resources.

Tim Wyatt described the development of MOSP (Modular Optimisation/Simulation Program) which uses a DP algorithm to derive multiple regime operating policies. It is run in association with a simulation model (SYSIM) which can be run independently and can thus be used to compare with alternative operating policies. Its modular form enables it to be applied to specific systems with minimal changes.

The system was used in the appraisal of the conjunctive use of thermal and hydropower generation in Uruguay with the resulting specification of the number of thermal units scheduled for use in a given month and with a given combined reservoir storage. The saving in the average annual operating cost was 16% ($US 6.9 mill). Such savings, as in the Lake

District Resources, would appear to justify their wider application.

Details of the DP algorithm used were not described but in response to a question from **Phil Johnson** we were informed that the system used was a modified stochastic DP rather than deterministic DP.

In discussion two speakers, **Duncan Read** and **Jerry Sherriff**, raised the problem of communication between those who derive the operating rules and those who actually operate the system. The need for simple operating instructions was recognised, irrespective of the complexity of the analytical techniques. On problems of application of new strategies by operators, Peter Walsh assured us there was a growing acceptance, to the point where requests for re-evaluation were now initiated by the operators.

Jerry Sherriff also noted the need for consideration of other phases of operation (treatment and distribution) in the developoment of control rules, where reallocation could for example produce unacceptable demands at some treatment works. He also wondered how the possible failure of major components during a critical period should be dealt with. Alan Lambert supported the need for reserve capacity to cover emergencies. Tim Wyatt suggested the use of probabalistic load dispatch techniques as used in electricity scheduling as a means of building such contingencies into the rules.

It is interesting to note how each drought provides some new twist for which the operator and his control rules are unprepared, but also how this experience leads to the development of new methods. It remains to be seen whether we are better prepared for the next drought.

One paper was presented on operational water quality management by **B.A. Finney** on behalf of himself and **M.B. Beck**.

As in the field of water resources, there has been a shift in emphasis since the early 1970s in river water quality away from exclusive interest in planning towards the problems of operational management. In particular, interest has shifted from average water quality to managing the variability, both seasonal and episodic. A case study for the Bedford Ouse was described in which the objective was to generate operating strategies using a simulation model. The study covers a 54 km reach of the Bedford Ouse whose characteristics offered particular advantages for analysis.

1. The major point discharge (Milton Keynes STW) at the upstream end and a water supply abstractor at the downstream end (Clapham WTW).
2. Seasonal variability (especially nitrate — N) and episodic variability (algal blooms).
3. Significant sources of non-point pollutants (nitrate — N).
4. Modern treatment works with potential flexibility of operation.
5. A comprehensive data base for the reference 1974 with daily observations at four locations of five water quality variables.

The simulation model operating on a daily time scale comprises three main components, a rainfall-runoff model determining quantity and quality of lateral inflows, flow routing, and water quality interactions among five state variables: BOD, DO, ammonium-N, nitrate-N and chlorophyll-a concentrations. The model was calibrated using the 1974 data with reasonable prediction apart from chlorophyll-a.

The study has now reached the point where it can address management problems. What operating strategy can minimise overall operating costs, encompassing waste disposal, water supply obligations and river water quality? For example what is the best balance in cost between process control at the upstream end or at the abstraction point?

In discussion **John Cole** drew attention to the need for data on pH to model free ammonia (of particular significance for fish). It was indicated that since pH is reasonably constant, free ammonia can be modelled satisfactorily. Phil Johnson noted the potentially important role of benthic respiration; in this instance there were poor data due to algal interference.

*David Archer*

# HYDROLOGY AS AN ARCHAEOLOGICAL TOOL

I have been allotted about 600 words for a follow-up of the Notice in *British Archaeological News*, March 1986. The object is to explain in a little more detail how hydrologists could help, "given the experience (you) had with your first enquiry".

That is not how it happened with me. Half a lifetime ago my latent interest in prehistory came to life when I found myself fundamentally disagreeing with received opinion about the prehistoric water environment. The *casus belli* was Baluchistan and the Harappan Civilisation. No-one initially consulted me — I wrote what I believed to be correct and, by good fortune, had it published. Journals that accepted my apparently maverick views included *Antiquity, P.E.Q., Ira Origini* (University of Rome), *Journal of Human Evolution*, etc.: about nine originally, now grown to perhaps forty, at an average of better than one per annum. There followed, and overlapped it, an apprenticeship in field archaeology, while working as an hydrologist, much aided by Beatrice de Cardi, George Dales and Rik Wheeler, of around six years. During the succeeding 24 years I began to be consulted. This led initially to the publication of an introductory book, *Water, Weather and Prehistory* (John Baker, 1967; second edition with Humanities Press, N.J. in 1984).

So what were the problems involved? Here is a selection: *Mohenjo-daro.* A total of around 17 metres of alluvial deposits, high in clay fraction occurred, necessitating frequent rebuilding at even higher levels, in the 1,000 years (or 800 or whatever) of the city's occupation. No silt deposit, but instead re-erosion of some 9 metres net, between the abandonment of the city and today. The flood plain would normally (on the authority of the Indian Irrigation Service) have aggraded some 6 or 7 metres, so probably there were 15 or so metres of post-abandonment erosion. The received view was of normal overspill floods. I have suggested still-water flooding of the (then) escape channel, due to essentially tectonic causes in a tectonically active area.

*Kalibangan* — funded by B.A. One of a chain of Indus Civilisation sites c. 2000 BC, clearly dependent on a river which is no more. Clear evidence of at least one other period (Painted Greyware) of dependence on the River Ghaggar, now dry. Test drilling showed sandy river beds at different depths. Provisional explanation is that River Yamuna, now flowing to Ganges, alternated (there being no watershed to stop it) between flow west to Indus and east to Ganges. (The same type of oscillation forms part of the full and complicated explanation for Mohenjo-daro.)

*Beidha*, Rift Valley, Jordan (c. 8000 BC calendar years). Now in a very dry valley (c. 150 mm mean winter precipitation; not enough for the rainfed cultivation of grain of which there is evidence, and no water for irrigation). Occupation coincided with a period of water table gradient decay from that corresponding with glacial/pluvial relatively substantial recharge to virtually no recharge in post-glacial: valley fill, evidenced by remnant terraces, was probably removed through Rift faulting and early post-glacial perennial flow. Former springs are now exposed and dry.

*El Faiyoum.* Received view was that Faiyoum B (with a typical mesolith industry) succeeded "uncomfortably" the Faiyoum A neolithic simply because the Faiyoum B lake shore and deposits are at a lower level. It was erroneously thought that the B people settled by a receding (evaporating) lake which takes no account of the fact that open water evaporation (c. 3.0 metres per annum) would dry the whole lake in half a century. The explanation is probably intermittent natural diversion of the Nile via Bahr el Yusuf due to oscillation of Nile course within flood plain (coriolis force).

*Geili*, Khartoum Neolithic. Geili is now high and dry and a long distance from the Nile. The explanation is that there have been some 7,000 years of gradual rock erosion in the granites of the Saboluka gorge, a few milometres north, through which the Nile flows northward.

There are a thousand and one phenomena where there is a more or less vital hydrological factor, such as: upward limit of cultivation in Britain (where temperature lapse rate is the constraint): bogs or mires which are *always* evidence of impeded drainage, sometimes helped

by unusual rainfall, but *never* due to rainfall alone; domestication of cereal cultigens in areas too dry for rainfed farming; the so-called Sahara Neolithic Pluvial where, as at Azraq in Jordan and Uruk period sites in Eastern Saudi Arabia, the most probable explanation is post-glacial (post-pluvial) ground water gradient decay; Silbury Hill where, because of aggradation, the water table of today bears no relationship to that of the third millenium BC, etc., etc., etc.

I have already exceeded the 600 words and hope I have given food for thought and a justification for consulting a hydrologist. A successor book is awaiting a publisher who will risk publishing non-conformist views.

Incidentally I was already pushing 45 when I first followed my bent, which suggests that it's never too late.

*R.L. Raikes*

# BOOKS

*Relation of Groundwater Quantity and Quality*, edited by F.X. Dunin, G. Matthess and R.A. Gras. Proceedings of the Hamburg Symposium, August 1983, IAHS publication 146, 316 pages, paperback, $20, ISBN 0-947571-15-9.

Having found nothing much of interest or novelty in the last two conference proceedings I reviewed for *Circulation*, I determined not to accept any more for review. So it was with low expectations that I turned to this volume, the last proceedings remaining in my reviews in-tray.

But they are excellent. Twenty-seven papers from such notables as **Herman Bouwer** and **George Matthess**. The six review papers alone make the volume worth reading: **Raats** on responses to changes in quality and quantity, **van Dam** on saline intrusion, **Dagan** on stochastic modelling of solute transport, **Back** on degradation of groundwater by land misuse, **Fritz** on geochemical indicators, and **Moser** and **Rauert** on environmental isotopes.

Here is the story of the deforestation of the Burren in western Ireland. Deforestation led to erosion, silting up of the underlying karstic limestone, reduction of infiltration and spring flow. This once potentially productive area now only supports limited cattle grazing on imported water.

Theoretical papers are mostly on pollutant transport modelling and trying to understand dispersion in aquifers. The many case studies span the world, agriculture, urban environments and overpumping. A volume well worth browsing through if you are interested in groundwater quality.

*David Lerner*

*Water Quality — Characteristics, Modelling, Modication* by George Tchobanoglous and Edward D. Schroeder. Published by Addison-Wesley Publishing Company Inc., 1985, 768 pages. Price £16.95, hardback, ISBN 0-201-05433-7.

This book is the first in a series on Water Quality Management. "Water Quality" is a comprehensive introduction to water quality management for undergraduates in civil engineering and environmental science. The book is divided into four main sections, which comprehensively deal with water quantity and quality; analytical models for water quality management; modelling water quality in the environment and finally modification of water quality.

The four sections follow a logical progression into the subject of water quality. The first section includes the sources and uses of water; its physical, chemical and biological characteristics and their significance and concludes with a study of water quality standards. The analytical section deals with stoichiometry, reaction kinetics, materials balances and the mathematical modelling of physical systems. The third section considers the production, uptake and transport of pollutants in the environment and their behaviour in specific environmental systems. These include rivers, estuaries, lakes, reservoirs, groundwater and ocean outfalls. The final section, on the modification of water quality, considers the numerous techniques for providing water of potable quality and treating polluted wastewater. There are also tables and appendices which contain a large amount of useful technical data.

As a general introduction to the topic of water quality this is a wide ranging and recommendable text for undergraduate and graduate course students. The book is hardbacked and the price of £16.95 is within the price range of its market.

Originally designed as a complete course book primarily for the North American market, it uses mostly North American case studies and examples. However, the style of presentation and format, with clearly worked and explained examples, problems, diagrams and emphasised key ideas, concepts and issues, makes the book highly appropriate for the UK market.

It is intended that two further volumes in this series, entitled "Fundamentals of water and wastewater treatment" and "Hydraulics of water quality management systems" will compliment this introductory volume by focusing more on engineering design for water quality management, a subject of ever-increasing importance for environmental pollution control worldwide.

*R.W. Crabtree*

*Hydrological Principles for the Deep-Well Disposal of Liquid Wastes and Wastewaters* by H. Aust and K. Kreysing, 1985. A contribution to IHP-II Project A.3.6 by the Federal Institute for Geosciences and Natural Resources, Hanover. Available through UNESCO. 102 pages, paperback. ISSN 0177-9915.

A dry read, but a reasonable introduction to the principles of deep-well disposal, worldwide statistics and many briefly-described examples. Not an engineering text, so don't expect to be able to design your own backyard disposal system after reading it.

Also received:

*World Health Statistics*, World Health Organisation, Geneva. Sr. fr. 80/year.

Despite the title, this is a quarterly journal containing articles such as *the application of appropriate technology in the field of rural water supply in Indonesia*, and *monitoring natural waters for drinking-water quality*. Articles are in parallel English and French versions.

# PUBLICATIONS

**Hydrological Research in the UK 1980-85**, the fourth edition of this overview of who is doing what, compiled at IH, is now available. Copies have been distributed to all contributors but anyone wishing to get extra copies (price £3.00 inclusive of postage) should contact the Library, Institute of Hydrology, Wallingford.

# BHS Additions to IH Library

*Scottish Forestry (1986)*, Vol. 40, Nos 1 and 2 (January and April).

# Two New Journals

In case you missed the preliminary announcements, John Wiley's two new hydrological journals are to be published this autumn.

**Hydrological Processes** — devoted to environmental hydrology. *Editor:* Dr. M.G. Anderson, Geography Dept., Bristol University, and **Regulated Rivers** — devoted to river research and management. *Editor:* Dr. G.E. Petts. Geography Dept., Loughborough University.

Free specimen copies/subscription details from: John Wiley & Son Ltd., Baffins Lane, Chichester, West Sussex PO19 1UD.

# Review of Periodicals

It has been suggested that a useful service for the busy consulting engineering sector of BHS would be a review of the journals to highlight papers of use, particularly for those working overseas. I have to confess that my initial reaction was one of scepticism that such a task is feasible, feeling that the reviewer's choice cannot help but be too subjective (and anyway, what is "useful" in an unknown context?). Also, Aqualine Abstracts and its supporting database, operated by Water Research Centre and published by Pergamon Infoline, already offers a very comprehensive service.

However, if any member feels like taking up this proposal, being prepared to produce a six-monthly or yearly review — perhaps even on the lines "Papers I have enjoyed" — please give me a ring to discuss it further.

*Editor*

# BHS Committee

## Nominations for the Main Committee — a reminder

The response to our call for nominees, sent out on 28th May, has been — how shall we put it — muted. Where, we wonder, are all those willing volunteers (more than 150 of you) who, three years ago, said they would be willing to consider a national role in the organisation of the Society?

To set the record straight, the vacancies are: (a) Honorary Secretary. (Mike Hall's term of office completed). A vital role with the emphasis on managing the programme of national meetings. Aspirants for this demanding job will not want to be making frequent trips overseas during the two years that they will be dedicating to the Society and its aims. The ideal candidate will be widely experienced, filled with boundless enthusiasm, currently unemployed and possessed of private means. Failing that, how about you? (b) Two ordinary committee members. As laid down in the Statutes, two members retire each year. John Rodda and Logan Jack have duly departed (*not* Des Walling as stated on the call for nominations).

## Subscriptions

The annual subscription for membership of the Society is to be £12.00 (£6.00 for students) as from the next financial year which begins in October. We are proud of the fact that the Society has been able to run for three years before a subscription increase has become necessary. And, of course, you are all aware, aren't you, that the subscription is tax-deductable.

# Nineteenth General Assembly of IUGG, 1987

Financial assistance from the Royal Society may be available for prospective participants in the XIX General Assembly of the International Union of Geodesy and Geophysics to be held in Vancouver, Canada, from 9th to 22nd August, 1987, who are normally resident in the UK, are of postdoctoral status and are not in Government or Research Council employ.

Financial assistance will be available, particularly for young scientists, including postgraduate research students, resident in the UK, from the IAHS Exeter Assembly Fund administered by the Royal Society, the IAGA Edinburgh Fund and the IASPEI/IAVCEI Durham Fund.

Accordingly, prospective participants who expect to apply for financial assistance from these sources should so advise the Royal Society, preferably before *1st October 1986.*

(a) For grants from the Royal Society: Miss B. de Vere, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG (tel: 01-839 5561 ext. 222).

(b) For grants from the IAHS, IAGA or IASPEI/IAVCEI Assembly Funds, to: Mr. C.R. Argent at the same address as above (ext. 249).

Application forms will be distributed thereafter but only when it is known whether the Council of the Royal Society has approved the provision of a block grant.

Outline details of the scientific programme during the 1987 IUGG General Assembly are given in the Second Circular together with an indication of registration and accommodation costs. Copies of the circular can be obtained by writing to: IUGG XIX General Assembly, 801-750 Jervis Street, Vancouver BC, Canada V6E 2A9.

# SOUTH-WEST SECTION OF BHS

Following the circulation of a questionnaire to members in Cornwall, Devon, Dorset, Somerset, Avon and Wiltshire and after discussion held at the Bristol National Meeting on 17th April, it has been tentatively concluded that there is sufficient support to inaugurate a South-West Section of BHS. At the outset it is envisaged that meetings of the Section would be held twice a year, with one of these being a field meeting if possible. The suggestion that meetings of the Section held at centres in Somerset and Avon could be organised jointly with the Welsh Hydrological Group was also welcomed. An initial meeting of the Section is being planned at Exeter for Autumn 1986 at which support and future prospects for the venture can be assessed. Further information concerning dates, venues and topics of meetings of the Section will be communicated to BHS members through *Circulation.*

*Bruce Webb*

# New Members

We welcome the following new members to the Society:

M. BONELL ..... Lecturer, James Cook University, Australia
S.K.C. CHAN ..... Hong Kong Government Services
T.J. JOLLEY ..... Imperial College
J.D. NEAT ..... Yorkshire Water Authority
P.J. THOMPSON ..... Student, Imperial College
J.O. ROBSON ..... U.N.D.P., New York
P.C. YOUNG ..... Department of Environmental Sciences, Lancaster

# Vegetation and Climate

Does climate control the vegetation, or does the vegetation control the climate? An important and controversial question which may be answered by a series of large-scale hydrological experiments being planned under the World Climate Research Program.

The first such experiment, HAPEX-MOBILHY (Hydrological Atmospheric Pilot EXperiment-MOdélisation du BILan HYdrique), is taking place this summer in south-west France. The project is designed to measure the evaporation from an area comparable in size to that of grid squares used in models of the general circulation of the atmosphere. An area 100 km by 100 km is being intensively studied: measurements include lysimetry, soil moisture, surface energy fluxes, spatially integrated fluxes (made with low-flying aircraft) and remote sensing from the NASA C-130 aircraft. These data will be used to test the existing parameterizations of evaporation and to develop new ones.

**John Gash, Jim Shuttleworth** and **Colin Lloyd** (IH) are studying the evaporation from Les Landes pine forest which covers about one third of the area. This was made possible with a grant from the EEC made under a twinning agreement with the French Centre National de Recherches Meteorologiques who are co-ordinating the project.

The development and use of hydrological expertise at area scales relevant to numerical models of global climate is an expanding area of hydrology. Jim Shuttleworth has just returned from three months at the NASA Goddard Space Lab in Washington DC, where a team is working on using computer simulation and remote sensing to predict the efforts of changes in land use on weather. The results of the recent IH micrometeorological experiment in the Amazon rain forest are now incorporated into the model, and the next problem is to extrapolate in time and space to cover the Amazon basin throughout the year. Satellite measurements of vegetation (green area?) index may be the key to the problem.

# FORTHCOMING EVENTS

## Meetings

### INTERNATIONAL WORKSHOP

**ESTIMATION OF NATURAL RECHARGE OF GROUNDWATER**
**(with special reference to arid and semi-arid regions)**
**7-15 March 1987**
**Antalya, Turkey**

Organised by the International Association of Hydrogeologists, in co-operation with the University of Istanbul.

The workshop includes the presentation of special lectures and discussion of the first draft of a manual of practice for estimating natural groundwater recharge. There will also be a post-workshop tour to hydrogeological and touristic sites.

Further details/circulars from: David Lerner, Dept. of Geological Sciences, University of Birmingham, PO Box 363, Birmingham B15 2TT. Tel: 021-472 1301.

### FOURTH INTERNATIONAL SYMPOSIUM ON REGULATED STREAMS

**Loughborough**
**14th-18th August 1988**

The objective of this Symposium is to advance the development of environmentally sound management policies and strategies for regulated rivers. It is part of a triennial series of International Symposia devoted to scientific research on rivers modified by dams and flow diversion schemes. There will be three themes: SPECIAL TOPICS — River Regulation in the UK; Water Management and River Regulation in Developing Countries; Hydro-power Schemes — River Management and Hydrological Effects. ECOLOGICAL CHANGES — Effects of Dams, Weirs and Diversions on Benthic Invertebrates, Aquatic Plants and Fish; Floodplain Dynamics and Wetlands; Estuaries. MANAGEMENT PERSPECTIVES — Water-quality of River-Reservoir Systems; Instream Flow Methodologies; Fisheries Management and Alternatives; River Regulation and Integrated Basin Management.

Abstracts by 30th November 1987. Further details from Dr. G.E. Petts, University of Technology, Loughborough, Leicestershire, LE11 3TU.

## NATIONAL HYDROLOGY SYMPOSIUM

### ✸ First Announcement ✸

*When:* September 1987.
*Where:* University of Hull.
*Theme:* The practical application of hydrological research. We seek papers from anyone who has used, or tried to use, a newish (i.e. developed since 1960) technique of applied hydrology, either in the UK or overseas. There should be emphasis on problems or uncertainties that have been encountered and the solutions adopted to overcome them, e.g. ways in which existing models or techniques have been "tweaked" to cater for particular circumstances. We are not excluding current research lines but there must be some evidence of use in the real world. We would particularly like to attract as authors people who might normally fight shy of such involvement.
*Cost:* Full board (two nights) including Conference Dinner and copy of Proceedings — approximately £60.00.
*Who to Contact:* The Symposium will be run jointly by BHS and the hydrological groups of ICE. Details of how to submit papers will be given in the next *Circulation* but, meanwhile, it would be useful if likely contributors could make informal contact with one of the following:

Mike Lowing (Institute of Hydrology)
Bob Sargent (Forth River Purification Board)
Des Walling (University of Exeter)
Terry Evans (Sir M. MacDonald)
Alan Weston (Welsh Water Authority)
Howard Wheater (Imperial College)
Richard Wood (Severn-Trent Water Authority)

# COURSES

**APPRAISAL OF FLOOD ALLEVIATION, COAST PROTECTION AND SEWER REHABILITATION SCHEMES**
**2-5 September 1986**
**Flood Hazard Research Centre**
**Middlesex Polytechnic**

This training programme runs over three days at the Polytechnic's conference centre and is designed for consulting engineers plus engineers in water authorities, local authorities and government departments. It includes an extended analysis of the principles of benefit assessments and practical sessions.

Further details: Middlesex Polytechnic Consultancy Services Organisation, Bounds Green Road, London N11 2NQ. Tel: 01-368 1299.

# Diary

*17-19 September 1986*
**Welsh Hydrological Group BHS/ Association of British Climatologists.**
**"Water: measurement and management". Swansea University.**

*19/20th September* 1986
Pennines Hydrological Group.
Field trip on "Time of travel in Chester sewage works".
14.00 h at Huntingdon Treatment Works.
Contact: Tony Lewis (NWWA).

*29th September 1986*
BHS Southern Section.
"Interpretation of soil survey data for hydrological practice" by John Hollis (SSEW) and Alan Gustard (IH).
Imperial College, 17.00 for 17.30 h.

*3rd October 1986*
Scottish Group.
"Mathematical modelling in flood alleviation studies with reference to the White Cart" by D. Banks and R. Falconer (Babtie, Shaw & Morton).
No. 2 Lecture Theatre, McCance Building, Strathclyde University, 18.00 for 18.30 h.

*15-16 October*
**Scottish Hydrological Group/Royal Society of Edinburgh.**
**'Hydrology in Scotland'.**
**Edinburgh.**

*12th November 1986*
BHS Midlands Section.
Contribution of geomorphology to hydrological knowledge. (Speakers to be announced.)
Leicester University.

*19th November 1986*
BHS Southern Section.
"Lake acidification" by Rick Baterbee (University College, London) and D. Brown (CEGB).
Central Electricity Generating Board, Sudbury House, 15 Newgate Street, London. 17.30 for 18.00 h.

*19th November 1986*
Pennines Hydrological Group/ Institution Municipal Engineers.
"Flow survey and verification", WASSP procedure.
14.00 h, NWWA, Warrington.

*5th December 1986*
Scottish Hydrological Group.
"Movement of groundwater pollutants". (Speakers to be announced.)
Wellcome Room, Royal Society of Edinburgh, 22-24 George Street, Edinburgh, 18.00 for 18.30 h.

## MICROCOMPUTERS IN HYDROLOGY

**1st December 1986**
**Institution of Civil Engineers**

**A National Meeting on the above theme is to be held following the Society's AGM on Monday, 1st December 1986. The format to be adopted for this event will be different from the usual National Meeting, and will consist of a series of demonstrations interspersed with short lectures. Numbers attending the meeting will be limited, and the programme structured so that all participants have an opportunity to see each demonstration. The programme is now being drafted, and the Honorary Secretary would like to hear from any members who would be prepared:**

1. **to demonstrate a program or the application of a standard software package to a hydrological problem;**
2. **to present a short 20-minute lecture on a topic connected with the use of microcomputers in hydrology or water resources work, including teaching and training applications; or**
3. **to mount a poster presentation on the theme of the meeting.**

**Only a broad indication of content is required at this stage. Please contact Dr. Mike Hall, c/o Sir William Halcrow and Partners, Burderop Park, Swindon, Wiltshire, SN4 0QD, or ring him on 0793 812479.**

# ✸ Stop Press ✸

**SPATIAL ASPECTS OF RAINFALL EXTREMES**
**A seminar at**
**Institute of Hydrology, Wallingford**
**Wednesday 20th August 1986**

The statistical description of rainfall fields has attracted considerable research in recent years. This seminar marks the close of a year's effort at IH in one aspect of tl problem: the relationship between the highest maximum rainfall for a collection of points in a region and the maximum rainfall at a typical point. This work — the result of collaboration between IH and CEMAGREF — will be described and the opportunity taken to contrast it with related research at a number of centres in the UK, France and Switzerland.

All are welcome to this seminar, which will emphasise advances in modelling and applications to regional data. A buffet lunch (£3.75) will be available.

Further details from: Julia Tucker. Institute of Hydrology, Wallingford, Oxon OX10 8BB. Tel: (0491) 38800. Telex: 849365.

**Copy Deadline for Issue No. 12 – 3rd October 1986**

*Circulation* is the quarterly newsletter of the British Hydrological Society. It is issued free to members but is also available on an annual subscription of £1[illegible]. Please address all correspondence to the Editor, Celia Kirby, Institute of Hydrology, Wallingford, OX10 8BB. Telephone: 0491 38800 extension 2224