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UNIVERSITY RESEARCH ... Part IV

Centre for Research on Environmental Systems, University of Lancaster

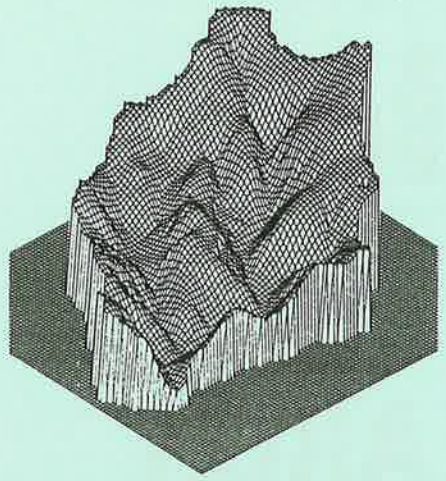
The *Centre for Research on Environmental Systems* (CRES) was set up in 1987 as part of the *Institute of Environmental and Biological Sciences* at the University of Lancaster with the aim of coordinating interdisciplinary research teams in a number of priority areas. The Institute, under the directorship of Professor *Terry Mansfield*, FRS, was one of only two departments given group 1 Interdisciplinary type A status in the recent UGC Earth Science Review. It offers five undergraduate degree courses in Environmental Sciences, Geophysical Sciences, Ecology, Biological Sciences and Biochemistry. Within the Environmental Science degree, it is possible to take a specialist stream in Aquatic and Atmospheric Sciences. A post-graduate Diploma and MSc course includes programmes of courses leading to specialisations in Hydrology and Water Resources, Environmental Pollution and Terrestrial Ecology. This year the Institute has received research grants totalling more than £1m.

CRES involves some 25 academic staff, combining physical, biological and chemical expertise, with Professor *Peter Young* as its first director. Lancaster has a long history of hydrology related research, particularly during the tenure of *Terence O'Donnell* as Professor of Hydrology. This tradition is being continued within CRES across a broad front of hydrological, fluid dynamics and water quality related research topics. This includes links with research on biological systems, notably as a result of problems arising from environmental pollution. A common theme that runs through much of the work at Lancaster is the desire to combine interdisciplinary expertise in both field work and modelling for the study of environmental processes and problems.

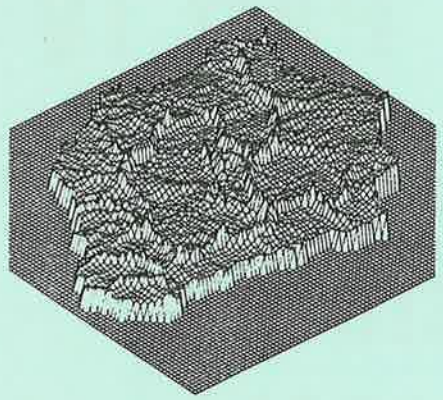
Hydrology and Fluid Dynamics

This research group involves **Cath Allen**, **Keith Beven**, **Vince Collinge** and **Peter Young**. One feature of the group is its use of computationally intensive methods in hydrological modelling and fluid dynamics. Cath Allen and **Carolyn Simon**, in collaboration with **David Prandle** of the Proudman Oceanographic Laboratory, are using the Cray X/MP supercomputer to construct a detailed water quality model of Liverpool Bay. Keith Beven and **Andrew Binley** are using the Cyber 205 at UMRCC to carry out some long period three-dimensional simulations of a small catchment with heterogeneous soil properties to create a unique (if hypothetical) data set in which all properties and boundary conditions are known. They are using the results to examine the concept of effective parameter values for physically-based simulation and have shown that it may be very difficult to relate an effective parameter value to the underlying distributions of soil para-

meters, whilst in some circumstances effective parameters just do not work. The 3-D simulations will also be used to develop calibration and uncertainty estimation techniques for simpler spatially distributed models such as TOPMODEL.



The Wye catchment 50 m digital terrain data.



Values of en(a/tanβ) derived from the Wye digital terrain data.

TOPMODEL is a conceptually simple, variable contributing area model developed by Keith Beven and **Mike Kirkby** at the University of Leeds: it uses topographic data to predict the dynamics of saturated contributing areas. Applications to date have shown that it is a potentially accurate simulator of catchment behaviour but has been limited by the tedium of analysing topography to obtain the distribution functions required by the model. Recent availability of digital terrain data however has transformed this analysis to a routine computer task. Application of these data is being explored by **Paul Quinn** working with **Roger Moore** of the Institute of Hydrology. Further applications of TOPMODEL in modelling the hydrological flow pathways required for water quality predictions are also being explored at IH by **Tym Musgrove** and with **George Hornberger** at the University of Virginia, where it has been shown in a study of 140 catchments in New England that the a/tanβ topographic index used by TOPMODEL is the first catchment characteristic to show a strong correlation with average catchment pH.

The TOPMODEL structure is also being used in a long term collaboration between Keith Beven and **Eric Wood** of Princeton University who have been investigating the relationships between catchment heterogeneity, catchment scale and concepts of hydrological similarity. It is hoped that this strategic research will eventually lead to improved methods of predicting the hydrological responses and flood frequency characteristics of ungauged catchments.

Peter Young, Cath Allen and Keith Beven are also working to understand and model the processes of dispersion of tracers and pollutants in rivers, where the traditional convective dispersion description often fails to predict the observed behaviour. Over the last five years, we have investigated an alternative description, the Aggregated Dead Zone (ADZ) model, which gives very good fits to tracer data. The ADZ model is derived from advanced time series analysis techniques developed by Peter Young, but can be interpreted in physical terms to suggest that the major cause of dispersion in channels is inefficient mixing across internal boundaries. This project is currently supported by North West Water, Yorkshire Water and the Water Research Centre.

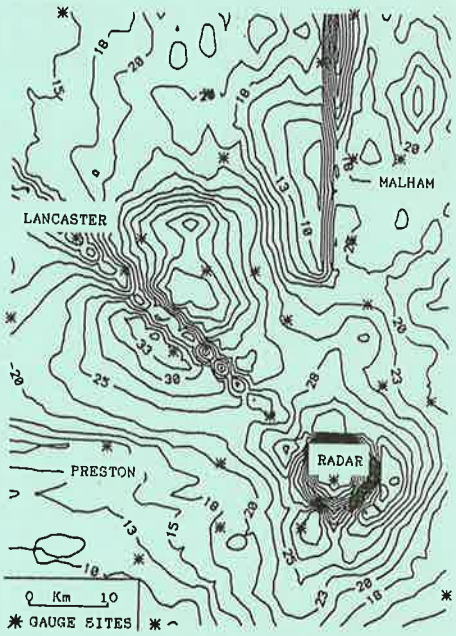
One of the most important results of this research has been the discovery that a basic parameter of this model, the dispersive fraction, is a very conservative parameter for a given reach, allowing the model to be used predictively over a wide range of discharges. **Chris Hutchings** is now extending the ADZ analyses to as wide a range of channel reaches as possible. Some detailed experimental work is in progess to try to understand the detailed mechanisms of mixing that lead to dead zone behaviour in natural channels. **Sally Heslop** is working on incorporating the results into the random particle tracking models of dispersion developed by Cath Allen. This will be extended in a series of laboratory experiments both in the Centre and in collaboration with **Ian Guymer** of Heriot–Watt University.

This work on dead zones in rivers struck a chord during discussions with **Colin Reynolds** of the Freshwater Biological Association at Windermere, who had inferred similar mechanisms to explain the population dynamics of phytoplankton in rivers. We are now exploring this link with Colin and **Paul Carling** in field work on two reaches of the River Severn near Shrewsbury.

Cath Allen's work also extends to dispersion on circulation processes in lakes, estuarine and coastal environments. The physical processes affecting biological organisms in Esthwaite Water are being studied by Cath and **Dave Smith** in collaboration with **Glen George** of FBA. Wind driven circulation and the associated temperature structures at different scales are being studied with a combination of field measurements and remote sensing data using the NERC aircraft fitted with a multi-spectral scanner. The NERC aircraft is also contributing to an investigation of the physical processes affecting flow and dispersion in the Esk estuary in Cumbria as part of a larger programme of study of environmental radioactivity in the area. Fieldwork and remote sensing are being combined with modelling studies to predict sediment movements. Satellite remote sensing will also be used in a study of costal sediment plumes along the Cumbrian coast which has recently been accepted as part of the ESA Marine Observation Satellite (MOS1) data utilisation programme.

Keith Beven is also continuing his interests in the area of flow and transport processes in the near surface zone on hillslopes in collaboration, under US EPA funding, with George Hornberger and **Peter Germann** of Rutgers University. Tracer techniques are being used to differentiate between direct flow and displacement processes in the response of unsaturated flows in undisturbed soil columns and plots. **Mohkta Abdulkabir** has recently finished a first series of experiments on soil experiments on soil columns at Lancaster, and last summer a series of experiments was run on a 9 m by 3 m block in Maine. The data obtained so far have been successfully modelled using techniques similar to the ADZ approach used for riverine dispersion. The recent award of an EC grant with Professor **Antonio Escarre** of the University of Alicante, Spain will allow development of models of water and solute fluxes through undisturbed soil based on these measurements.

Since moving to Lancaster from the Water Research Centre in 1984, Vince has taken an active research interest in the calibration of rainfall radar. He had a major hand in setting up two major radar research facilities in the UK, the Dee radar and the North West Radar Project. Now, with funds from NERC, he is working on methods of improving the calibration of the Hambledon Hill radar which has involved understanding and removing anomalies in the radar data, such as the shadow effects shown in the illustration. **James Buxton** has been running a network of ground truth raingauges in collaboration with North West Water. A particular concern of the project is the problem orographic enchancement. Working with Peter Young and **Cho Ng**, recursive time series analysis and forecasting techniques are being applied to the Hambledon Hill data. Recently Vince has become involved in an EC Weather Radar project under the Climatic Hazards programme, working with the University of Birmingham, IH and teams in four other countries.



Hambledon Hill decalibrated radar data (total event 3/4 December 1986) showing shadow effects.

Peter Young continues his research on recursive methods of estimation applied to various environmental systems, including hydrological modelling and forecasting. With Cho Ng and **Steve Benner** he has developed the microCAPTAIN and hydroCAPTAIN computer programs for the IBM PC range, the latter in conjunction with the ADZ project. Micro-CAPTAIN's novel recursive smoothing and forecasting algorithms are useful in all

aspects of hydrological data analysis. Version 2 of the package will shortly be available commercially. HydroCAPTAIN is intended primarily for the analysis of tracer and flow data.

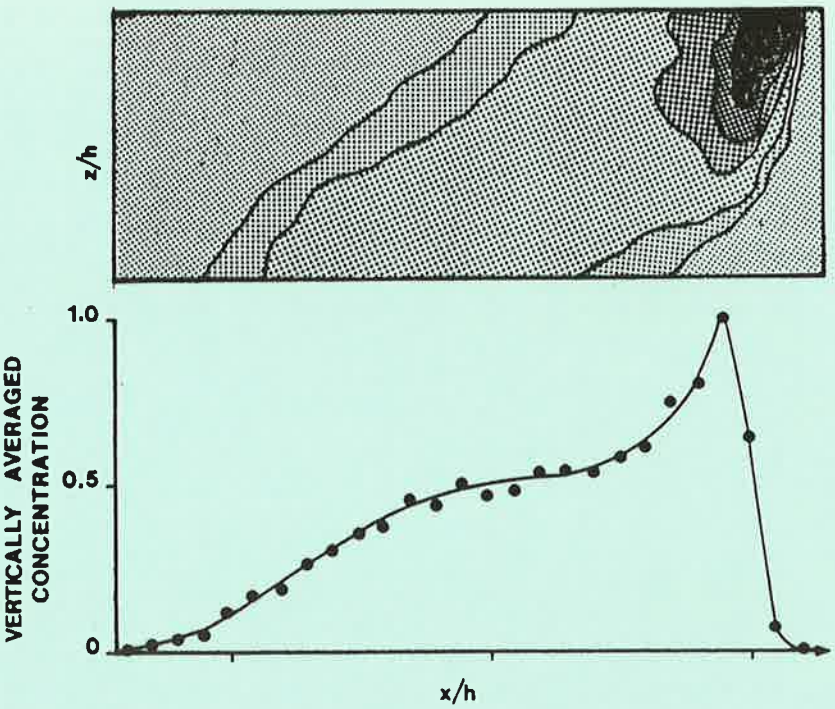
Environmental Chemistry

Several of the projects in environmental chemistry at Lancaster have close links with hydrology and fluid dynamics. The work on the Esk estuary mentioned above is primarily concerned with the behaviour of radionuclides derived from the BNFL nuclear fuel reprocessing plant at Sellafield. **Mike Kelly**, **John Hamilton-Taylor** and **Steve Mudge**, with funding from DoE, are gathering data on the geochemistry on plutonium and other transuranic elements which will be used as the basis for developing a model of chemical behaviour in the Estuary in collaboration with **David Turner** of the Marine Biological Association, Plymouth. Mike Kelly and **Matthew Emptage** are also working on the role of sediment processes in the dispersion of radionuclides.

John Hamilton–Taylor is collaborating with both **Bill Davison** and his colleagues at FBA and **Mike Edmunds** of BGS in a study of element biogeochemistry in Cumbrian lakes. The studies have focussed on the sources and biochemical cycling of various transition elements (e.g. Mn, Fe, Cu, Zn, Cd) and alkaline earth elements (e.g. Sr and Ba). As a result of finding extensive high salinity groundwaters in the Lake District, the work has been extended to include an assessment of deep groundwaters as a significant source of certain elements (e.g. Ca and Ba).

Environmental Biology

Hydrologists and hydrological modellers tend to treat the relationship of actual evapotranspiration with atmospheric demand during dry periods as primarily a function of soil moisture. The plant physiologist, on the other hand, has tended to regard any constraints on evapotranspiration rates as results of physiological controls. **Bill Davies** is investigating plant responses to water stress, at scales from the cell to whole plants, in a number of different environments with a view to understanding the different mechanisms involved. The air pollution research group led by **Terry Mansfield** and **Allan Wellburn**, who are studying the problem of "forest decline", have identified ways in which air pollutants disturb the normal physiological control of water loss in plants.



Particle tracking model simulation of dispersion from a line source.

The interdisciplinary nature of the research at Lancaster is also illustrated by water quality related projects in environmental biology. **Johanna Laybourn–Parry**, for example, has been collaborating with John Hamilton–Taylor, **KeithJones** and **Andrew Rogerson** of the FBA on the impact of protozoan grazing on the phytoplankton community structure and nutrient regeneration processes in Esthwaite Water and Windermere. This is the first major freshwater study of the critical role of microzooplankton in biochemical processes.

Studies of microcrustacea populations over the last 10 years in Esthwaite Water have shown a marked decrease in some benthic populations. Johanna and John Hamilton–Taylor are working to understand the factors responsible for this decline.

Finally, some of the most important processes affecting water quality take place in sewage works. Johanna Laybourn–Parry has a long standing research interest in the role of Nematoda and other microfauna in sewage treatment processes and has studied the microbiology of percolating filter plants, activated sludge and tertiary nitrifying filters.

The *Centre for Research on Environmental Systems* serves the purpose of bringing these different types of expertise to bear on particular problems or field situations, in a way that crosses traditional University departmental boundaries. In this manner, it is well placed to tackle the kind of multidisciplinary research that is required to understand the complex processes that underlie environmental problems in the area of hydrology and water resources.

FLOODS IN CHILE

It is only during the early hours of the morning or after a storm that the inhabitants of Santiago can catch a glimpse of the incredible natural beauty that surrounds their city. As the morning progresses the western foothills of the Andes fade behind a blanket of dense, yellow smog. Government restrictions on vehicle use have done little to prevent the continued build-up of smog except to infuriate car owners who identify the industrial and domestic burning of wood as the main source of the problem.

On this particular morning smog is not the only problem facing the people of Santiago. Following several days of continuous rain the river Mapocho has burst its banks and the roads in central Santiago are impassable. This is the second consecutive winter that central Chile has been hit by serious flooding. In a region where winter flows are generated by a combination of snow melt and rainfall and rivers never maintain a permanent channel, flood frequency analysis is not a straightfoward task. The electricity generation authority (Empreas Nacional de Electricidad SA) recognised the need to research flood hydrology in the central region following the floods of June 1986 and subsequently promoted research into the subject at the Universidad Catolica de Chile.

The bus I am travelling on pulls up at the University and the doors open allowing water to submerge the bottom two steps of the exit entirely. The locals are not people to miss an opportunity like this and willingly accept my 20 pesos in return for a lift across the road on the front of a tricycle.

I have been working as an assistant to Dr. Eduardo Varas of the Universidad Catolica de Chile researching into the applications of a two component extreme value distribution (TCEV) to central Chilean flood data for the past three months.

The TCEV has been introduced into hydrology as a way of modelling flood samples generated by two processes, one of which generates less frequent outlier events. Preliminary work has indicated that our choice of

Figure 1

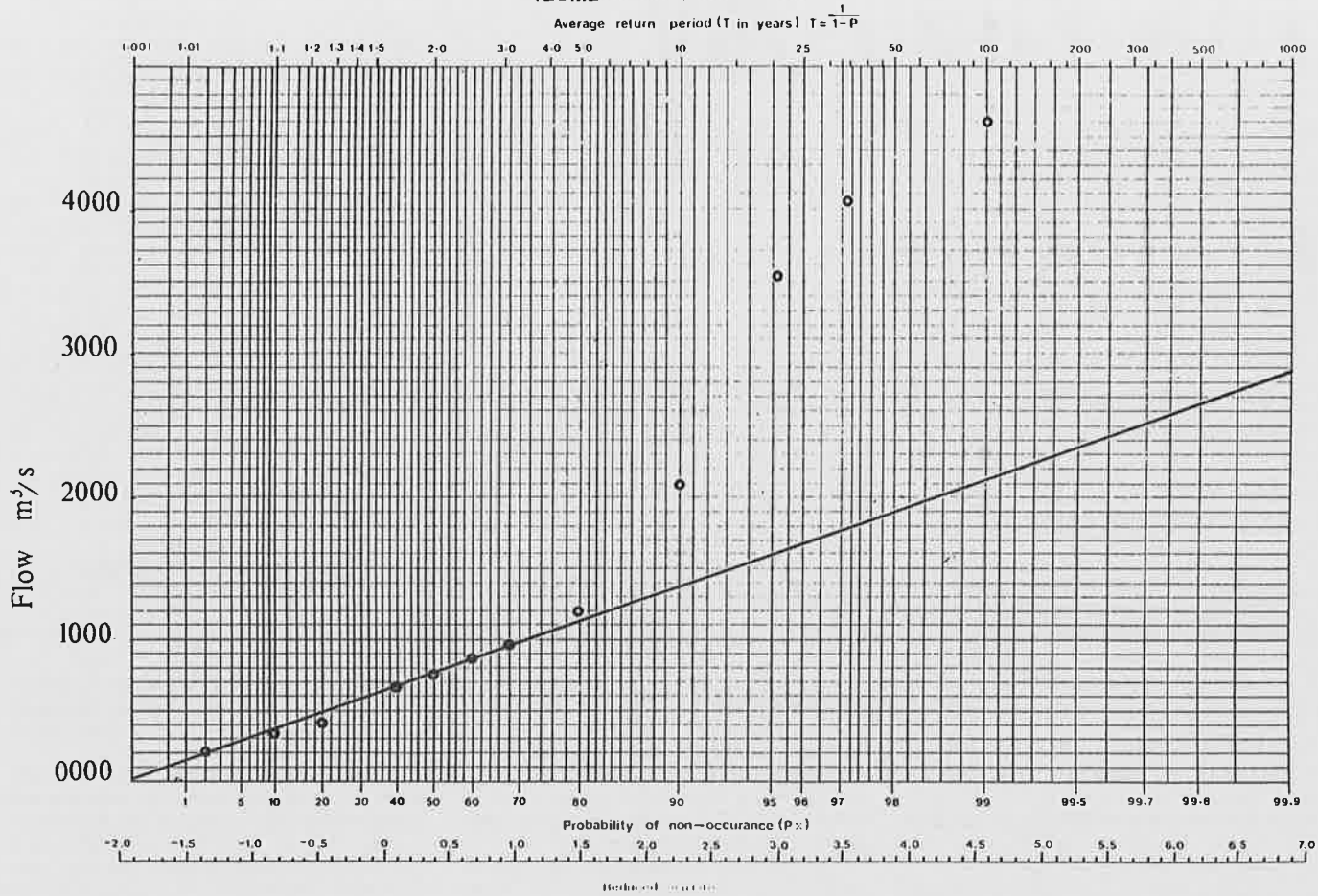
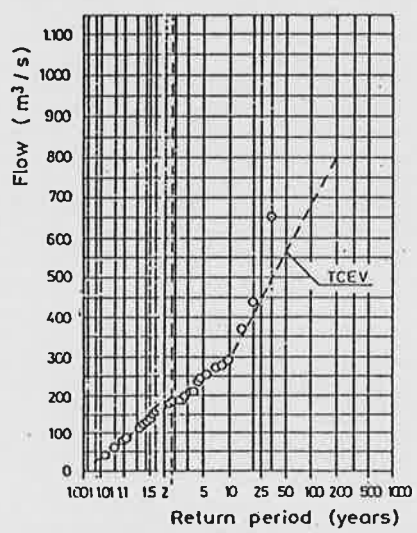
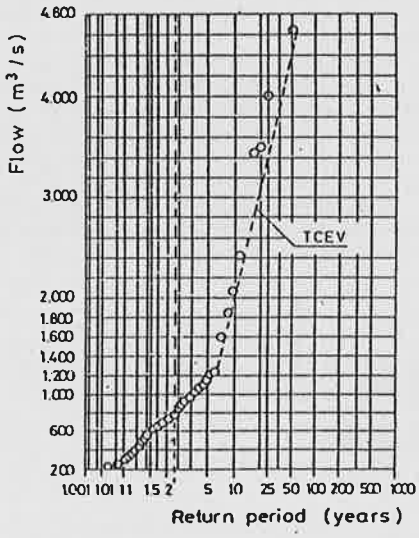


Figure 2



RIO COLORADO EN JUNTA CON PALOS



RIO LAJA EN TUCAPEL

an extreme value type 1 distribution for both the inlier and outlier samples is a reasonable one (see Figure 1).

The fit of an extreme value type 1 distribution to the inliers of each record has been significantly improved upon rejection of the large, outlier events. This has strengthened our hypothesis that larger floods, which are caused by combinations of warmer winter temperatures, low levels of snow cover in the mountains and several days of continuous rainfall, belong to an outlier component distribution. The parameters of the TCEV can be estimated from the complete samples without prior separation of outliers, but the identification of outliers endorses the use of a TCEV. In samples containing no outliers and of low skew the TCEV approaches an EV type 1 distribution. The regional TCEV is given in Figure 2 for two records which contained statistical outliers and can be seen to model the data significantly better than an EV type 1 distribution.

The purpose of flood frequency distributions is to model the underlying processes that produce floods whilst being parsimonious in parameters. The TCEV requires four parameters to be estimated from the flood record available, compared to two for an extreme value type 1 distribution and three for a general extreme value distribution. When selecting a distribution type, the hydrologist must balance the theoretical benefits of a distribution against the practicalities of data quality and sample size. The TCEV does theoretically model floods generated by mixed processes better than single component distributions, but it is not a way of providing more accurate estimates of flood return periods from poor quality and sparse data. The choice is still subjective and site specific.

Progress today is slow, so I decide to have a coffee with Daniel. Daniel is not happy: financing his studies is proving difficult despite working two days a week. The necessity to study for seven years only exacerbates his financial position. After six years he is considering suspending his studies indefinitely in order to fulfil his financial obligations to his family. We arrange to see Cola-Cola play Sao Paolo at the national stadium next Saturday and leave for home.

Typically of all South American cities, Santiago's population is growing rapidly. The population has grown by over a million since 1975. With increased pressure on housing resources people are forced to build closer to the Mapocho and accept the risk of flooding each winter.

The floods are receding now and people are digging their wooden shacks out of the sediment left by the receding Mapocho. I catch a glimpse of the social reality of flood frequency in Santiago.

Tim Jolley

The Yugoslav Association for Hydrology

The Yugoslav Association for Hydrology was founded on 2 April 1962, while on May 1963 the Association was registered as one of the nine specialised associations belonging to the general Association of civil engineering and engineers in Yugoslavia. The Yugoslav Association for Hydrology is an organisation with experts and scientists engaged in mutual collaboration, exchange of experience, organisation of various forms of specialised training and initiation of scientific research in the field of hydrology. The Association is included in the Association of civil engineers and technicians of Yugoslavia. The Association has its Statute which is the basis of its activities and it collaborates with the similar associations in the country and abroad. The Centre of the Association is in Belgrade and it covers the entire territory of Yugoslavia. The Association includes regular, collective and honorary members. The collective membership refers to the working organisations from the field of water resources management which support the Association from the moral and material standpoint.

By the end of 1986 the Association included 480 regular members and 84 collective members.

The main objectives of the Association are: (1) Stimulation of the development and improvement of hydrology in all its forms, as well as the development of the theoretical and applied hydrology; (2) Assistance in the solution of tasks imposed by the water resources management authorities; (3) Participation and co-ordination in the research and studies of hydrological problems; (4) Specialized training and education; (5) Organisation of professional meetings and publication of the result of hydrologic research.

The organisation of seminars and symposia has been one of the main activities of the Association, for example, a cycle of seminars for technicians and engineers just starting their work, the first of which was "Hydrometry" held in 1973 and the next entitled "Application of current technologies in hydrology", which will be held in May 1988 in Ohrid.

In addition to the organisation of the seminars, the Association has been concerned with the development of theoretical and applied hydrology particularly through conferences.

The Association is currently planning a Conference on Hydrometeorological information systems and modern methods of measurements of hydrological quantities. The papers presented at these conferences have been published in special Proceedings or as separate publications in the journal *Vodoprivreda* (*Water Resources Management*).

There has also been a permanent and successful collaboration between the Yugoslav Association for Hydrology and the Yugoslav Committee for the International Hydrological Programme, on topics such as a monograph on the Danube River, hydrological budget of the Adriatic Sea, conferences on the hydrological forecasting of Danube countries, etc.). Successful co-operation was also established with the Yugoslav Institute to develop Yugoslav standards in hydrology, hydraulics and hydrometry. Efficient collaboration was also established with the Federal Republic and regional hydrometeorological institutes as most members of the Association belong to them. The Association has also continued a close co-operation with the majority of civil engineering faculties in Yugoslavia.

For its successful work on the development of civil engineering the Yugoslav Association for Hydrology has been awarded a gold medallion and a charter at the VI Assembly of SGITJ. A certain number of the Association members have been proclaimed as honorary and meritorious members.

Finally it can be said that with regard to the financial situation, the Association has never had any problems in spite of the significant expense in the organisation of seminars and conferences. The income of the Association results from the sale of its publications, registration fees for the seminars and conferences, membership fees of individual members and particularly of the supporting members, and the support of the Yugoslav Committee for the International Hydrological Programme. The positive budget of the Association is, to a great extent, the result of the conscientious, social work of the members and the Presidency of the Association as well as of their consciousness of the importance of the Association for our country and for the hydrological theory and practice in general.

Prof. Ognjen Bonacci

NEWS FROM MEMBERS

CONSULTANTS

J. Ramsay has asked us to record that "another fool has gone freelance" (his words!) – from Senior Soil and Water Engineer with Land Capability Consultants of Cambridge to Principal, J. Ramsey Associates. Their first major assignment: two months with Scott Wilson Kirkpatrick & Partners carrying out an environmental impact assessment of the proposed Arun Access Road in eastern Nepal.

David Plinston and **Chris Kidd** have joined forces to form a new company Hydroconsult Limited. Although based in the rural south-west, they offer an international consulting experience covering all aspects of surface water hydrology. Historically, they were both at the Institute of Hydrology where David managed the overseas consulting group, and Chris led the urban hydrology project before spending some years on a WMO project in Malawi. More recently both have been working as freelance consultants for the UN and a number of firms of consulting engineers. They can be contacted on Torrington (0805) 22252 or Liskeard (0579) 21019.

MEMBERS ON THE MOVE

As reported in *Circulation* No. 16, **John Rodda** has moved from the Institute of Hydrology to the WMO in Geneva. He also leaves the IAHS after 16 years' service, during which time co-operation with UNESCO/IHP increased substantially.

Henny Colenbrander of The Netherlands succeeds him as IAHS Secretary General.

The Economic Uses of Water Resources in the North West of England

For water resource studies, the late '60s and early '70s were typified by the use of simulation models for resource allocation and system operation. In the late '70s, the emphasis changed to looking at interlinking resources and unified regional approaches. Now, in the latter '80s, the emphasis has again shifted; this time with economic considerations to the fore. In a paper presented to a joint meeting of the Northern Counties Association of ICE and the Pennines Hydrological Group at Carlisle, *Mike Knowles* and *Sue Walker* described how North West Water are using a number of techniques to determine strategies for providing reliable water resources in the most cost effective manner.

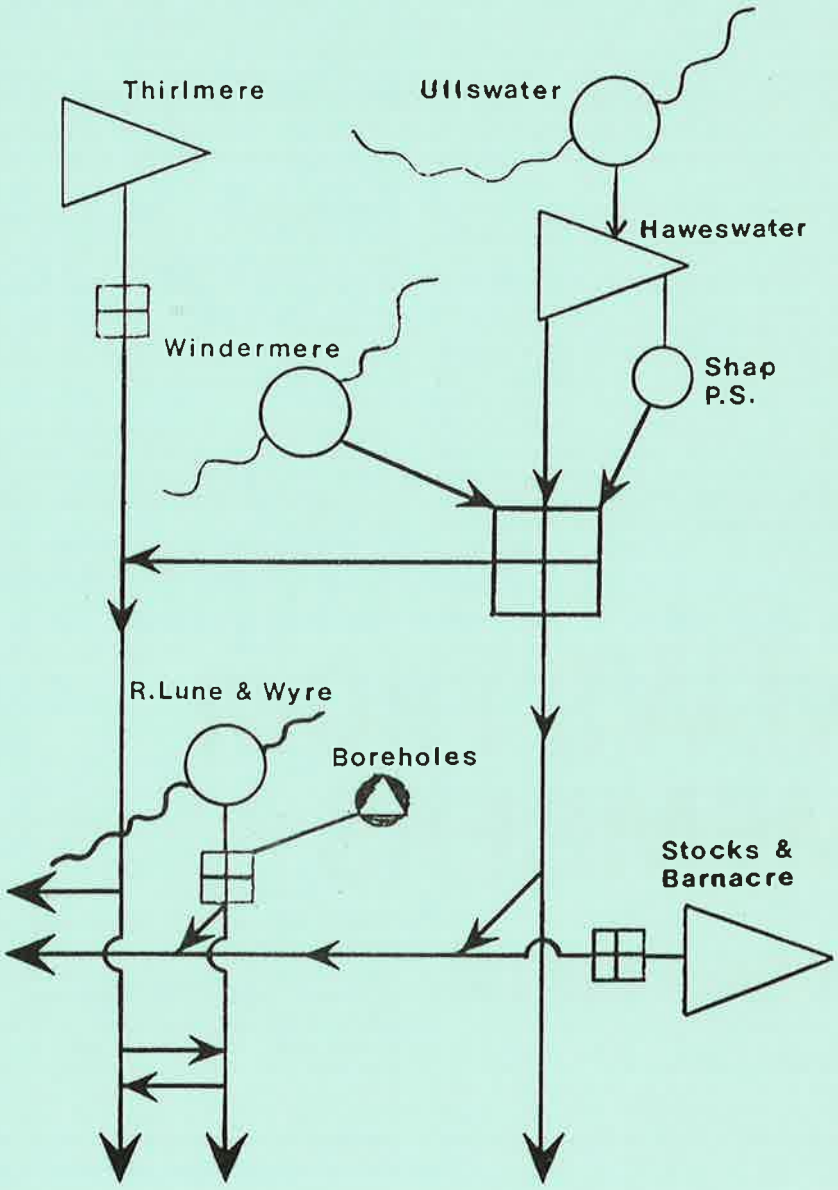
Pennines Hydrological Group/Northern Counties Association of ICE Meeting 25 February 1988

In studying any source, initial work generally entails determining the reliability of supply and calculating the yield for a suitable critical period. For most systems in the north-west, the severity was set at 1 in 50 years, whilst for major strategic systems, such as the Lake District, it was set at 1 in 100 years.

In periods which are not as dry as the design period it is possible to abstract more than the design yield without jeopardising the reliability of the source. To identify such periods when sources can safely be over-drawn, control curves have been developed, showing the amount of water which needs to be in store on a particular date to meet the demand during a repeat of the critical period. Using such curves it is possible to maximise the use of cheap Pennine sources, without impairing their reliability. In addition to their use for operational purposes, control curves can be used for planning purposes, such as assessing the size of treatment works which can be supported by a reservoir system. From this information, a balance between extra available water and extra required capacity can be reached.

Whilst this control curve policy is used for the small sources in the North West Water area, it was realised that for the larger complex strategic sources involving pumped refill a different approach would be required, particularly when considering operating costs. As far back as the early '70s, multiple control curves had been derived for the Lake District sources, giving a set of zones for each reservoir, requiring a different amount of pumped infill in each zone. During this time, the Lake District sources were treated as two independently operated sub-systems.

Simulation studies in the early '80s gave the opportunity to compare these multiple control curves and a single control curve with two zones (no/full pumping) in terms of both cost and reliability. The results showed that 18% savings could be made by integrating the whole system and using a single control curve, whilst maintaining reliability. In the other major resource area of the Northern Command Zone of North West Water, the Lancashire Conjunctive Use Scheme (LCUS), reservoirs are used in conjunction with river abstractions and groundwater. A



Lake District and LCUS water resources.

similar analysis was carried out to that for the Lake District. Together, the two sets of studies established control curves for the optimum independent operation of the two systems.

The next stage in the work was to identify an optimum methodology of operating all the sources in the Northern Command Zone as a single integrated system. Allocation of resources to demand centres was carried out using quadratic programming with minimisation of costs across the region as the objective function. The system was constrained by the supplies available and the transfer capabilities. This work allowed expensive LCUS borehole water to be replaced by surplus Lakes water.

After the '84 drought, emphasis shifted from the drawdown approach to control curves, to a refill approach. This resulted from concern that reservoirs should be as full as possible each spring. A decision was subsequently taken to modify the usual drawdown curves to follow an 80% probability refill line between autumn and spring, whenever it was higher than the drawdown based control curve. This approach enhanced the refill capability of sources without significantly affecting the operating costs. The refill approach also showed the type of operating regime required at pumping stations to give an adequate likelihood of refill. This produced a family of refill lines giving the same probability of infill from different pumping regimes: from this, managers can decide on an operating strategy taking into account both reliability and costs.

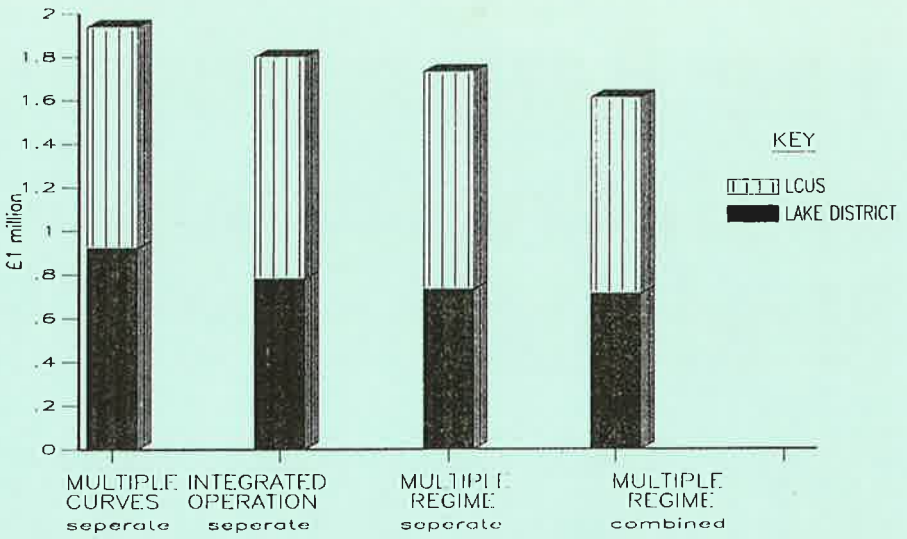
As these curves were more expensive to operate than the conventional control curves due to large volumes of spill produced, investigations were carried out into reducing operating costs, whilst maintaining an adequate chance of refill and reliability of the source. The curves required needed not only to protect against spill, but also to equalise the risk of pumping being wasted through the year.

To investigate the problem further, a dynamic programming approach was adopted in 1986, in conjunction with Power and Water System Consultants Ltd. of Henley. The approach minimises operating costs over all reservoir states, rather than just at critical drawdown periods. The policy obtained is defined in terms of differing modes of operation depending on the water in store in reservoirs. In contrast to the conventional curves for the Lakes, the multiple regime approach assumes a phased introduction of an increasing number of pumps.

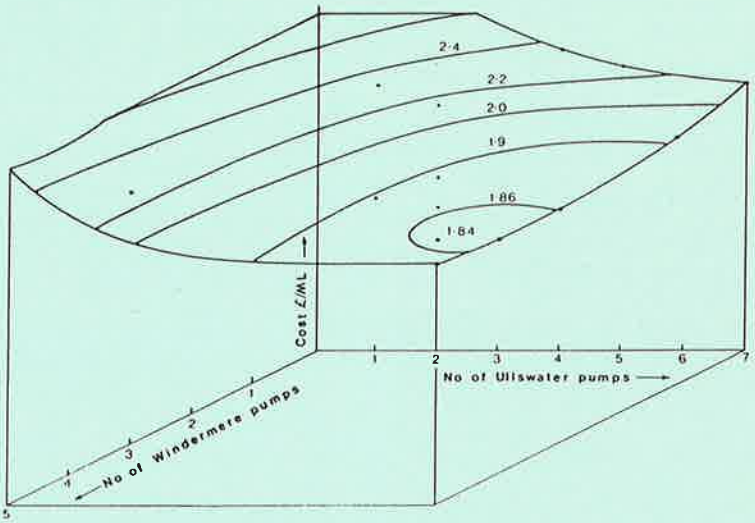
After applying the approach to the two systems in the Northern Command Zone independently (i.e. Lakes and LCUS), the approach was then used to optimise their joint operation, giving further substantial savings. In total, the potential overall savings from the integrated operation of the Northern Command Zone is 15% £1.9m compared with the separate operating policies used in the late '70s.

In conclusion, the ongoing nature of the work needs to be emphasised. Water resource systems are not stable, the constraints on the system can change frequently. Investigations need to take this into account if operating policies are to be secure as well as cost effective.

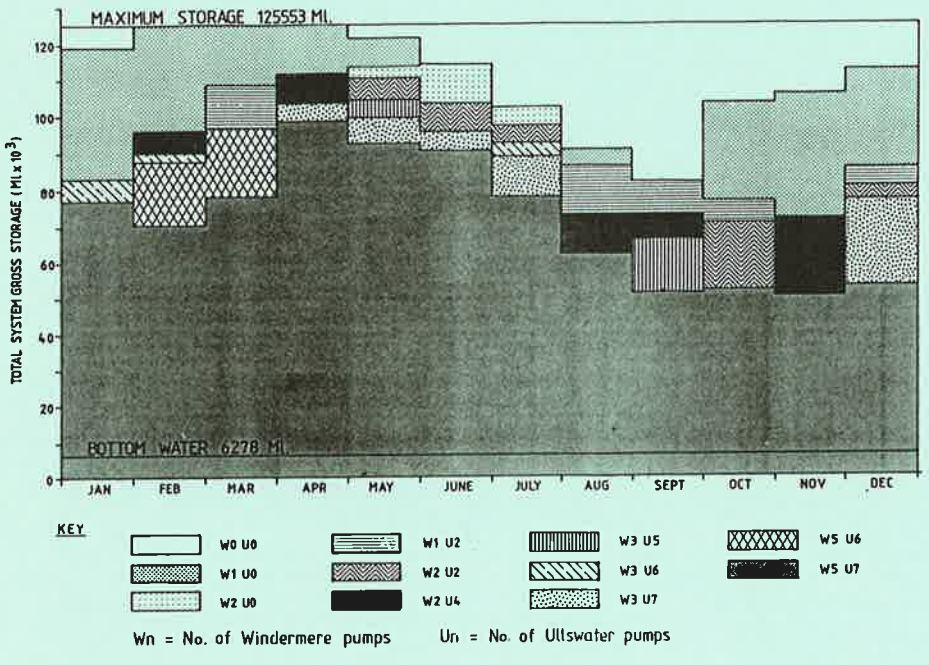
Ed Bramley



Northern Command Zone of NWW: History of savings in average annual operating costs.



Cost of operating Lake District at a demand level of 600 Mld.



Multiple regime policy.

The Association of Hydrologists of India

The Association of Hydrologists of India was formed in September, 1981 with a group of scientists belonging to various hydrology related faculties of Andhra University and the Andhra Pradesh State Government Departments located at Visakhapatnam, India. It is very heartening to note that there was a spontaneous response from scientists, industrialists and private entrepreneurs belonging to several facets of hydrology representing all parts of India and today there are about 50 life members, 250 members and 10 Institutional members on the rolls of AHI. There are also some Honorary members elected by AHI at its annual conventions as well as enrolled members from different parts of the world. In addition, there are several hundreds of non-members actively participating every year in the activities of the Association of Hydrologists of India.

The Association is an independent organisation, registered under the Society of Registration Act XXI of 1860 of the Government of India. The activities and other affairs of the Association are managed by five officers and 15 executive committee members elected by the membership once in two years.

The aims and objectives of the Association are:

1 To promote the cause of advanced study and research and to effect co-ordination of research and investigations in all disciplines related to Hydrology.
2 To promote exchange of ideas amongst the hydrologists belonging to various facets like geohydrology, hydrogeology, geophysics, hydrogeomorphology, hydrometeorology, environmental hydrology, engineering hydrology, agro-hydrology, water resources engineering, water management, nuclear hydrology, remote sensing etc., and to promote discussion on subjects of interest in the field of hydrology and related disciplines by organising meetings, conferences, seminars, symposia, annual lecture programmes, etc.
3 To strengthen the level of hydrological instruction by causing the preparation and publication of teaching and training aids in all disciplines related to hydrology.
4 To encourage research activities and disseminate information in hydrology and related disciplines by publishing research bulletins, journals, memoirs, monographs, etc.
5 To institute prizes, medals, etc., to honour scientists for their outstanding contributions to any branch of hydrology or a related discipline and to encourage scientists in their pursuits in these disciplines.
6 To co-operate in appropriate ways with other national and international organisations having similar objectives.

The Association of Hydrologists of India is actively involved in orienting its activities to meet the above objectives. So far, it has organised six Annual Conventions and Seminars, the details of which are given below.

The Association has published Proceedings of the first three seminars and the remaining volumes are in preparation. The Association also honoured some distinguished national and international hydrologists during its Annual Conventions.

The Association is deeply involved in the promotion of hydrological education and research in Indian Universities. It is responsible for the establishment of a two-year M.Sc. Hydrology course at Andhra University, Visakhapatnam. This course is the first of its kind being offered by an Indian University: B.Sc. graduates with combinations of Mathematics, Physics, Chemistry and Geology are eligible to study this course. It deals with integrated aspects of various facets of hydrology and has the approval of the University Grants Commission and the High Level Technical Committee on Hydrology of the Government of India.

The AHI is pursuing with the Government of India the establishment of another National Institute of Hydrology to cater for the needs of the peninsular region of the country, which experiences totally different hydrological phenomena compared to the Himalayan region and requires much hydrological research to be carried out.

To provide interaction between the Indian hydrological community international hydrologists, the Association of Hydrologists of India is going to organise its VIIth Annual Convention and International Seminar on "Hydrology" with a colloquium on "Water Resources Problems of South Asian Countries" at Visakhapatnam during 20-23 October, 1988. The Association welcomes all members of the British Hydrological Society to participate in this International Seminar and make it a grand success.

Prof. V.V.J. Sarma,
Secretary and Treasurer, AHI

Dates	Seminar	Colloquium	Venue	No. of papers presented	No. of original part
23rd–24th May, 1982	First Annual Convention of the AHI and Seminar on "Hydrological investigations during the last 25 years in India".	Rural and Industrial water supply.	Andhra University, Visakhapatnam.	60	21
8th–10th June, 1983	Second Annual Convention of the AHI and Seminar on "Hydrology".	National Grid of Rivers.	Osmania University, Hyderabad.	124	45
29th June to 2nd July 1984	Third Annual Convention of the AHI and Seminar on "Hydrology".	Precipitation Analysis and Flood Forecasting.	Indian Institute of Tropical Meteorology, Pune.	109	50
14th–16th June, 1985	Fourth Annual Convention of the AHI and Seminar on "Hydrology".	Impact on Water Resources on Agriculture.	Haryana Agriculture University, Hissar.	145	65
15th–17th July, 1986	Fifth Annual Convention of AHI and Seminar on "Hydrology".	Water logging and Drainage.	Moulana Azad College of Technology, Bhopal.	97	56
28th–30th August, 1987	Sixth Annual Convention of the AHI and Seminar on "Hydrology".	Urban Water Supply.	Madras University, Madras.	99	66

A note from history: Ancient Korean raingauge

The ancient Korean raingauge, invented in 1441, the 23rd year of the reign of King Sejong of the Yi Dynasty, was the first of its kind in the world. It was King Sejong himself who invented the raingauge and set up a network of them in the Seoul Palace and in each of the provincial offices throughout Korea.



The amount of rainfall had been measured since 1423 AD but the indications were not accurate. So a rain measuring instrument, made of copper or other materials of the time, was fabricated. Its dimensions were about 41.2 cm in height by 16.5 cm in diameter. It was known in the Korean language as *chug-u-gi* which means "rain measuring instrument". These raingauges were in use for more than 400 years, until the end of the Yi Dynasty.

The raingauge shown on the photograph (from the Central Meteorological Office, Seoul) is the only one of that type existing now. It was made of bronze in 1837 AD, the 3rd year of the reign of King Hyunjong. It is 31.5 cm high, 14.7 cm in diameter and it weighs 6.2 kg.

Rainfall data in Seoul, measured with such raingauges from 1770–1907, are preserved in Seoul. After that time, the methods of observation were modernized.

25 years of IHD/IHP (1965–1989)

When IHP-III finishes in 1989, the International Hydrological Programme (including the 10 years of the Decade) will have completed its first quarter century of helping nations to help themselves in the management of their water resources. UNESCO is considering ways in which this milestone can be appropriately recognized and one decision has been to hold a major scientific symposium at the time of the March 1990 session of the Intergovernmental Council of the IHP, in Paris.

In the past, many Member States have honoured the IHD/IHP by issuing commemorative postal stamps. UNESCO is now soliciting ideas on alternative ways in which this might be done. Any suggestions?

BOOKS

Water Resources and Water Management – M.K. Jermar (Developments in Water Science, No. 28) Elsevier Science Publishers, Amsterdam, 1986. 398pp. US$72.00. Hard back. ISBN 0–44–42717–1.

The first title in this Elsevier Series on "Developments in Water Science" that the reviewer came across was McMahon and Mein's excellent monograph on "Reservoir Capacity and Yield". That was some years ago, but the impression remains that in spite of the quality of the work, the price seemed excessive for what appeared to be a photo offset copy of the author's original typescript.

Whilst the quality of the content is the prime determinand, good quality type and presentation do make for easier reading. Conversely, with a less than compelling text . . .

This monograph by Jermar on "Water Resources and Water Management" is, unfortunately, a disappointment: it lives up neither to the title nor to the overall series "Developments in Water Science". The list of references cited seems dated and hardly reflects recent developments: of about 90 listed references, most date from the 1970's, with less than 10 from the 1980's, and about 30 are from the period 1945–1970.

A number of references are cited in the text but not listed and there is an irritating variety of other typographical and spelling errors, unlabelled axes on graphs and so on.

The first part of the monograph is really concerned with water science, and comprises a catalogue of items associated with the hydrological and biogeochemical cycles; the text presents numerous empirical and other formulae (often without derivation or references), various definitions and stoichiometric equations. Most of this material must surely be available elsewhere and the value of bringing it together in a monograph would be of greater value if the Index were more detailed and comprehensive. The remaining sections on water and its functions in society and agriculture, the impact of development on the hydrological cycle and finally management policy, also read like a catalogue and are consequently uninspiring.

The material looks as though it might have been typed up from sets of seminar notes, originally intended to convey the requisite vocabularly and general equations but which would require significant further work before the listener would be in a position actually to do anything.

There are several excellent texts, both recent and not so recent, which address Water Resources and Water Management. Sadly, this is not one of them.

Paul Jowitt
Edinburgh

Estimation of Natural Groundwater Recharge – NATO ASI Series C: Mathematical and Physcial Sciences Vol. 222. Editor: I. Simmers. D. Reidel Publishing Co. 1987. 510pp. £66.95. Hardback. ISBN 9027726329.

The book presents the papers from a NATO sponsored Advanced Research Workshop held in Turkey in 1987. There are some 32 papers contributed under five headings; the most comprehensive coverage lies in estimation methods based on physical or chemical techniques, numerical modelling methods and case studies. Before delving into detail, it is worth considering the general aims of a collection of this nature.

First let us examine the purpose of a workshop. In the beginning is a problem. A group of individuals who are familiar with the problem assemble in the hope that collectively they will progress towards a solution. At best, they succeed and the world is better off by the elimination of the problem. At worst, they make no progress at all and depart suitably chastened. An outcome somewhere between these extremes results in the participants learning from each other and leaving with new ideas with which to attack outstanding aspects of the problem. A somewhat idealistic view of a workshop but nonetheless a workable model.

At a more practical level, the participants need a basis from which to deliberate – papers must be written. Unfortunately, it is likely that all potential participants will wish or will be required to make a submission. Some because they will not attend without presenting their work but, more likely, because funds will only become available if they are seen to be doing so.

As each contribution is made, it will be subject to careful analysis by the participants. Does it contain the seeds of an answer? Is it relevant to the problem? Discussion, exchange of views, enlightenment, boredom may all arise. And at the end, conclusions will be drawn as to how next to proceed.

What, then, does this book provide in the way of a guide to the workshop. Certainly it identifies a problem. As the preface points out, the meeting was held to "critically address such specific topics as recharge determination methodology, estimation with

inadequate data and regionalisation from point observations". To help in discussion a number of particular questions were posed. These are summarised below as:

- is sufficent known about recharge?
- under what conditions are particular methods appropriate?
- how can remote sensing help?
- what information is needed to allow theory to be put into practice?

It also provides a full account of the starting point of the workshop. All the basic information is there.

Unfortunately, there is no coverage of the discussion or deliberations of the participants. This is a significant omission in a work of this kind. Perhaps the papers gave rise to little comment, in which case the workshop was a failure. If important points were brought to light then the reader should be informed and be allowed to benefit from the assembled expertise.

A more serious shortcoming is the lack of an indication of the final outcome of the workshop. There is no summary of the findings or recommendations of the participants. One is left with the feeling that little was achieved simply because there is nothing to contradict that impression.

Turning to the individual contributions, the majority of the papers deal with case studies; some more disguised than others. It became clear that many authors had grappled with the problem of estimating recharge and often discovered a workable though not always satisfying solution to a specific problem. There is considerable value in many of the contributions in that they provide a record of partial success under a wide range of conditions.

Each section of the proceedings contains an initial review paper, whether by accident or design is not clear. These are some of the best features of the book since they are informative and also provoke the reader into serious thought. They should certainly have produced interesting comments during the workshop. There are two papers which cannot be allowed to pass without comment. The first, by S.S.D. Foster, sets out a framework within which recharge studies should be undertaken. This is extremely good and deserves a much wider audience than it is likely to find in a collection of this nature. Practical advice, based on experience of a variety of studies, is brought together to provide a valuable insight into what recharge studies are all about.

The second paper illustrates the extremes to which one can go in a mathematical treatment of groundwater problems. I confess to being almost totally overwhelmed by the erudition of the author. The purpose, I assume, is to prove beyond a shadow of doubt that estimating recharge by working back from head information is hard. However, should you wish to attempt this you will find the required mathematics in a paper by H. Allison. I feel sure that behind all the symbols lies a fundamentally simple concept trying to escape.

Overall, the book achieves its somewhat limited objectives of providing the base information for a workshop. It is a useful work of reference for indications of what people have done in many parts of the world under a variety of conditions. The price precludes individual purchase but a copy might be justified in a large organisation with a high degree of work overseas.

Andrew Spink
Birmingham

New Members

R.M. Hughes	Student, City University
S. Mandel (Professor)	Hebrew University
W.B. Wilkinson (Professor)	Royal Military College of Science
R.E. Manley	WMO
R. Talbot	Self Employed
M.J. Corcoran	McDermott Eng
D.J. Oliver	Research Fellow, Birmingham University
Dr. M.F. Mylne	Senior Scientific Officer, Meteorological Office
C.H. Woolhouse	Thames Water Authority
M.J. Livermore	J. Wiley & Sons
P.G. Holland	DOE, N. Ireland
P.S. Kalmaki	Student, University of Athens
N.D. McKenzie	Student, Exeter University

NATIONAL HYDROLOGY SYMPOSIUM

A small group of Committee members has met to start planning our second BHS National Hydrology Symposium. At the moment, it looks as if the dates will be **Monday 4 September** to **Wednesday 6 September** (so far, we have not found this to clash with other "watery" events but we are still checking). The structure will be the same as the Hull meeting – mid-morning on Day 1 to lunch-time on Day 3 – incorporating four separate sessions.

Symposium topics

We dó not intend to define an overall theme for the Symposium but propose the following four session topics which we hope will attract contributions from both practitioners and researchers:

Headwater and hillslope
Urban catchments and receiving waters
Coping with excess
Operating surface and groundwater resources

Given the timing of this meeting in relation to developments in the organisation of the UK Water Industry, we intend to invite a speaker from the National Rivers Authority to give an opening address on "The Future of Hydrology in the UK Water Industry"; such a theme might well be opened up for more informal discussion in an evening workshop on the night not occupied by the Conference Dinner.

Proceedings

As before, we shall be pre-publishing the Symposium Proceedings and, with this in mind, this note is a first call for papers. Titles and short abstracts would now be welcomed by **Max Beran** at the Institute of Hydrology who is the Convenor/Editor of the Symposium volume.

Finances

The aim is to set the registration free at a break-even price; at this stage it is hard to give precise figures because locations vary slightly but we are setting a ceiling fee of £100 inclusive of accommodation, meals and proceedings volume. The location will be a university campus in a reasonably central position (likely to be Sheffield).

START THINKING ABOUT *YOUR* CONTRIBUTION NOW!

IHE DELFT

International Institute for Hydraulic and Environmental Engineering (IHE)

Oude Delft 95, Delft, The Netherlands

During its 32nd Academic Year from 20 October 1988 - 9 September 1989, IHE will offer the following 11 months postgraduate courses

A Postgraduate Course in Hydraulic Engineering

The course in hydraulic engineering has six branches corresponding as closely as possible to needs expressed by developing countries. The study programme of each branch includes basic subjects to be studied by every participant, and facultative subjects from which participants make a selection.

The various branches are:

Branch 'a'
Hydraulic engineering in upland areas
for the design and construction of dams, barrages, weirs, river control and flood protection.

Branch 'b'
Hydraulic engineering in lowland areas
for the design, operation and management of plans and structures for flood protection and the control of rivers and estuaries.

Branch 'c'
Land and water development
for the development of soil and water resources for agricultural and other purposes.

Branch 'd'
Experimental and computational hydraulics
for mathematical modelling and laboratory investigations in support of the design, management and construction of various hydraulic structures and works.

Branch 'e'
Port engineering
for the planning, design and construction of ports and harbours.

Branch 'f'
Coastal and offshore engineering
study of the physical properties of the sea and the coast and their influence on coastal and offshore structures.

A Postgraduate Course for Hydrologists

The course for hydrologists is directed towards solving water-related problems of quantity, quality and availability. The growing need for guaranteed supplies of water, and protection from flooding and pollution, imposes heavy demands on hydrological scientists and engineers. Participants study the latest developments in the field and are trained in the use of new methods and techniques. Apart from the study of fundamental transport processes, the course deals with engineering hydrology, which includes aspects of analysis, planning and design.

Awards
Both courses lead to a Certificate of Attendance, Diploma or Diploma with Distinction. *Participants who have obtained the Diploma with good results can continue with the IHE M.Sc. programme (additional duration approx. 6 months).*

Admission requirements
For both courses a degree in civil engineering or a related field of science or engineering, with at least three years of practical experience. A good command of the English language is indispensable.

Tuition fee
5,000 Dutch guilders.

Fellowships
Available through various international organizations: Unesco, World Meteorological Organization, World Health Organization, Food and Agricultural Organization (FAO), Commission of the European Communities, Association of Southeast Asian Nations, International Association of Ports and Harbours etc. Nationals from developing countries may also apply at the Netherlands Embassies for fellowships from the Netherlands government.

In addition, during 1988 IHE will organise the following

Short Courses

International Seminar on Port Management
from May 24 - June 30, 1988

Modelling Groundwater Flow and Solute Transport
from March 7 - 11, 1988

Stochastic and Geostatistical Analysis in Groundwater Modelling
from June 6 - 10, 1988

New developments in Groundwater Modelling (Expert Meeting)
from September 14 - 16, 1988

Applied Modelling of Groundwater Pollution
from October 3 - 7, 1988

Short courses on
. Coastal Management
. Offshore Management
. Dredging
are under preparation, to be held end 1988 / beginning 1989.

For all courses, please contact the IHE registrar for detailed brochures, application forms and further information. Address: P.O. Box 3015, 2601 DA Delft, The Netherlands. Phone: (0)15-784466. Telex: 38099 ihe nl. Cables: Interwater Delft.

IHE in Delft also offers postgraduate courses in sanitary engineering, water quality management, environmental science and technology, transportation and road engineering and can organize courses on topics in its areas of competence tailored to special needs, which can then be conducted either in Delft or overseas. IHE assists governments and universities in developing countries in designing and conducting postgraduate training courses. IHE moreover carries out research and projects in hydraulic engineering, hydrology, sanitary engineering, water quality management and environmental management.

FORTHCOMING EVENTS

Meetings

INTERNATIONAL CONFERENCE ON PUMPED STORAGE
18–20 September 1989
Manchester

Three main themes:

- ★ Operational experience, including maintenance of existing schemes.
- ★ Latest developments in the design specification and construction of current or projected schemes.
- ★ Evolving roles of pumped storage and its integration into power systems.

Further information from Conference Office, Institution of Civil Engineers, 1–7 Great George Street, London SW1P 3AA.

IAHS INTERNATIONAL SYMPOSIUM ON REGIONALISATION IN HYDROLOGY: HYDROLOGICAL MODELLING AND ESTIMATING TECHNIQUES FOR RELEVANT PARAMETERS
Co-organised by the Yugoslav Association for Hydrology and the International Geographical Union
23–26 April 1990
Ljubljana, Yugoslavia

Conference themes:

1 Data Acquisition
2 Hydrological Modelling
3 Regional Transfer Modelling

Abstracts for papers (c. 300 words long) should be submitted by 1st October 1988 to Professor M. Brilly, Faculty of Architecture, Civil Engineering and Survey Hydraulics Department, Hajdrihova 28, 61000 Ljubljana, Yugoslavia.

A registration form and full details of the International Symposium including registration fees, accommodation, proceedings, workshop exhibition and study tours, is available in a First Circular available from Mr. Max Beran, Institute of Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, Oxon OX10 8BB.

Copy Deadline for Issue No. 19 – 4th July 1988

INTERNATIONAL CONFERENCE ON FRIENDS IN HYDROLOGY

FRIENDS: Flow Regimes from International Experimental and Network Data Sets.

Convened by the Norwegian National Committee for Hydrology in co-operation with the FREND Project Steering Committee, UNESCO/IHP and IAHS at Bolkesjø, Norway on 1–6 April 1989.

The conference will discuss the results of analysis of small research basins and network data in the study of spatial variability on hydrological characteristics and the impact of man on the hydrological regime.

A focus will be the presentation of the results of research associated with the FREND project (UNESCO IHP-III Project 6.1: Flow Regimes from Experimental and Network Data), an example of international co-operation. Opportunities to consider the outcome and organisation of similar research projects from other parts of the world will be provided.

Authors are invited to submit an original and one copy of an abstract in English of 600–800 words. The abstracts should include the name, affiliation and address of the author(s).

A Poster Session will be organized.

Please observe the following deadlines:

1. Provisional registration	1 May 1988
2. Receipt of abstracts of papers	1 June 1988
3. Final registration for the Conference	1 November 1988
4. Receipt of final papers for the Proceedings	1 December 1988

Contact: Norwegian National Committee for Hydrology, PO Box 5091, Majorstua, 0301 Oslo 3, Norway. Telephone: + 47 2 46 98 00 ext. 383 or 327. Telex: 79397 NVEO N. Telefax: + 47 2 69 61 51.

Diary

21st June 1988
BHS Southern Section Meeting.
Technical visit to Thames Flood Barrier: 2 p.m.
Meeting at Imperial College, London: 5 p.m.
"Floodwarning in London" – C. Haggett;
"Response to flood warning" – J. Neal.
Details: Dr. Nigel Arnell, Institute of Hydrology (ext. 2345).

12th July 1988
BHS South-West Section.
Field visit to Roadford Dam – if interested contact: Dr. Bruce Webb, University of Exeter.

22 September 1988
BHS National Meeting.
"New Developments in Urban Hydrology".
University of Salford, Manchester.
Contact: Ian Cluckie, University of Birmingham.

20–23 October 1988
VIIth Annual Convention and International Seminar on Hydrology.
"Water Resources Problems of South Asian Countries" at Visakhapatnam.

Members should please note the comments made on page 8 . We hope some may be able to contribute a paper to the meeting and if so, BHS would approach both the Royal Society and the British Council for possible funding – please contact the Secretary, Dr. Bruce Webb at Geog. Dept., Exeter University if you are able to make such a commitment.

10 November 1988
BHS/IAHR/WHG/IWEM meeting.
"Two Stage Flood Channels".
Bristol University.
Contact: Bob Sellin, University of Bristol.

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 £10. Please addresss all correspondence to the Editor, Celia Kirby, Institute of Hydrology, Wallingford OX10 8BB. Telephone: 0491–38800 extension 2224.