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UNIVERSITY RESEARCH ... Part III

Civil Engineering, Imperial College

BACKGROUND

Imperial College has a long and distinguished history as a major centre of hydrological research and postgraduate training. The first Engineering Hydrology postgraduate course in the UK was initiated by BHS President, **Peter Wolf**, in 1955 (with former President **Mike Mansell-Moullin** a student in that year) and the continuing role as a postgraduate centre has maintained a strong research presence over the subsequent three decades. Former staff include **Professors Wolf, O'Donnell, O'Connell, Hall** and **Jowitt**, who, together with **Elizabeth Shaw**, continue to play leading roles in British Hydrology. The current team is led by **Howard Wheater, Paul Johnston** and **Bruce Beck** with part-time assistance from **Terence Davis** and in recent years the level and range of research activity has expanded in the pursuit of new developments in research and teaching in the UK and overseas.

Within Civil Engineering, 11 academics specialise in Water Engineering, supported by visiting Professors **Peter Ackers** and **Ron Packham** and colleagues from Mathematics and Engineering Geology. Three full-time MSc courses are run: in Engineering Hydrology, Public Health (Environmental) Engineering, and in River, Estuary and Coastal Hydraulics. Current hydrological research has a strong emphasis on problems of surface and sub-surface water quality and water quality modelling, and the combination of hydrological and modelling expertise with the water chemistry interests of **Roger Perry**'s Public Health group provides a powerful base for multi-disciplinary research appropriate to the needs of the UK water industry. The group also has a long history of overseas involvement, and this continues in current research into the more traditional areas of flood hydrology and water resources development as well as water quality. Overall, the full-time research group in hydrology and water quality numbers approximately 30 post-graduate students and research assistants, supplemented by project work from some 35 MSc students. Annual turnover on research contracts is of the order of £500,000.

SURFACE WATER QUALITY

Current interest in environmental issues throws out new questions to the hydrologist with respect to the interpretation and modelling of hydrological processes, and a key area of research is the application of models to the interpretation of field data, in the identification of flow and chemical processes, in the identification of model structure and parameters, and in defining modelling uncertainty and predictability. The issue of surface water acidification provides a focus for this work, and a research group of seven, led by Howard Wheater and Bruce Beck, is involved in two collaborative projects. As part of the Royal Society Surface Water Acidification Programme, the group is working with the Institute of Hydrology, Freshwater Fisheries Laboratory, Macaulay Land Use Research Institute and Forth River Purification Board at two experimental sites in Scotland. Collaborative plot experiments within experimental catchments are providing continuous monitoring of inputs, throughflow fluxes and three-dimensional soil water flow fields as well as routine and event-based chemical monitoring. These results are being used to aid conceptualisation of catchment processes (**Simon Langan**), and finite element modelling techniques have been developed to evaluate soil water residence times, the occurrence of macropore flow, and as an aid in the generalisation of plot results (**Sergio Koide**).

At the catchment scale, modelling research is focussing on the identification of short term flow and chemical response using conceptual models and time series' analysis (**Frank Kleissen**) and also in long term response and the effects of canopy processes and nutrient cycling (**Stella Kaemaki**).

An NERC-supported project with the Institute of Terrestrial Ecology has just commenced to investigate the hydrology and hydrochemistry of macropore-dominated systems, based on the upper Wye research catchments at Plynlimon (**Adrian Muscutt**).



Automtic tensiometer network and through-flow pit, Mharcaidh catchment, Cairngorms.

SUBSURFACE WATER QUALITY

Howard Wheater commenced research on subsurface water quality in 1981, with work on the modelling of advectively dominated solute transport in groundwater. Recent developments include a study of the identifiability of unsaturated flow and solute transport models, including solute-solid reactions (**Roberto Abeliuk**), the development of integrated soil-plant-water models (**Iannis Karavokyris**), and an NERC-supported study of saline intrusion in groundwater, concentrating on the observation and modelling of dispersion at the freshwater-saltwater interface (**Adrian Butler**). This latter study, in collaboration with IH, has used new resistivity probe techniques to monitor detailed response of the salt-water interface in a shallow, unconsolidated coastal aquifer, and the performance of alternative numerical approaches, including density-dependent finite element and characteristic methods, is being investigated. The work is currently being extended to Dungeness in collaboration with Southern Water.

Research in Groundwater has been considerably strengthened by the return to Imperial College of **Paul Johnston** in 1987. In addition to extensive involvement in African hydrology and a broad experience of overseas postgraduate training, Paul has a major interest in problems of groundwater contamination. A number of studies for local authorities in Ireland have now been succeeded by a major investigation for British Gas of point-source pollution and in collaboration with Howard a novel study of the use of groundwater cooling systems has been carried out for British Telecom.

The themes of waste management and contaminated land are also a strong interest of **Roger Perry**'s research team. The Department of the Environment are supporting research into the stabilization of hazardous waste and the in-situ treatment of contaminated land, and a recent study for WRC has concerned the inorganic contamination of groundwater, specifically with respect to volatile chlorinated hydrocarbons.

The combination of expertise in subsurface water quality and groundwater and unsaturated transport provides a strong base for future research in this area.

WATER QUALITY MANAGEMENT

Bruce Beck joined the Department in 1982 (following a five-year appointment at the International Institute for Applied Systems Analysis) and now teaches time-series analysis and a course on Environmental and Water Resource Systems Analysis as part of the Engineering Hydrology MSc programme. His research interests are in the areas of uncertainty, identifiability and predictability in water quality modelling, wastewater treatment process modelling and control, and the operational aspects of river basin management. Some of these interests have already been described with respect to the Department's work on surface water acidification. Bruce's long-standing association with operational water quality management (predated perhaps only by his association with Kalman filtering) seems at last to be coming to fruition. Much of the research – on developing a dynamic discharge-quality model for catchments – has been done in collaboration with **Brad Finney** of Humboldt State University, Arcata, California. After many years of gestation the model is about to be coupled to a dynamic wastewater treatment plant model, so that questions of the economics of seasonal treatment policies, the impact and control of stormwater sewer overflows, and the operational management of high nitrate episodes can be studied. Bruce has recently been joined by **Bayo Adeloye**, formerly a PhD student at the University of Newcastle and now a Fellow of the Royal Commission for the Exhibition of 1851. Bayo's previous work with John Mawdesly on the economic worth of hydrologic data is to be extended to the operational aspects of water quality management, involving him in working with new environmental quality objectives and new monitoring technologies that can be addressed to the detection and control of transient pollution events.

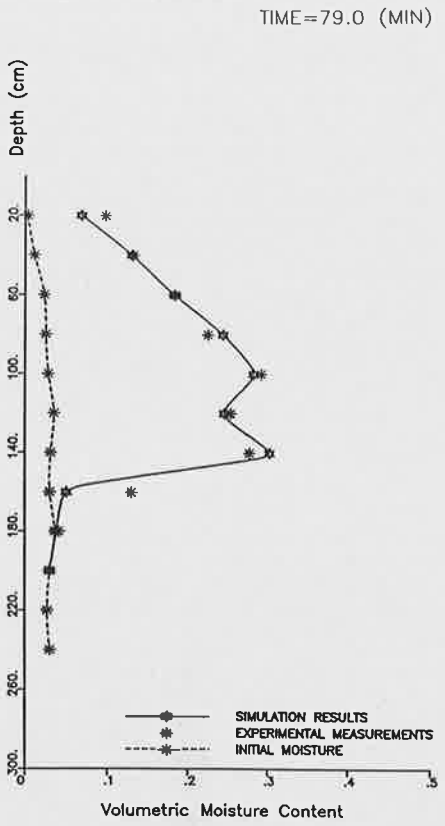
Bruce's interests in wastewater treatment are complemented by **John Lester**'s extensive experience in the chemistry and microbiology of treatment processes and in the fate of heavy metals in the environment. John's work has included a wide range of studies of the fate of pollutants in treatment processes, and a recent collaborative study by Bruce, John and Howard for Anglian Water involved detailed monitoring and modelling of heavy metal throughputs in wastewater treatment plant and their subsequent distribution and transport in river sediments.

Other current interests of John's are the fate of chlorophenoxy herbicides in wastewater treatment processes and in receiving waters, and the problems associated with tributyl tin in navigable rivers.

OVERSEAS HYDROLOGY

Although much research is focussed on issues of UK water quality, staff are extensively involved with overseas students, in training programmes overseas and in overseas projects and research.

Howard Wheater has pursued an interest in arid zone hydrology for several years. In 1981 Imperial College undertook a flood study of N Oman and more recently it has had a substantial involvement with Dames & Moore in a respresentative basins study for the Saudi Arabian Ministry of Agriculture and Water. This latter project has proved an important addition to the arid zone data base, and has provided a vehicle for research into the spatial and temporal characteristics of



Simulated and observed response to Wadi bed infiltration, Wadi Habawuah, SW Saudi Arabia.



Flash flood, Wadi Tabalah, SW Saudi Arabia.

rainfall in SW Saudi Arabia and for process studies of groundwater recharge from ephemeral flows. Regional analysis of rainfall I-D-F relationships and areal reduction factors has been carried out and a new multivariate spatial-temporal rainfall model developed (**Adrian Butler** and **Lisa Stewart**). Two-dimensional unsaturated-saturated soil moisture models have been developed to investigate the recharge processes for management processes, including effects of heterogeneity, hystersis and evaporation (**George Parissopoulos**). Supplementary studies, of regional evaporation and soil moisture characteristics and of rainfall-runoff relationships have been investigated with MSc support. In addition, advice has been given to Dar-al-Handasah on the flood hydrology of Mecca and Madinah.

Strong links have been developed with the Catholic University of Chile, via staff exchange and short courses, and in 1987 **Tim Jolley** carried out his MSc project in Santiago, applying a two-component extreme value distribution to a regional flood study.

Currently, research links in East Africa are being pursued by **Paul Johnston**, who has an existing interest in groundwater development in developing countries and has been working on studies of well loss and on the performance characteristics of large-diameter hand dug wells. **Nigel Graham** has developed an emergency water supply kit for refugee camps on behalf of Oxfam, currently deployed in Ethiopia, Somalia and Central America.

Roger Perry is currently advising the Pakistani government on water quality legislation, and staff are involved in short courses on various aspects of hydrology and water resource development in Africa, South America, the Middle East and the Far East under the sponsorship of FAO, WMO and UNDP.

CONCLUSION

This brief review has sketched out the main areas of research interest and activity in Hydrology and Water Resources at Imperial College. Space has not permitted an account of the diverse and often important contributions made by our MSc students in their project work, in topics which range from urban storm sewerage design to arid zone evaporation. Nor has account been taken of contributions from departments other than Civil Engineering, in particular Sir David Cox's current research into stochastic rainfall models, reported in this issue of *Circulation*, and of the research support from our many collaborating bodies, particularly IH.

Looking to the future, we see an extension of overseas research and training, in water resource development and water quality management, and an increasing emphasis in the UK on environmental issues, waste management and operational water quality management. Existing multi-disciplinary collaboration, within our group, within the College and externally, is likely to strengthen and in 1988 we look forward to new collaborative ventures with Imperial College colleagues **Nigel Bell** (Life Sciences) and **Margaret Minski** (Reactor Centre) on radionuclide soil water transport and vegetation uptake, and with **David Cox** and **Anthony Davison** (Mathematics) on rainfall modelling and extreme value statistics.

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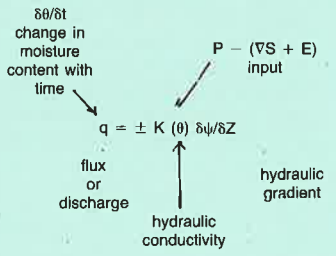
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Aspects of Hydrological Studies in SW England: Monitoring and Resources

BHS South-West Section Meeting
21 October 1987

Over 40 people attended this meeting held at Plymouth Polytechnic which had been organised by *Peter Sims* and *Les Ternan* of the Polytechnic's Department of Geographical Sciences. The theme of the meeting was chosen to bring together both academic and practising hydrologists and successfully attracted a number of Water Authority personnel, as well as staff and researchers from the Polytechnic, Seale Hayne College of Agriculture and Exeter University.

Five papers were presented during the course of the afternoon beginning with **Nick Chappell** (NERC Research Student, Plymouth). Nick's work stems from studies undertaken in the Narrator Brook Catchment on South West Dartmoor, although he is currently based at IH's Plynlimon field station. He is concerned with monitoring soil water pathways through forested catchments and is only part-way into his programme of field data collection. Soil water pathways beneath two adjacent hillslopes, one forest and one grassland, are presently being monitored at Plynlimon. The flux changes resulting from coniferous afforestation are being modelled by solving the components of the Darcy equation:



Of considerable interest were the field techniques described by Nick for his data. These include banks of automatic tensiometers and ring and well permeametry. Even the localised impact of individual trees and tree roots upon Darcinian hillslope flux is being measured. The HYSPAC soil water Geographic Information System will be used to hopefully produce a process-oriented hydrological pathway model. This when combined with time-synchronised chemical data, should indicate the solute fluxes important within catchment acidification.

Rob Parkinson's (Seale Hayne) paper dealt with two case studies of the hydrology of agricultural drainage systems. Rob pointed out that over 50% of the agricultural land in England and Wales (approximately 6 million hectares) has been underdrained during the last 150 years. In addition, current estimates suggest that the rate of drain installation, including both new facilities and the replacement of derelict systems, is of the order of 100,000 hectares per year. Thus the impact of such widespread alteration to the hydrological system is not without some significance.

A four-year study of a heavy clay soil was described which indicated that patterns of drainflow are primarily dominated by the soil water status of the site. Two important phases were identified: during autumnal rewetting, when desiccation cracks begin to close, and in the winter "mean water content" period. Further investigations on the clay soil indicated that drainage response of individual tile laterals was strongly controlled by slope angle and the position of the drain on the upper, middle or lower part of the slope. On the steepest part of a convex slope water contents were maintained at higher levels than further up the slope, resulting in rapid and large responses to rainfall events in the autumn. However, once the soil is fully rewetted, the drains on the more gentle slopes discharged a larger proportion of the incident rainfall. Rob Parkinson hypothesized that this behaviour could be explained in terms of changing catchment size with slope angle.

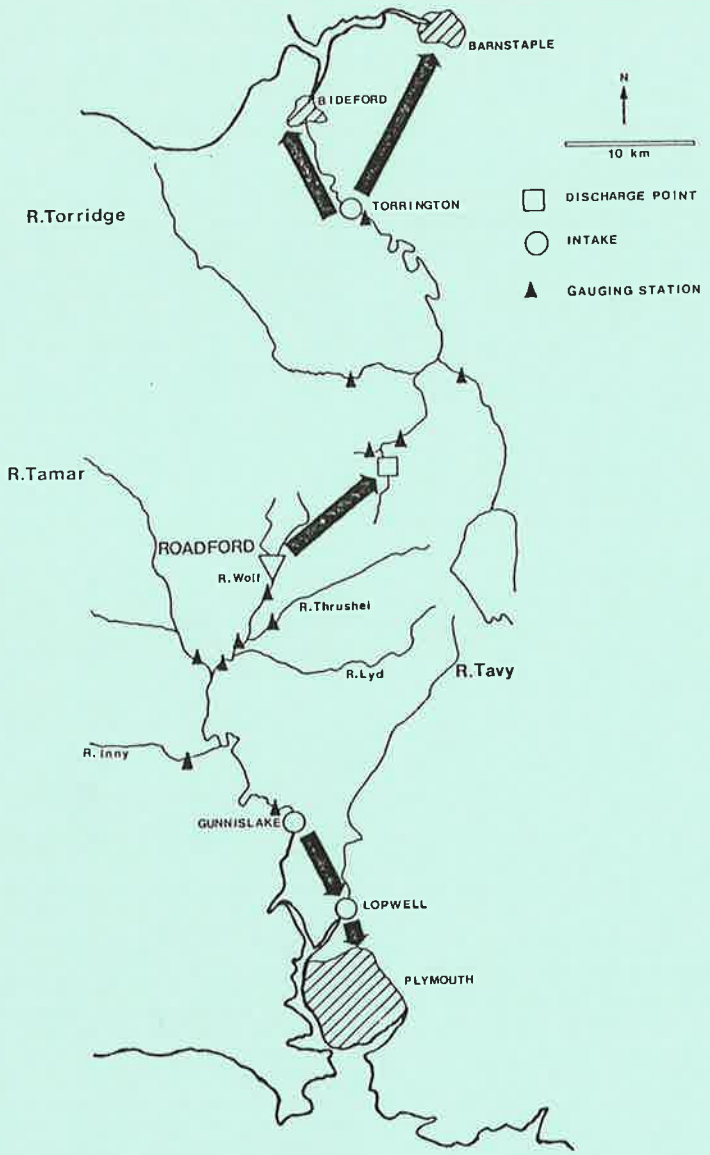
The case study of a Devonian slate soil, with their characteristic variable stone content and depth to bedrock, necessitate different drainage practices to deep clay soils. Here, soil loosening significantly reduces bulk density with marked effects on the movement of soil water. Examples of hydrographs for the autumn and winter period show that loosening markedly alters both the timing and quantities of drain discharge in the first year after loosening. Monitoring of soil water energetics shows that during winter the loosened soil delays water transmission over a 24-hour period, but that over 48 hours more water discharges from the loosened than the unloosened soil.

The higher water contents recorded in the loosened soil during the winter months result in significantly reduced soil shear strength. Thus the modification of the soil water disposal patterns in this soil may well lead to restricted machinery access or grazing, contrary to expectation.

The next paper carried the intriguing title "How to wring blood from a stone – or deriving information from groundwater level records in South West England". **Cliff Tubb** (South-West Water) presented results obtained from groundwater monitoring programmes in East Devon over the last 20 years. Initial monitoring programmes had been based on information gleaned from geological maps with rocks classified into two basic groups characterised by intergranular or fissure permeability. Although this basic work yielded useful data, more sophisticated hydrogeological interpretations were required. Nevertheless, groundwater storage and yield still tended to be the accumulated error function in the water balance equation. What was really required was replenishment/recharge analysis to predict stability of groundwater storage or yield for say a 30-year period. This interesting review paper ended with a plea that we should choose suitable monitoring strategies based on known errors and pitfalls – only in this way will problems be overcome and reliable data be achieved.

The after-tea session was devoted entirely to material relating to the new Roadford Reservoir Scheme. **Neil Whiter** and **Glynis Weilding** (South-West Water) spoke about the development of a water resources strategy in south-west England based upon the use of three large river regulating reservoirs: Wimbleball, Colliford and Roadford. The first two reservoirs are in operation and the construction of the third at Roadford has just begun. The whole system would operate in conjunction with existing resources.

The Roadford Scheme (gross storage 36,910 Ml) on the River Wolf between Launceston and Okehampton is programmed to be completed by 1990. It has a long and chequered history after the siting of the third reservoir in the regional strategy became a "cause celebre" for both the agricultural lobby and Dartmoor preservation groups. Three Public Inquiries were held at which numerous undertakings were given by the Water Authority to safeguard the fishing and environmental interests which could be affected by the scheme. Thus Neil Whiter and Glynis Weilding became involved in a hydrological and operational model for the Roadford Reservoir System. The model was aimed



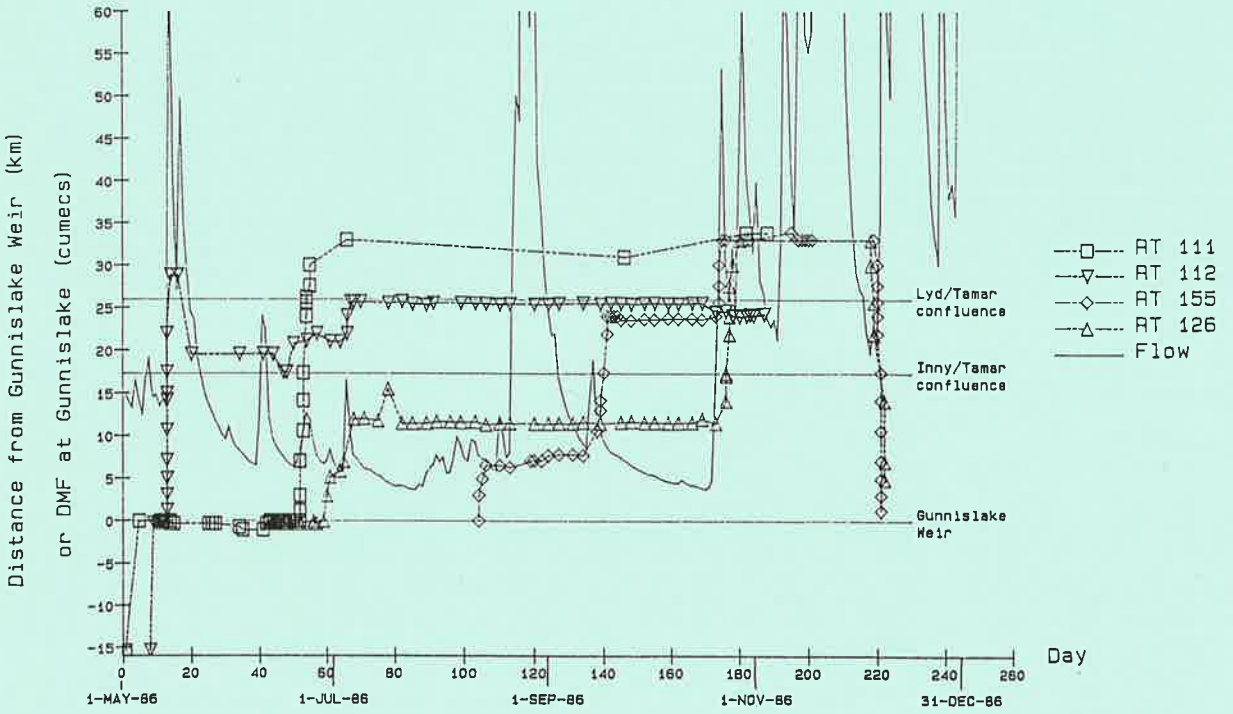
specifically at providing information for studies relating to the Authority's environmental undertakings, its main purpose being to find the optimal method of operation, by simulation, under a given management philosophy.

Inputs into the model included historical meteorological and mean daily river flow data. Derived flow data for new stations based on cross-correlation analysis were also used. On the demand or output side, predicted annual average demands for the years 1991–2011 for 10 demand centres were input to the model together with separate weekly demands for each centre which reflected seasonal demands for tourist areas with high mid-summer peaks. Clearly some objectives are, if not actually mutually exclusive, extremely difficult to reconcile. The system, therefore, has conflicting objectives and some degree of compromise is essential. Information will be required by the environmental staff on the changes in flow regime caused by Roadford.

An important function of the model is its ability to simulate the effects of different modes of operation of the resource system. Where should the water controller take the water from first? At what rate should the reservoirs be drawn down (equal per cent full; according to rate of refill etc.)? What is the balance between security and economy in terms of reservoir operation? Control curves are determined objectively but they are operated subjectively.

A very pragmatic approach to modelling was described with an emphasis on operational practicalities rather than hydrological theory. The model should be seen as a tool capable of continual refinement and modification. It should help resolve the conflicts that are certain to occur with the operation of such a complex system. Compromises will have to be made and policies decided and therefore the consequent optimisation of the system will become subjective rather than objective.

The final paper was given by **Sally Huish** (South-West Water) and dealt specifically with fisheries aspects of the Roadford River



Tracks of four salmon radio-tagged in the River Tamar during 1986

Regulation Reservoir Scheme. The Water Authority (and environmentalists) are concerned about the environmental impact upon the Rivers Tamar and Torridge. The most fundamental effects will be changes in river flows and water quality which will in turn affect plant and animal communities within and around the rivers.

Sally Huish described the work of the Roadford Fisheries Investigation Team dealing with trapping, radio tracking and micro-tagging of two species of salmonid, the Salmon (*Salmo salar L.*) and Brown Trout (*Salmo trutta L.*).

The figure below shows the tracks of several salmon radio tagged in 1986 and through an analysis of approximately 170 fish tracked over a two-year period, the fisheries team note a number of interesting features of the behaviour of Salmon.

(i) the movement of fish upstream appears to be related to flow;

(ii) fish may migrate in a stepwise fashion, holding up in pools for several months;

(iii) there appear to be features in the river which are of significance to the fish:
   a. Gunnislake Weir,
   b. Holding Pools,
   c. Confluences;

(iv) time of year appears to be an important factor and fish may be stimulated to move under a wider variety of conditions later in the year than they are early in the year.

There would appear to be considerable scope here for collaborative work between hydrologists and fisheries personnel. In particular, exact trigger mechanisms such as sudden changes in water quality or temperature may be significant. From the Water Authority's point of view, it is quite obvious that water discharge changes and the mixing of waters from different sources in the river systems may affect salmonid fish movements and ultimately fish stocks in different parts of the system. Changes in the environment as a whole are being, and must continue to be, monitored and as far as possible the data gathered should be used to advise how best to maximise any beneficial effects and minimise detrimental effects of the Roadford Scheme.

Thus ended a highly successful paper meeting which may yet spawn a generation of "fishy hydrologists". Thanks go to all presenters for the high standards of their papers which stimulated some lively discussion and to the Faculty of Science at Plymouth Polytechnic who generously provided hospitality for BHS members.

Peter C. Sims

Simple Stochastic Models of Rainfall

BHS Southern Section Meeting 9 November 1987

***Sir David Cox*, F.R.S. (Department of Mathematics, Imperial College) and *Dr. Valerie Isham* (University College of London) presented some recent work on stochastic rainfall models undertaken with Ignacio Rodriguez–Iturbe (Simon Bolivar University and IDEA, Caracas).**

One may distinguish between three types of model: those describing the process of rainfall at a single point (univariate models), at a fixed set of points (multivariate models) or over an area (spatio-temporal models). The meeting dealt mainly with models of the first type, and concluded with possibilities of extension of the methods used to the second and third types.

The aim of a stochastic rainfall model is threefold:

- to gain an understanding of the process at work;
- to summarise the data;
- to provide an input for other hydrological models.

To fulfil these objectives, a model is required to incorporate the observable features of the data, require as few parameters as possible – all of these parameters being interpretable – and to work well regardless of level of temporal aggregation of the rainfall data used in fitting the model.

Valerie Isham presented the univariate model: rainfall is represented by cells characterised by a cell origin generated by a Poisson cluster process, a cell duration which is a random variable L (generally considered as exponentially distributed) and a random cell depth X.

Among the possible choices of Poisson cluster processes, two are particularly attractive. First, the Neymann–Scott process in which storm origins are generated by a homogeneous Poisson process and c cells are generated per storm (c is independent of the storm origin process); the origins of these cells follow the storm origin, the displacements being exponentially distributed and independent. Second, the Bartlett–Lewis process, which also assumes a Poisson process for the storm origins, but the cell origins appear according to a finite renewal process (c: number of cells) which exponentially distributed inter-arrival times.

In both cases, a jitter may be added to allow for a random variation of the rainfall depth: X becomes X.exp(Z(t)). We obtain the rainfall depth at t as:

$$Y(t) = \int_0^{+\infty} X_{t-u}(u)\, dN(t-u)$$

where:

$X_{t-u}(u) = X$ with probability $P(L > u)$
0 with probability $1 - P(L > u)$.

and N counts the cell origins in the cluster process.

The model, which requires five parameters if the depth X is assumed to have an exponential distribution (λ: rate of arrival of storms; β: rate of arrival of cells; γ: rate at which a storm dies; η: rate at which a cell dies and μ: average rainfall depth), was fitted to US data (summer months only) and the fit was tested by comparing the moments of order 1 and 2, the autocorrelation of lags 1, 2 and 3 and the probability of no rain (probability dry) of the simulated rainfall sequence; it gave good results for all variables except the last one: too many dry periods were obtained.

Therefore η was made to vary from storm to storm, with β/η, γ/η, λ and E(X) fixed: η was given a Gamma distribution $\Gamma(\alpha,\nu)$. This improved the model's performance.

David Cox then talked about the fitting of the model. He showed how it could be used to establish a comparison between the rainfall regimes of two chosen raingauges, in Denver and in Boston. The mean cell depth obtained was larger in Boston than in Denver; the number of cells per cluster was found to be larger in Denver.

Further tests of adequacy were carried out: extreme value tests showed the historical data to have more extreme values than the model-simulated data but otherwise the results were satisfactory up to the 90% level. The discrepancy in the large values could be remedied by a longer-tailed distribution of rain depth.

Finally, although the agreement between the historical data and fitted values was very good, the irreversibility of the phenomena – which means that the average rainfall depth on the last wet day is on the whole smaller than that on the first wet day – was not clearly reproduced by the fitted model.

Possible extensions of this work were also sketched out. The spatial dimension should be incorporated: to that effect, one could integrate over time, or better, use a multi-site model consisting of a master-process gener-

ating points which are storm origins for a random number of sites. This could become the basis for a full spatio-temporal model, making a comparison with G.I. Taylor's hypothesis of the identity of the spatial and temporal correlation functions for turbulence phenomena.

The presentation of the model was followed by extensive discussion from the audience: it was pointed out by David Cox that correlation in the data is no great problem as regards the distribution of extremes, since one would expect to find a Gumbel distribution for the extremes, as long as the tails are exponential. **John Marty** (University of Newcastle) asked how one could distinguish between two sets of data, the one with more cells and the other with a greater rainfall depth per cell. This is detectable through the correlation function which dies out at a higher rate when there are fewer cells per storm. **Adrian Butler** (Imperial College) suggested that it would be of value to test the model structure for frontal rainfall in addition to the predominantly convective conditions considered and it was agreed that UK data would be of interest.

C. Onof

The Ecological Effects of Resource Development

BHS South-West Section/Welsh Hydrological Group Meeting 2 December 1987

***Dr Stephanie Tyler* of the RSPB was the main speaker at this joint meeting held in the Department of Civil Engineering, University of Bristol. Those who made the journey from the Principality and from the peninsula were entertained to an absorbing and excellently illustrated account of the effects which various water resources developments have on ecosystems in general and the avifauna in particular. Dr Tyler drew examples from a wide range of geographical, climatic and ecological settings, and in her presentation effectively mixed information derived from field visits with detailed research data.**

Introducing some of the impacts associated with water resources developments, Dr Tyler made reference to projects in Africa and in the United States. In the case of the River Nile, impoundment has resulted in the trapping of large quantities of silt, an increased need for fertilizer use in downstream floodplain areas and a decline in the delta sardine fishery. The State of California provides several examples where increasing demand for water is jeopardising plant and animal life. The delicate equilibrium of Lake Mono, a saline ecosystem which supports a large population of birds, is being threatened by a dramatic fall in water level of 13 m, occasioned by an increasing need for water in the Los Angeles conurbation. Further south in the Mojave Desert region, groundwater abstraction to support residential development has led to a decline in water table levels of 0.3 m per annum and the imminent demise of existing palm trees and associated bird life.

Turning her attention to the United Kingdom, Dr Tyler considered firstly the potential ecological impacts of a number of projected schemes for barrages across estuaries to provide water supply or power-generating facilities. Internationally important colonies of wading birds and wildfowl are at risk, since many barrage schemes would permanently flood large areas of invertebrate-rich mudflats which form the major food source for estuarine birds. Although many of these schemes, following revised projections for water demand, are now in abeyance, there is concern regarding some projects, and Dr Tyler particularly highlighted the scheme for the Taff and Ely estuaries which at present attract 8,000–9,000 waders in winter months. It is feared that some birds, such as the Little Dunlin which has already decreased in numbers by 35% since 1970, will be totally lost if this project is implemented. The provision of greater areas of *Spartina* in the Severn estuary was not seen as providing suitable alternative feeding grounds, and in any case, such areas would also be drowned if a barrage were constructed across the Severn. The net effect of the latter scheme on bird populations, however, remains uncertain, and there is a need for more predictive studies to assess potential impacts.

Dr Tyler explained that the ecological effects of river impoundment varied with the function of the dam, whether water or power supply, and with its setting in an upland or lowland environment. In the latter situation, flooding may provide a richer habitat for waders and wildfowl, whereas in the former case, ecological problems could arise in the environment below the impoundment because of channel scouring, regulation of flow or rapid fluctuation in water levels. Release of water from thermally stratified reservoirs may reduce river temperatures for several kilometres downstream. This effect is know to persist for at least 8 km below the Elan reservoirs in Wales where cold and deoxygenated water released from the impoundments has caused Fe and Mn deposition on the river bed and has in turn led to an impoverishment of the invertebrate fauna, plant life and fish and bird populations. Additional land-use changes associated with reservoir developments, such as afforestation, may also cause ecological problems especially through acidification of waters.

Dr Tyler went on to outline a study of how river regulation had influenced Dipper populations in Wales. The bird feeds on stonefly, caddis fly and mayfly nymphs and is suited to riffle sites with shallow and well oxygenated flows. Increase in water level and reduction of invertebrates consequent upon regulation, especially in the naturally acidic headwaters of the River Wye which are underlain by Silurian and Ordovician strata, have greatly reduced Dipper numbers in comparison with populations in downstream reaches underlain by an Old Red Sandstone succession. Strong correlations between Dipper numbers and water quality parameters can be readily demonstrated, although the effects of regulation on river birds may be purely physical. Some species, such as the Ring Plover, require shallow shingle and shoal areas to feed and breed successfully, and these may be obliterated if regulation maintains water levels at artificially high levels.

The effects of water abstraction was the last area of ecological impact to be considered by Dr Tyler. Direct abstraction from rivers for agricultural and domestic purposes was not considered a problem in winter months but could have serious consequences in the summer period. Some watercourses, such as the River Piddle in Dorset, may run dry with deleterious effects on the total life of the stream. Over-abstraction of groundwater was also a problem especially in eastern areas of Britain, and the consequent drying out of wet meadows was disadvantageous to several bird species, including the Lapwing and the Curlew. Loss of water through leakage from pipes was of particular concern to conservation bodies, and Dr Tyler concluded that environmental costs had to be taken into greater account in future water resources developments.

Dr Tyler's excellent presentation stimulated much discussion which ranged across many issues. These included the ecologically beneficial aspects of reservoir development, the need for a greater understanding of nutrient dynamics in wetlands, the evolution of environmentally-sound control rules for reservoir releases, the longer-term and more extensive impacts of water resources developments and the psychology of bird migration!

South-West Section members attending this meeting welcomed the chance of making contact with neighbouring hydrologists and enjoyed the hospitality provided by the Welsh Hydrological Group. The Section very much looks forward to further successful joint ventures of this kind in the future.

Bruce Webb

BRITISH HYDROLOGICAL SOCIETY Minutes of 4th AGM

held at the Dept of Civil Engineering, Aston University, Birmingham 7 December 1987

PRELIMINARIES AND PRESIDENT'S INTRODUCTION

Apologies for absence were recorded from Professor M.J. Hall, Mr. M. Mansell–Moullin, Professor P. Novak, Mr. D.W.C. Rodda and Professor D.E. Walling, and the minutes of the 3rd Annual General Meeting of the BHS were approved. The President, **P. Johnson**, welcomed members to Aston and recorded the Society's thanks to **W.T. Bradford**, **Dr. T.R. Chidley** and **Dr. T.R. Wood** for making the arrangements for the AGM and the National Meeting following it.

REPORT OF THE HONORARY SECRETARY

The report of the Honorary Secretary, **Dr. B.W. Webb**, was contained in issue no. 16 of the Society Newsletter, *Circulation*. In summarising this report, Dr. Webb acknowledged that the excellent foundation for Society business laid by his predecessor, **Professor M.J. Hall**, had made his job as Honorary Secretary very much easier. Several long-standing issues had come to a satisfactory conclusion in the year under review, and these included the granting of Charitable Status, the publication of the Proceedings of the Lancaster National Meeting held in 1985, and the appearance of the *British Directory of Hydrology*. Publication matters had been much discussed in Main Committee Meetings, and a Standing Sub-Committee had been established to assess the form and feasibility of a BHS Occasional Paper Series.

The Meetings Sub-Committee had reviewed the organisation of National Meetings, had established a provisional programme which extends to December 1989, and had evolved guidelines for future planning of this activity. Six National Meetings had been arranged during the year. These had been well-supported, and in some cases had involved a novel format or had led to a publication. The staging of the First National Hydrology Symposium at Hull in September and the pre-publication of the associated Proceedings had been a particular success, and especial thanks in connection with this event were due to **Professor R. Ward**, **Mrs. C. Kirby** and **Dr. M.J. Lowing**. The Society continues to be active at a Regional as well as a National level, and this year had seen the inauguration and the establishment of a South-West Section.

In the period under review, the Main Committee had endeavoured to heighten the national and international profile of the Society and to keep the Membership informed of developments in hydrology at home and abroad. The Society had responded to Government proposals for privatisation of the Water Industry, had established contacts with six overseas hydrological societies and had solicited information on UK research in hydrology.

In concluding his summary, the Honorary Secretary thanked his colleagues on the Main Committee for their support, encouragement and help, and made special mention of the valuable assistance provided by the Technical Secretary, **Mr. N. Tyler**, and his associates at the Institution of Civil Engineers. He also thanked all those individuals who had assisted in Society activities over the year. Adoption of the Honorary Secretary's Report was moved by the President, seconded by **Mr. F. Farquharson** and carried without dissension.

REPORT OF THE HONORARY TREASURER

The report of the Honorary Treasurer, **Dr. H.S. Wheater**, was also circulated in issue no. 16 of *Circulation*. Dr. Wheater distributed a Balance Sheet at 30th September 1987, together with an Income and Expenditure Account for the year under review. The latter had shown heavy expenditure with items relating to the production of two "directories" and the staging of the Hull Symposium representing particular additional outgoings. Subscription income, however, had increased and a surplus of £671 had been achieved by the end of the year, which had brought the net assets of the Society to £2,639.

The Society subscription would be held at £12 for the coming year, and the Honorary Treasurer recommended that reserves of £4–5,000 should be allowed to accrue so that the Society would be able to undertake major events from a sounder financial position. The Honorary Treasurer urged that more members consider paying their subscriptions by direct debit. Questions of a reduced membership fee for those paying in the latter manner and the consolidation of mailing to centres with sizeable numbers of BHS members were raised from the floor.

Adoption of the audited accounts was moved by the President, seconded by **Dr. R.H. Sellin** and carried without dissension.

REPORT OF THE EDITOR OF *CIRCULATION*

The Editor, **Mrs. C. Kirby**, reported that four issues of the Newsletter had again been produced during the year and expressed her thanks to all contributors. The year had been marked by the appearance of two BHS publications. The book on *Weather Radar and Flood Forecasting* had taken longer to be published than would normally be expected by the Society and future liaisons with commercial publishing houses would be reviewed. Copies of the Proceedings of the Hull Symposium were still available at a cost of £18.

Dr. A.T. Newman, speaking from the floor, congratulated the Editor on the style and content of recent issues of *Circulation*.

RETIREMENTS FROM THE MAIN COMMITTEE

The following members retired from the Main Committee at the Annual General Meeting:

P. Johnson	(President)
Dr. H.S. Wheater	(Honorary Treasurer)
Dr. M.J. Lowing	(Elected Member)
Professor D.E. Walling	(Elected Member)

RESULTS OF ELECTIONS TO THE MAIN COMMITTEE

In the election to fill the vacancies on the Main Committee:

Professor P.O. Wolf	(President)
F.A.K. Farquharson	(Honorary Treasurer)

had stood and been elected unopposed. It was announced that in a ballot for the two vacant positions of Elected Member, 33% of the members had voted and the following candidates were successful:

M. Beran
Dr. S. Walker

On her appointment to the Main Committee, Dr. Walker would also act as the Representative of the Pennines Hydrological Group and A. Weston, who had been serving in this capacity, would retire from the Main Committee.

VOTE OF THANKS

The President called upon the Honorary Secretary to propose a vote of thanks to the retiring members for their services to the Main Committee and to the Society. The Honorary Secretary highlighted the contributions made by each of the five individuals leaving the Main Committee and made special mention of P. Johnson who had been both an enthusiastic and energetic President and one who had done so much to enhance the reputation of BHS in Water Industry and other circles. The Honorary Secretary expressed the wish that all the members retiring from the Main Committee would continue to play an active role in the Society, and moved a vote of thanks for their outstanding service. The motion was carried unanimously and with acclamation.

REVIEW OF THE RETIRING PRESIDENT

The retiring President reviewed progress achieved by the Society towards four main

objectives, which he had identified on coming into office as:

(i) maintaining a balance between scientific and applied interests
(ii) maintaining a balance between disciplinary interests
(iii) remaining a self-governing society
(iv) increasing the national and international standing of BHS.

It was felt that the programme of National and Regional Meetings held by the Society over the last two years had covered a good range of topics at a geographically wide distribution of centres and had therefore done much to secure the first two objectives.

The financial position of the Society, which was presently sound and expected to improve further in the coming years, had provided a secure base for the continuing independence of BHS. The activities of the Society were becoming well known at home and abroad, especially through the distribution of BHS publications, such as *Circulation* and the *British Directory of Hydrology*. The retiring President echoed the congratulations expressed earlier for Mrs. Kirby's work with the Newsletter and also recorded his thanks to **Dr. I. Cluckie** and all the other members who had been involved in the production of the Directory. Comments as to how the latter publication might be revised in future editions were welcome.

Growing International Membership of BHS and increasing contact with overseas hydrological societies had extended the Society's "sphere of influence" beyond Britain. At home, the Society also had an important role to play in responding to Government proposals concerning the Water Industry, and BHS had made its views known on three major policy documents. In concluding his remarks, the retiring President expressed his confidence in a flourishing and developing BHS in the future, welcomed the incoming President, **Professor P.O. Wolf**, and invited him to close the AGM.

CLOSURE OF MEETING

Before closing the meeting, the new President took the opportunity to respond to P. Johnson's remarks and welcome. He saw the Society as having excellent "godparents" in the Institute of Hydrology and in the Institution of Civil Engineers, and at the same time it enjoyed a great advantage in being an independent organisation. The Society was a lively one, run with great energy by highly competent officers, and one aim held by the new President was to increase even further enthusiasm for BHS. It was hoped that members would readily continue to become involved in Society activities and business, and Professor Wolf urged all members with ideas, and especially those who had been unsuccessful in recent elections to the Main Committee, to get in touch with him so that they might make the fullest contribution.

The new President outlined a preliminary view of the issues which he hoped would be discussed during his term of office, and these included professional qualifications, further support from the Institution of Civil Engineers, the Institute of Hydrology and the Royal Society, and development of strong links with related UK bodies. Views of the membership on these and any other issues relating to the Society would be welcomed by the Main Committee.

Professor Wolf concluded by expressing his pleasure in taking up this new post, and there being no other business, he closed the meeting which was attended by 82 members.

Remote Sensing Applications for Water Management

BHS National Meeting
7 December 1987

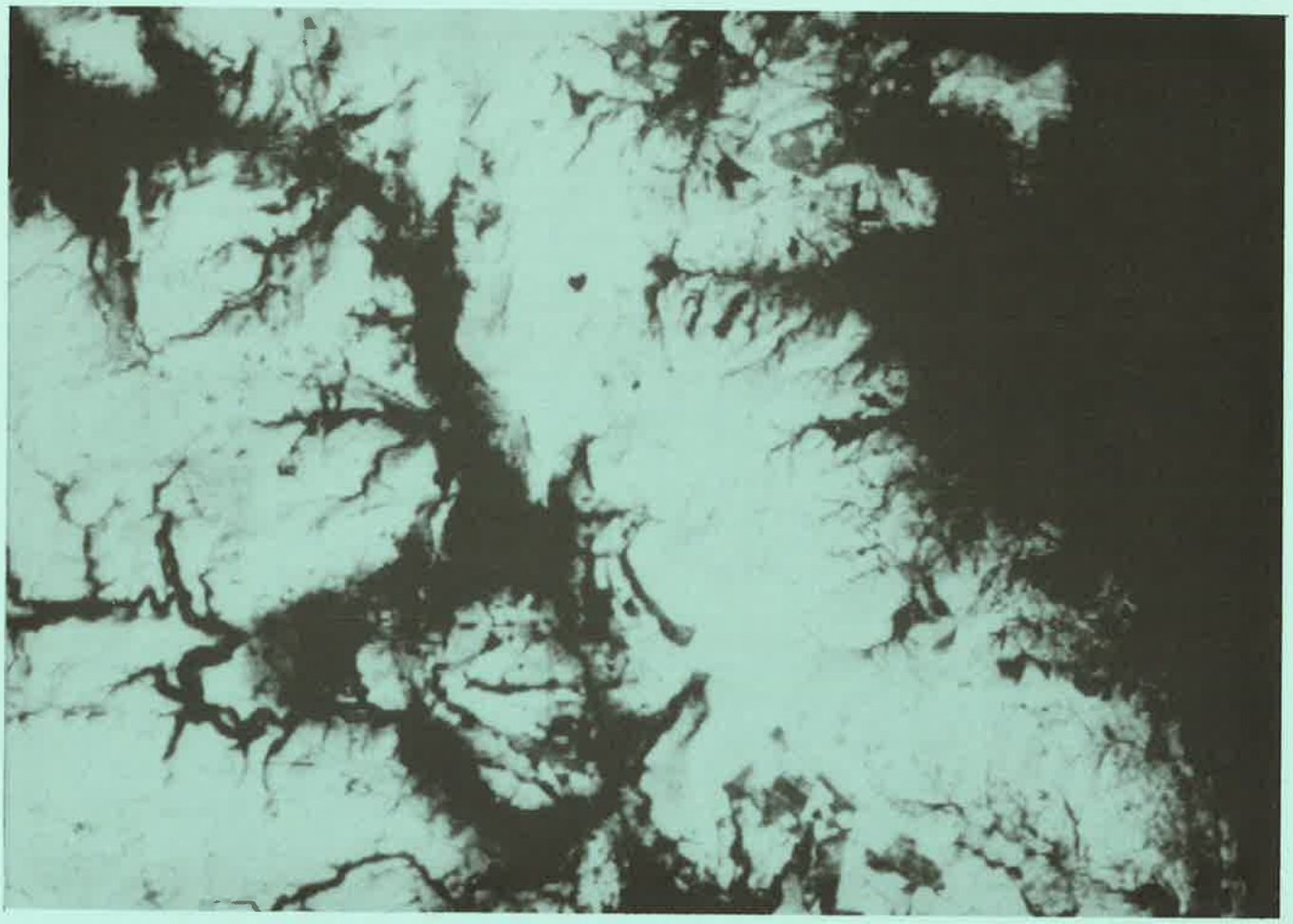
This half-day meeting was organised jointly with the National Remote Sensing Centre Working Group on Hydrology and Water Management. The meeting was held at Aston University, taking the form of a presentation of two papers followed by the demonstration of a number of up-to-date techniques for data processing and analysis.

The first paper was given by Dr **Chris Collier** (Meteorological Office) on forecasting rain using satellite data with radar and conventional meteorological data. Chris Collier confined his discussion to short-period forecasting. This type of forecasting has a timescale of up to two days and is of major importance to hydrology in general, particularly to real-time flood forecasting. Forecasts for up to six hours ahead are based on the extrapolation of current weather, a process which has been termed "nowcasting". The prime requirement for nowcasting is the availablility of detailed observations of current precipitation. Satellites can provide a great amount of data, but over small areas radar data give better resolution. Blending the data from these sources together with conventional rainfall observations is carried out in the FRONTIERS system, which has been developed in the UK by the Meteorological Office in close co-operation with the water industry. Basically, the satellite data are used to distinguish areas of rainfall from areas with no rainfall and the radar data are used to determine intensities. Short-period forecasts produced by the system are based purely on linear extrapolation. Chris used the example of the "hurricane" in the south of England on October 16 1987 to illustrate the strengths and limitations of such a nowcast: a good forecast was produced by the system for the north of England and for Wales, whilst in the south-west linear extrapolation was unable to predict the subsequent rotation of a band of precipitation. Improvements in forecasting for longer periods ahead have been made by using precipitation data as input to mesoscale models, although this system is not yet operational.

Margaret Cottingham (Yorkshire Water) asked when FRONTIERS forecasts would be available and how they would be distributed. Chris replied that they would be transmitted via the computer network using dedicated telephone lines and would be available at the end of 1988 at the earliest.

The second paper was given by **Ken Blyth** (Institute of Hydrology) on remote sensing of soil moisture and snow. Ken gave an overview of the advantages and disadvantages of various techniques of remote sensing from space satellites for the study of soil moisture and snow. Although remote sensing usually provides a better description of spatial variability than can be obtained from ground observations, factors such as the presence of cloud cover or the degree of spatial resolution required often mean that remotely sensed data are most useful when used in conjunction with data collected from other sources.

Sensors can be divided into three types according to their wavelength. These are visible and near infrared, thermal infrared and microwave. Remote sensing in the visible spectrum can be used to recognise the presence of snow, but problems occur in distinguishing cloud from snow and in determining soil moisture content. The near infrared spectrum gives more detail, being able to separate snow from cloud cover, and it can also sense the presence of vegetation which is a good indicator of soil moisture. This is particularly useful in arid regions. Remote sensing of snow using thermal emission is less reliable than other types, especially when it is the only source of data, but it does allow for monitoring of snowmelt. It is considerably better for analysing soil moisture.



Landsat multispectral scanner image of Derbyshire Dales, near Bakewell, showing snowfall.

Microwave sensing is currently a prime area of interest because it is unique in being appropriate to all weather types. Passive microwave radiometers are ideal for measuring soil moisture and snow, although a major problem is the relatively poor resolution given. Active microwave systems (radar), which can be mounted on aircraft or satellites, give higher ground resolution, although they are more affected by surface roughness.

Ken concluded that the remote sensing technique chosen for any particular application depends on the data requirements and the prevailing conditions. He added that the technology is being developed very rapidly and that multi-frequency systems are likely to provide better data in the future.

James Bathurst (University of Newcastle upon Tyne) asked whether any progress had been made in developing ground-penetrating radar. Ken commented that a ground-based instrument does exist. **Tom Chidley** (Aston University) added that it can be aircraft-mounted but that the technology is not as advanced as remote sensing using satellites. **Michael Hyde** (British Waterways Board) suggested that since attending the recent Southern Section meeting on dowsing, he would question the need for such technology. **Henry Gunston** (Institute of Hydrology) asked whether remotely sensed data had been used for irrigation management. Ken answered that some work had been carried out in the United States. **M. Francis** (Hydraulics Research Ltd) commented on the existence of impulse radar systems which had been used to look down through 600 m of ice. This is a ground-based system, although it can be airborne, and a heli-based system also exists.

Unfortunately, the third speaker of the afternoon was unable to attend the meeting. However, the following contribution on the subject of remote sensing applications in hydrology has been received from **Mike Thoms** (WLPU Consultants).

A study aimed at identifying the hydro power potential within a river basin of some 4,400 km^2 has recently been completed for the National Electricity Board of Malaysia. Although the major part of the basin is covered by primary jungle, high sediment loads are causing problems for existing hydro schemes. The high loads are due to the increased level of agricultural development in the upper (accessible) reaches of the study area.

In order to quantify the changes in land use, aerial photography was examined initially but the coverage was not available for the areas of interest. Satellite imagery, based on mid-1985 conditions, was therefore used to identify the location and extent of cultivation within the upland catchments. Recent sediment gaugings, together with survey data from an existing reservoir, have been used to determine the current soil erosion rate from cultivated areas and hence more accurately determine the likely effect of future agricultural development.

The rest of the afternoon was devoted to an interesting demonstration of remote sensing applications for water engineering.

Lisa Stewart

SITUATION VACANT

BINNIE & PARTNERS
CONSULTING ENGINEERS

HYDROLOGIST

required to join a small team of hydrologists in the Redhill office. This post would suit a new graduate or someone looking for a first career move, and provides the opportunity to gain wide ranging experience through a variety of projects.

Candidates should have a first degree in engineering or an environmental science, be computer literate and willing to undertake both short and long overseas assignments. A post-graduate qualification in hydrology and a second modern language would be an advantage.

A competitive salary is payable together with a package including portable pension, free BUPA and staff loan scheme.

Please apply briefly in writing with full CV to David MacDonald, Binnie & Partners, Grosvenor House, 69 London Road, Redhill, Dorking, Surrey, RH1 1LQ or phone on 0737 774155 ex. 294 for further details.

INTERNATIONAL HYDROMETRIC STANDARDISATION

INTRODUCTION

Standardisation on a worldwide basis is achieved through ISO, the International Organisation for Standardisation. Except for use in extreme climatic conditions – for example ice coverage or excessive aridness – British hydrometry has remained at the forefront of world hydrometry and it is not surprising that there has been an intense British involvement from the earliest days in the development of hydrometric Standards. The following resumé outlines the place of Standards in the hydrometric spectrum and describes the considerable hydrometric contribution by the British Standards Institution (BSI) to the work of ISO.

WHY STANDARDISE?

As the world becomes mores dependent on technological exchange there is an increasing recognition that the integration of existing and new techniques is to the benefit of both developed and developing countries. Standardisation, however, can be a very powerful weapon and, like all weapons, must be pointed in the right direction: and used with skill and restraint. In broad terms, Standards provide:

- a means of helping to derive economic benefits
- the capacity for removing technical barriers
- methods of improving health, safety and environmental conditions
- better understanding and communication.

Hydrologists will not have to think very deeply to realise that the above-noted facets of the production of Standards apply very properly to the management of the natural hydrological cycle: a cycle that is devoid completely of political and national boundaries. The BSI premise is to "do it right" and to "do it internationally". In the hydrometric arena, this is the basis of the British involvement.

HISTORICAL DEVELOPMENT

The ISO/TC30 – the Technical Committee dealing with Liquid Flow Measurement in Closed Conduits – on the initative of the then Indian Standards Institution (ISI) (now the Indian Bureau of Standards), set up in 1954 a Sub-Committee to consider Liquid Flow Measurement in Open Channels. Four Working Groups evolved, embracing active participation by Belgium, France, Germany, India, Italy, The Netherlands, Romania, Switzerland, the UK, USA and USSR; with the ISI accepting the Secretarial responsibilities. There was fringe involvement also by Austria, Czechoslovakia, Indonesia, New Zealand and Switzerland, so the international element has existed continuously for over 33 years.

This Sub-Committee eventually led to the formation of ISO/TC113 (Liquid Flow Measurement in Open Channels) which met

Table 1

Title of Standard	ISO Standard
Vocabulary and symbols	772:1978
Dilution methods	
– constant rate method	555/1:1973
– sudden injection method	555/2:1987
– radioactive tracers	555/3:1982
– general requirements	q555 Pt 1
– radioactive tracers	q555 Pt 2a
– chemical tracers	q555 Pt 2b
– fluorescent tracers	q555 Pt 2c
Velocity area methods	738:1979
Establishment and operation of a gauging station	1100/1:1981
Stage discharge relation	1100/2:1982
Moving boat method	4369:1979
Ultrasonic (acoustic) method	6416:1985
Data for determination of errors	1088:1985
Guide for the selection of methods	8363:1986
Errors in velocity data stations (TR)	7178:1983
Electromagnetic method (TR)	9213:
Stage fall discharge method (TR)	9123:1986
Three verticals method (TR)	9823:
Wet-line correction (TR)	9209:
Measurement under ice conditions	9196:
Measurement of large river flow and flood flow (TR)	9825:
Free surface flow in closed conduits (Methods) (TR)	9824:
Measurement in meandering rivers	9210:
Thin plate weirs	1438/1:1980
Triangular profile weirs	4360/1:1986
Flumes	4359:1983
Compound gauging structures	—
Rectangular broad crested weirs	2846:1977
Round nose horizontal crest weirs	4374:1983
Flat V weirs	4377:1982
Guide for the selection of a measuring structure	8368:1986
V shaped broad crested weirs	8333:1985
End depth method	3847:1977
End depth method (non-rectangular channels)	4371:1984
Trapezoidal profile weirs	4362:
Hydrofoil weirs	4372:
Trapezoidal weirs in trapezoidal channels	xxxx:
Short throated flumes	9826:
Streamlined triangular profile weirs	9827:
Slope area method	1070:1973
Tidal channels	2425:1974
Measurement of stage	—
Pressure actuated instruments	—
Float operated water level recorders	—
Water level measuring devices	4373:1979
Current meters	2537:1974
Sounding and suspension equipment	3454:1983
Current meter callbration	3455:1976
Cableway system	4375:1979
Ultrasonic velocity meters	6418:1985
Echo sounders	4366:1979
Hydrometric data transmission system	6419/1:1984
Hydrometric data transmission system	6419/2:
Position fixing equipment	6420:1984
Electromagnetic method – combined TR	xxxx:
General performance specification for hydrometric equipment	xxxx:
Free surface flow in closed circuits (equipment) (TR)	xxxx:
Sediment load samples	3716:1977
Methods for measurement of suspended sediment	4363:1977
Bed material sampling	4364:1977
Determination of concentration, particle size and relative density	4365:1985
Methods for measurement of sediment in reservoirs	
Bed load discharge (TR)	9212:
Gravel bed material	9195:
Uncertainty of measurement of a flow rate measurement	5168:1978
Uncertainty in linear calibration relations	7066/1:
Uncertainty in non-linear callbration	7066/1:

initially in Paris in 1968. Since then ISO/TC113 has met in New Delhi (1973 and 1982), The Hague (1974 and 1983), Zürich (1975), London (1976 and 1987), Washington, Leningrad, Ottawa, Paris again (1980), Berne (1984) and Beijing (1986). During the mid-1960s, British interests had been developing within the aegis of BSI and, in Paris in 1968, the British pattern of Working Groups was adopted in principle by ISO/TC113. This was formalized properly in New Delhi in 1973. Thus, right from the beginning, BSI and ISO have been acting in tandem with consequent avoidance of duplication of effort. With the heavy involvement of British consultants throughout the world, it must be remembered that Britons working abroad need Standards applicable to the countries in which they are working as much as home-based Britons need Standards for UK conditions.

HOW DOES IT WORK?

Table 1 summarises the hydrometric Standards and Technical Reports which are available currently or in preparation. Almost all of these Standards are available in the BS3680 series and the reader is directed to the BSI Catalogue for the details of prices and availability. It is interesting to note that the BSI is able to produce the BS3680 copies at a considerably cheaper price than the corresponding ISO documents (especially to BSI Members).

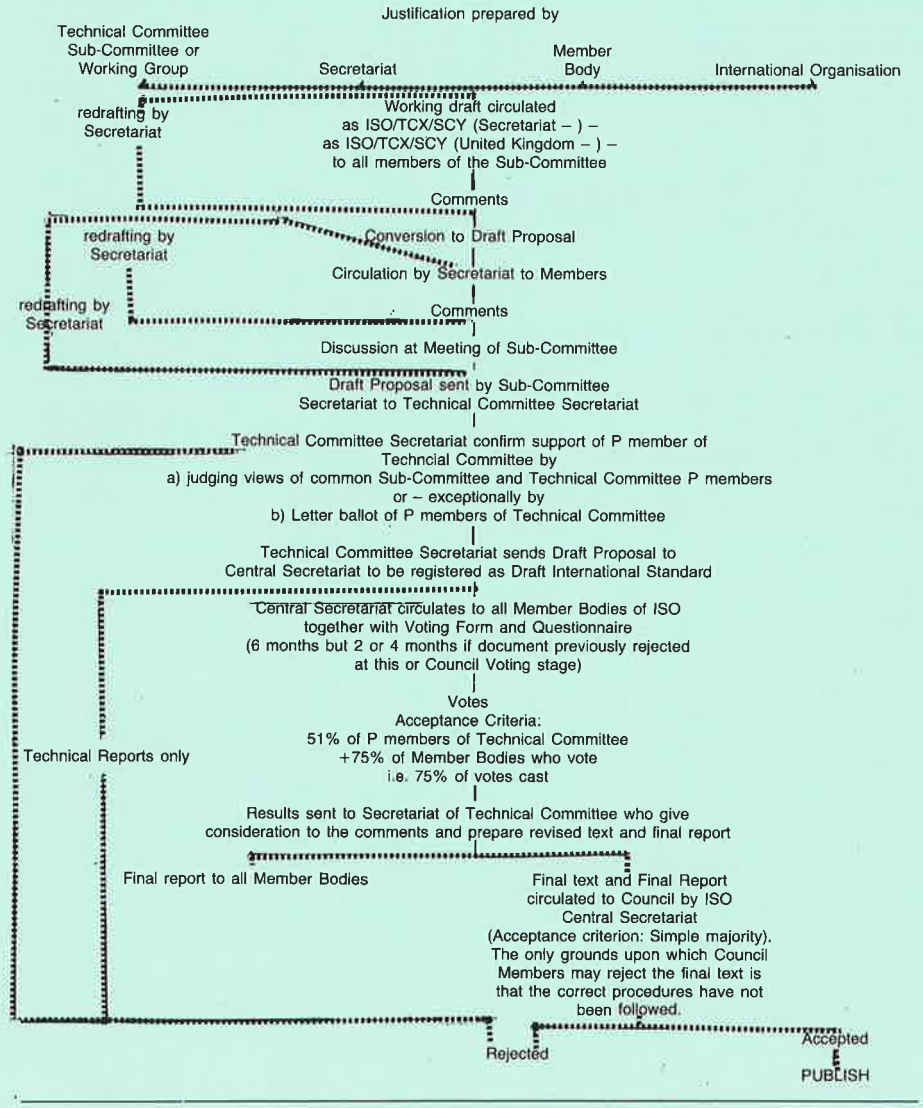
The preparation of an ISO Standard is complex: the detailed procedure is shown on Table 2. This can take years. in the most complicated cases but, especially if the initiative for the Standard or Report is by the UK, the BSI is able usually to produce a BS3680 Part in a surprisingly short time: quite often as an "advance copy" of the eventual ISO document.

CURRENT SHORTFALLS AND PROSPECTS

It will be seen from the foregoing that the preoccupation has been with liquid flow measurement in open channels. This has meant that other facets of the hydrological cycle and of man's adaptation of that cycle have been somewhat neglected. In the developed world relatively little work has been undertaken in the assessment of sewer flows – sewers are, effectively, open channels and, generally, there is far too little knowledge of groundwater quantities and movements. With these aspects in mind the name of the BSI Committee (BSI/PCL/3) concerned with open channels has been changed recently to "Measurement of Surface and Ground Waters". This has prompted an interest by the Meteorological Office in the possible incorporation of meteorological instrumentation into the work of BSI/PCL/3. In addition, the ongoing development of the UK National Water Archive at the Institute of Hydrology has highlighted the need for standardisation of the collection, collation and publication of hydrometric data, and BSI/PCL/3 has already a draft Standard in preparation to cover these aspects. It has also transpired that the UK is at the forefront of data communication developments, especially in telemetry, and there are already Parts of BS3680 available for hydrometric data transmission systems. BSI/PCL/3 has taken every opportunity to bring these aspects into the work of ISO/TC113, with reasonable success.

Where there is difficulty is in combining Standards with such documents as the Technical Regulations of International Organisations and with the Statutory Regulations and Laws of the various countries. Standards are not mandatory unless they are included in legal or statutory documents, but they are commonly used as a basis of legal or statutory requirements. A UK example may be cited. For some years BSI/PCL/3 has had a draft document for the very important matter of Safety in Hydrometric Practice, but it would be quite impossible to publish this as a Standard without very complicated involvements with UK legislation: all BSI/PCL/3 can do is to take every opportunity to include safety recommendations whenever it can.

Table 2 The preparation of an ISO Standard



Note: TC113 and Sub-Committees serviced by one Secretariat.

CURRENT INVOLVEMENT

Active participants in the work of BSI/PCL/3 are drawn from the various water authorities, government departments throughout the UK, universities, research organisations, consultants and manufacturers. The combined expertise is taken forward to ISO/TC113, with whom there is active involvement by Australia, Canada, China, Czechoslovakia, India, The Netherlands, South Africa, Switzerland, USA and USSR. Several other countries contribute from time to time.

Long may it continue.

R.W. Herschy, Reading
P.G. Holland, Belfast

Copy Deadline for Issue No. 18 – 5 April 1988

The South African National Committee for the International Association of Hydrological Sciences (SANCIAHS)

There never has been a professional society for hydrologists in South Africa, so that the establishment of SANCIAHS on 30 September 1983 provided a much needed official body to represent the interests of the many people working in the multi-disciplinary field of hydrology and to promote a sense of fellowship among them. The establishment of SANCIAHS was a prerequisite to meaningful participation by South African hydrologists in international activities. The committee also has an important role to play in concentrating attention on the need for careful and co-ordinated development of the limited water resources of the southern part of the African continent.

It was decided at the first meeting of SANCIAHS that the term of office for members of the committee would be four years in order to conform with the four-year cycle of membership for our parent committee, the SA National Committee for the IUGG. The committee membership of SANCIAHS for the four-year period 1983 to 1987 was made up as follows:

CHAIRMAN:
Dr. P.J.T. Roberts,
Senior Adviser,
Water Research Commission,
PO Box 824,
0001 PRETORIA
(National Representative (correspondent) for the IAHS and member of SA National Committee for the IUGG.)

VICE CHAIRMAN:
Mr. D.W.H. Cousens,
Senior Adviser,
Water Research Commission,
PO Box 824,
0001 PRETORIA
(Committee representative for the International Committee on Remote Sensing and Data Transmission.)

MEMBERS:
Dr. C.P.R. Roberts,
Manager,
Scientific Services,
Department of Water Affairs,
Private Bag X313,
0001 PRETORIA
(Commission representative for the International Commission on Surface Water.)

Mr. J.R. Vegter,
Director,
Division of Geohydrology,
Department of Water Affairs,
Private Bag X313,
0001 PRETORIA
(Commission representative for the International Commission on Ground Water.)

Prof. R.E. Schulze,
Head: Agricultural Catchments Research Unit,
Department of Agricultural Engineering,
University of Natal,
PO Box 375,
3200 PIETERMARITZBERG
(Commission representative for the International Commission on Snow and Ice.)

Mr. E. Braune,
Director,
Hydrological Research Institute,
Department of Water Affairs,
Private Bag X313,
0001 PRETORIA
(Commission representative for the International Commission on Water Quality.)

Prof. W.J.R. Alexander,
Department of Civil Engineering,
University of Pretoria,
0002 BROOKLYN Pretoria
(Commission representative for the International Commission on Water Resources Systems.)

Prof. A. Rooseboom,
Department of Civil Engineering,
University of Pretoria,
0002 BROOKLYN Pretoria
(Commission representative for the International Commission on Continental Erosion.)

Prof. D.C. Midgley,
8 Jellicoe Avenue,
2196 ROSEBANK Johannesburg
(Additional member: Associate Editor of the Hydrological Sciences Journal.)

The aims of SANCIAHS are to provide a formal link between the IAHS and South African hydrologists; to keep the local hydrological community informed with relevant information from outside and within the country; to promote the science of hydrology in South Africa by way of conferences, workshops and seminars; to provide an organisation to represent the interests of South African hydrologists, and to promote a sense of fellowship amongst all those working in the multi-disciplinary field of hydrology.

In accordance with IAHS guidelines for national committees, one of the first tasks facing SANCIAHS was to draw up a register of all hydrologists in the country that would reflect the interest of each hydrologist in the specific activities of the international commissions of the IAHS.

The first problem to be overcome was the question of who or what is a hydrologist? It was decided that for the sake of our register, a hydrologist would be any person (regardless of sex, race, religion, political philosophy, ethnic origin, citizenship or language) who is active in or interested in the hydrological fields represented by the international commissions or committees of the IAHS. The stress is therefore on active interest or participation at all levels of hydrology rather than on academic qualifications. On this basis, hydrologists were invited to register with SANCIAHS and more than 300 hydrologists have responded to date. These hydrologists are the members of SANCIAHS and include some hydrologists from neighbouring countries. The neighbouring countries do not have national committees for the IAHS and it was felt that SANCIAHS could provide a useful service to their hydrologists provided that they live close enough to participate in our activities on a regular basis.

SANCIAHS has no membership fee or registration fee. The costs of providing the services to the hydrological community are covered by profits from symposia, donations and assistance from institutions such as the Water Research Commission. The shortage of operating funds limits the range of services that can be provided and it is possible that a modest fee will be introduced in the future.

The Commission Representatives serving on the National Committee are elected every four years by those South African hydrologists that have registered their names with SANCIAHS under one or more of the international commissions or committees of the IAHS. The National Representative of the IAHS is *ex officio* a member of the National Committee and is appointed by the Council for Scientific and Industrial Research which is the body that pays South Africa's membership fee to the International Council of Scientific Unions (ICSU). The National Representative is usually the Chairman (or Secretary) of SANCIAHS and also serves on the National Committee for the International Union of Geodesy and Geophysics (IUGG).

An examination of the information provided on the registration forms for the SANCIAHS register indicates that 32% of the hydrologists are employed in the private sector, 36% in government departments and 32% in statutory bodies such as universities, municipalities, commissions, councils and water boards. As far as education is concerned, 4% indicated that they have a matric (school leavers' certificate) as highest educational qualification, 9% had technical diplomas, 37% had a bachelor's degree (3 or 4 year), 30% had a master's degree and 20% a doctorate. It was interesting to note that of those who had university degrees, 40% had a training in engineering while 60% were scientists. Three per cent of those who registered were full-time students, 10% were teachers or lecturers, 18% were fulll-time research officers, 30% were full-time practising hydrologists, 7% were hydrological technicians, 12% were managers, 1% were retired but retaining an active interest in hydrology and 19% indicated that hydrology

constituted a minor component of their job. The ratio of technicians to professional hydrologists is alarming, being the inverse of what it should be and calling for a concerted effort to promote hydrology at the technical colleges.

In 1983 the IAHS introduced the concept of individual membership of the IAHS in terms of Article 12 of the Bylaws which stipulates that:

"The membership consists of hydrologists named by National Committees of the member countries from amongst those hydrologists with established reputations who have played, or are playing a substantial part in IAHS activities."

SANCIAHS is pleased to report that, after further consultation with the Secretary General about the nature of the qualifications required, 64 South African hydrologists have been nominated by the National Committee for individual membership of the IAHS.

Numerous workshops and seminars on various aspects of hydrology in South Africa are organised in response to changing needs by bodies such as the Water Research Commission, Department of Water Affairs and university research groups. However SANCIAHS soon realised that there was an obvious need to stage a national conference on hydrology on a regular basis to bring together all the different disciplines and interest groups in hydrology to discuss progress towards the unifying and common goal, that being the efficient utilization, management and planning of the limited national water resources. SANCIAHS has consequently adopted as one of its functions the staging of a national conference every two years, the first of which was held in 1983. These conferences have been a great success and it is clear that they have done a great deal to open direct channels of communication and cooperation between the various specialist groups. The most recent national conference, held in September 1987, was run in parallel with the Ground-water '87 conference of the Ground Water Division of the Geological Society of South Africa. The parallel sessions promoted better dialogue between the geohydrologists and water resource engineers and as a result, it has been decided to continue with this format in the future in the form of a National Water Week.

In 1986, IAHS National Representative, Peter Roberts, was appointed as the National Correspondent for the International Association of Hydrogeologists (an association of the IUGS) and this appointment has improved the links between the IAHS and the IAH in South Africa. Newsletters and other information from both associations is now distributed to about 100 selected hydrologists who pass the information on to their colleagues. The distribution of information is also facilitated by a regular SANCIAHS news column published in the "SA Waterbulletin" which covers most aspects of the water industry.

The recent establishment of a more formal information transfer link with the British Hydrological Society has been warmly welcomed by the members of SANCIAHS and there is little doubt that the hydrological sciences in South Africa will benefit from this initiative.

Dr. Peter J.T. Roberts,
Water Research Commission

BOOKS

Alluvial Fans

Hydraulic Processes on Alluvial Fans – R.H. French. Developments in Water Science No. 31, Elsevier, 1987. 244pp. US$ 62.25. ISBN 0–444–42781–3.

Richard French addresses an extremely stimulating area of Earth Science process studies in a way that more than bridges the 'pure/applied gap'. Upon my first view of a fresh alluvial fan (resulting from the Lawn Lake Dam failure in Colorado, 1982) many of my concepts in fluvial dynamics changed, particularly those associated with timescales. From then on alluvial fans seemed to appear everywhere and flood-prone settlements on them – even Reeth in the Yorkshire Dales appears to suffer from being built on a very old fan! The flood hazard problem in the USA is, however, much more serious and local zoning ordinances do not help the average citizen of the expanding sun-belt states to avoid the threat. Fans are captivating settlement sites and apparently off the floodplain: in fact this means off the *annual* floodplain. In reality the alluvial fan environment is hazardous even if the long intervals between formative flash floods can lure the realty market into a profitable sense of security!

For a book which appears to be heading for differential equations from the outset, French has kept the material admirably readable and well-referenced. Although slightly dismissive of "our colleagues the geologists" as contributing in qualitative terms, the first two chapters present a wealth of material (from *geomorphologists* actually!) which sets up the geometry and empirical relationships of fans with their catchments. He divides fans into channelized, braided and sheetflow zones, and immediately, therefore, sets up a hydraulics "can of worms" for later chapters to follow. The reader is slowly lured from the straight and narrow (in terms of open channel flow hydraulics) into the much less predictable area of debris flows and infiltrating flows.

Because so many settlements (Los Angeles, Las Vegas, San Diego, Phoenix . . .) now need protection from fan activity and because the Federal Emergency Management Agency needs quantitative advice, there have been a number of attempts at modelling fan processes and forms over both geomorphological and engineering timescales. The main ones are described in simple, well-illustrated terms, although I find constant references to "Anon. 1985" somewhat tiresome, a feeling possibly shared by those working in the prestigious government labs hidden by this nomenclature.

French's use of summaries, tables and diagrams makes the book an ideal student text and this is a badly-needed shot-in-the-arm for those who spend their time in awe of 32 tonne boulders littering main streets (or merely being exposed by quarrying in Quaternary deposits). On balance it errs towards the practical, but the plates of flooding at Caesar's Palace, Las Vegas, show the scale of the market for applications. It is perhaps a graphic demonstration of the Divine that flash flooding should so affect a settlement which surely has the world's most concentrated folk wisdom on probability!

Malcolm Newson
Newcastle

Snowmelt

Intercomparison of models of snowmelt runoff. Operational Hydrology Report No. 23 (WMO – No. 646). World Meteorological Organisation, 1986. 36pp. (+ 393 pages of Annex 1–17). Soft covers. ISBN 92–63–10646–0.

Since more than half of the land surface of the Earth may be covered with snow during the northern hemisphere winter, routines for forecasting contributions of snowmelt to runoff are of considerable importance in operational hydrology. Several types of model are available to describe melt-related processes at the snow surface and to represent processes within the snowpack which influence the flux of melt water to the base. Air temperature index or degree day methods are empirical and site specific, whereas full energy balance treatments require high quality meteorological measurements which are invariably lacking in mountain basins. Assessing the relative performance of various snowmelt models over entire basins, in conjunction with precipitation-runoff models, is a difficult task, of a different order from the comparison of point snowmelt rate predictions against flow lysimeter observations. Which snowmelt model is appropriate for a particular basin and the detail involved depend on the time resolution demanded, the size of the catchment area and the pathway followed by meltwaters to stream channels. The WMO therefore organised a project from 1976 to 1983 to allow an intercomparison of models used for forecasting snowmelt runoff, with a view to describing models currently used operationally and to assessing their comparative performance under a variety of conditions, the results of which are presented in this report.

The performances of eleven models developed in eight countries, including one from the UK, were tested on data sets for up to six river basins of dimensions between 8.4 and 2,170 km^2, from climatically and geographically varied areas (European Alps, Rocky Mountains, Sweden and USA) according to model data needs and availability in a basin. Four of the basins had the added complication of glaciers. Parameters of each model were established on concurrent input and output data for a six-year calibration period and used to produce four years of simulated runoff from observed inputs. Three graphical and nine numerical criteria were used to evaluate the simulated hydrographs. Values of these criteria varied from year to year as well as between different models in one year, and confidence intervals, or measures of spread, might usefully have been employed.

No attempt has been made to rank the performance of the models.

The short written section of the report barely digests the information available, but snow-melt modellers will find much of interest in the 393 pages of annexed information which includes descriptions of the models, procedures used, parameters generated during fitting the models, and 147 pages of graphs of runoff simulations and original data. Intermediate values related to the snowpack alone are also presented. The tabulated numerical verification criteria reflect a range of different aspects of model performance. A general conclusion must be that the temperature index method has produced good results (from one temperature station only). There was a lack of real-time data for the energy balance approach. Comparison of the sensitivity of the models was surprisingly not undertaken. Needs for more information about temperature lapse rates, which influence precipitation form in addition to melting, are identified. Overall, the written part of the report hardly introduces the wealth of detail. The descriptions of model structures and data needs, and of their performance characteristics, will be of value to those interested in selecting a model for a particular purpose, but they will have to interpret the tables of comparative performance figures for themselves.

David A. Collins
Manchester

Pot-Pourri

Developments in Hydraulic Engineering – 4, editor P. Novak, Elsevier Applied Science, 1987, 351pp. £47.00. Hardback. ISBN 1–85166–095–X.

This book is the fourth in a series edited by Professor Novak. There are contributions from six authors, all of whom are well known experts in a given area of hydraulics. Each contribution is about 70 pages in length, longer than a paper but less than a text book, and as the editor states in the preface the aim of the book is to provide "state of the art" information which has not yet appeared in text books. Inevitably each author has interpreted this aim in his own way and so I shall discuss each article separately.

The first article is Lake Hydraulics, by K. Hutter and D. Vischer. This is well written and interesting, although the authors have assumed that the reader has some prior knowledge of the subject. The contribution includes methods of data collection and the relevant theory and also an extensive list of references. The only omission is a section on computer models, but presumably lack of space limited the scope of the article.

The second article is by Professor Wilson, who will be well known to many hydrologists as the author of an introductory text on hydrology, and M. Balls. The subject is Tidal Power Generation. The article is wide ranging including such diverse subjects as electricity demand and construction techniques. The information given should be useful as an introductory text to those who know little about the subject, but in the attempt to include so much information, the authors tend to fall into the trap of being superficial in certain areas. Unusually for a hydraulics text there is very little mathematics.

Article number three is by H.J. Morel-Seytoux, on the subject of Multiphase Flows in Porous Media. The author is from the USA and like so many from that country has the knack of making things seem more complicated than they really are. Unfortunately his chosen topic is already very complicated, an unhappy combination. The subject matter will be of increasing importance to hydrologists as we attempt to obtain a better understanding of groundwater flows in the unsaturated zone, but before tackling this article it is advisable to read one of the many texts on the subject. If this approach is followed it will be found that despite the awkward style the article contains much of value.

The fourth article has two authors: J. Bear, well known to groundwater hydrologists, and B. Berkowitz. Their chosen topic is Groundwater Flow and Pollution in Fractured Rock Aquifers. This article commences with a good discussion of methods of representing flows in fractured rocks and the problems that arise, followed by a section on contaminant transport. The list of references is comprehensive and will be of use to those wishing to study the subject further.

Before giving my comments on the fifth article, I must first admit to a degree of bias. The author is Professor Rushton with whom I worked for some five years; the subject is Groundwater Models. The article is an update of the information contained in the author's book on the subject. It is well written and easy to understand and the text contains details of practical applications of the models. The description is largely restricted to the author's own work. This I believe is deliberate: Professor Rushton likes to assess things thoroughly before he uses them. This has the advantage that one can be sure that what he presents will work, but the disadvantage that some areas of groundwater modelling, such as unsaturated zone models, are not discussed.

The final article is on Groundwater Utilisation and Protection by E.P. Nemecek. The author works at Graz in Austria and the content matter leads one to believe that groundwater sources in Austria are of a very different nature from those found elsewhere. The article also contains an interesting piece of advice for those investigating the resources of an aquifer: it recommends exploration boreholes at 150 m centres! Surely this is a printing error.

In general the book contains much that is of use, although probably only certain sections will be useful to a given individual. The price is rather high for a book which needs to be read in conjunction with standard reference texts.

John Miles

NEWS FROM MEMBERS

M. Riaz Hasan has joined FAO as Senior Water Resources Specialist to the Ministry of Mineral and Water Resources, Mogadishu, Somalia. His TOPS include establishment of a National Water Centre (NWC) in the Ministry. The NWC plans to use the IOH's software HYDATA and GRIPS for hydrological data processing.

NEW DIRECTOR FOR INSTITUTE OF HYDROLOGY

Professor Brian Wilkinson, at present Professor of Civil Engineering and Deputy Dean at the Royal Military College of Science, Shrivenham, has been appointed Director of the Institute of Hydrology, Wallingford and Head of the Wallingford Laboratory. He is to take up his new post on 5 July 1988.

RESEARCH REPORT

The Institute of Hydrology's three-year review of its research programme should be arriving on people's desks at much the same time as this copy of *Circulation*. Many BHS members and/or the organisations they work for will be on the mailing list but if you have not received a copy by the end of February and you would like one, please contact the Librarian at IH (0491–38800).

"Weather Radar and Flood Forecasting"

– anyone having trouble getting their copy at the BHS discount price should make sure that their orders are addressed to Ms Lesley Valentine, Product Manager, John Wiley & Sons.

UNESCO Freebies

Write to UNESCO, Division of Water Sciences, 75700 Paris, France for copies and catalogue.

Hydrology and Water Balance of Small Islands: a review of existing knowledge by A.A. Diaz Arenas and J. Febrillet Huertas. Tech. Doc. in Hydrology, 1986, UNESCO, 25pp.

Most useful for its references, as it contains almost no hydrology.

Study of groundwater and soil moisture movement by applying nuclear, physical and chemical methods by H. Moser, W. Rauert, G. Morgenschweise and H. Zojer. Tech. Doc. in Hydrology, 1986, UNESCO, 104pp.

A thorough review.

Water utilization and conservation techniques in domestic, agricultural, navigational and energy uses by A.T.J. Calcogno. Tech. Doc. in Hydrology, 1987, UNESCO, 107pp.

Mostly about the organisation of organisations (UNESCO, WMO, WHO, ESCAP . . .)

David Lerner
Birmingham

New Members

Professor P.J. Ergenzinger ..... Professor, Free University, Berlin
O.A. Dairo ..... Engineer, London Borough of Hammersmith and Fulham
N.J.C. Tranter ..... Research Student, Middlesex Polytechnic
J.D. Foster ..... Severn Trent Water
J.M. Channon ..... Student, Imperial College
A.J. Sheppard ..... Student, Imperial College
P.E. Hardistry ..... Student, Imperial College
Ann K. Dixon ..... Anglian Water Authority
K.A. Tilford ..... Research Associate, Birmingham University
C.P. Lambert ..... Research Fellow, NERC
M.P. McCartney ..... Student, Imperial College
C. Blasi ..... Student, Imperial College
S. Burne ..... Research Fellow, Birmingham University
D. Mukherjee ..... Student, Birmingham University
A.R. Roberts ..... Tutor, University of Exeter
Ann Matthews ..... NERC
B.C. Watson ..... Scientific Officer, NERC
C.J. Onof ..... Research Student, Imperial College

FORTHCOMING EVENTS

Meetings

INTERNATIONAL SEMINAR ON THE STATE OF THE ART OF HYDROLOGY & HYDROGEOLOGY IN THE ARID AND SEMI-ARID AREAS OF AFRICA
7–12 November 1988
Ouagadougou, Burkina Faso

Designed for all those involved in the planning, development and operation of water resources systems. Researchers from disciplines related to the understanding, use and management of water resources in Africa are invited to submit abstracts of a paper for presentation or poster display.

Short courses: 3–5 day courses will be organised on the various objectives of the seminar and held immediately beforehand to provide additional educational opportunities.

Call for papers: Abstracts (approx. 500 words) in English and/or French should be submitted no later than March 15 1988, to: M. le Secretaire General, CIEH, BP 369, Ouagadougou, Burkina Faso, and IWRA, University of Illinois, 208 North Romine Street, Urbana, IL 61801, USA.

Further details and copies of the first announcement are available from: Bob Moore, Institute of Hydrology, on 0491–38800.

Courses

GROUNDWATER POLLUTION
UNIVERSITY OF BIRMINGHAM
18–22 April 1988

A one-week course offering an introduction to sources and effects of pollution, investigation techniques, transport and chemical processes, modelling, prevention and remedies. The course will include lectures, workshops and case studies.

For more information contact: David Lerner, Department of Geological Sciences, University of Birmingham, PO Box 363, Birmingham, B15 2TT. Telephone: 021–414 6156 or 6138.

Diary

25th February 1988
Pennines Hydrological Group/Northern Counties Association of ICE.
"The economic uses of water resources in the North West" – J.M. Knowles and Dr. S. Walker (NWWA).
Carlisle Civic Centre. 6.00 p.m.

11th March 1988
NERC Seminar.
"Acid Rain and British Forests".
Royal Society, London.
Details: Mr. M. Cannell, Institute of Terrestrial Ecology. Tel: 031–445–4343.

17th March 1988
Welsh Hydrological Group.
"The Cardiff Bay barrage" – speaker from Wallace Evans & Partners.
University College, Cardiff. 5.30 for 6.00 p.m.

20th April 1988
BHS Midlands Section Spring Meeting.
"Agriculture and water quality in the Midlands" – Andrew Skinner (STWA), Roger Unwin (MAFF) and André Carler (Soil Survey).
Coventry Polytechnic. 2.00 p.m.

24th–29th April 1988
International Symposium.
"Hydrological Processes and Water Management in Urban Areas".
Duisburg, Federal Republic of Germany.

6th May 1988
BHS/Welsh Hydrological Group.
Field visit to Llyn Brianne. Provisional notice of trip which will be restricted in numbers. Full details to be circulated later.

6th–11th June 1988
International Workshop on Hydrology of Mountain Areas.
Czechoslovakia.

19th–21st October 1988
ICE/WRC.
Conference on "Long Sea Outfalls", Glasgow.
Details: Conference Office, ICE.

20th–23rd October 1988
Association of Hydrologists of India.
International Seminar on "Hydrology and Colloquium on Water Resources Problems of South Asian Countries", Andhra University.
Details: Prof. V.V.J. Sarma, Dept of Geophysics, Andhra University, Visakhapatnam 530 003 India.

24th–26th October
International Water Conference, Engineers' Society of Western Pennsylvania, Pittsburgh, USA.

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