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UNIVERSITY RESEARCH ...Part VI

Middlesex Polytechnic

Continuing our series on current water research in the UK, this issue features Middlesex Polytechnic and the work of the Flood Hazard and Urban Pollution Research Centres.

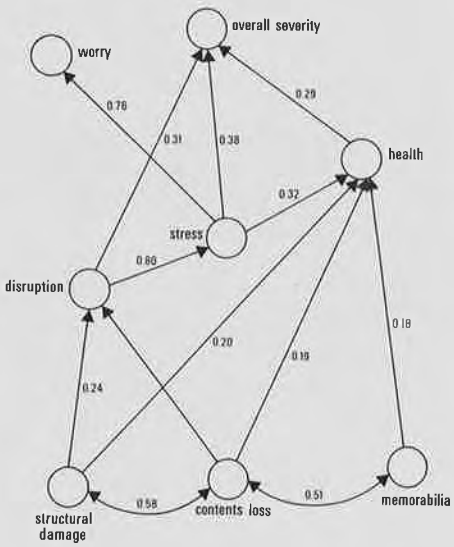
The Flood Hazard Research Centre was founded in 1970 and has grown to include six academic staff, three Research Fellows, eight Research Assistants and two research students. The Centre is located within the School of Geography and Planning, in the Faculty of Social Science, and the main thrust of the research is developing techniques for the social and economic appraisal of water and coastal investment decisions.

The social costs of sewerage

This is a collaborative study with WRc to develop a benefit assessment methodology for sewerage schemes covering the benefits of alleviating flooding and of reducing the risk of collapse by sewers. The main staff involved have been **Colin Green**, **Mohamed Suleman** and **Sylvia Tunstall**. It also provides methods and standard data to evaluate the benefits of river water quality improvements resulting from improvements to continuous and discontinuous sources of discharge. A simple table to present flood alleviation benefits, including some non-monetary impacts of flooding such as disruption and stress, has been developed – Wessex WA have adopted a procedure based on this table. As the casual model (Fig. 1) shows, these non-monetary impacts are more important to the household than are the monetary impacts of the flood but they are, in turn, partly determined by these monetary impacts.

Standard methods and data have also been developed to assess the recreational and non-user benefits of water quality improvement. These have been evaluated using the Contingent Valuation Method and also by surveys of river corridor users and households adjacent to a river corridor and at least two miles from any accessible river corridor. There is a risk of confounding the benefits of water quality improvement with the benefits of environmental improvement to the river corridor which usually is undertaken either before, or at the same time as, improvements to the river corridor. Therefore, a necessary part of the study has been both to control for corridor quality and to identify the preferred features of a river corridor. Similarly, since recreational benefits will not accrue unless the individual perceives the water quality as having improved, it has been necessary to explore those indicators which determine perceived water quality. This latter work is now being extended by Margaret House and integrated with water quality indices.

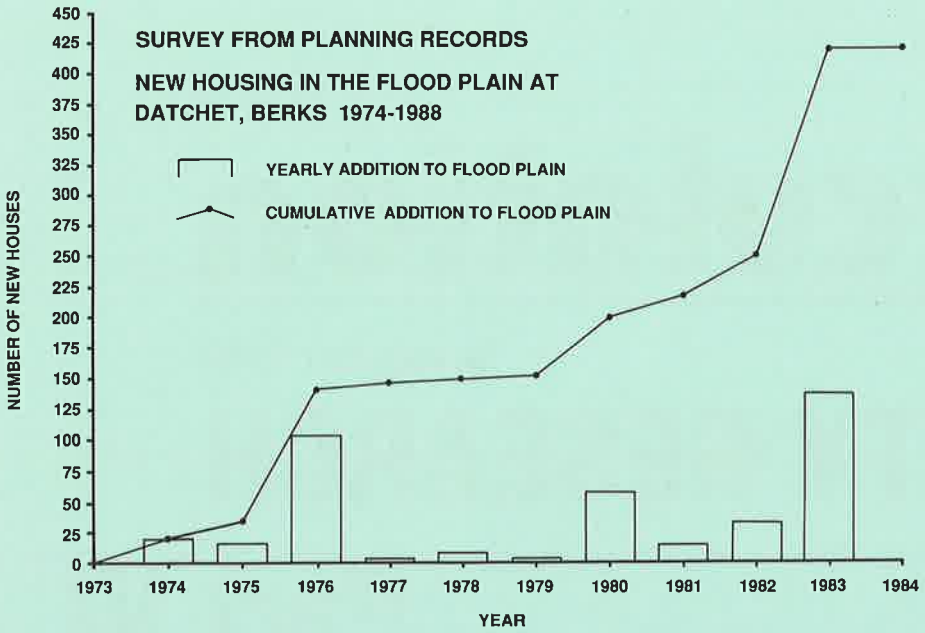
Fig 1 Path analytic model – Beta coefficients



The control of development on flood plains

Jeremy Neal and **Dennis Parker** have recently completed a study of flood plain development control at Datchet, Berkshire. The study analyses trends in development and planning applications over the period 1974–1984. The work involves a critical appraisal of the policies of authorities concerned in the planning liaison process. The

Encroachment into the Thames flood plain, west of London



results shown by the graph "Encroachment into the flood plain, west of London" illustrate the magnitude of the problem. Datchet is an area without existing flood protection works and it is possible that, in similar areas where protection works are provided, rates of development may be even higher.

Research has recently begun at the Flood Hazard Research Centre into the post-project appraisal of urban flood protection schemes, through which the relationship between rates of development and levels of flood protection may be assessed. This work is sponsored by the Ministry of Agriculture, Fisheries and Food and is being carried out by Dennis Parker and Jeremy Neal. It expands upon existing research at the Centre including the Datchet study and the work carried out by **Paul Thompson** into the effectiveness and efficiency of flood protection schemes in Bangladesh.

Results from the Datchet study show the rates at which development may occur on flood plains that do not have flood protection works. Through time the demand for such protection will grow as more life and property are put at risk adding to the vulnerability of the community to the effects of flooding. The Thames Water Authority has funded research at the Centre that will evaluate the attitudes of their customers towards the threat from flooding and the need for flood protection. The work, carried out by **Maureen Fordham** and Datchet, will be one area where customer perception will be assessed.

Integrated water planning in 20 OECD Countries

Edmund Penning-Rowsell and Dennis Parker are working with the OECD Secretariat in Paris to investigate the conditions under which policy integration can be maximised between the water resources sector and other public policy sectors such as agriculture, energy, fisheries, land use and recreation. This research has involved the development of 106 case studies in 20 countries, identifying the factors which lead to greater policy integration, the political and economic benefits of such integration, and the negative environmental effects when policies are in conflict.

The results show that basin management is not a pre-requisite for integrated management, and that federal countries such as Australia have particular policy integration problems. Countries such as Spain and Portugal are making considerable progress towards closer integration of water and land use policies, from a position where policies have often been conflicting, owing to greater political commitment to environmental enhancement, whereas Italy is moving in the opposite direction with its emphasis on devolved water resource planning. Most progress in policy integration appears to have been made in Norway, Denmark and Sweden, with greater use of EIA and public involvement in water planning through a coherent system of public consultation.

The research is leading to an OECD Council recommendation to countries on the institutional, legal and economic policy changes to promote harmony between their policies in the water sector and those in related areas. Particular emphasis is being placed on the promotion of the "User Pays" principle, as an extended form of the "Polluter Pays" principle, whereby subsidies to water users are reduced and externalities incorporated in the prices for water and water services. The development of this Principle will not be easy but the theoretical analysis shows that its adoption could lead to environmental enhancement when project and policy externalities are minimised.

Coastal erosion and sea defence (the COPRES project)

Sylvia Tunstall, **Antu N'Jai**, **Annabel Coker** and **Edmund Penning-Rowsell** are researching the benefits of coast protection and sea defence schemes for the Ministry of Agriculture, Fisheries and Food. To date, project appraisal techniques in this area have been limited. This three-year research programme is investigating the correct ways of measuring the national benefits of this substantial investment. These benefits include the prevention of property loss through cliff erosion, the loss of amenity and recreation facilities if cliffs and beaches are removed, and the environmental gains and losses from continued coastal erosion and flooding.

Results so far, from case studies at the Naze in Essex and at Hengistbury Head, Dorset, show that recreation and amenity losses from inadequate coastal management can be very high. However in many cases the large investment necessary to prevent coastal erosion cannot (unless erosion rates or property numbers are high) be justified by the loss of only buildings and agricultural land. Research is continuing into the recreation benefits of beach protection, with surveys in 1988 at Dunwich, Scarborough, Filey, Clacton, Frinton, and Hastings.

The Urban Pollution Research Centre was established in 1976 to bring together staff with a mutual interest and experience in pollution processes and controls within urban catchments. The Centre is formally aligned to the School of Applied Science, in the Faculty of Engineering, Science and Mathematics, and as such is responsible for a number of long-standing Postgraduate Diploma courses in Air and Water Pollution Control, Water Supply and Public Health Engineering, Environmental Health as well as an MSc in Water Pollution Control. The Centre contributes to a variety of undergraduate courses including BSc Natural Science, BSc Geography and a new 4-year sandwich degree (BSc Environmental Technology), as well as offering a variety of professional short courses. The Research Centre comprises seven academic staff supporting 10 full-time Research Fellows, Assistants and Students, supplemented by four part-time staff and the project work of some 15 MSc students.

Stormwater runoff quality

Many of the problems associated with the generation, transport and fate of pollutants in the urban environment have a hydrological basis. The flow controls determining their particle size association, speciation and transport potential have been an active area of the Centre's interest for many years.

The role and contribution of highway surfaces and gullypots to storm sewer loadings has provided one focus for a number of collaborative projects. Work undertaken by **Ron Hamilton**, **Mike Revitt** and **Ron Warren** with London Scientific Services shows that aerial deposition dominates metal accumulation rates, and that resuspension can be a major factor influencing the overall mass balance. NERC sponsored studies by **Bryan Ellis**, Mike Revitt and **Owen Harrop** have

shown that impermeable surfaces provide a virtually unlimited sediment store, with loads being a function of runoff transport capacity. Novel reconnaisance techniques based on sediment magnetic properties are also being developed by **Paul Beckwith**, in collaboration with the University of Liverpool, to identify source inputs.

NERC, the Swedish Environmental Protection Board and the Building Research Council continue to support collaborative studies by **Greg Morrison**, with the Chalmers University of Technology, Gothenburg, on the transport mechanisms and processes for metal species in gullypot systems. The contribution of gullypot suspended solids and toxic loadings in the sewer pipe is highly dependent on the hydrological properties of the storm in question. During high-volume, intense events, the liquors and interstitial waters of the gully chamber make a substantial contribution to the "first flush" experienced at the outfall. The significance of chemical solubilisation in surface transfer mechanisms and the importance of the bioavailable species present in the gullypot discharge have been confirmed by other collaborative work being undertaken in Spain with the University Polytechnics of Madrid and Valencia.

The characterisation of stormwater loadings has also included SERC sponsored SEM investigations of sewer sediments, undertaken by **Helen Roberts**. The Centre has also conducted research into the effects of land use on hydrocarbon forms and distributions within urban catchments (**Angela Gavens**) and **Marc Brizio** and **Chris Abbess** are working on an EWPCA and EC contract to characterise the probability distributions of SWO discharges. This latter work has been considerably strengthened by the extensive experience of **Mike Hall** who is also contributing, with **Nick Tranter**, to a SERC sponsored modelling study of storm runoff in a small 183 ha. urbanising catchment that is dominated by agricultural inputs. This work on catchment runoff is to be extended with the support of ADAS.

Water quality management

Ecological monitoring procedures for the evaluation and management of heavy metal pollution in urban catchments is a major current focus of interest.

This SERC sponsored work by **Andy Bascombe**, **Brian Shutes**, Bryan Ellis and Mike Revitt is extending existing BMWP methods for river quality classification as well as developing in-situ procedures for evaluating impact effects and recovery times on receiving stream ecology resulting from toxic, episodic, urban discharges.

The Urban Pollution and Flood Hazard Research Centres are collaborating on a major study led by **Margaret House** to develop and apply Water Quality Indices for the classification and operational management of surface water quality. This major research effort is being undertaken with **Alan Burrows** in co-operation with North West Water. The project also involves WRc and a number of other Water Authorities and consulting agencies.

Current contract work on the design of flood storage ponds by **Mike Hall** and Bryan Ellis on behalf of CIRIA is shortly to be extended to a review of runoff controls at the strategic catchment level under combined DoE/Water Authority/CIRIA funding. Mike Hall and Bryan Ellis are also involved in a review of urban drainage effects in the critical sub-estuaries of the River Severn under contract from the Severn Tidal Power Group.

The Nature Conservancy Council and NERC are providing support to the Centre for future investigations of the ecotoxicological impacts of oil discharges in storm runoff to urban areas. A formal agreement with the Chinese Research Academy of Environmental Sciences in Bejing is supporting collaborative studies of reed bed technology for oil clean-up in ecologically sensitive urban ponds.

Atmospheric inputs

The control of toxic pollutants in urban environments requires accurate information on the sources of those pollutants. Street surface sediments are the major source of toxics in urban runoff, but the mechanisms whereby the pollutants are accumulated into surface dust are less well understood.

A series of research programmes has been developed by the Centre to investigate these processes. **Ron Hamilton**, Mike Revitt and **David Candeland** are working with the Ford Motor Company to quantify polyaromatic hydrocarbon emission rates from vehicles and to assess their environmental consequences. **Ian McCrae**, Mike Revitt and Ron Hamilton have been investigating the effects of road cuttings and street canyons in restricting atmospheric dispersion, in collaboration with the Transport and Road Research Laboratory.

In addition, the British Council and the EC have supported Brian Shutes, Mike Revitt, Owen Harrop and Ron Hamilton to work with the University of Aveiro, Portugal, and the Universidad Politecnica, Valencia, Spain. This project concerns the development of area dispersion models. **Trudie Mansfield**, Bryan Ellis and Ron Hamilton have studied the processes of smoke deposition on to urban surfaces and the consequent soiling of materials. The DoE has funded further research in this area, as part of their Acid Rain and Buildings Exposure research programme.

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Parker, D.J. and Thompson, P.M. 1988. An "extended" economic appraisal of coast protection works: a case study of Hengistbury Head, England. *Ocean and Shoreline Management*, 11, 45–72.

Penning–Rowsell, E.C., Chatterton, J.B. (et al.) 1987. Comparative aspects of computerized floodplain data management. *Journal of the Water Resources Planning and Management Division, A.S.C.E.*, 113 (6) 725–44.

Penning–Rowsell, E.C. and Parker, D.J. 1987. The indirect effects of floods and benefits of flood alleviation: evaluating the Chesil Sea Defence Scheme. *Applied Geography*. 7, 263–8.

Penning–Rowsell, E.C., Parker, D.J. and Harding, D.M. 1986. *Floods and drainage: British policies for hazard reduction, agricultural improvement and nature conservation*. London: Allen and Unwin.

Roberts, A.H., Ellis, J.B. and Whalley, W.B. (1988). The progressive alteration of fire sediment along an urban storm drain. *Water research*, 22(6) 775–781.

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ROADFORD DAM SITE VISIT

BHS South-West Section
12 July 1988

The BHS South-West Section party assembled at the site offices of Babtie, Shaw and Morton, situated just off the A30 in West Devon between Okehampton and Launceston, at the start of a visit to view construction work on the Roadford Dam and Reservoir and to hear how this scheme fits into the water resources strategy developed for the peninsula by South West Water.

As part of an introduction to Roadford, **Glenis Weilding** (South West Water) described the water resources background to the scheme and went on to outline some of the environmental, operational and hydrological considerations which are associated with this project. The construction of a reservoir in the Roadford area was first mooted in 1974 when the Water Authority sought a third site to complement major reservoirs planned for Wimbleball and Colliford. The latter two schemes have been completed and between them supply Exeter and East Devon, much of Cornwall and parts of North Devon. A third reservoir is required to solve supply problems of Plymouth, part of South West Devon and North Devon, and to complete the water resources strategy for the South West Water area (Fig. 1A). However, the history of Roadford Reservoir has been somewhat chequered, and three public enquiries were held before the scheme, which is situated on the River Wolf tributary of the River Tamar, was approved by the planning authorities in 1985.

The strategy based on Roadford (Fig. 1B), evolved to secure supplies in the North Devon area, involves construction of a major abstraction on the River Torridge, which at times of shortfall will be augmented by water pumped from the reservoir. Existing sources for the Plymouth area, which consist of a gravity supply from Burrator Reservoir on Dartmoor and a pumped supply from the River Tavy at Lopwell, will be supplemented by a pumped supply from Gunnislake on the River Tamar (Fig. 1B). Releases from Roadford will augment the natural flow of the Tamar when required, and use of water from Roadford to supplement the supply to Plymouth will allow Burrator Reservoir to be used further for supplying Torbay and South West Devon (Fig. 1B).

The development of Roadford has spawned a wide range of investigations designed to safeguard the environment of the Rivers Tamar and Torridge which will be affected by the scheme. A 10-year £2.5M water quality and fisheries study was started in 1984, and fish movements in relation to flow, for example, are being assessed by a programme of radio- and micro-tagging. The objectives are to predict the effects of construction, impoundment and releases of water on the quality of the Tamar and Torridge, and to develop operating rules for the reservoir which will minimise any detrimental impact on fish populations, especially those of salmon, sea trout and brown trout. An additional five-year £382K environmental study began in 1986 and includes time-of-travel investigations, surveys of river bed sediments and their influence on spawning grounds, and water quality modelling work.

Glenis Weilding also explained the hydrological and operational model which had been developed by the Hydrology Section of South West Water to simulate the Roadford scheme. It is programmed in FORTRAN 77, uses daily mean flow data, can cope with different demand horizons, and may be calibrated with 30 years of historical data. Outputs relate to environmental impact, such as pre- and post-dam flows, and to optimisation of operating procedures, including the financial costs involved. The model has proved to be a very flexible tool in, for example, assessing the feasibility of HEP generation at the Roadford site. It allows prediction of the best scenario for the use of the generating capacity which at the same time will avoid environmental damage and conflicts with the water supply function of the scheme. The model is also capable of simulating the "knock-on" effcts of changing any part of the operationally complex supply system which will be based on Roadford.

David Evans (Resident Engineer, Babtie, Shaw and Morton) introduced the construction work at Roadford and explained that the scheme had reached a very interesting stage, with 25–30 per cent of the dam fill currently placed and erection of the valve and overflow towers in progress using a slip-forming process for the placement of the concrete.

Work on the scheme commenced in

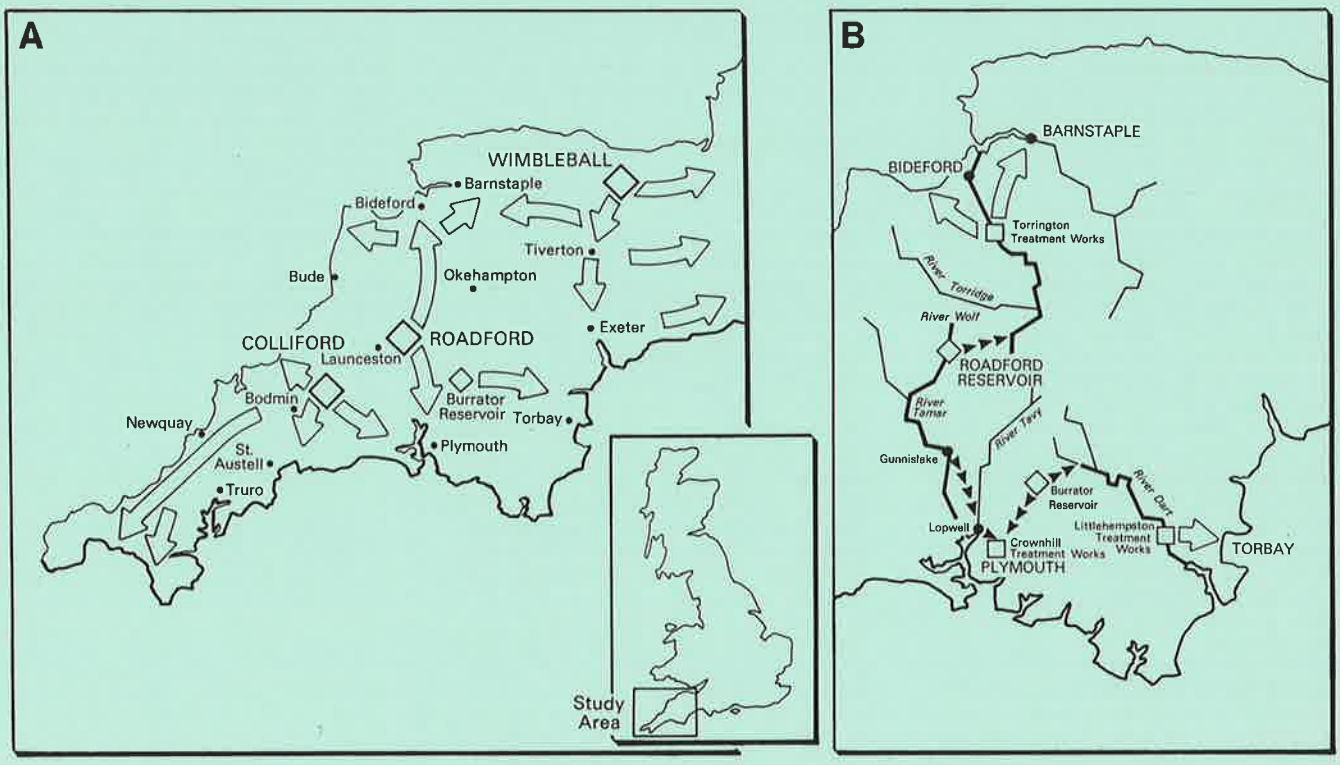


Fig. 1 Water resources strategy for the South-West region (A) and details of the Roadford Scheme (B)

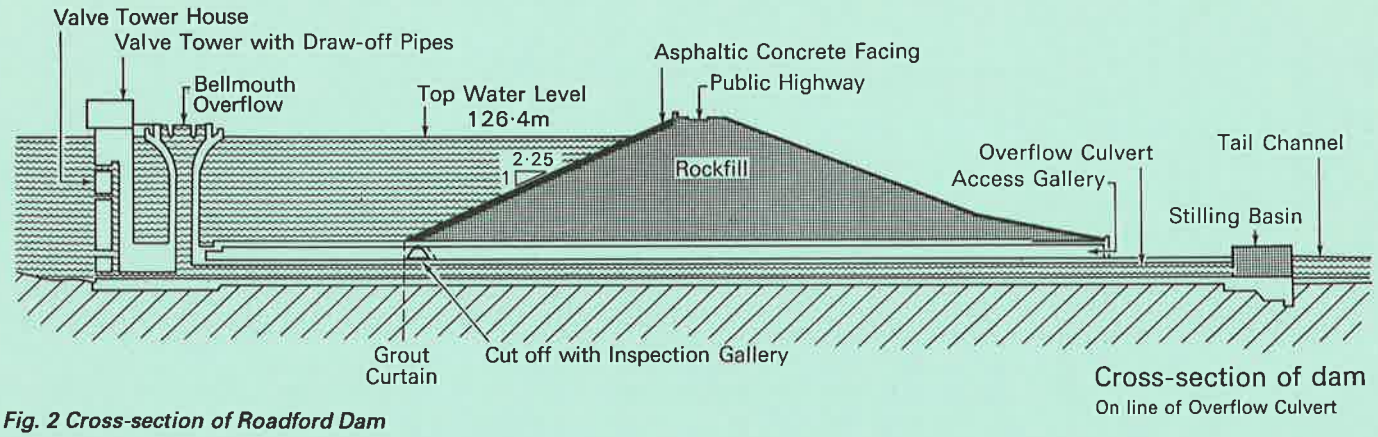


Fig. 2 Cross-section of Roadford Dam

December 1984 with roadworks to improve access beween the A30 and the site. This first phase also involved construction of a new bridge over the River Thrushel at Hayne and was completed in the spring of 1986 at a total cost of £2M. The Southweek road scheme comprised a second major contract – began in May 1986, it was completed by the end of June 1987 and cost a further £2M. This part of the project was needed to divert an existing road that will be flooded on impoundment, and included the building of a nine-span viaduct, which has won a Concrete Society 1988 award, to carry the road over an arm of the reservoir.

Work on the £16M contract for the construction of the rockfill dam began in February 1987, and it is planned that three summer seasons will be necessary before impounding can start in the autumn of 1989 with the objective of augmenting supplies over the summer of 1990. Roadford dam will impound the River Wolf at a catchment area of 31 km^2 (1200 mm average annual rainfall) to form a lake with a surface area of 3 km^2 and an overflow capacity of 37,000 Ml. David Evans explained that the first stage in building the dam was to construct the overflow culvert (Fig. 2), which is situated on the east side of the valley where foundation conditions in the highly folded Carboniferous sandstone and shale are more predictable. The culvert is a large concrete structure, 4.5 m wide by 3.5 m high, which has been designed to take a probable maximum flood of 148 m^3s^{-1}. The culvert structure will carry an access gallery which will run from the downstream toe of the dam to the base of the valve tower. At what will be the upstream base of the dam embankment, a concrete cut-off trench is being constructed across the valley (Fig. 2). This varies in depth from 5 to 15 m, depending on geological conditions, and will be supplemented by the formation of a "grout curtain" in the bedrock extending to a depth of as much as 50 m. An inspection gallery is being built on top of the cut-off and will be used to collect and monitor for safety any seepage through the dam. A discharge channel and stilling basin downstream from the dam (Fig. 2) was completed in the autumn of 1987, and the River Wolf was diverted early in 1988 through the overflow culvert which leads to these downstream works.

Present work is focussed on the construction of the rockfill embankment of the dam. The foundation was prepared by stripping off 2.5 to 3 m of unsuitable material from the valley floor and laying a 1.5 m blanket of crushed dolerite. The main body of the dam comprises a mixture of sandstone, siltstone and mudstone which is being quarried locally. The upstream face of the dam will have a 1 vertical to 2.25 horizontal slope and will be faced with an asphaltic membrane (Fig. 2) to ensure a watertight structure and to cope with any settlement of the rockfill. The junction of the membrane and the cut-off trench is a critical area where a fine sand fill will be used to avoid problems arising from shearing. The dam, which will have a crest length of 430 m and a maximum height of 40.5 m, is being instrumented for detection of pressure conditions and a range of movements. The valve tower (Fig. 2) presently under construction will have three draw-off levels discharging into a common pipe laid within the access gallery, and a bottom reservoir scour pipe will discharge directly into the overflow culvert. Excess water, once the reservoir is full, will flow over a bellmouth spillway (Fig. 2) being built next to the valve tower and will discharge via the overflow culvert and the downstream channel.

Having been fully briefed, the South-West Section party went on site to view construction work in progress. A first stop was made at the car park and viewing area. David Evans explained that plans are currently being drawn up for the recreational use of the reservoir. Activities which may be developed include fishing, walking, horse-riding and birdwatching, although parts of the reservoir will also be designated as nature reserves. The party then descended the eastern side of the Wolf valley to get a better overall view of the scheme, and it was explained that a large conservation exercise has been built into the 18 month £32K contract to clear the reservoir basin of trees, hedges and buildings. Removal work started in February 1988 and has been carefully phased to minimise the disruption to bird and other animal habitats. There is also a programme of transplanting ecologically important acid marshy grassland plants to sheltered and protected areas above top water level.

At the next stop the party viewed the completed downstream overflow works and the pumphouse which is under construction and will eventually also house the hydro-generation plant. From there, the group moved onto the current surface of the embankment to see the process of dumping, rolling, grading and scarifying by which the rockfill dam is being built up. An area of rock slippage close to the cut-off structure on the western side of the valley was apparent; it has required additional stabilisation measures and will need careful emplacement of the fill. The party survived the menace of numerous 50 ton dumper trucks, which move about the embankment at speeds of up to 50 mph, to return safely to the site offices. En route, there were good views of the valve and overflow towers as well as the upstream end of the overflow culvert at its junction with the cut-off structure (Fig. 3).

The BHS party was very impressed by the scale and complexity of the works at Roadford, was extremely grateful to David Evans and Glenis Weilding for their lucid and informative presentations, and much appreciated the hospitality provided by Babtie, Shaw and Morton at the end of a successful and very enjoyable visit.

Bruce Webb

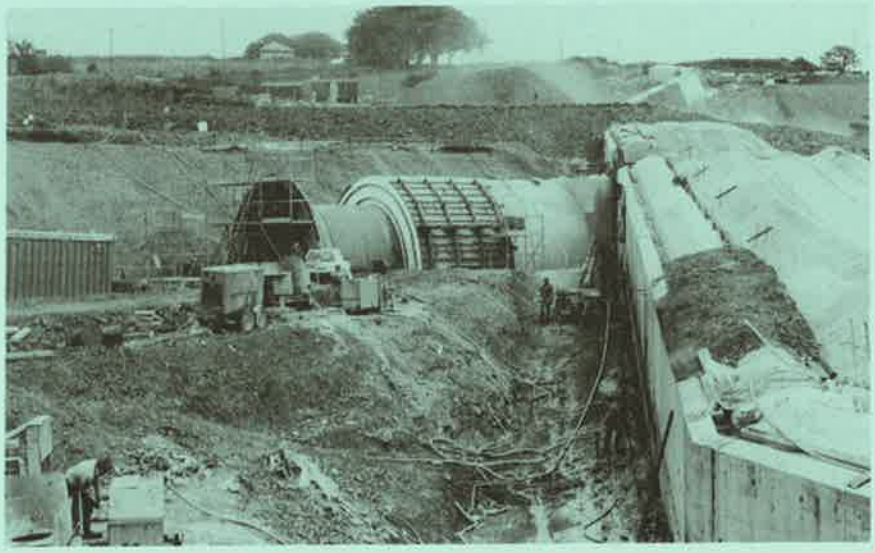


Fig. 3 Junction of the overflow culvert and cut-off structure at Roadford

Second BHS National Meeting September 1989

Note to would-be contributors:
We know postage problems may have caused some of you to receive the call for papers too late for action but DO NOT WORRY . . . Max Beran is still very happy to receive abstracts.
Particularly wanted are (1) papers from Water Industry hydrologists on operational aspects of ground and/or surface water supply schemes – including wter quality aspects and (2) from consulting engineers on "coping with excess" at home or overseas.

Developments in River Quality Modelling

Pennines Hydrological Group
11 May 1988

The first paper at this meeting "Pollution prediction using the ADZ model", by **Prof P. Young** and **Dr Keith Beven** from the Lancaster University, focussed on a specific modelling technique. The traditional approach to studying longitudinal transport in rivers has been via the advection dispersion equation (ADE). This assumes that longitudinal dispersion arises through the interaction of differential longitudinal advection and cross sectional diffusion and describes this mathematically in terms of a Fickian diffusion equation.

As an alternative to this approach, it is suggested that storage or dead zone dispersion is the dominant factor governing dispersion and that such zones could be aggregated. The resulting aggregated dead zone (ADZ) model has a lumped parameter ordinary differential equation form, which appears to offer considerable advantages over the distributed parameter partial differential form of the ADE model. The ADZ model offers the advantages of easier formulation of the discrete time solution, inherent stability, as well as being better able to describe observed patterns of dispersion at all time-scales.

To represent dispersion, the ADZ model does not use the common approach of pairs of partial differential equations. Instead, all dispersive processes in a channel are represented as a lumped effect, modelled by one or more aggregated dead zones. As dead zones are regarded as the major physical cause of dispersion in natural channels, it is sensible to assume initially that the simple dynamic structure used to describe a whole reach will be the same as to describe a single dead zone. In formulating equations for a single dead zone, the crucial assumption is made that the aggregated effect of all dead zones in a reach can be represented by a single effective dead zone volume. After formulating a description of the dispersive processes at reach level, the advective processes are considered as a simple time delay between the upstream and downstream concentration – time profiles, related to the leading edge of the leading edge of the solute cloud.

The number of ADZ elements required to model a channel system depends on the length and characteristics of the reaches being considered. An equation can be written which relates the mean travel time of the solute through the reach to the transport time delay and the ADZ residence time.

The model is calibrated using a statistical methodology based on the computer package hydroCAPTAIN. This package evaluates two test statistics for different model orders and time delays. The best identified model is that which provides both a good explanation of the data and well defined parameter estimates. As the number of model parameters is increased, the explanation of the data tends towards a plateau with little improvement in fit for further increase in model order, whilst the error variance term will often increase markedly when the model has too many parameters. This type of calibration allows the appropriate model order to be determined from the data, rather than fixed beforehand, as in the ADE approach. Given an incomplete understanding of the underlying mechanisms, such flexibility is a major advantage of the ADZ approach.

Data for the ADZ experiments have been collected from a number of tracer experiments, using equipment specifically modified at the University. The tracer used was Rhodamine WT and concentrations were measured at both ends of reaches using microcomputer based fluorometric data logging systems developed by the study team. The logging system consisted of a fluorimeter interfaced to a portable computer via a microelectronic analogue to digital converter, developed in the department's electronic workshops. The fluorometer sensitivity, fluorescence intensity and water temperature were recorded by the microcomputer at an interval of 15 seconds. In addition, the microcomputer automatically controlled the fluorimeter sensitivity range.

Within the hydroCAPTAIN package, estimates of reach discharge, travel time and reach volume can be made, to allow interpretation and evaluation of modelling results. From a study of travel time data, a power law relationship was initially devised. Later evidence however suggests that a simpler inverse law may be adequate. Estimates of reach volume show general good agreement between model results and observed sections. The relationship of time delay and residence time to discharge were found to obey a smooth decreasing pattern.

Of more significance is the fact that the ratio of travel time to residence time appears to be approximately constant for the discharges so far investigated. This ratio, termed the dispersive fraction, describes the time the tracer appears to spend being dispersed in the reach, as a fraction of the total time it spends in the reach. Since this is also directly equivalent to the ratio of effective volume to reach volume, it can also be interpreted as a measure of that fractional volume of the reach which appears responsible for dispersion. This suggests that a small number of tracer experiments, when combined with estimates of travel time based on the hydraulics of flow, could eventually be used to calibrate the ADZ reach model over a wide range of flows.

So far, the ADZ model has shown that it can potentially offer a number of advantages over the traditional advection dispersion equation. To enable the model to be used with complete confidence however, more research is still needed to relate the ADZ model parameters to a wider range of channel and flow characteristics.

P. McCrae of Babtie, Shaw and Morton then offered some general considerations on how computational models are being used in river hydraulics and quality. He noted that the development of models takes place within a number of organisations in the UK, but the place of origin may have a bearing on the role of the model. For instance, University models are often for teaching or research purposes and are therefore not always suited to commercial use. Models formulated in the consulting sector are intended for commercial use, but can suffer from separation from centres of research.

In considering model studies he felt that careful thought should always be given to the alternatives, such as hand calculations, physical models and experienced judgement, to avoid using a model for prestige purposes

only.

Next, when selecting a modelling consultant, three principal categories may be considered: specialist modellers, general engineering consultants and Universities. Whilst specialists are clearly not using modelling merely to win engineering design work, they cannot offer the continuity between analysis and design provided by a more general consultant. Universities, while suited to problem solving, rarely have the resources or experience to undertake major commercial work.

The present procedure for appointing a modeller frequently involves competitive tendering. This rarely benefits either the client or modeller due to the time and cost involved in becoming completely familiar with the work required. This is shown by the considerable variability in bids for many modelling contracts. The cost of preparing these bids is invariably passed to the client in higher overheads and hence charges.

If competitive tendering is used then tender documents should be very detailed, allowing the tenderer to assess the content of work accurately. The tenderer however should not be overly constrained on methods, the choice of which should be conditioned by the required result. Flexibility in the contract should extend throughout the study, excepting the final completion dates for which variation must be justified.

If models are transferred to the client for continuing use, contact should be maintained between client and modeller both for support of the software and for feedback to the developers on the program's use. This is all too often overlooked.

Finally, **Dr R.W. Crabtree** from the Water Research Centre, Swindon, gave a paper on "Urban river pollution in the UK: the WRc River Basin Management Programme".

Traditionally, rehabilitation of combined sewer systems has concentrated on hydraulic and structural upgrading. However, in recent years, the limited capacity of the receiving watercourse has begun to assume greater importance. To employ scarce capital resources to the best effect a rigorous working methodology, which recognises both the limitations of the sewerage system and those of the receiving stream, is required. To this end, the River Basin Management (RBM) programme which co-ordinates resources from WRc, Hydraulics Research Ltd, DoE, SERC, much of the Water Industry and several universities has been initiated.

Products which are intended to arise from the RBM programme include the following:

1 Appropriate rainfall events for sewer flow modelling.
2 A sewer flow quality model, which includes the transport and erosion of sediment associated pollutants within the sewer.
3 A river impact model: to give the required information for assessing impacts and to provide information on storage requirements, a time versus concentration type model will be developed. The final model will provide information on suspended solids, ammonia, dissolved oxygen, BOD, COD, hydrogen sulphide, sediments, bacteria and metals.
4 Environmental standards for transient discharges.
5 Engineering solutions: to include effective designs for overflow structures, flow control devices and storage tanks.

Research is also being carried out to assess the impact of any changes to the sewerage system on sewage treatment works performance, such as the effect of higher flows for longer periods. In the long term, the programme effort will also address other sources of pollutants and other types of discharge such as non-point agricultural pollution.

In the interim, a number of tools have been developed to provide some means of spill pollution control for ongoing sewerage rehabilitation schemes. One interim tool developed by WRc is based on the concept of comparative acceptable river pollution (CARP). This seeks to calculate acceptable storm sewage overflow (SSO) loads to individual river reaches by comparing the pattern of load input rate per event with a reach which is not believed to be unacceptably polluted but receives significant SSO spills. This simple pragmatic approach avoids the need for pollutant specific transient event river quality standards.

The concept of using a comparison of input rates is valid only if rivers with similar characteristics are compared. A family of acceptable curves is therefore required to represent a range of river types. The acceptable curves implicitly include an assessment of the rivers capacity for pollution assimilation and self-purification within each identified reach. The identification of individual reaches should be based on river characteristics and experienced judgement.

The CARP method assumes that for each short time period transient event, the effects of the input to a reach are not passed to the next reach downstream. As the total river volume for the reach is available for dilution and mixing by this method, there may be an overestimate of the receiving capacity of the river. However, this enables a systematic optimisation of spill allocation to be made. The alternative approach, which is to pass pollutant loads downstream, may produce a gross underestimate particularly in reaches where loads accumulated upstream imply no available downstream capacity. In reality, the river will behave between the two extremes, but time of travel and decay rate information is required to model this.

CARP is intended as an interim river quality planning tool, developed as a methodology within the RBM programme. It provides a basis for assessing acceptable volumes of spill to river reaches, based on comparison with other, acceptable standard reaches. The approach avoids the need to specify recurrence intervals for overflows and offers flexibility in design and planning. The simple pragmatic approach used in CARP will be superceded by the major initial products of the RBM programme. However, the CARP procedure may have a continued future use for application to small schemes or as an initial screening tool for major projects.

Lincoln Weather Radar Project Long Range Calibration Study Group (LORCS)

The consortium of Severn–Trent, Anglian and Yorkshire Water Authorities and the UK Meteorological Office have convened a study group to examine the quality of data from the new Ingham aerial. The group is particularly concerned with the ability of the radar to produce subcatchment totals that are compatible with existing data derived from rain gauges. Many hydrological applications have to be met using data from beyond the nominal limit of quantitative radar coverage (75 km). At this range the radar beam can overshoot low level precipitation and therefore underestimate precipitation. The impact of distance from the aerial on the quality of the data is to be examined. It is hoped that any requirement for improvement in the existing climatological range correction procedure will be identified.

So far the work of the group has been mainly to review existing quality requirements for rainfall data, to consider previous evaluations of the quality of UK radar products and to define timescales and techniques for assessment of the Ingham radar data.

On timescales of approximately one month, comparison of areal totals from 26 subcatchments derived separately from gauge and radar measurements will commence in autumn 1988. More than half of these subcatchments lie further than 75 km from the Ingham aerial. Over the next two years the group aims to compare near real time daily catchment totals derived from radar and the fairly sparse network of daily reporting gauges with a "truth" field derived from the Meteorological Office climatological network of gauges (average spacing approximately 8 km) supplemented by additional Water Authority gauges. Comparison of both areal and point totals will be made. Statistical summaries of the radar performance during the study period are envisaged for a range of rainfall types and intensities. These will be used to quantify the capabilities of radar for hydrological applications and to develop and test range correction relationships.

GROUNDWATER MODELLING

BHS National Meeting
29 March 1988

Over 50 people attended the meeting which was organised by *Ian Goodwill* of Leeds with help from *Howard Wheater* of Imperial College. The objective of the meeting was to find out the present state of groundwater modelling in Britain, particularly the extent to which USGS packages are being used. The meeting attracted university researchers, water authority personnel, consultants and a good number of postgraduate MSc students. Seven papers covering both recent theoretical developments and practical applications were presented.

The first paper, "Inclusion of physical features in groundwater models", by **Ken Rushton** and **Andrew Spink** (both of Birmingham University) was presented by Ken Rushton. Using slides he described the effects of a wide variety of physical features, both natural and man-made, which should be taken into account when making a groundwater model. He first considered the effect of physical features on the determination of recharge where leaky sewer and water supply pipes were present. Taking the City of Liverpool as an example, he demonstrated that these were an appreciable component of the total recharge. This example was complicated by the layer of drift material above the aquifer. Just how does the leaking water infiltrate through the drift to the aquifer and how long does it take? He then moved on to conside the Gipping Valley in Suffolk which is a rural aquifer overlain by boulder clay. Here the problem is to determine the mechanism and quantity of percolation through the boulder clay to the aquifer. The quantity and the timing of this recharge will be of critical importance when comparing the computed and measured hydrographs of groundwater levels during the calibration process. He continued this theme with a brief mention of a similar problem in South Humberside.

He then turned his attention to the variation of the purely physical characteristics of the aquifer, namely the spatial variation of transmissivity and storage coefficient. He emphasized that these parameters were bound to vary over the areal extent of the aquifer and also with depth, hence one could not expect to model an aquifer accurately unless these variations were properly accounted for.

Ken Rushton concluded by saying that for an aquifer to be modelled successfully, it is essential to find out what is significant for that particular aquifer and then make sure that it is modelled accurately. This requires a great deal of painstaking and expensive fieldwork.

Ian Goodwill (Leeds University) presented the second paper entitled "The multiple cell method for the simulation of groundwater flow". He gave a brief history of the method which had been in use for more than 25 years and suggested that it sat between the finite difference and finite element approaches. It was numerically less elegant than either but provided precisely the same end result. He showed how an aquifer could be divided up into an irregular polygonal network which could be designed to handle both the irregularities of aquifer geometry and the problem of a constantly varying finite difference grid density. By considering Darcy's law and the equation of continuity separately he showed that the method was essentially a water balance which did not require the evaluation of the second order derivative. This made the approach very easy to understand and it required only a short, easy to write computer program which could readily be mounted on quite modest microcomputers. He continued by giving examples of the use of the method in developing countries and showed how the polygonal network could be used to provide a framework for making an attempt to determine an optimal solution to water supply problems. To demonstrate this point he used the example of an irrigation scheme where both groundwater and surface water were available. In this case the polygons became water using areas which could be supplied from any of several sources. This approach provides a useful and easy to use method to determine both an optimal water distribution and to assess the effect of different cropping patterns on the reliability of the overall water resources of the region.

Finally, he said that, as far as he knew, the method had not been used in the UK. This may be because it was not sufficiently well known or it may be that users felt that the straightforward finite difference approach was more suitable when a relatively large amount of field data was available. Furthermore the method could not be adapted to include the advection-dispersion equation therefore was of limited use for water quality problems although this problem was being investigated at the moment.

The third paper by **Adrian Butler** and **Howard Wheater** (both of Imperial College), "The modelling of coastal aquifers", was delivered by Adrian Butler who began by outlining the historical development of saline intrusion modelling. He then showed that detailed model simulations of coastal aquifers in hydraulic connection with the sea require solutions to both the density dependent fluid mass balance and advection-dispersion solute transport equations. Generally these are achieved using standard finite difference and finite element techniques. However these methods can lead to numerical dispersion problems in dynamic-advectively dominated systems. Therefore an alternative approach was presented which used the method of characteristics to solve the solute transport equation, where the movement of solute is represented by particle tracking. The model results presented were produced using a modified version of the USGS Sanford-Konikow model which had been tested against the SUTRA model by Voss for solutions to Henry's problem.

He demonstrated a practical use of his model by showing the results of an application to some highly pervious gravels on the south coast of Britain. He simulated the effect of a tidal surge which took four days to rise and a further eight to fall. This resulted in a large movement of the saline wedge inland. He simulated the rise and decline of the isochlors and was able to come to the surprising conclusion that after 200 days the isochlors had not returned to the pre-surge level.

The afternoon session was opened with a paper by **Brian Connorton** (Thames Water). He started by describing various models used by Thames Water since the mid-1970s together with a brief description of the geology of the Thames catchment. The particular characteristics giving the most concern from the groundwater modelling point of view were the high levels of variation of transmissivity with depth and the effect of leaky streams. The first model that he described was a radial flow model with a cylindrical solution grid which had been used to analyse the behaviour of individual wells. This model had the facility for varying the values of the specific yield and the transmissivity both laterally and vertically; it appeared to give adequate results.

He then described a linear regional flow model, used in the eastern part of the catchment around Lambourne, which gave poor results. Holding the transmissivity and specific yield constant with depth resulted in the groundwater not maintaining the flows in the rivers properly. The high river flows were not high enough and the low ones were too low. A non-linear model, developed in the Civil Engineering Department at Birmingham University which modelled both the high and low river flows accurately, was then tried. In order to demonstrate further the need for taking into account the vertical variation of transmissivity and specific yield he referred to an aquifer in the Cotswolds where the Thames at Ewen dried up quickly during periods of low rainfall. A linear model was first used but this did not model the drying up of the river and had to be abandoned; a non-linear model predicted the drying up at Ewen correctly.

Brian continued by outlining a land drainage problem in the Lower Colne Valley in the Slough area. He described a finite element model which was used to find out the volume of water seeping into and out from gravel pits together with the amount of stream leakage. This model successfully demonstrated that the bulk of the water in the gravels came from stream seepage and not from recharge.

He then very briefly looked at the work Thames Water were doing on water quality modelling in conjunction with Newcastle University. At the moment this was confined to looking at boreholes close to the Thames and Lea. The particular need of the Authority was to answer the question "what would happen to groundwater quality in the event of a pollution incident?"

He ended with a brief look at the time-scale of modelling and concluded that modelling is frequently on the critical path and that three years should be allowed to set up and calibrate a model. Work should be proceeding on this simultaneously with data collection.

The second paper of the afternoon was presented by **Ken Vines** (North West Water Authority). He described the East and West Cheshire aquifers, the Ormskirk aquifer and the Liverpool aquifer. These were all sandstone aquifers which in places were suffering saline intrusion due to over pumping. This was particularly so in Ellesmere Port and Birkenhead. He described the West Cheshire aquifer model which had been made using a Rushton and Redshaw finite difference code in some detail. He said that it had been difficult to determine a flow balance for the catchment because of ungauged discharges from the Shropshire Union Canal and several sewage works into the River Gowy. He was particularly interested in the determination of natural recharge from precipitation and had developed an elaborate procedure for its determination. He used potential evaporation as his initial field data and combined this with the potential soil moisture deficit to determine the actual evaporation hence the actual recharge from precipitation. This procedure resulted in a large amount of computation – hence capacity for error – but did indicate the extent to which it was necessary to go in order to obtain a realistic recharge rate.

The final paper before tea was presented by **Gerry Spraggs** and **Lawrence Holden** (of Anglian Water and L.G. Mouchel & Partners respectively). Gerry Spraggs started off by describing the chalk aquifer between Cambridge and Newmarket, an area of 600 km^2. He said that the reasons for the study were threefold, namely, the water demand of the area was rising and likely to exceed the reliable output of the existing boreholes in the early 1990's; it was already difficult to satisfy demand at peak periods; and the chalk-fed springs and rivers were experiencing lower flows. He described the geology of the aquifer, in particular the mechanisms of recharge due to the infiltration of surface runoff from the outcrops of boulder clay. The study, which was carried out with a Rushton and Redshaw model, was used to assess the effect on the aquifer of several proposed changes such as further groundwater abstraction for public water supply, effluent dilution in the rivers, enhancement of streamflow for fisheries conservation and how the aquifer would be affected by the abstraction of streamflow for spray irrigation.

The results of the model runs indicated that the aquifer was over-exploited in the West where public water supply accounted for 54% of the total recharge, but that additional abstraction was possible in the East where only 17% of the recharge is exploited. This situation resulted in river and spring flows being reduced and river support being required at five sites.

Lawrence Holden continued by describing the problems that had occurred in applying the model to this particular aquifer. The vertical changes within the aquifer had made it essential to model the vertical variation of transmissivity and specific yield. If this was not done then large errors in head were present although the flow volumes were reasonably accurate. Finally he described the recharge mechanisms of the aquifer. It appeared that there was a strong similarity with the recharge in the West Cheshire aquifer. Having tried unsuccessfully to estimate recharge using a similar approach to Ken Vines, he refined this procedure by calculating recharge for two different soil types; an approach which appeared to yield better results. This study is still continuing.

In the third session after tea there was only one paper, "Uncertainty in modelling contaminant transport in heterogenous media", which was presented by **Rae Mackay** (Newcastle University). He began by saying that in pre-groundwater modelling days a conceptual framework was needed and from this a flow model could be developed which, if necessary, could have a contaminant transport model coupled to it. Transport models may have to simulate the movement of both conservative and reactive pollutants. All groundwater systems were deterministic in nature but it was extremely difficult to assign values to the various parameters. This was particularly difficult with contaminant transport modelling due to the lack of field measurements for both longtitudinal and transverse dispersion coefficients. Since the numerical values of all the parameters depended on field measurements and were point values which were to be extrapolated over a large area, they were subject to uncertainty, hence, it did not seem unreasonable to treat them stochastically. As a simple demonstration of the effect of the variability of the parameters he presented some results from the Villa Farm Lagoons Industrial Waste Disposal site near Coventry. A block-centered finite difference scheme was employed for the modelling and the permeability varied on the model grid for each run by means of the following function

$$K = K_{det} \pm 0.9 \times RN\ [0,1] \times K_{det}$$

where K is the actual mesh element permeability, K_{det} is the calibrated deterministic permeability and RN is a random number generated from a uniform distribution in the range 0–1. The choice of function was made purely for demonstration purposes and does not reflect the true underlying variability of the aquifer system at the site. By making a number of runs with this model he showed that the values of head were generally insensitive to the local variability of K. He then showed simulations of a pollutant plume using particle tracking for fixed longitudinal and transverse dispersivities which produced different plume geometries. By making multiple simulations, a measure of the likely magnitudes of error in local concentration is obtained.

This procedure is analogous to the generation of stochastic streamflow traces which can be used to determine the likely reliability of a reservoir when subject to different demands. The methodology described by Rae appears to be a promising way of quantifying the likely errors in groundwater models which are calibrated with insufficient data of, usually, unknown accuracy. This must be particularly so when quality models are being made.

The chairmen for the three sessions were **Howard Wheater**, **Andrew Spink** and **David Lerner** to whom we owe a debt of gratitude for looking after the proceedings. The meeting covered a wide range of topics and, although there was no obvious underlying common thread, two issues were clearly causing concern to model users. The first was how best to handle the variation of transmissivity and specific yield with depth; the second was how to determine recharge from precipitation. It became quite clear that if these aspects were incorrectly handled then very poor or even misleading results would be obtained.

The extent of the usage of USGS models in the UK was not answered although, with the exception of the paper by Howard Wheater and Adrian Butler, all the speakers had used codes written in the UK. In the case of Wheater and Butler's work they had substantially modified the American code.

It was useful to have some papers describing water quality models because, despite the difficulties associated with the practical application of these, aquifer pollution is becoming such a serious problem that it cannot be neglected. The stochastic approach adopted by Rae Mackay may well be the way forward until such time as a better understanding of solute transport processes is possible and the necessary field data become available.

David Lerner drew the meeting to a close and in his summing up pointed out that a great deal of time had been spent discussing models and modelling with very little time on associated geological problems. Perhaps consideration of these could be the subject of another meeting or, possibly, a joint meeting with one of the geological associations.

Ian Goodwill

HYDROLOGICAL ANNIVERSARY

It isn't just the Australian bicentennial year; 1788 was the dryest year in the whole rainfall series for England and Wales kept by the Met. Office. In that form it goes back to 1766. The year of 1788 was particularly notable for having only 70mm rain in the last quarter, including a December total 'nationwide' of 9mm, a record low. Presumably river flows were pitifully low by Christmas Day.

New Zealand Hydrological Society

The New Zealand Hydrological Society (Incorporated) was formed in 1961 to further the development of the science of hydrology in New Zealand and is affiliated to the Royal Society of New Zealand.

The Society has nearly 500 members – 280 from New Zealand, a large contingent of 205 overseas members and 11 student members. Typically, members are Government employees, or from catchment authorities, universities or consultant engineering firms concerned with research and management of the physical environment.

The Society, whose aim is to further the development of the Science of Hydrology, broadly defines hydrology as the study of the distribution and quality of water, including its management.

Twice a year the Society publishes the Journal of Hydrology (NZ) which is distributed throughout New Zealand and to many overseas libraries. The Society also publishes reviews on the progress of the Science of Hydrology in NZ and assisted in the production of the recent book on New Zealand rivers, "Faces of the River". Annually, the Society hosts a Symposium for the formal and informal presentation of papers on aspects of hydrology (see details this issue *Circulation*).

On its funding front the Society provides grants to assist NZ members to attend overseas conferences or to make study tours. It also supports the Prince and Princess Awards Scheme which provides grants for New Zealand students to study overseas. The Society also promotes an award for outstanding achievement in the study of hydrology or in the management of New Zealand's water resources.

The affairs of the New Zealand Hydrological Society are run by an honorary committee comprising a President, a Secretary/Treasurer, an Editor and several ordinary members; all applictions for membership of the Society must be approved by this committee.

General inquiries or inquiries regarding membership, subscription to the Journal of Hydrology or purchase of the review publication "Physical Hydrology: New Zealand Experience" should be addressed to The Secretary, NZ Hydrological Society (Inc), PO Box 12–300, Wellington North, New Zealand. Correspondence on editorial matters in the Journals should be addressed to The Editor.

Thank you for your interest.

A. Dons

HYDROLOGICAL DATA UK

A series of yearbooks and reports relating to nationally archived hydrological data

The Hydrological Data UK series is published jointly by the Institute of Hydrology and the British Geological Survey and was launched – in 1985 – at a seminar to celebrate 50 years of systematic surface water surveying in the United Kingdom. The founding fathers of hydrological surveying on a national scale, were convinced advocates of the co-ordinated assessment and monitoring of water resources with regard to both quantity and quality. However, in the field of hydrological data publications, as with monitoring and archive management generally, legislative and administrative arrangements have, for the most part, served to limit the benefits that the joint exploitation of rainfall, river flow, groundwater level and river quality data can bring.

An important break with the past was made with the publication of the inaugural Yearbook (the 1981 edition) in the Hydrological Data UK series. This brought together the principal data sets relating to catchment rainfall, catchment runoff and groundwater levels; previously the latter two hydrological variables had been published separately. Beginning with the 1986 volume (available in December), water quality data from a representative network of monitoring sites wil also be included. As with the other variables, data for the featured year will appear together with summary statistics derived from the preceeding period of record.

Emphasis in the Yearbooks is placed on ready access to basic data both within the volumes themselves and via the data retrieval facilities which complement them. Selected Yearbooks also include commissioned feature articles concerning aspects of hydrometry or hydrological data acquisition and archiving. Given the rare topicality afforded to such matters by certain aspects of the Government's proposals for the creation of the National Rivers Authority, two of the features are of particular interest. The history of inland water surveying is examined in the 1985 Yearbook and the 1986 edition incorporates a review of the major changes in river flow measurement, and data archiving, practices and procedures over the last decade – attention is directed to the impact of new technology and the need to maintain hydrometric standards in the face of declining resources.

In addition to the Yearbooks, the Hydrological Data UK series includes – as part of each five-year publication cycle – a catalogue of river flow measurement stations and groundwater level recording sites together with summary statistics covering the featured period. The first of these reference volumes, the "Hydrometric Register and Statistics 1981–5", was published early this year. The main objectives of this publication are to document the variation in surface and groundwater resources and to assist data users to select the most appropriate data for any given application. UK rivers – mere streams in a global context – are characteristically short, shallow and subject to considerable artificial disturbance. As a consequence the hydrometric performance of individual gauging stations and the net effect of upstream abstractions and discharges on the flow regime are especially important considerations. The gauging station and catchment descriptions given in the Hydrometric Register and Statistics volume allow the data held on the national river flow archive (maintained by the Institute of Hydrology) to be exploited more effectively and data analyses to be interpreted with more confidence.

A complete list of the publications in the Hydrological Data UK series is given below. The 1987 Yearbook is in preparation and, beginning with the 1988 edition, future volumes will be published on a following year basis.

Copies of the Hydrological Data UK publications are available from:

Surface Water Archive Office,
Institute of Hydrology,
Wallingford,
Oxon OX10 8BB
Tel: (0491) 38800

Price (inclusive of postage):

Title	*Bound*	*Loose Leaf*
1981 Yearbook	£12	£10
1982 Yearbook	£12	£10
1983 Yearbook	£15	£12
1984 Yearbook	£15	£12
1985 Yearbook	£15	£12
1986 Yearbook	£15	£12
Hydrometric Register & Statistics 1981–5	£15	£12
The 1984 Drought	£15	–

A binder for holding the loose-leaf editions may be obtained from the Surface Water Archive Office.

BHS OVERSEAS CONTACTS

At the April 1987 Meeting of the Main Committee, it was decided to initiate a programme of making contact with overseas societies and institutions which have an interest in hydrology. Before 1987, successful links had been established with the Hydrology Society of South Australia, which regularly sends its Newsletter to BHS, and with the Hydrologic Committee of the Chinese Society of Hydraulic Engineering. It was felt that an expansion of this activity would heighten the international profile of BHS and could provide useful information and contacts for members with interests abroad. It was also agreed that links should be kept on a relatively informal basis in the first instance and that the initial objective would be to exchange information on activities and membership with as many overseas societies as possible.

To date, nearly 50 enquiries have been made worldwide and contact has been achieved with 17 societies and institutes. Establishment of a link involves sending the overseas society a copy of the BHS Register of Members and British Directory of Hydrology as well as putting it on the mailing list for *Circulation*. The overseas society is invited to contribute an article which explains its interests and activities to the Newsletter, and to advertise its events in the Diary section of *Circulation*. In return, BHS expects to receive equivalent publications from the overseas society and to have the opportunity of publicising BHS events among its membership. Information received from overseas groups is archived by the Society and members wishing to access it should contact Norman Tyler.

Links have been firmly established with nine societies and institutes, details of which are given below. Similar arrangements are being negotiated with the remaining organisations and it is hoped that many more contacts will be formed in the future.

B.W. Webb

Country	Society	Contact	Address	Material Received	Article in *Circulation*
Austria	Austrian Society for Meteorology	Prof. Dr. H. Pichler (First Chairman)	Universität Innsbruck Institute für Meteorologie und Geophysik Innrain 52, A–6020 Innsbruck, Austria	Membership list Information series Wetter und Leben (Journal) Proceedings of Conference on Alpine Meteorology, Rauris 1986 Proceedings of Conference on Statistical Climatology, Vienna 1986	
Brazil	Brazilian Hydrology and Water Resources Association	Dr. J. Kelman (President)	CEPEL Caixa Postal 2754 20001 Rio de Janeiro RJ, Brasil	Membership list Newsletter Society Journal Volumes on Water Resources	
German Federal Republic	Hydrology Section of the German Society for Water Resources	Chief of Hydrology Section of DVWK	c/o Ruhrtalsperrenverein Postfach 10 32 42 Kronprinzenstrasse 37 4300 Essen 1 West Germany	Membership list Newsletter Reports on hydrological topics	
Hungary	Hungarian Hydrological Society	Mr. B. Bencsik (President)	Hungarian Hydrological Society H–1371 Budapest FOU.68, Hungary	Journal of Hydrology (bimonthly)	
India	Association of Hydrologists of India	Prof. V.V.J. Sarma (Secretary & Treasurer)	Department of Geophysics Andhra University Waltair 530 003 India	Membership list Copies of Society publications	Issue No. 18
India	Indian Association of Hydrologists	Dr. D.C. Singhal (Secretary)	Department of Hydrology University of Roorkee Roorkee 247 667 India	Newsletter Hydrology Journal	Issue No. 19
New Zealand	New Zealand Hydrological Society (Inc)	Mr. A. Dons (Secretary & Treasurer)	PO Box 12–300 Wellington North New Zealand	Journal of Hydrology (New Zealand)	Issue No. 20
South Africa	South African National Committee for the IAHS	Dr. P.J.T. Roberts (Chairman)	Water Research Commission PO Box 824 Pretoria 0001 South Africa	Membership list (includes workers in Lesotho & SWA/Namibia) SA Waterbulletin Water SA (Journal) Various reports and conference proceedings	Issue No. 17
Yugoslavia	Yugoslav Association for Hydrology	Prof. O. Bonacci (President)	Faculty of Civil Engineering Sciences 58000 Split V. Masele bb Yugoslavia	Various conference proceedings	Issue No. 18

BRITISH HYDROLOGICAL SOCIETY

Report of the Honorary Secretary for the year ending 30 September 1988

In the 12 months since I last reported to the Annual General Meeting, the BHS Main Committee has met on four occasions and, in this period, the Society has consolidated developments initiated in 1986–87, has finalised policy on issues raised in previous years and has taken a number of new initiatives.

Considerable progress has been made in establishing informal contacts with overseas societies and institutions which have an interest in hydrology. In addition to the four contacts reported to the last Annual General Meeting, links have also been developed with the Brazilian Hydrology and Water Resources Association, the South African National Committee for the IAHS, the Austrian Society for Meteorology, the Hydrology Section of the German (FRG) Society for Water Resources and the Hungarian Hydrological Society. Fuller details of the nature of these contacts are given in an article elsewhere in this issue of *Circulation*. Similar arrangements are being made with Orstom and the French National Committee for the IAHS, the Israel Hydrological Society, the Stichting Hydrologisch Centrum in the Netherlands, the European Institute for Water, the Latin American Association of Subterranean Hydrology, the Polish Society of Geophysics and the Hydrologic Section of the Joint Geophysical Committee of the Presidium of the USSR Academy of Sciences. Enquiries concerning overseas Societies have been made in a further 30 countries, and BHS will continue to heighten its international profile through this activity.

A series of reports on University research in hydrology, the first of which appeared in the August 1987 issue of *Circulation*, has also been continued throughout the year under review. Five Universities, including two Civil Engineering Departments, two Geography Departments and one Centre for Research on Environmental Systems, have been covered to date. Further reports are in the pipeline and it is hoped to expand the scope of the series to include research being undertaken at Polytechnics and Research Institutes. Information on the hydrological activities of major overseas organisations is also being solicited and a report on the World Meteorological Organization has already appeared in the *Newsletter* and one on the United States Geological Survey is expected.

Over the past year, the Publications Sub-Committee has spent considerable time investigating the feasibility of a BHS Occasional Publications Series, an issue which has been mooted several times in previous years. A recommendation from the Sub-Committee that a modest series, involving relatively low-cost publications, should be inaugurated was accepted. It is envisaged that the series would be the responsibility of the Publications Sub-Committee, that papers would be refereed and follow an agreed house style, and that the subject and content outline of potential contributions would be vetted by the Main Committee. The first paper in the Occasional Publications Series, *An Introduction to Operational Control Rules using the 10 Component Method*, will shortly appear as a joint BHS/IH publication, and it is hoped that the ICE bookshop will become involved in the distribution of Occasional and other BHS publications.

During the past year, the Main Committee has taken a number of new initiatives, particularly in relation to the programme of scientific meetings – a major activity of the Society. A field visit was included as a National Meeting for the first time in the history of the Society, and members who attended the meeting on "Problems of Water Acidification", held jointly at Llyn Brianne with the Welsh Hydrological Group, were rewarded by a fascinating trip in magnificent sunshine around experimental catchments located in splendid mid-Wales countryside. National Meetings were also held on the topic of "Remote Sensing Applications for Water Management" at Birmingham, where a mixture of "lecturettes" and practical demonstrations again proved a popular blend; on the subject of "Groundwater Modelling" at Leeds, where presentations addressed both quantity and quality simulation; and on the issue of "New Developments in Urban Hydrology" at Manchester, where papers included a contribution from the University of Hanover, FRG. BHS also co-sponsored the session on "River Regulation in the UK" held during the Fourth International Symposium on Regulated Rivers" (FISORS II) at Loughborough.

Where possible, the Society is keen to increase the participation of speakers from overseas in BHS meetings and has recently introduced the category of "Invited Lecture" to provide an opportunity for eminent hydrologists, already visiting the UK, to address the Society. The first lecture of this type is included in the BHS Southern Section programme for 1988–89.

The Regional Sections continue to provide a considerable number of meetings for the membership. During 1987–88, the Southern Section held five meetings, the South-West Section held three and the Midlands one. These varied widely in topic ranging from "Dowsing" to the "Ecological Effects of Water Resources Developments", and also included field visits to the Thames Barrier and to Roadford Reservoir. Together with events staged by the Welsh, Pennines and Scottish Hydrological Groups, BHS National and Regional activities provided a total of 25 meetings on hydrological topics in the year under review. Planning for the programme of meetings in 1989 is well advanced. Six meetings are scheduled (current details are published elsewhere in this issue of *Circulation*) including the BHS Second National Hydrology Symposium, which is being held at Sheffield in September and will have sessions on Process Research, Urban Catchments, Flooding, and Water Resources.

In its work since the last AGM, the Main Committee has considered a mixture of ongoing and new issues. Government proposals concerning the privatisation of the Water Industry have again received attention, and a Sub-Committee has been set up to formulate a response to Government plans for the National Rivers Authority focussing on technical aspects rather than political issues. The professional interests of members, including examining for MICE via the Hydrologist Specialist Route, are again under review, and matters relating to membership and publicity have recently received attention. A 50 per cent reduction in the annual subscription is offered to members who are fully retired from work, and the Society is keen to increase membership levels substantially from the current position of about 530. A publicity campaign is being devised to achieve this end.

In this my last report to the AGM, I would again like to acknowledge the substantial help I have had in the post of Honorary Secretary from my colleagues on the Main Committee. In this regard, I express my especial thanks to **Mr. N. Tyler** and **Mr. P. Bacos** of the ICE Secretariat who have done a great deal to alleviate the Honorary Secretary from many of the more onerous administrative duties associated with the running of a major UK Society. I also have pleasure again in expressing the gratitude of the Officers and Main Committee to all those individual members who have assisted with Society activities particularly to local organizers, speakers and reporters who have, with considerable skill and enthusiasm, maintained the high standard of BHS Meetings at National and Regional level. I trust that my successor will receive similar support and hope that he will derive the same enjoyment and satisfaction as I have in serving the Society as its Honorary Secretary.

B.W. Webb

REPORT OF THE HONORARY TREASURER

The accounts for the Society for the year ending 30th September 1988 have now been audited and agreed by the committee. The past year has been one of below average expenditure because neither the Membership Directory nor the Directory of British Hydrology have had to be produced. There has also been no National Symposium, and consequently we have been able to build the Society's funds to £4,462, a very healthy increase of £1,823 over the year.

It is felt that the Society needs such a balance in order to meet the costs of the Second National Symposium to be held in Sheffield next September, where the turnover is expected to exceed £10,000. Similarly, a Membership Directory must be produced next year, at a cost of about £500.

There have been no other major changes in the pattern of income or expenditure over the year and membership remains steady at just over 530. It is proposed that the subscription be raised to £13 for next year, the first increase since 1986.

Meeting expenses have increased this year, partly because one or two meetings made losses. In addition, some committee members are having to claim expenses for attending committee meetings because of changed rules within universities and Water Authorities. Such expenditure is at present believed to be at an acceptable level however.

Overall the Society's finances appear to be in a healthy position, and the prospects for 1988/89 are that income should more or less balance expenditure, although some contingency must be allowed for the National Symposium at the end of the year.

Frank Farquharson

★★

BHS ANNUAL GENERAL MEETING
Institution of Civil Engineers
5th December 1988
Coffee at 10.30 a.m. followed by
AGM at 11 a.m.
BHS National Meeting
"Hydrology Overseas"

★★

HOW LIKELY A 10,000-YEAR FLOOD?

Return

Return periods can get the hydrologist a bad name.

A flash flood in January inundates a town centre, leading to insurance claims totally six figures. The river has been gauged since 1968. The January flood has an estimated peak of 22 m^3/s, just over three times the "mean annual flood". Rapid reference to a regional flood growth curve indicates a return period of 350 years: an "outlier".

The water authority reassures the public that it was a freak event and staff return to thinking about the National Rivers Authority, and problems that recede less easily.

In October an almost identical event occurs; the flood "returns". The local MP says that the authority might as well have said it was a 0.35-year flood. Pity the hydrologist; trying to explain that the river has no memory of the previous event only makes matters worse.

Roulette

Perhaps a safer way of describing a 350-year event is to quote an annual non-exceedance probability of 0.9971. The river engineer will still understand it, and the layman might just twig that there's an element of roulette.

Reservoirs

Recognizing the 10,000-year flood as the event with an annual non-exceedance probability of 0.9999 is useful to the reservoir engineer too. Consider that there are a thousand major impounding reservoirs in the UK for which a 10,000-year event would present a severe test of spillway facilities. Simple probability suggests that we might expect such an event to occur at one or other of these 1,000 reservoirs about once in ten years on average. That we don't appear to experience such exceedances quite this often, might be taken to indicate that the hydrologist is over-egging the 10,000-year flood.

In fact things aren't that simple. Flood events at one site are not entirely independent of flood events at neighbouring sites.

Research

Recently completed research at the Institute of Hydrology, Wallingford, has yielded a model to describe the spatial dependence seen in extreme rainfall.

The model is built on data from 400 long-term daily raingauges and many shorter term ones. Interestingly, many of the long-term gauges are for reservoired catchments – installed originally to help determine a fair division of resources between water abstracted for supply and releases to the river in "compensation".

Risk

But what does the spatial dependence model tell us about reservoir flood risk? Well, it provides a procedure for assessing the annual collective risk of a T-year exceedance for a network of critical sites. The method uses the concept of an equivalent number of independent sites.

The effect of spatial dependence in rainfall is judged to make the thousand impounding reservoirs equivalent to only about 250 independent sites. Thus we can expect an exceedance of the 10,000-flood to occur four times less frequently than the once in ten years assessment made earlier.

Rider

A sting in the tail is that, when an event giving rise to an exceedance does occur, it may well affect several sites simultaneously. This "clustering" of exceedances is evident in past incidents such as the Mendip floods in July 1968.

Reference

The collective risk assessment procedure is given in Flood Studies Supplementary Report No. 18, available from the Institute of Hydrology, Wallingford, Oxon OX10 8BB (Tel: 0491–3800). The research on which it is based was funded by the Department of the Environment, contract no. PECD7/7/135.

Duncan Reed

Recently submitted to BNCOLD News and Views.

New Members

We welcome the following new members to the Society:

Y Q LI	Nottingham University
B R WELLAND	Student, City University
S PEAT	Student, City University
A C SPRING	Student, City University
M J SMITH	Student, City University
D E CHAMBERS (Miss)	Student, City University
J S SMITZ	Head, Environment Centre, University Liege
D A COWDREY	Thames Water
Dr A C SKINNER	Severn Trent Water

NEWS FROM MEMBERS

New Management IH

There's a new management shake-out at IH now that **Brian Wilkinson** has got his feet firmly under the table since arriving in July. There are four scientific divisions: HYDROLOGICAL PROCESSES (headed by Dr **Jim Shuttleworth**, (IH's expert on evaporation physics and lately back from a year with NASA), ENVIRONMENTAL HYDROLOGY (headed by Dr **Paul Whitehead** who led the IH Surface Water Acidication Programme Team), ENGINEERING HYDROLOGY (headed by **Frank Law** – from Binnie & Partners Australian Office), and APPLICATIONS RESEARCH (headed by **Tony Debney** who also leads Research Marketing activities for the Terrestrial and Freshwater Sciences Directorate within NERC. **Jackie Webb**, recently transferred from the Swindon-based TFS Directorate, is Head of Administration and **Celia Kirby** leads on Policy Studies and Information.

Hydromet Data: West and Central Africa

John Stowell writes to enquire whether there are other BHS members who are interested in having more convenient access to the publications of ORSTOM and of the Comité Interafricain d'Etudes Hydrauliques, particularly those which relate to West and Central Africa, than seems at present to be the case. The National Meteorological Library holds some of the ORSTOM rainfall publications, and the ICE library has copies of the ORSTOM Annuaires Hydrologiques. The British Library, inexplicably, has a single copy of the Bulletin de Liaison of the CIEH (no. 27, Nov. 1976). Perhaps there already is another library somewhere in this country with a good collection; if so, he would be pleased to hear about it.

Otherwise, he would like to know whether there is enough interest to justify trying to organise a more complete collection, either through the ICE or IH libraries and invites members to write and let him know what they think.

His address is: 32 Brambledown Road, Wallington, Surrey SM6 0TF.

International Decade for Natural Disaster Reduction

John Rodda, Director of the Hydrology and Water Resources Department at WMO, writes to let us know that the United Nation General Assembly has designated the 1990s as the "**International Decade for Natural Disaster Reduction**" and that WMO will be playing an active role in this international effort.

BOOKS

Hydrology Textbook

Applied Principles of Hydrology – John C. Manning. Merrill Publishing International, 1987. 278pp. £11.95. Paperback. ISBN 0–675–20780–0.

Why does it seem to be so difficult to write a satisfactory introductory text on hydrology? Perhaps it is in part because there are many different introductory courses that cater to different types of students wanting to study hydrology. Some have background knowledge of maths and physics, others little or no mathematics at all; some will be interested in the nature of hydrological processes, others only in the nature of flow records in so far as they affect the management of a pollution or water resource problem; while many will be interested in hydrology from the perspective of some other discipline such as plant physiology, aquatic ecology or boundary layer meteorology. There should surely be some core of common hydrological knowledge that should be offered at the introductory level, a core that reflects both the physical principles that govern hydrology, a measurement techniques and data analysis, and qualitative knowledge about the operation of hydrological processes in different environments.

Looking at recent introductory texts reveals some agreement about such a core of knowledge, at least as far as the book structure and chapter headings. The book by John Manning is traditionally routine in this respect and similar to many other examples. It starts with a chapter on the water cycle followed by the structure and properties of water, evaporation and condensation, precipitation, infiltration and soil water, evapotranspiration, groundwater, runoff and the chemical quality of natural water. In this particular case, the material is aimed at a particular group of students, undergraduates at the California State College in Bakersfield, who were not majoring in science and might have little or no background in mathematics. As such the material is presented in a very non-mathematical way but with a generally excellent verbal description of the physical principles governing hydrology. There are numerous examples of hydrology in practice and as practised, which are almost exclusively limited to California (a map of California is included as an appendix showing the various locations mentioned). This particular viewpoint is also reflected in the presentation of some of the material, for example the chapter on water quality is concerned primarily with salinity problems. The approach is traditional, without much reflection of modern advances in hydrological knowledge. The author has served his intended audience quite well, but its Californian bias might make it of limited use for similar courses in this country without a good deal of work in providing similarly local illustrative material.

So, why do I find this and many other textbooks so unsatisfactory? I think it is particularly because the traditional approach to the presentation of the different hydrological processes plays down the links and interactions between the processes. This then undermines the impression of hydrological systems as dynamic systems and, for me at least, the dynamics are what makes hydrology interesting and exciting. A secondary reason may be that these "mainstream" texts present only a body of "accepted" hydrological knowledge and do not point out how fuzzy (and often incorrect) some of that knowledge is and how little we know about some hydrological systems. I would suggest that there is a need for a fundamental, different hydrological textbook. For those who are interested, a pointer in the right direction is the book by Harald Grip and Allan Rohde, "Vattnets väg från regn till bäck", published by Forskningsrådets förlagsjänst, Stockholm in 1985, at least if you read Swedish.

Keith Beven

Wells and Boreholes

The Field Guide to Water Wells and Boreholes – Dr. Lewis Clark, Head of Land Use at the Water Research Centre, Medmenham is published in the Geological Society of London Professional Handbook Series, Open University Press (ISBN 0–335–15203–1) and Halsted Press (ISBN 0–470–21074–5), 1988, 155pp. £15.95. Soft cover.

A textbook which forms a useful summary of water well and borehole practice that is good value. The reviewer found the drilling descriptions informative, while Dr. Clark considers water well chemistry, maintenance, the variability of materials, permeability and yield assessments and techniques of establishment.

The text is well presented although column printing makes it less easy to read, but easier to note specific points. The illustration selection is good although some illustrations are less than well reproduced, and the tables of procedures and criteria and helpful. The book impresses the reviewer particularly because

of its inclincation to describe the realities of hydrology and hydraulics, the problems that should be expected and have to be designed for in engineering and its "design brief" approach to the subject. The book is not full of theoretic modelling and some of the accepted procedures therein are well criticized to place them in their correct context. It contains some useful case descriptions for illustration of points of operation.

The book does not provide wide ranging reviews of the literature in hydrogeology, but that should by no means deter the researcher. Its theme of operational procedure yields many points for us all to consider, many answers to problems encountered and good lessons for the use of data collected – whether in geotechnical hydrology (the reviewer's particular interest) or in resource and water balance hydrology. It is a textbook every student should read within the discipline. I would encourage those involved in planning, social science and development studies, and other scientists and engineers to read this book to assist with decision making programmes.

There might have been some listing of data showing variations around means of aquifer formation, well pumping tests, chemical and physical yields and problems, to strengthen the author's statements. Knowing some aspects of the subject well one can agree with, and on two or three occasions question, the author's statements of an advisory nature, but a new student to the subject would have to search for the data to confirm the points made. The textbook is nevertheless a well-timed and excellent contribution to hydrology and hydrogeology that has many practical implications for resource engineering.

Mike Stagg

World Groundwater

The Role of Ground Water in the Hydrological Cycle and the Continental Water Balance – I.S. Zekster and R.G. Dzhamalov. Technical Document in Hydrology, IHP III Project 2.3, published by UNESCO (Paris), 1988, 133pp. Available free of charge from the Division of Water Services, 7 place de Fontenoy, 75600, Paris, France.

The title of this report reflects the title of the IHP project from which it stems. As such, its structure closely follows the aims of that project. After a brief introductory chapter, chapter 2 highlights the modern concepts on the hydrological cycle and the world water balance; chapters 3 and 4 discuss the scientific and methodological principles for estimating and mapping of groundwater and its contributions to oceans/seas; chapter 5 covers the principal laws of generation and distribution of groundwater runoff; chapter 6 integrates groundwater into the total water balance, producing estimates of contribution it makes to both land-bound catchments and the oceans; chapter 7 considers some practical applications including the production of dissolved load estimates associated with groundwater runoff.

The report provides an extensive (if brief on occasion) review of current methods of analysing groundwater data with respect to the total water balance and, as such, will prove a useful source for anyone contemplating a water balance study. The text is sensibly studded with useful references, many of which appear to be well worth further investigation.

The report aims to "expediate the exchange of information" concerning groundwater and in this it succeeds admirably. Its coverage is extensive yet, amazingly, ignores the most recent IAHS publication on water balance computation techniques (Publication No. 148). This is not a detailed text from which practitioners can lift methodologies, but rather an informed review of recent thoughts/concepts on the role of groundwater. Indeed, we will have to wait for the future publication entitled "Principles and methods of regional quantitative estimation and mapping of groundwater runoff", mentioned in the conclusions. The report also serves to highlight a wide range of research results from around the world.

Should water balance studies be of interest, several other reports are also available from UNESCO ranging from the water balance of small islands to the water balance of Europe and the USA. A catalogue of other hydrological reports and publications is also available from the above address.

Charles Essery

FORTHCOMING EVENTS

Provisional Programme of BHS National Meetings for 1989

Date	*Topic*	*Venue*	*Contact*
March 16th	Computerised data bases and hydrology	British Antarctic Survey, Cambridge	Frank Farquharson (IH)
May 9th	Forest hydrology	IH, Wallingford	Howard Wheater (Imperial College)
July 4th	Groundwater recharge (Joint with Hydrogeological Group of Geol. Soc. London)	Birmingham	David Lerner (Birmingham)
August 14th–17th	International Symposium on Hydrological Applications of Weather Radar	Salford University, Manchester	Ian Cluckie (Salford)
September 4th–6th	Second National Hydrology Symposium	Ranmoor Hall, Sheffield University	Max Beran (IH)
December	Simulation of water management (with AGM)	ICE, London	Terry Evans (Sir M. McDonald & Partners)

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STOP PRESS

A BHS meeting is being planned for late Spring 1989 on "Flow management and protecting the environment". Presentations will include the historic development and regional variation of release patterns below reservoirs, their impact on downstream flow regimes and developments in physical and biological modelling techniques used for assessing the environmental impact of river abstractions.

Further details of the meeting can be obtained from Alan Gustard (Institute of Hydrology) or Geoff Petts (Loughborough University).

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Meetings

WORLD WATER '89
MANAGING THE FUTURE – LEARNING FROM THE PAST
14–16 November 1989
Wembley, London

The third Congress, organised by The Institution of Civil Engineers, will consider the future of water supply beyond the UN Drinking Water Supply and Sanitation Decade 1981–1990. Conference aims to review the achievements (of the Water Decade), lessons learnt and effects on institutional structures and legislation. It will discuss current problems, and those foreseen for the next decade, and standards of service achieved in industrialised countries. The Conference will open with two keynote papers on "The Decade and After".

Sessions on:

- experience in developing countries
- management of underground assets
- water resources
- treatment of water for potable supply
- waste disposal – alleviation of environmental problems
- managing high technology in 1990–2001
- advances in sludge treatment and disposal
- financing and accounting for fixed assets
- the customer

Preprinted copies of the papers will be circulated to delegates in advance of the conference and a final bound Proceedings, including the papers and edited discussion, will be published after the conference.

A major international exhibition of products and technology associated with the needs of the water industry wil be held alongside. It is promoted by the City of Westminster Chamber of Commerce. Further details of the exhibition from Westrade Fairs Limited, 28 Church Street, Richmansworth, Herts, WD3 1DD. Tel: 0923–778311.

Correspondence should be addressed to: World Water '89, Conference Office, Institution of Civil Engineers, 1–7 Great George Street, Westminster, London SW1P 3AA.

HYDROLOGY AND WATER RESOURCES SYMPOSIUM
COMPARISONS IN AUSTRAL HYDROLOGY
28–30 November 1989
Christchurch, New Zealand

Sponsored by the New Zealand Hydrological Society and co-sponsored by the National Committee on Water Engineering of the Institution of Engineers, Australia, and the Technical Group on Water, Institution of Professional Engineers, New Zealand.

Seven themes:

- hydrological archiving systems
- real-time data collection and warning systems
- hydrological effects of land use change
- erosion and sediment transport
- extrapolation of hydrological information
- hydrological processes
- impacts of "user pays" principle.

Intending authors should submit a synopsis of 250 words and a statement of intention to attend the symposium by **31st December 1988**. Two types of papers will be accepted:

- full papers to be presented by the author/s and limited to five pages, standard Institution of Engineers, Australia, format
- poster papers of two pages to be published in pre-prints are invited on above themes plus: computers in hydrology – hardware, software and applications.

Correspondence to The Conference Manager, Hydrology and Water Resources Symposium 1989, PO Box 2607, Christchurch, New Zealand. Tel: (03) 790275/6.

CONFERENCE ON CLIMATE AND WATER
11–15 September 1989
Helsinki, Finland

This conference is organised within the context of WHO's Regional Association VI (Europe).

Subjects to be discussed include the impact of climate variability and change on:

- the environment
- land-use
- food
- energy production, etc.

SEMINAR ON URBAN WETLAND MANAGEMENT
3 February 1989
Middlesex Polytechnic, London

Details from Mrs. V. Norman, Centre for Urban Pollution Research, Middlesex Polytechnic, Queensway, Middlesex EN3 4SF. Tel: (01) 368 1299 ex. 2466.

Courses

URBAN ENVIRONMENTAL MANAGEMENT
DELFT UNIVERSITY OF TECHNOLOGY
THE NETHERLANDS
Three week international course starting 7 May 1989

The course aims at a better understanding of the present problems in urban environmental management with particular emphasis on prevention of environmental problems. It is open to professionals and post-graduate students and will consist of lectures and workshops. Lecture topics (one week) are:

- theory of urban systems
- urban environmental impacts
- urban environmental management
- environmental impact assessment

Workshops (two weeks) will focus on a case-study in the Rotterdam area, including an environmental impact assessment procedure. Course tutors will be from several faculties of the Delft University of Technology, from Leider State University and Erasmus University, Rotterdam; teaching will also be by experts from national and international institutes.

For further details contact: Course Director, Ir Tjx Deelstra, Delft University of Technology, PO Box 5048, 2600 GA Delft, The Netherlands.

Diary

5th December 1988
BHS ANNUAL GENERAL MEETING.
Institution of Civil Engineers. Coffee at 10.30 a.m. followed by AGM at 11 a.m. and BHS National Meeting "Hydrology Overseas".

7th December 1988
BHS Southern Section.
"Groundwater and the management of chemical wastes".
Dr A. Clark, Dames & Moore, Dr G.M. Williams, BGS, and R. Harris, Severn Trent Water Authority.
4–7 p.m. Department of Civil Engineering, Imperial College, London.

9th December 1988
Scottish Hydrological Group.
"CIRIA erosion trials" – A.K. Macleod, MMG Erosion Control Systems.
6 p.m. for 6.30 p.m. The Wellcome Room, Royal Society of Edinburgh, 22–24 George Street, Edinburgh.

13th January 1989
Scottish Hydrological Group.
"Hydrology of ash lagoons" – A.J. Cowan, Jas. Williamson & Partners.
6 p.m. to 6.30 p.m. No. 2 Lecture Theatre, McCance Building, University of Strathclyde, Glasgow.

18th January 1989
BHS Southern Section.
"Acidification – a Scandinavian perspective" – Nils Christophersen, Norwegian Centre for Industrial Research.
5.30 p.m. for 6 p.m. Department of Civil Engineering, Imperial College, London.

14th February 1989
BHS Southern Section.
"Flood frequency analysis of chalk catchments".

10th March 1989
Scottish Hydrological Group.
"Hydrological aspects of forest management" – Dr O.G. Pyatt, Forestry Commision.
6 p.m. to 6.30 p.m. The Wellcome Room, Royal Society of Edinburgh, 22–24 George Street, Edinburgh.

12th April 1989
BHS Southern Section.
"Hydrological aspects of environmental impact analysis" – and AGM.
5.30 p.m. for 6 p.m. Department of Civil Engineering, Imperial College, London.

16th May 1989
BHS Southern Section.
"Monitoring and prediction of Sahel rainfall" – afternoon visit and evening meeting.
UK Met. Office, Bracknell.

Copy Deadline for Issue No. 21
5th January 1989

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