THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

Circulation

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SECOND NATIONAL HYDROLOGY SYMPOSIUM

4th-6th September 1989 at the University of Sheffield

There has been a good response to this meeting, with 25 papers accepted for the following four technical sessions:

Headwater and hillslope (Convenor: Howard Wheater)

Urban catchments and receiving waters Convenor: Robert Sellin)

Coping with excess (Convenor: Frank Farquharson)

Operating surface and groundwater resources (Convenor: Susan Walker)

Just as for the first BHS National Symposium held two years ago at Hull, the proceedings are being pre-published, with the bound volume circulated to delegates in advance. (Copies will of course be available at Registration for those who decide to come at short notice.)

If you have not already made your reservation, may we try and persuade you to come to at least part of this major event in the BHS Calendar. Daily registrations are possible for those who cannot be there for all three days but we do urge you to try and attend on a residential basis because - as every practised conference-goer knows - it is the informal exchange of ideas which can take place outside the official proceedings which cements the profession together.

Remember, at £95.00 for all accommodation and food (includes a sherry reception and the Conference Dinner) plus the bound copy of the Symposium proceedings, this is truly excellent value. Details of the papers to be presented are shown on page 11 of this issue.

FOREST HYDROLOGY

BHS National Meeting

9 May 1989

Forty members and guests met at the Institute of Hydrology, Wallingford, on a beautifully sunny day to be welcomed by the organizer, Dr Howard Wheater of Imperial College

The first session on Canopy and Soilwater Processes was chaired by **Tim Birt** of the University of Oxford. **John Roberts**, the senior plant physiologist at IH, described tropical rainforest canopy experiments conducted in Brazil near Manaus in the three seasons 1983 to 1985. Interest centred on stomatal and boundary-layer conductance variations at different heights above ground and different times of day. Monteith-Penman evaporation had been estimated for five different layers from canopy to ground to identify major sites of transpiration flux. Some notably different conductances were illustrated (Figure 1) with values falling nearer to a common value as the humidity deficit grew. He stressed that a tropical canopy was not as well ventilated as those in the temperate zone. Stomatal conductance shows a small response to increasing soil water deficit, possibly a leaf ageing effect. Discussion centred on leaf area measurement problems. **John Pitman** (Kings College, London) referred to recent Thai stomatal conductance experiments and his concern that tower readings reached only a relatively small number of trees. **Mike Mansell-Moullin** queried the wider experimental context in the Amazon and was informed by John Roberts that he would like to move into similar work in rubber plantations and new pastures: IH were using the relationships found in broad-scale climate modelling.

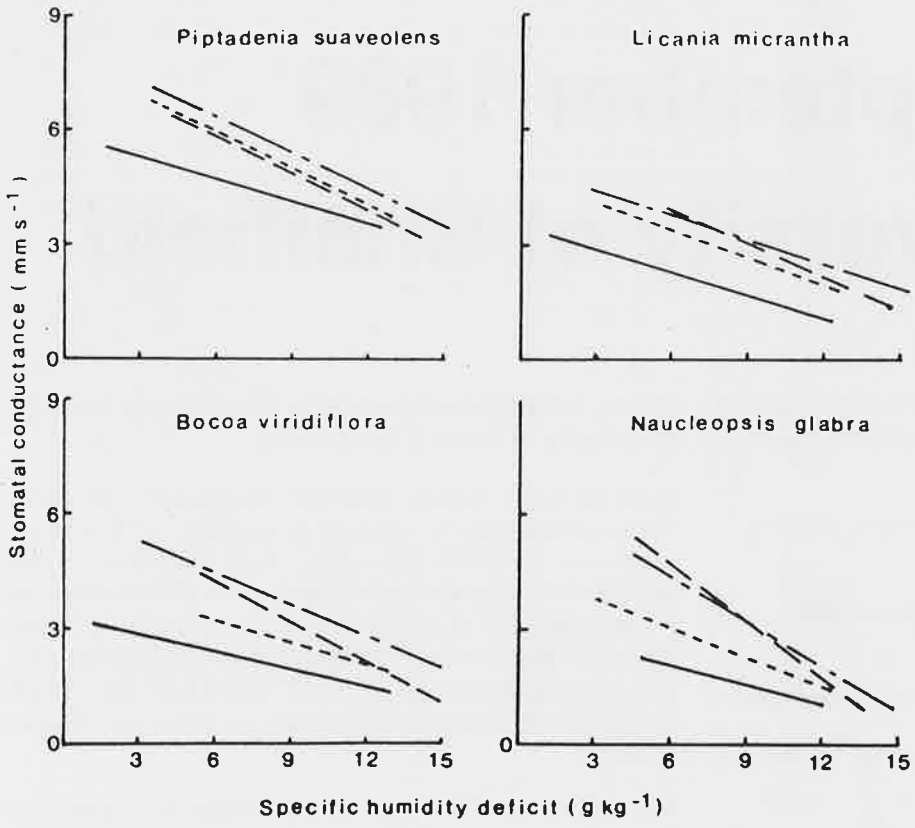


Figure 1. The relationship between stomatal conductance and specific humidity deficit for four upper canopy species. Data are pooled from the three study periods but separated depending on above canopy solar radiation conditions, <400 Wm⁻² (___), 401-500 (- - - -), 501-600 (__ __ __) and 601-700 (___ _).

Nick Chappell of Polytechnic South West presented a joint paper written with **Brian Reynolds** of the Institute of Terrestrial Ecology and Plymouth colleagues Drs **J L Ternan** and **A G Williams**. They have made a detailed event-based study of water and solute movement beneath a coniferous hillslope at Plynlimon in mid-Wales. By keeping to a 40 m long profile they have followed the chemical signature of stream drainage, noting high concentrations of acidic ion solutes such as hydrogen, aluminium, sulphate and nitrate. The soil profile has been carefully sampled and streamflow has been shown to originate largely as near-surface flow at the O/A and E horizons of the podzol soils (where hydraulic conductivity was 112 and 75 cm h^{-1} respectively). The datasets from 10 storms are presently being re-analysed with the full Richards and Advection-Dispersion equations. Figure 2 shows results of the acid anion transformation in this tiny catchment alone; similarly helpful acid cation results were given. **Colin Neal** queried whether there was not another major pathway missing on the grounds that he had found baseflow at Plynlimon with a pH of 7, something that could not be achieved by an in-channel process. **A. A. Rowan** commented that the site concerned would be prepared differently under current pre-planting procedures of the Forestry Commission and hence the results given might apply only to a particular generation of conifer forests.

John Miller (Macaulay Land Use Research Institute), spoke on hydrochemical fluxes in forested catchments in Central Scotland where his Research Institute and Imperial College (through **Howard Wheater**) are due to complete a research programme this year. Intensive afforestation beside Loch Ard began in the 1950s in an area subject to high sulphate deposition. Precipitation chemistry (at pH 4.5 to 4.65) is strongly modified by canopy interactions, the dominant species being Norway and Sitka spruce. There are preferential flow paths in B and C horizons beneath the trees, confirmed by 2D modelling,but throughflow chemistry is consistent between replicates for a given species. Canopy effects are found to persist right through to streamflow chemistry. The Kelty catchment is now fishless. Because Sitka Spruce dominates there SO_4^{2-} is at higher concentrations in throughfall than at the Chon catchment with its Norway Spruce. However by the time stream outflow chemistry is measured the sulphate values have come together again. With a tensiometer array they proved that once a lower layer of the soil profile is saturated there is transfer of water up through the profile. Interestingly throughflow and temperature have been looked at together in an attempt to locate influences on biological activity. Soil CO_2 was also being logged. If sulphate levels at Chon are compared with the pristine Hoylandet site, the results are very similar, masking the fact that only the latter is in balance: the Chon has a doleritic dyke area, of no great size, but it influences stream chemistry. **Ian Reed** (Birkbeck College) queried how instrumentation had been located given the variability of the soils and solid geology. Saturated hydraulic conductivity was quoted as about 700 cm h^{-1} in answer to **Ann Calver** (IH).

After lunch **Paul Whitehead** (IH) took the chair for a session on Forestry Impact at Catchment Scale. **Jim Hudson** and **Graham Leeks** did a double act in putting over IH experiments in Wales. (A copy of their 3-page abstract is

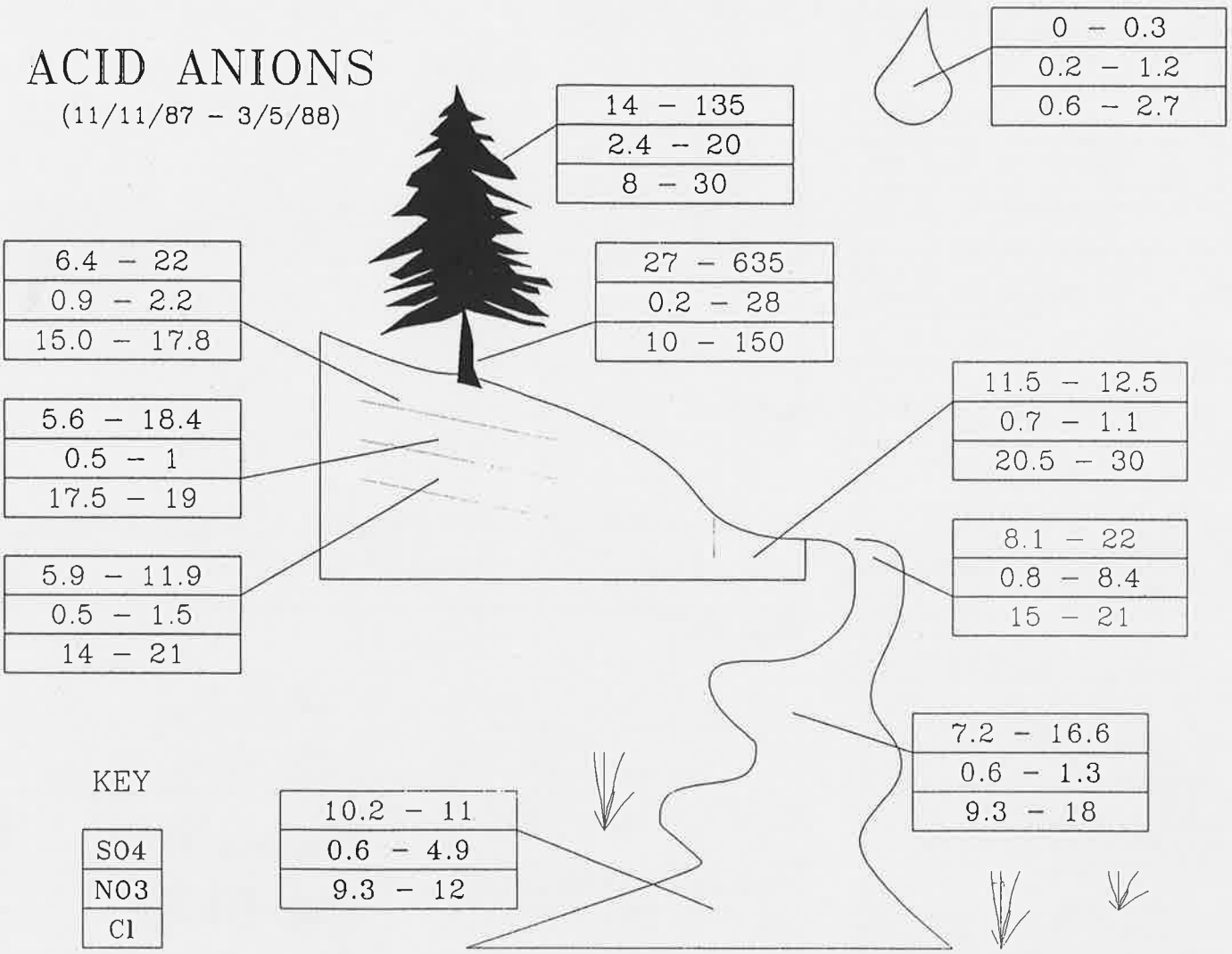


Figure 2. Acid anion transformations, Plynlimon catchment.

available on request to any interested reader' They drew attention to government policy in encouraging plantation forestry expansion in upland Wales. This is despite experimental proof at Plynlimon that the conifer canopy will intercept 25% of the rainfall while only depressing transpiration (relative to grass) by 5% of the rainfall. Differences in nitrogen, phosphorus and potassium losses between the grassed Wye headwaters and the afforested Severn had been shown to be slight, despite large differences in internal nutrient cycling fluxes. At Llanbrynmair Moor ammoniacal-N and phosphorus released by ploughing failed to reach the catchment outlet, trapped in a wet riparian mire. Nitrate levels in the felled Hore forest on the Upper Severn have risen gradually for four years now, especially in summer. Sediment changes have been traced by innovative monitoring of magnetic characteristics (with the University of Liverpool) and of Chernobyl caesium (with Harwell). Forest access tracks are again seen as a significant source of sediment growth although the bedload component could be delayed by debris dams. Details were given of differences to the catchment between felling by skyline or forwarder as recorded in the Hore area. The Cray catchment was 14% afforested in the early 1980s with the reservoir water going brown in subsequent spates. A cost of £1000/day was incurred in each event to use an alternative source. The problem was traced to one eroding forest drain right on the catchment divide.

Forestry effects on water quality in Scotland were tackled by **Ron Harriman** of Pitlochry Freshwater Fisheries Laboratory. He noted that in upland catchments with pH above 6.0 the biological problems are associated with sedimentation and changes in light/temperature regimes. *Forests and Water Guidelines*, published by the Forestry Commission in 1988, attempted to address these physical problems. The link was now clear between percentage forest cover and the extent of acidification. In catchments with a low acid neutralising capacity, pH has gone below 5.5 with serious consequences for fish and certain invertebrates. A dramatic pH map of Scotland was shown with a pH of 4.7 in the Western Isles. Acidified waters were characterised by low organic content. Dr Harriman suggested there were probably no pristine sites left in the UK which had no sulphate. Dumfries and Galloway had suffered the greatest loss of alkalinity. His Laboratory has been helping the Forestry Commission to identify where new forestry would not cause too adverse a change; that means avoiding areas with a high natural calcium + magnesium level. In the 14 years to 1986 precipitation measurements at Loch Ard showed sulphate falling from 70 to 30 milliequivalents but rising nitrate levels.

All was not gloom however as some data showed moorland pH rising between 1979 and 1988. **John Pitman** suggested that as dry deposition to the canopy was probably similar for moorland heath and forest it was worth reflecting that dry to wet deposition ratios varied greatly across the country.

Policy implications

The final session on Policy Implications for Forest Management followed the tea break. **Douglas Hammerson** of Clyde RPB guided the meeting skilfully from the chair. A A Rowan, now retired from the Forestry Commission, explained the development of the *Forests and Water Guidelines* from earlier documents and new research. In an aside we learned that 1895 saw Sir John Stanley Maxwell's pioneering research at Inverness into upland forest development. Mr. Rowan's working group had a wide ranging membership with consequent advantages. He highlighted the problem where, as in Scotland, changing from stock husbandry to forest had implications for water abstractions which had not been paid for. It was stressed that private forestry could only proceed on the basis of an initial working plan approved by the Forestry Commission. Multiple objectives needed consideration: e.g. streamsides had value for landscape, wildlife and recreation as well as for water quality. Scope existed for avoiding some deep ploughing by using scarifying, ripping or mole draining. Better pesticide use and access road drainage were being targetted. The sale of standing timber to merchants who use contractors to cut and remove it posed problems for effective control when profit margins were tight. The guidelines specify that conifers must be

kept back from stream edges. Applicants for felling licences were getting copies of the guidelines and companion notes.

Mr Rowan encouraged us to belive that we were not entering an era of second rotation forests (as at Plynlimon) and that this would be a spreadout process, having much less impact. Readers may care to write to IH for his 6 page paper and also for that of Professor Newson.

Professor Malcolm Newson gave the final talk, well illustrated, on water management implications. Beginning with the existence of those up-to-date guidelines on forest management, he posed a series of questions. Would it be preferable for both foresters and water suppliers to use the water quality objectives to regulate their, at times, rival interests? Will the privatised water industry be under more pressure to sell off upland catchments to private forestry; or will the principle of protection zones be incorporated into leases, banning afforestation? Can the Forestry Commission escape censure by putting both private and public sector major (over 200 ha) forest proposals through Environmental Assessment? What is the Best Practicable Environmental Option for forestry practice? How should an EA handle timber harvesting? He reported that terrestrial ecologists had examined 39 Border mires, where the new forests around them were diminishing their water areas as the predictable interception effect took place: the end result so far was a reduced range of flora. Two other illustrations stick in the mind. The first (Figure 3) is from a current Bangor PhD which plots the percentage of forest in Welsh catchments versus rainfall-runoff ratio; the second is of a signboard that starkly says "CALF HOLES NGS SD 804776 Floods rapidly due to forestry ditches upstream".

A A Rowan commented that Strathclyde Council had been against forest expansion in its catchments but could not stop it. The chairman felt that private Scottish forestry firms had been more careful about their developments than had the Commission. **Jim Blackie** (IH) reported that the Balquhidder experimental catchment near Stirling had been showing unexpectedly high evaporation at higher altitudes; **Sir Charles Pereira** felt that the Balquhidder results should be taken seriously. He also cautioned that there should not be a complete swing away from the old view that trees make rain towards one claiming that trees always use up rain. Your rapporteur then fell temptation to commenting that for all the research results there was little evidence of the water industry taking them at face value and removing trees from catchments they owned. This was despite it being about 80 years since Baldwin Latham measured some (subsequently lost) weir plate flows on catchments somewhere behind Newport, Gwent, which proved that forests used more water than grassland in that climate. Regrettably he appears to have left only a brief discussion summary of his findings, an even shorter summary than this.

All in all this was a good symposium with every author having much worth listening to. What a pity there is no formal seminar proceedings volume. Perhaps the reference list below will make some amends.

Frank M Law
Institute of Hydrology

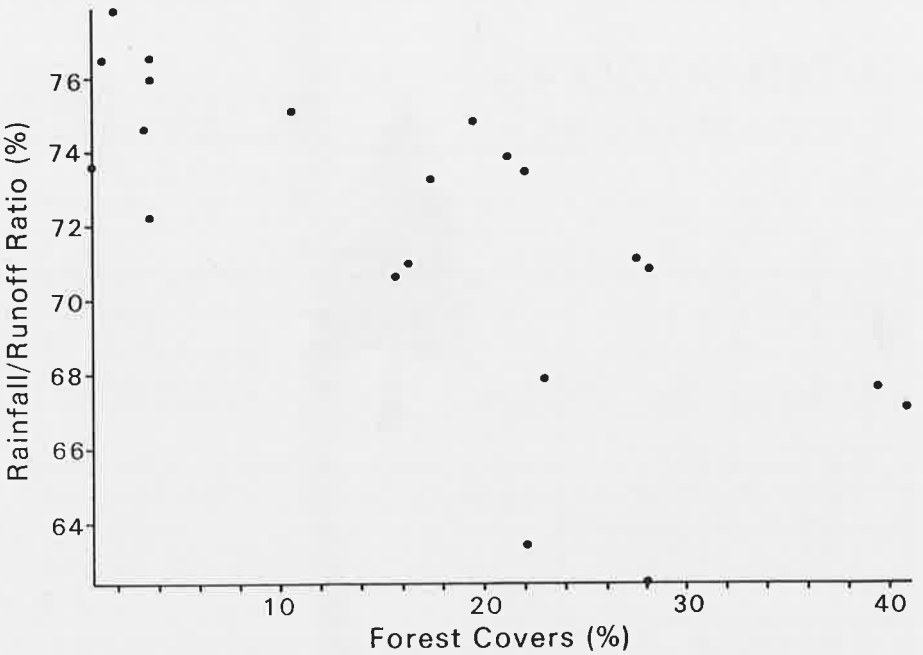


Figure 3. Percentage of forest versus rainfall/runoff ratio in Welsh catchments (after Ahmad Fauzi Mas'ud, 1987).

Authors' Recent References:

Roberts, J., Cabral, O.M.R and Ferreira de Aquiar, L. (in press) Stomatal and Boundary-Layer Conductances in an Amazonian Terra Firme Rain Forest. *J. Applied Ecology.*

Reynolds, B., Neal, C., Hornung, M., Hughes S. and Stevens, P.A. 1988. Impact of afforestation on soil solution chemistry of stagnopodzols in mid-Wales. *Water Air and Soil Pollution, **38**,* 55-70.

Roberts, G., Reynolds, B and Talling J. (eds.) 1989 Upland Management and Water Resources. Contract report to Welsh Office/DoE.

Rowan, A.A. (ed) 1988 *Forests and Water Guidelines.* Forestry Commission.

Ahmad Fauzi Mas'ud 1987. Land Use and Physical Hydrology of Selected Mesoscale Catchments in Wales. PhD thesis, UCNW, Bangor.

News from the BHS Committee:

Because of concern about the mounting cost of meetings, particularly travel expenses for speakers, the Committee is now considering levying a minimum charge for attendance at meetings, with a preferential rate for BHS members.

New Members

We welcome the following new members to the Society:

Blyth, E. M. (Ms) ..... Engineer
Burrows, A.C.W. ..... Hydrologist
Foster, S. M. .....
Frost, D. W. ..... Southern Water
Patel, D. ..... Student

Ven Te Chow Memorial

The International Water Resources Association has invited our President to contribute to the memorial fund honouring Professor Ven Te Chow who had been the IWRA's founder president, and to approach potential donors in the UK. The Main Committee has agreed to send a sum matching the President's personal gift and to invite members of the Society to send their contributions to the Hon. Treasurer, Frank Farquharson at the Institute of Hydrology, Wallingford, OX10 8BB (by name or anonymously).

Until his death in 1981, Chow was considered in the USA and in the international hydrological and water resources community as a fruitful and influential contributor to hydrological research and education and a leading international consultant. He attracted an unrivalled list of academic and professional honours, but was perhaps even more remarkable for the personal affection he inspired in his colleagues, students and all those whom he involved in his numerous publishing and professional ventures.

The memorial is to consist of a fund of £50,000, the income from which is to be used for periodic lectures by outstanding hydrologists at the world congresses of IWRA, with which BHS hopes to establish closer relations.

Hydrological Aspects of Environmental Impact Assessment (EIA)

BHS Southern Section Meeting
12 April 1989

At this well-attended meeting held at the Department of Civil Engineering, Imperial College, the two speakers, John Lawson and Jan Brooke, stimulated numerous questions and a lively discussion which were concluded skillfully by Howard Wheater in time for a succinct AGM.

Increased pressure on water resources, the recent land drainage statutory instrument and growing awareness of the sensitivity of the local environment to water resource developments has lead to substantial work on environmental impact assessment (EIA). This well attended meeting was addressed first by **John Lawson** of Halcrow Consulting Engineers who outlined the characteristic stages of EIA for water resources development.

The results of most EIA are required rapidly. This often precludes the use of specific surveys to obtain local data and most assessments must therefore make use of existing data. Through consultation with interested parties, specific foreseeable problems are identified, thus permitting the developer to devise alternative schemes. Once a scheme is identified, operational models and water quality models are used to establish its environmentally important characteristics. With this knowledge the probable impact of the new scheme on local flora, fauna, agriculture and recreation can be assessed. If the plan is rejected after this first assessment the proposed scheme can be modified and the EIA repeated until the impact is considered acceptable. In his presentation, John concentrated on the role of hydrological simulation modelling. Particular attention was given to the setting of site-specific operating rules for abstractions and impounding reservoirs in the context of local problems and historic factors; drought yield assessment was also considered, as was the presentation of simulation output (especially impact on river flow and reservoir draw-down) in a format suitable for use by other members of the EIA team. The

need to strike a balance between scheme yield, operating costs and environmental impact was stressed.

A detailed example of the use of hydrological models in EIA was given in a case-study of a scheme to increase abstractions from the River Exe. This scheme sought to allow abstractions from a tributary river, pump storage extraction from Exebridge to Wimbleball reservoir and modification of the operating rules. Of particular concern in this project was the impact on salmon fisheries. Modelled hydrographs at critical locations were presented for before and after the proposed development. It was shown that salmon catches (and assumed salmon movement) peaked during peak flows, the spates appearing to trigger upstream movement during the migration period. Through this study it was possible to devise operating rules which would permit maintenance of those daily peaks which were likely to have the greatest impact on fisheries if altered.

Figure 1 shows flow duration curves used to assess the likely impact of the proposed scheme on channel morphology: most morphological changes were associated with high flows. Major changes in discharge had already occurred as a result of building the Wimbleball reservoir and the proposed modifications would have little further effect.

A final worry expressed by opponents of the scheme was that extensive areas of reservoir floor would be exposed more frequently with the new abstraction scheme. John at this point gave a beautiful example of how the method of presentation has a major impact on the appraisal to the evidence. If results were expressed in terms of the average year, then, for example, on a 30 year average map, the drought in 1976 which left the reservoir empty for 30 days would imply that the reservoir was almost empty for 1 day per year, which is not generally the case. "Typical" rather than average conditions should be used wherever possible.

Jan Brooke, research coordinator of the Environmental Appraisal Group at the University of East Anglia, reviewed two schemes of land drainage in East Anglia which have been subject to EIA as a result of the recent land drainage statutory instrument. The new legislation requires the EIA reports to contain descriptions of the proposed changes to existing land drainage schemes, the existing environment and likely significant consequences of the proposed scheme on the environment, as well as possible remedial measures to minimize undesirable consequences and a non-technical summary for general appraisal.

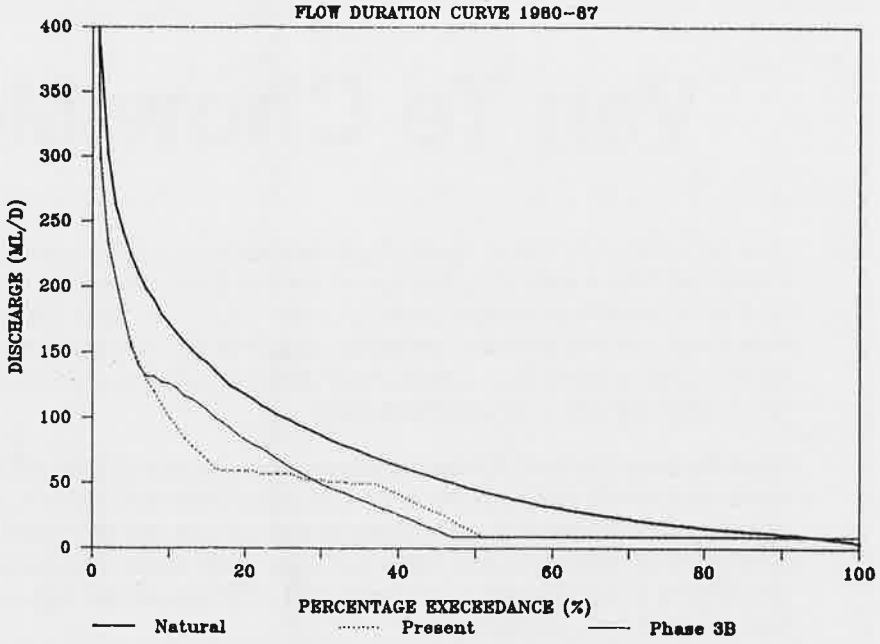


Figure 1: Flow duration curve downstream of Wimbleball reservoir

The EIA can be approached with varying degrees of cooperation, communication and involvement between the various parties proposing and likely to be affected by a scheme. It was emphasized that good communication, the involvement of as many interested parties as possible as early as possible, and flexibility to assess, modify and reappraise schemes before the final report is submitted appear to be major factors influencing the success of EIA.

External specialists are essential to advise on various implications and to separate ill-founded concern from true environmentally significant impacts. The early involvement of many local interests or pressure groups not only brings concerns to the fore before resources are committed, but can also provide useful data which may be of great value in the EIA. For many ecological consequences, 12 to 18 month surveys are necessary to identify sensitive parts of the system. Unfortunately the time-scale of requests for EIA does not normally allow sufficient time for such surveys, and so data from local groups are invaluable to independent specialist assessors.

These points were exemplified in interesting case-studies of EIA carried out by the Environmental Appraisal Group for changes in the flood protection works in the Halvergate area of Norfolk and the Woodbridge region of Suffolk, both of which could have significant human and ecological impacts.

Maureen Mylne
Metorological office

BOOKS

Book reviewers needed

The book reviews in *Circulation*, edited until recently by **David Lerner**, have provided invaluable and often entertaining critiques of a wide variety of new publications. The new Book Reviews Editor is **John Griffin** who works for Celia Kirby at the Institute of Hydrology.

New book reviewers are urgently needed, as well as newly published books for review. BHS members with general or specific expertise who would like to share their critical opinions with the readership of *Circulation*, while at the same time adding to their own libraries, should write to John at the Institute of Hydrology, Wallingford, OX10 8BB, giving their particular specializations or interests. It would also be helpful if existing reviewers could update their addresses and subjects of interest.

Books received

Two new books are awaiting review: "Water Management in Reservoirs" by L. Votruba and V. Broza, and Sir Charles Pereira's "Policy and Practice in the Management of Tropical Watersheds".

IH Publications

Two new Institute of Hydrology Reports have just been published. Report 102 , by Marion Dales and Duncan Reed is entitled "Regional flood and storm hazard assessment", 159pp, ISBN 0 948540 14 1. It is the outcome of a three year study of regional flood and storm hazard over reservoired catchments, funded by the Department of the Environment. Report 106, "The Catchment Research Data base at the Institute of Hydrology", by Anne Roberts,52pp + tables, ISBN 0 948540 15 X, summarises the archiving of hydrological data from the IH experimental catchments.

These reports are available, price £8 each, from the librarian at the Institute of Hydrology, Wallingford, OX10 8BB.

PRESCRIBED FLOWS, ABSTRACTIONS AND ENVIRONMENTAL PROTECTION

BHS National Meeting
16 June 1989

In welcoming participants to the National Meeting the President, Professor Peter Wolf, congratulated the organisers on the timeliness of the meeting with respect to the Water Industry's privatisation and the growing environmental awareness.

Session A: Review

Alan Tetlow, Chairman for the first session, introduced the speakers saying that the NRA will have responsibilities for integrated river basin management. We had to recognise that conservation needs and ecological requirements now bring additional constraints to water resources planning and river engineering works. This national meeting provides a timely opportunity to demonstrate that we intend to utilise all our available expertise to optimise the management of our water resources, whilst achieving a high level of environmental protection. **John Sheail** introduced his paper on the "Legislative Background", which illustrated how ideas as to the volume and manner of discharge of compensation water developed between the early 19th century and the Water Act of 1945. In seeking powers to abstract water to meet the growing needs of urban populations, undertakers adopted a wide range of strategies so as to minimise the impact on existing industrial, fisheries and other interests along the water courses affected.

Alan Gustard, author of the second paper on "Compensation Flows: A Hydrological Perspective", described the work carried out at the Institute of Hydrology on a national study of compensation flows below impounding reservoirs. Compensation flows were at their highest at the beginning of the 19th Century, with some as high as 80% of average daily flow, but these maximum awards were gradually reduced towards 30% for the present day. He concluded that using the 95 percentile exceedance discharge as an index of low river flows, compensation flows are on average 26% higher than the pre-impoundment natural low flow and concluded that the annual value of providing current levels of compensation flows was in excess of £150 m per annum.

The third paper, on Methods for assessing Minimum Ecological Flows in British Rivers was introduced by **Professor Geoff Petts**. He described three categories of method for setting minimum acceptable flows - discharge methods, habitat methods and biological response methods. As a rough rule of thumb 20% of average daily flow provides an appropriate criterion for protecting aquatic habitat - in the UK, the 95 percentile is less than this on many rivers. There is need for ongoing research in the evaluation of environmental impacts, particularly to evaluate the discharge methods currently used by the UK Water Industry.

Mike Hyde (British Waterways Board) said that the earliest canal reservoirs did not always have compensation obligations. When they did these could be defined by orifice dimensions rather than flow, which could raise problems of interpretation. He contrasted the rational outcome of Awards jointly agreed by engineers acting for the interested parties with the adversarial method of Select Committees to the disadvantage of the latter. **Geoff Mance** (Severn Trent NRA) asked what should be the objectives of setting compensation flows and how will we know when the objectives have been met. Alan Gustard replied that the chief objective was to obtain a balance between the interests of abstractors and downstream riparian interests and protected rights. Whilst there were useful water quality models, there were as yet no satisfactory models for simulating the effect of flows on river habitat. Professor Petts said that environmental models are needed to evaluate flow changes to complement the existing economic models used to evaluate costs and benefits. More efficient environmental impact analysis could lead to savings in water, rather than requiring extra flows. Alan Tetlow (Anglian NRA) was reminded that we are still experiencing the effects of huge allocations of resources in the 1950 s which later became Licences of Right. **Elizabeth Shaw** (Imperial College) referred to the work of Gerrard Boulton and MAFF on low flows in the 1960s. Dr Sheail pointed out that under the thirty year rule these Ministry files were not yet available to researchers. **Sue Walker** (North West Water) said that there are dangers in generalised approaches and identified the need for specific studies of individual catchments, within a framework of generalised principles, with particular respect to their dominant characteristics such as storm water overflows. **Terry Newman** (Wessex NRA) said that usually a Hydrologist bore responsibility for recommendations on minimum residual flows. The subject required inputs from a range of disciplines and yet other specialists had not the same burden of urgency. It was sometimes heard that at least 10 years of site specific studies might be necessary to give adequate data on fisheries. It was therefore surprising to learn that assessment of environmental impact might be achieved with little new fieldwork. He urged that, where fieldwork was required, the Hydrologist was the appropriate person to give this the necessary impetus. Professor Petts agreed that detailed environmental impact analysis takes a long time but an appropriate balance needs to be drawn between desk and field studies, which he agreed should be led by hydrologists. **Dr E Maltby** (Exeter University) said flood plain wetlands were a source of very important environmental and ecological functions and that the effects on water quality parameters such as nitrates and phosphates etc need to be assessed in relation to stream flows and their effect on the environment. **Geoff Petts** agreed that there was a general under-estimation of the ecological importance of the riparian zone in the river flow management, which is not managed as appropriately as seen to be the case on the continent. **Mr H Casey** (Institute of Freshwater Water Ecology) agreed with the authors that the main problem in interdisciplinary studies was acquiring an adequate long term data base for ecological

modelling such as exists at the IFE River Laboratory.

Session B: Practice

Geoff Mance (Severn Trent NRS), Chairman for the Session, said that although the Water Resources legislation was unchanged the public had an unrealistically high expectation of the NRA. All the problems of licences of right and over abstraction would be expected to be resolved. It is essential that work on methods for determining minimum flows should be consistent, whether for abstraction control or for determining compensation flows from reservoirs. The NRA would need to adopt a consistent approach to these issues nationally. **Andy Bullock** (Insitute of Hydrology) introduced his paper on "Environmental Protection with PHABSIM: US Standard, UK Future". He described the main components of the model together with current UK applications of PHABSIM. American users seem to find the model either too simple or too complicated in equal proportions, but 70% of users accepted the results as being relevant. "Guidelines for Controlling Abstractions from Rivers and Aquifers" was introduced by **Richard Franklin** (Yorkshire NRA). Yorkshire Water had pioneered a new practical methodology which he described as "rationalised", if not totally rational! This was in reaction to a build-up of licensing problems and demands by fisheries interests for reduced abstraction. The method used an environmental weighting to assess permissible volumes of net abstraction and to set prescribed flows. The system now provided a consistent basis for licensing both surface and groundwater abstractions throughout the Yorkshire Region.

Peter Herbertson (Southern NRA) asked if use of the methodology for determination of licences had resulted in any appeals again refusals and if the fisheries committees were not satisfied with licence determination. Richard Franklin said that they had no actual appeals, although several threats were still pending. The Regional Advisory Committee welcomed the adoption of guidelines but would like to see prescribed flows backdated and applied to old existing licences. Terry Newman posed the question, if the PHABSIM suitability factor 'substrate' was regarded as independent of velocity, how then could sensible predictions be made? Dr Bullock agreed that this part of the model needed modifying in the UK to take account of the geomorphic variability of the substrate/cover. **Dr C Gupta** (University of Birmingham) asked Mr Franklin what methods he used to estimate groundwater recharge. Available resources were calculated by fairly simple assessments of residual recharge and aquifer outcrop area. The distance of aquifer zone boundaries from rivers and springs were based on average characteristics for the aquifer and could be refined in specific cases if necessary. **Dr M Owen** (Thames NRA) said that he did not accept Dr Mance's presumption that licences should be granted - the policy in Thames is to refuse a direct surface water abstraction in the Summer, and has been so for twenty years, during which time it has been challenged only once. In Yorkshire it was felt that a dramatic change in policy, from granting licences to refusal, needed to be justified by appropriate analysis. **David Evans** (Anglian NRA) questioned whether the methodology and/or the parameters derived for Yorkshire would be appropriate in Regions with lower river flows and higher irrigation demands. **Roger Goodhew** (Severn Trent NRA) pointed out that spray irrigation is becoming increasingly "peaky", with ADAS providing detailed advice to farmers as to when to irrigate. Irrigation seasons may be much reduced and concentrated in the months of June to August. This was also found to be the case in Yorkshire. This increases the resource planning requirement but for only a small part of the year. The economics of this situation require sophisticated consideration. **Paul Jowitt** (Heriott Watt University) asked how sensitive the PHABSIM model was to changes in the input parameters. So far present research by the Institute of Hydrology shows that whilst the shape of suitability functions remain constant, the absolute values do vary by as much as an order of magnitude. The Yorkshire methodology is not particularly sensitive to the environmental weighting scheme, with the permissible nett abstraction ranging from 6% to 13% of dry weather flows. **Graham Sharp** (NRAAC) said that the NRA needed a common methodology within which appropriate applications between and within Regions could but a consistent policy. Dr Bullock said that PHABSIM provided a pragmatic approach to the validation of prescribed flows.

Ms G Weilding (South West Water) asked if the Yorkshire methodology was also applied to public water supply abstractions. Richard Franklin said this was not the case as the method was primarily intended for numerous smaller abstractions. Large abstractions would each be assessed on their merits. **Mr G Phillips** (Thames NRA) urged NRA Regions to work closely together to avoid embarrassing differences of policy. In particular, having set prescribed flows they need to be policed and he asked Yorkshire how well they were staffed for monitoring and enforcing abstractions. Richard Franklin now has four staff wholly engaged on liaison with abstractors and licence monitoring and enforecement. (In fact Yorkshire can claim two-thirds of the national licence enforcement manpower, the other two members of staff working full-time on enforcement coming from Severn Trent NRA. The other eight Regions are all without licence enforcement staff.)

Session C: Policy

Graham Sharp (NRAAC), Chairman for the Session, said that the NRA will be responsible for both the quantity and quality aspects of catchment management policy. He had a hunch that quantity would re-emerge as a major issue for the next decade or two, particularly as an abstraction licence was now a financial asset to be quoted in privatisation prospectuses.

Andrew Skinner (Severn Trent NRA) introduced his paper "Towards a Policy for Low Flow Management in the National Rivers Authority". One of the major issues is the large public water supply Licence of Right, resulting from abstractions established in the 1950's, where the NRA is now being pressed by conservation interests to reconsider the balance of interests between abstraction and riparian ecology. Changes in policy for the discharge of sewage effluent could have a dramatic effect on the base flow of many industrialised rivers. There are two important areas of policy which the NRA will need to consider: firstly providing a national framework for low flow management, with a consistent methodology giving flexibility for local application, and secondly deciding on an approach to low flow augmentation, both to correct for past over abstractions, and to provide benefit for all river interests.

Duncan McDonald (Scottish Development Department) introduced his paper on "Environmental Protection in Scotland". Here the legislative position had remained unchanged from the pre-1963 years. Water rights accompany hereditaments and common law would be used to deal with disputes. From the Scottish perspective it is important to be clear whom we are compensating and for what. Compensation would only be obtained for the loss of a tangible or quantifiable right having an economic value. These rights are marketable. As the exception to the rule there do exist in one small catchment in East Lothian seven spray irrigation licences issued at a cost of £5 each. His experience over twenty years of non-departmental public bodies led him to reassure apprehensive NRA staff that Government control need not be too onerous!

Richard Franklin asked whether there was a central register of abstraction rights in Scotland. In fact these rights are probably only contained in land registers, but general riparian rights are always assumed to be present.

Mike Mansell-Moullin (consultant) had assisted a number of environmental and river interest groups with groundwater problems in Southern England. Although he understood the reasons why Minimum Acceptable Flows had not been designated, this was regarded outside the Water Industry as a cover up. If Yorkshire's methodology were applied to many chalk catchments in the South, the existing large Licences of Right would be seen to be quite unacceptable by modern environmental standards. He hoped that the NRA would be open with the public on these matters and be prepared to introduce new policies where possible. The NRA would be well advised to educate the public in these issues so that public participation could be increasingly well informed.

Andrew Skinner did not apologise for not having set statutory minimum acceptable flows, arguing that equally good, and more practical, alternatives have been used. He agreed that the prevailing culture of the NRA should be both evenhanded between abstractors and conservationists, and openhanded.

Alan Tetlow recommended that the British Hydrological Society should provide press releases on the results of their technical meetings as has been done on the continent. Dr Owen (Thames NRA) said that the pressure was mounting to deal with over-abstracted catchments by providing low flow augmentation. If the NRA delays in deciding an appropriate policy its credibility will be lost. He felt that traditional cost-benefit analysis was not entirely appropriate in these cases. In the Thames Region the groundwater abstraction causing low flow problems has a current replacement cost of £100m, whilst the proposed environmental works to make restitution for the effects of over abstraction in the past amounted to a mere £10-£15m. Society is likely to place increasing financial value on the environmental amenity provided by rivers to adjacent properties. Alan Gustard said that the Institute of Hydrology recognised the importance of the problem of artificial interference with flow and groundwater level data. He would like to know whether actual abstraction records were available for analysis and whether such archives were on computer databases. Andrew Skinner said that abstraction data were not legally in the public domain. Severn Trent tended to release data on anonymous groups of abstractions so that individual licence holders could not be identified. **Roger Goodhew** (Severn Trent NRA) warned that with the privatisation of the Electricity

Industry there might be an increase in generation by hydro-electric power. He asked what experience there was in Scotland of the diurnal effects of hydro-electric power generation. Duncan McDonald said that individual landowners and farmers had to negotiate on their own with the hydro-electric boards, so generalised information was not easy to come by. Geoff Mance (Severn Trent NRA) said that data did not have to be 100% accurate to provide useful guidelines for policy makers. Water resource modelling now had to begin to take into account the possible effects of climatic change. The emphasis should always be on making progress with approximate methods first, but ensuring consistency nationally, and then applying more robust analysis to detailed situations which required it. **Professor Wolf** asked if the NRA would have adequate hydrological networks and hydrologists to maintain the necessary data bases etc. Andrew Skinner felt that Severn-Trent NRA was adequately resourced on both counts.

In conclusion Professor Wolf said that this was one of the best attended national meetings of the British Hydrological Society that he could remember. Some gaps in his knowledge had been filled, but he regretted that he had learnt very little actual hydrology! New techniques such as PHABSIM models needed cautious introduction with careful validation against adequate data. There was much to be done by the NRA, particularly a fundamental appraisal of the need to correct for the effects of over authorsation of public water supply abstractions in the past. He expressed the thanks of the meeting to the authors for their excellent papers and to the organisers, Dr Alan Gustard, Professor Geoff Petts and Dr J Pirt for their excellent and timely organisation of the meeting.

A fuller account of the meeting, including written contributions, can be obtained from Celia Kirby at the Institute of Hydrology. This contains additional comments by Messrs. Wolf, Tetlow, Mansell-Moullin, Hyde and Newman.

Peter Herbertson

Urban Flood Storage

ICE Pennines Hydrological Group Meeting

10 May 1989

More than 80 delegates, from North Wales, Bristol, Oxford and Cumbria as well as from the Yorkshire region, attended this one-day meeting at Sheffield University. Three papers were presented on different aspects of urban flood storage. This excellent attendance reflects the steady growth of and continuing interest in the work of the Pennines Hydrological Group which currently operates under the umbrella of the Yorkshire Association of the Institution of Civil Engineers.

Dr A Saul of Manchester University described the design concepts involved in on-line storm sewer storage tanks provided for the protection of rivers against gross pollution and primarily for the alleviation of urban flooding. Historically, the size of the storage tank has been based on empirical methods such as the retention of a volume expressed as a multiple of catchment dry weather flow. To predict hydraulic performance on an annual basis it is now recommended that use is made of a known sequence of historic rainfall events relevant to the district (Time Series Rainfall). The use of such a series, together with the Wallingford Procedure (WASSP) results in the prediction of flow retention as a function of tank size and the outlet control arrangements. As a consequence, several large tanks (up to 15,000 cubic metres!) have been constructed, often with severe restrictions on their geometry. A number of alternative geometric layouts have been devised at Manchester to minimise this problem, and the results of full-scale observation and hydraulic scale model tests show that complex flow patterns are established within tanks as the discharge through them varies. The presentation highlighted these patterns, some of which involved reverse flow. Attention was also focussed on the use of the WASSP procedures in simplifying and solving the basic flow equations and on other recent literature from the Water Research Centre and elsewhere.

In the second presentation **Dr C. J. Pratt** of Coventry Polytechnic addressed the subject of Control of Stormwater Runoff at Source and suggested that this approach might well give better protection against the most damaging pollutants (micro-organisms). Because Britain has, until recently, seen relatively little large-scale development where stormwater discharge threatens the capacity of existing sewers, new methods of storage and disposal developed largely in North America and Australia have not been adopted here. Dr Pratt presented many examples of these new methods, including swales (long narrow depressions for initial surface storage), direct infiltration over large areas of grasscrete and the use of porous macadam. He encouraged the use of soakaways rather than closed pipe systems, and cited a case where soak-aways had been used in an area underlain by boulder clay in order to limit consolidation of the clay. He maintained that with good design it is possible to dispose of between 25 and 45% of storm runoff through evaporation from these infiltration systems, thus relieving pressure on the sewers, and at the same time reducing pollution and maintenance costs.

Finally, a trio of speakers, **Professors M.J. Hall** and **J.B. Ellis** of Middlesex Polytechnic and **Mr D.L. Hockin** (Consultant) gave an update to the CIRIA Guide to the Design of Flood Storage Ponds. This guide, originally issued as a "draft for discussion" in 1980, has been amended and extended and is due for publication in the autumn of 1989. Flood storage ponds, or washlands, represent the most downstream method of flood alleviation and may be on-stream or (better and more usually) off-stream. Attention was drawn to the Flood Studies Report which includes flow-charts for deciding whether or not to use such ponds and leads on to their design. The new material in the CIRIA Guide will include a short-cut method for flood estimation and reservoir routing for small catchments, a discussion of water quality considerations and expanded guidance on maintenance. This last section will focus on the conservation aspects which are now considered more important, and on secondary uses such as recreation. For recreation, microbial pollution control requires careful design to give an adequate retention time in storm events and avoid short-circuiting of pollutants. Other design methods touched on, for example diversion of the "first flush" and the promotion of vegetation for pollutant uptake, concluded a very full and wide-ranging series of lectures.

David Jackson
Honorary Secretary

SITUATION VACANT

AN OPPORTUNITY IN GROUNDWATER MODELLING

WLPU are an international firm of Civil Engineering Consultants with sixteen offices worldwide.

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Contributions to the next *Circulation*

Changes are afoot to the way *Circulation* is produced. The text in this issue has been typeset using "Pagemaker" on a personal computer. Contributions for *Circulation 24* will be typeset much more easily, quickly and accurately if the computer can read them directly from a 3.5" or 5.25" disk.
Many articles are already produced on a word processor, and Pagemaker can read text from the following: Microsoft Word, HP Advance Write, Word Perfect 4.2, Wordstar 3.3, Olitext Plus, Samna Word, Multimate and Xywrite III. Others such as Wordstar 2000 can be read if converted to a DCA file or simply sent as unformatted ASCI text.
If you can send an article on disk, please send a hard copy as well, and details of the word processor file, but of course normal typescript is still as welcome as before.

Copy Deadline for Issue No. 24
5th October 1989

Surface Water Archive Regional Representatives

Institute of Hydrology staff working on the Surface Water Archive attempt to improve its performance by having a named person from Wallingford as the linking individual with each gauging authority. At a time of major change, as NRA regions establish themselves and PLCs reorganise, it seems worth making the representatives' names more widely known. They will welcome any news on the gauging front.

Hydrometric Areas	*Representative*	*Hydrometric Areas*	*Representative*
N. Ireland	Alan Gustard	" 34-35	Sue Bryant
Highlands RPB	Mike Lowing	" 36-37	Jackie Carr
North East RPB	" "	Thames	Terry Marsh
Tay RPB	David Morris	Southern	" "
Forth RPB	Mike Acreman	Wessex	Sue Bryant
Tweed RPB	David Boorman	South West	Martin Lees
Northumbrian	Andy Bullock	Welsh 59-67, 102	Ian Littlewood
Yorkshire	Mark Robinson	" 55-58	Rob Brown
Severn Trent	Martin Lees	Solway RPB	David Boorman
Anglian 29-32	Nigel Arnell	Clyde RPB	Roger Moore
" 33	Roger Moore		

Hydrological Data UK 1987

The Institute of Hydrology and the British Geological Survey have just published Hydrological Data UK 1987. This volume includes flow and groundwater data together with 16 water quality stations and a feature article on the Tywi flood in October 1987. It is available from Shirley Black at the Institute of Hydrology for £15 (bound) or £12 (loose leaf). An order form is enclosed with this issue of *Circulation*.

FORTHCOMING EVENTS

Second BHS National Symposium

4 - 6 September 1989
University of Sheffield

Session 1: Headwater and hillslope

Hillslope hydrology: a multiple interacting pathways model
K. Beven, G. Hornberger and P. Germann

Hillslope processes: observations from the Allt a Mharcaidh catchment, Scotland
H.S. Wheater, S.J. Langan, A. Brown and M.B. Beck

Modelling heterogeneous Darcian headwaters
A. Binley and K. Beven

The role of sub-surface drainage in the generation of runoff from sloping clay land under different agricutural management regimes
R. Arrowsmith, A.C. Armstrong and G.L. Harris

The use of digital terrain data in modelling the response of hillslopes and headwaters
P. Quinn, K. Beven, D. Morris and R. Moore

Coloured waters in Wales: spatial and temporal trends
D. Kay, J. Crowther and R. Boon

Discoloured runoof in the Yorkshire Pennines
A.T.McDonald, A.M.C. Edwards, P.S. Naden, D. Martin and G. Mitchell

Session 2: Urban catchments and receiving waters

The statistical distribution of event mean concentrations of pollutants in stormwater runoff
M.G. Brizio, M.J. Hall and J.B. Ellis

Managing the effects of urbanisation in the upper Lee
C.H. Woolhouse

MOSQITO - A sewer flow quality model
J.A. Payne and G.D. Moys

Session 3: Coping with excess

The changing role of flood warning systems in flood hazard mitigation
J. Neal

Maximum flood estimation in the UK
M.C. Acreman and M.J. Lowing

An assessment of flood estimates using the Flood Studies Report
D.B. Boorman, M.C. Acreman and J.C. Packman

Mathematical modelling of the Ouse Washes
N. Balfour, K. Guganeshrajah and P. Halifax

Numerical simulation of dike-breach inundation alsong the Cho-Shui Rivèr in Taiwan
Jinn-Chuang Yang and Euan-Lung Hsu

Limitations of design hydrographs in arid areas - an illustration from south-west Saudi Arabia
H.S. Wheater and R.P.C. Brown

Focus on rainfall growth estimation
D.W. Reed and E.J. Stewart

Spatial structure in point rainfall: a geostatistical approach
E.J. Stewart and D.W. Reed

Session 4: Operating surface and groundwater resources

Management and operation of groundwater resources
K.R. Rushton and A.E.F. Spink

The Otter Valley catchment study - an integrated approach to modelling
W.J. Finlinson

Stages of construction and operation of a scheme to augment river flows using seasonal groundwater abstraction
V.A. Lowings and P. Midgley

Control rules - conjunctive use - complexity?
A. Weston

A further approach to the assessment of reservoir yield
A.J. Tollow

The development and use of medium-term policies for operation of a major regional water resource system
S. Walker and T. Wyatt

An introduction to operational control rules using the 10-component method
A.O. Lambert

Meetings

THE 1989 EAST HIGHLAND FLOODS
A One Day Symposium
27 October 1989
The National Hotel, Dingwall

During January and February 1989, exceptional rainfall occurred over the catchments of the Rivers Conon and Ness in the East Highlands of Scotland. Severe flooding resulted in damage to livestock and property and caused considerable local concern.
This one day symposium has been organised jointly by the Scottish Hydrological Group and the Highlands and Islands Branch of the Glasgow and West of Scotland Association of the ICE to examine the causes of the flooding and its effects. Presentations will come from the Scottish Development Department, Highland Regional Council, the North of Scotland Hydro-Electric Board, the Highland RPB, the Meteorological Office and Mott MacDonald Group Consulting Civil Engineers among other interested organisations. Subjects will include the review of rainfall and surface runoff, the damage which occurred, involvement of the Regional Council and local flood warning systems.
The symposium will open with a morning visit to the Dingwall operations centre of the NSHEB.
The provisional cost is £16, which will include lunch and a copy of the papers presented.
Further details from: Dr J.G.Herbertson, Dept. of Civil Engineering, University of Glasgow, Glasgow, G12 8LT. Tel.: 041-339 8855.

*** All Postgraduates ***

BHS FIRST SYMPOSIUM ON POSTGRADUATE RESEARCH IN HYDROLOGY
April 1990
Loughborough University

This will be a two-day meeting including workshops on practical aspects of hydrological

research, a guest lecture by an invited speaker and contributed papers. Accommodation will be provided on the university campus. Anyone who wishes to contribute a paper on any aspect of hydrology or just to participate should write to Rob Wilby, Department of Geography, University of Technology, Loughborough, Leicestershire, LE11 3TU. Tel.: 0509 - 222791.

VIII INTERNATIONAL CONFERENCE ON COMPUTATIONAL METHODS IN WATER RESOURCES
11-15 June 1990
Venice, Italy

This conference will review the advances in computational simulation of surface and subsurface water, present new research and allow the exchange of practical experience. Contributions are welcome on any of these topics:
- modelling groundwater flow in porous and fractured media,
- modelling estuary, river, lake and ocean hydrodynamics,
- modelling surface and subsurface transport,
- modelling water quality,
- modelling sedimentation processes,
- optimising water resources,
- non-linear methods,
- parameter estimation techniques,
- numerical methods and software advances.

Abstracts (not more than 300 words) and registration details should be sent by **1 October 1989** to Professor Giuseppe Gambolati, Dipartimento di Metodi e Modelli Matematici per le Scienze Applicate, via Belzoni, 7, 35131 Padova, Italy.

ModelCARE 90
International Conference on
CALIBRATION AND RELIABILITY IN GROUNDWATER MODELLING
3 - 6 September 1990
The Hague, The Netherlands

The usefulness of groundwater models is often limited by uncertainty about their reliability. Errors arise in the model formulation, for example from inadequate description of processes and interactions, or incorrect values of parameters. Solution errors may also occur, because of computer precision, incorrect analysis or inappropriate approximation.
This conference will provide a forum for presenting the state of the art of incorporating information about these errors into the modelling process.
Fields of modelling will include:
* saturated and unsaturated zone,
* groundwater flow,
* groundwater quality,
* interactions between surface water and groundwater,
* geochemical and biochemical processes
* evaluation of field tests,
* laboratory experiments with model validation.

Abstracts of papers or posters (300-500 words, single spaced, in English), should be received by **1 September 1989.** A scientific and commercial exhibition is also being planned.
Details from the Conference Secretariat, KIvI, PO Box 30424, 2500 GK, The Hague, The Netherlands. Tel. +3170 91 98 90.

INTERNATIONAL CONFERENCE
on
THE CONSERVATION AND MANAGEMENT OF RIVERS
10 - 14 September 1990
University of York

This conference will bring together all those interested in greater integration of conservation within river management. Scientists, policy makers, water resource managers, engineers and nature conservationists will be able to discuss theory and practice of river conservation, describe progress in different parts of the world and define future strategies together.
Emphasis will be laid on habitat and wildlife conservation, within the water resource management context. Subject matter and attendance should be truly international, reflecting a range of perspectives across the developed and developing world.
The topics presented in papers will include:
- Catchment characteristics and river ecosystems,
- The case for conservation: threats to rivers and the value of protection,
- Integration of habitat conservation with wider management objectives,
- River management,
- Recovery and rehabilitation of rivers and streams,
- Protecting rivers by legislation - geographical overviews.

Further details may be obtained from Dr P J Boon, Dept. FBB, Nature Conservancy Council, Northminster House, Peterborough, PE1 1UA.

HYDROLOGICAL RESEARCH BASINS AND THE ENVIRONMENT
24 -28 September 1990
Wageningen, The Netherlands

Much of our basic knowledge of hydrological processes has come from studies in experimental and representative basins. Such basins are now considered to be irreplaceable tools for studying anthropogenic effects on water resources and on the environment. This conference, which includes the 3rd General Assembly of the European Network of Experimental and Representative Basins, will address the role and importance of these basins in predicting anthropogenic effects on water resources and the environment. Particular emphasis will be on
- biogeochemical cycles, surface water quality and transport of contaminants in soils and groundwater;
- interactions between atmosphere, plants and soil, including evapotranspiration and climatic effects.

Abstracts of papers or posters (maximum 300-500 words) should be submitted to the IAC-Section OCC, PO Box 88, 6700 AB Wageningen, The Netherlands by **1 October 1989**.
Proceedings will be pre-published and a poster presentation will be included in the programme. Further details are available from P. Warmerdam, Agricultural University Wageningen, Dept. of Hydrology, Soil Physics and Hydraulics, Nieuwe Kanaal 11, 6709 PA Wageningen, or from Alan Gustard at the Institute of Hydrology.

Diary

BHS Southern Section Programme

11th October 1989
"River flows and channel geometry"
G.Wharton, G.Heritage and R.D.Hey

15th November 1989
"Hydrology of African wetlands"
A. Bullock, J. Sutcliffe and Y. Parks

13th December 1989
"Historical floods on the R. Thames"
F.M. Law

24th January 1990
"Chalk, groundwater and low flows"
Speakers to be announced

28th February 1990
"Operational water quality management"
B. Beck and J. Tyson

All the above meetings will be held at Imperial College, London, usually starting at 6 p.m..

25th April 1990
"Water resources forecasting in southern Britain"
Speakers to be announced. Afternoon meeting at the Institute of Hydrology, Wallingford.
Contact: Nigel Arnell, Telephone: 0491-38800.

ICE Pennines Hydrological Group

Provisional programme:

8th November 1989
Paper & visits: Alwen Reservoir.

14th February 1990
"Stochastic hydraulics".

9th May 1990
AGM and "Geographic Information Systems in hydrology".

ICE Scottish Hydrological Group Programme:

8th December 1989
"Clyde Dredging Study".
D.J. Banks and R.H. Falconer.
McCance Building, Strathclyde University.

12th January 1990
"The Loch Fleet Project: Restoring Acid Waters by Catchment Liming".
Dr T.R.K. Dalziel.
Wellcome Room, Royal Society of Edinburgh.

9th March 1990
"Satellite Remote Sensing in Hydrology".
Dr E.C. Barrett.
McCance Building, Strathclyde University.

Meetings start at 6.30 p.m.: details from Dr J.G. Herbertson, Glasgow University. Tel.: 041-339 8855, ext.5215.

Circulation is the quarterly newsletter of the British Hydrological Society. It is issued free to members, but is also available on an annual subscription of £13. Please address all correspondence to the Editor, Institute of Hydrology, Wallingford, OX10 8BB. Telephone 0491–38800.