THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

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National Hydrology Symposium, Southampton

By the time you read this, of course, the official closing date for registration will be long past. However, it is still possible to come for one or more of the daily sessions*. All six sessions have been well supported and most of the papers accepted by the convenors have materialised as promised. The programme now looks something like this:

Session 1 : Demand forecasting & management (Monday 16 September)

Keynote presentation by Peter Herbertson of NRA Southern, followed by papers from Bircumshaw & Fenn, Fenn & Gurnell, Hall, Lambert and Shaw. Topics to be covered include Southern Water's Testwood Lakes scheme, regional variations in demand, estimation of *per capita* consumption and use of fuzzy regression analysis.

Session 2 : Low flow management (Tuesday 17 September)

Keynote presentation by Jerry Sherriff of the NRA, followed by papers from Glenny & Kinniburgh, Goldsmith & Parry, Mukherjee, Newman & Symonds, Tollow, and Tubb, Sambrook & Hawker. As well as case studies of a variety of rivers in England and Wales, other aspects to be considered include linear programming and principles of ecologically acceptable flow management.

Sessions 3, 4 and 5 will run concurrently with **Session 2** from 11.00 on Tuesday, 17 September.

Session 3 : Hydrograph separation (Tuesday)

Keynote presentation by Keith Beven of Lancaster University, followed by papers on Alpine meltwater hydrographs, dominant quick and slow flow components, what chemical signals imply for water movement and the use of chemical tracers. Authors include Henderson, Beven & Reeves, Littlewood & Jakeman, Robson & Neal, Tranter & Brown and Ward & Zaidky.

Session 4 : Snow and ice (Tuesday)

Keynote presentation by Martin Sharp (Cambridge University) on hydrological inferences from meltwater quality, followed by papers on proglacial river monitoring, extreme snow melt in the UK and flood risk estimates. Authors include Futter, Gurnell, Mawdsley, Dixon & Adamson.

Session 5 : Unusual events (Tuesday)

A hydrological review of 1988-90 by Marsh & Bryant, followed by papers from Acreman & Collinge on the Calderdale storm, Archer & Wheeler on heavy rainfall and radar calibration, Farquharson, and Rosier on soil moisture in woodlands.

Session 6 : Large data bases (Wednesday 18 September)

Keynote presentation on global aspects by Ole Hebin of UNEP, followed by papers from Boorman, Clark, Collier, Houghton-Carr, Parks & Sene. Integration with GIS, application of a radar database to atmospheric GCMs and developing a database for Norway are some of the topics.

As well as the Symposium proper, we have had our usual good support from exhibitors of hardware, software and services. The final attraction is of course the hydrological games (after the conference dinner on Tuesday). Do try to come for a day, or more if you can.

***It is still worth enquiring about accommodation: it might be possible to fit you in - call the Local Organising Committee on 0703 583565.**

Land/atmosphere interaction studies for global-scale prediction

BHS Southern Section Meeting
Imperial College, London
13th February 1991

An unfortunate combination of changed date, adverse weather and transport difficulties meant that only a very small audience gathered to hear Dr Jim Shuttleworth, Head of Hydrological Processes at the Institute of Hydrology, speak on Land/ Atmosphere Interaction Studies for Global Scale Prediction. Dr Shuttleworth divided his talk into three sections: the BACK-GROUND to land/atmosphere observational studies; PROGRESS in the last decade in selected experiments; and consideration of the FUTURE , highlighting important areas for global hydrological programmes.

Describing the Background, Dr Shuttleworth noted that large-scale land use changes may have important consequences for climate. Modelled climate is sensitive to certain hydrological processes, and parameters including albedo, roughness and soil moisture. Thus land/atmosphere interactions may have important implications for regional predictions of the greenhouse effect and the climatic consequences of major land-use changes including deforestation and desertification.

Progress in land surface observation in the last decade has mainly been through the studies carried out under the World Climate Research Programme (WCRP) and ISLSCP, the International Satellite Land Surface Climatology Project which has covered a series of experiments at several scales relevant to land surface/atmospheric interactions.

ARME, the Amazon Region Micrometeorology Experiment, was an Anglo-Brazilian initiative which studied transpiration and interception losses, soil moisture assessment and measurements of leaf properties at a single site in Central Amazonia. Models have been developed towards a state where predictions of the effect of changing land use upon various meteorological parameters, including temperature, precipitation and evaporation, become possible.

HAPEX, the Hydrological Atmospheric Pilot EXperiment, involved experiments undertaken at a scale more appropriate for calibrating the hydrology in GCMs. The first HAPEX study in the Bordeaux region of south-west France has provided valuable insight into hydrometeorol-ogical conditions in a large area of mixed vegetation of forests and various agricultural crops.

The focus of studies within ISCLP has been to develop the use of remotely-sensed data for use in climate models and climate prediction. The first major study was undertaken in Kansas in 1986 and 1989, over a 15 x 15 km area of uniform pastureland in order to compare satellite and ground-based measurements of solar radiation and evaporation estimates. Aircraft were used to measure surface fluxes, and these were compared with the ground based systems, showing that the airborne based systems were missing a sizeable proportion of the surface fluxes of latent and sensible heat.

In summary, the experiments of the last decade have helped the develop-ment of boundary layer models, and provided useful single point calibrations for tropical forests, prairie grassland and mixed agricultural crops. Insight has been provided into aggregating these results, improving the mesoscale models and offering a test bed for remote sensing data.

The Future was described in terms of ongoing bilateral work and upcoming international programmes. Experiments in Niger in West Africa will consider evaporation from savannah and bare soil. The ABRACOS (Anglo Brazilian Amazonian Climate Observing Study) project will look in more detail at energy budgets in undisturbed forest and deforested locations. Initial studies have shown significant differences in diurnal temperatures, wind speeds and humidity profiles between pastureland and forests.

Global programmes, including GEWEX (Global Energy and Water Cycle Experiment) within the World Climate Research Programme and the IGBP (International Geosphere-Biosphere Programme), contain various hydrological elements. The products to be studied have been defined from the past experiments and the aims are to provide clear descriptions of soil/ vegetation/atmosphere transfer schemes (SVATS). Joint collaboration on experiments was recommended with an increasing frequency of experiments and looking at the priority issues of tropical deforestation, desertification and trace gas exchange in boreal forests and tundra.

The aims will be to develop mesoscale models andthe studies planned include models for tropical deforestation in Amazonia, commencing in 1993; desertification in Spain and the Sahel, starting in 1991; and trace gas exchange experiments in Canada, commencing in 1993/94. Continental scale studies are planned, including the Continental Scale International Project (CSIP) under GEWEX which will undertake comprehensive monitoring of the Mississippi Basin between 1991 to 1995.

There is an ongoing British commitment through the TIGER (Terrestrial Initiative in Global Environmental Research) Programme which will cover studies in mesoscale experiments, SVATS and global modelling issues. Ultimately Global Hydrological Models are seen as desirable with a possible view to coupling with atmosphere/ocean GCMs if appropriate.

Questions raised related to the availability of hydrological data for large scale modelling and the importance of hydrological assessment on the global scale compared to ocean modelling. Dr Shuttleworth emphasised that the land surface representation is particularly important for regional predictions and impact assessment.

It is hoped that circumstances will allow a future meeting to enable a larger audience to benefit from hearing about the developments in land/ atmosphere studies which Dr Shuttleworth described in his very interesting and informative talk.

Sue Postle
Department of the Environment

Water quality in agricultural catchments

BHS Southern Section Meeting
16 April 1991

The Ministry of Agriculture, Fisheries and Food hosted the BHS Southern Section April meeting and AGM at the ADAS Field Drainage Experimental Unit, Cambridge. The theme for this day reflects the current widespread concern about the impact of agricultural practices on water quality. Papers were presented on various aspects of pesticide, nitrate and organic loadings in surface and ground waters.

Delegates attending this one-day conference were welcomed by the Director of the FDEU, **Doug Castle**, and many of his staff in the foyer of Anstey Hall, Trumpington, Cambridge. MAFF set up the FDEU in the early 1960s to research into aspects of field drainage, in particular the more applied problems facing the agriculture industry at the time. Today the staff, which number more than twenty, continue to carry out a range of field, laboratory and modelling studies of problems relating to land drainage, hydrology and water quality. Much of the experimental work carried out at FDEU is orientated towards a scientific analysis of the causes and mechanisms by which potential pollutants find their way into water bodies.

The first two papers of the day described recent findings relating to pesticide residues in runoff from agricultural catchments. **Graham Harris** (FDEU) summarised some of the results collected to date from a series of catchment studies to assess the environmental impact of agricultural and other land uses on some small (<5 km^2) catchments in central and eastern England. The chosen study areas were all underlain by heavy textured soils with substantial underdrainage networks. However, Graham pointed out that even in the smallest catchment there will be some non-agricultural land that may contribute some contaminants to the surface waters. Major experimental problems are associated with the assessment of the extent of pesticide leaching from soils, primarily due to the low concentrations of the determinands, often at levels <1 gl^{-1}. Current EC legislation specifies acceptable concentrations at levels of 0.1 gl^{-1} for each individual pesticide, up to a total of 0.5 gl^{-1} for a suite of contaminants of potable water. The cost of analysis alone becomes a major factor in the design of any sampling scheme as a result of the level of precision needed to obtain meaningful results. Several pesticides were frequently present in land runoff; these included isoproturon, dimethoate, chlortoluron and, interestingly, atrazine, which is most frequently used as a broad spectrum weedkiller on railway embankments. Occasionally the sampling programme picked up point source contamination which on investigation was linked to an accidental spill in a farmyard.

Joe Gomme (WRc) reported the results of a long-term study funded by Anglian Water and the NRA to relate land use to pesticide concentrations at catchment scale, and to assess the potential threat to groundwater sources of this pollution. A range of herbicides, fungicides and insecticides was investigated in surface and groundwater in the Granta catchment, Cambridgeshire, which is dominated by arable cropping (95%). Pesticide leaching patterns were observed to match flow closely, with marked leaching losses occurring during the January-April period. Isoproturon and mecoprop in particular were found to be a persistent problem, reflecting their heavy usage within the catchment, which is underlain by chalk. In groundwater, simazine and atrazine were found to be additional problems.



Flume monitoring flow, with support water quality monitoring, at the ADAS FDEU set-aside site in Cambridgeshire

Detailed pesticide studies are few and far between, and have only recently emerged into the bright light of day. In contrast, research work on problems of nutrient leaching from agricultural systems has been in progress for many years. The FDEU have been and are still involved in several long-term experiments, the results from one of which were presented in the last paper before lunch. **Steve Rose** (FDEU) selected some recent results from the substantial database built on the Brimstone Farm experiment, Oxfordshire and from a number of FDEU small catchment sites. Eight-year mean nitrate-N losses for drained and undrained treatments clearly demonstrate the control that soil physical conditions exert on nutrient leaching (see Table 1). The dry autumn of 1989 led to low leaching losses, but the subsequent wet December saw a large flush of nitrate-N, with a peak concentration of 63 mgl^{-1} mitrate-N at a 200 ha site near Ashby-de-la-Zouch, Leicestershire.

During the questions following Steve's paper, discussion centred on the possibilities for reducing nitrate concentrations while maintaining intensive production methods. One particular irony was noted: the early sowing of crops will help to reduce nitrate losses, but may well lead to higher pesticide usage to control leaf diseases.

After lunch, conference delegates were shown some of the laboratory and experimental facilities at FDEU. Considerable expertise has been built up at the Unit over the past thirty years into problems of measuring low flow, often <1 ls^{-1}, emanating from field drains and in drainage ditches. Then, prior to the formal conference proceedings commencing again after lunch, **Howard Wheater** (Imperial College) chaired the most succinct and efficient regional group AGM I have ever attended! No dissent, no debate, and all over in the twinkling of an eye!

Richard Williams (IH) began the afternoon session with a paper on the monitoring and the potential hydrodynamic modelling of the fate of pesticides leaching from an



Brimstone Farm, Oxfordshire: pesticide spray deposition testing at a joint ADAS FDEU / AFRC RES site

photographic evidence was presented to illustrate the extent of the problems when they occur. It appears that at dissolved oxygen levels below 5 mgl^{-1} many invertebrates find conditions unsuitable, and move downstream. The presence of sewage fungus was clearly correlated with the contamination of water courses by direct point source agricultural pollution. Graham concluded by outlining a strategy for the evaluation of the impact of agricultural practices based on biological techniques with which the Farm Waste Group of the NRA is currently experimenting.

And so ended what for me was an interesting and stimulating day. Thanks must go to Howard Wheater for organising the conference, and to the staff of FDEU for making us all feel so welcome. I for one felt the journey was worthwhile.

Rob Parkinson
Polytechnic South West

experimental site at the Rosemaund Experimental Husbandry Farm, Herefordshire. Cropping at Rosemaund includes cereals, grass and hops. The latter crop routinely receives a wide range of pesticides, including simazine and paraquat. Richard reported that over a single storm event of 24 hours at the end of February 1989 0.3% (60 g) of simazine was exported in concentrations up to 68 gl^{-1}. For the pesticides being monitored, there was, once again, a direct positive relationship between concentration and flow. Discussion following this paper revolved around the question of the proportion of applied pesticides that were leaching out of soil systems. The consensus was that values <1% were typical.

Graham Rutt (WRc) completed the day with a well illustrated discussion of the impact of dairy farming activities on river water quality. He drew on examples from West Wales, where water pollution from intensive livestock housing is common. Graham distinguished between contrasting types of problem: those regular events, for example caused by yard runoff from parlour washings, contrasted with catastrophic events associated with slurry store failures. In both cases

Table 1. Nitrate leaching losses recorded over an eight-year period at Brimstone Farm

	Cultivation method	Nitrate-N loss $kgha^{-1}y^{-1}$
Drained	Ploughed	38
	Direct drilled	30
Undrained	Ploughed	4
	Direct drilled	8

Operational Experience with FRONTIERS Rainfall Forecasts

BHS Southern Section Meeting Imperial College, 21 May 1991.

Welcoming the audience to this Southern Section meeting, the chairman *Bob Moore*, introduced the speaker, *Rod Brown* from the Meteorological Office. FRONTIERS stands for Forecasting Rainfall Optimised using New Techniques of Interactively Enhanced Radar and Satellite data. It has been operational within the Central Forecasting Office since 1986, and since last October the forecasts have been available to the NRA North West and Thames Regions, for a trial period of one year.

Rod Brown explained that the purpose of FRONTIERS is to combine radar and satellite data into one system to produce short-term rainfall forecasts. There are three parts to each half-hour forecast cycle:

(a) Radar analysis

The radar data can be modified by removing spurious echoes, making a correction for the effect of an increasing radar beam with height, and correcting for the seeder-feeder effect over hills, which intensifies precipitation.

(b) Satellite analysis

A correlation table is constructed which matches radar data with visible and infra-red satellite data at the same point. The probability of precipitation at each point in the image is found and when the probability exceeds a certain threshold, precipitation is indicated in a rain/no rain fashion. This rain/no rain satellite-diagnosed precipitation field is combined with the radar image and any spurious satellite-derived precipitation areas may be removed,

with the help of surface observations.

(c) Forecast

The velocity is found by setting up a radar sequence of consecutive images. Using an estimated velocity in a Lagrangian frame, the sequence is replayed continuously, applying this velocity to the data. If the velocity is correct the field will appear to be stationary within the frame. To allow more variability across the field the picture is split into sectors where each sector is given its own velocity and an intensity trend may also be included.

Following the system's introduction to the Central Forecasting Office, the system was modified so that two extra forecasts are computed using mesoscale model forecast winds, at two heights. Looking at model winds and radar fields prior to the forecast time, and the forecasts themselves, the forecaster can choose which he believes to be the best forecast.

In order to forecast accumulations, wet pixels are tracked individually and are advected using the nearest model wind. In general, advected pixels do not coincide with the grid pixels and so interpolation between neighbouring pixels is carried out. Orographic enhancements and intensity trends are included in finding the accumulations.

The evaluation of FRONTIERS is carried out on-line six times per day. Monthly results for Critical Success Index (a criterion based on the success of forecasting rain over each radar pixel) against time for January, February and March 1991 show that on average FRONTIERS performs better than persistence.

In addition to this on-line evaluation, a one-year trial is being conducted with the NRA North West and Thames Regions, concentrating on the accumulation forecasts. In the North West Region heavy rainfall warnings are issued, for each catchment, when the intensity of rainfall is above a given amount. Comparison between average accumulations from FRONTIERS forecasts over catchments and those from raingauges show that the quality of forecasts is better than when persistence is used but that FRONTIERS forecasts tend to underestimate accumulations.

In the Thames region there is a greater density of raingauges but due to the small size of catchments there are not enough gauges in each. Therefore, a set of artificial rectangular catchments, of two orientations (size 30 x 5 km and 45 by 15 km) have been proposed. Preliminary results show a deterioration of forecast accuracy with time and a smooth increase in a log root mean square error performance criterion (Fig. 1).

The performance of FRONTIERS is variable between events and it is hoped that over the coming year more will be understood about the conditions for which FRONTIERS forecasts are useful and for those where it is not accurate enough.

Discussion

Howard Wheater asked how the corrections for orography were made. Rod Brown replied that daily gauge data from the early 1980s were used in covering events where rainfall patterns were dominated by orographic effects. The basic rainfall rate was subtracted and the orographic enhancement found. Recent studies using a dense gauge network over London on an hourly timescale have given results consistent with the FRONTIERS corrections.

Elizabeth Shaw commented on the difficulties in forecasting precipitation in frontal situations where the front is slowed down over hills or when it is dying out.

A discussion followed on the use of cross-correlation techniques to infer the velocity. The cross-correlation method is the most simple and convenient, but complications occur with this method, for example, when inferring a whole field of velocities. **Rodney Blacknall** also commented on the potential difficulties in matching up precipitation centroids between different time-frames when using a cross-correlation technique.

Chris Haggett (NRA Thames) and **Dawn Hotchkiss** (IH) made brief presentations on their experiences with radar-based rainfall forecasting from an operational and research point-of-view respectively. Chris Haggett reviewed the NRA's assessment of FRONTIERS.

FRONTIERS has long been awaited by the NRA Thames Region, particularly because of the flash flooding problem affecting the London area, where there are some 10,000 properties at risk from a 50-year flood. Convective storms which develop and decay within two hours, and are associated with a lot of rainfall, are of particular concern. Rainfall forecasts with lead times as short as two hours ahead are very useful in such situations and could be of great help in providing effective flood warnings to the general public. Once properties at risk are identified, resources can be targeted towards them. FRONTIERS data are received in instantaneous and accumulated forms at the NRA's flood warning centre at Waltham Cross, and may be displayed by flood duty officers both at work and at home. The 15-minute FRONTIERS accumulation forecasts, up to six hours ahead, on a 5 km grid square, are received every 30 minutes. These are integrated to form subcatchment totals, which typically involves an average area weighting of four or five radar grid squares.

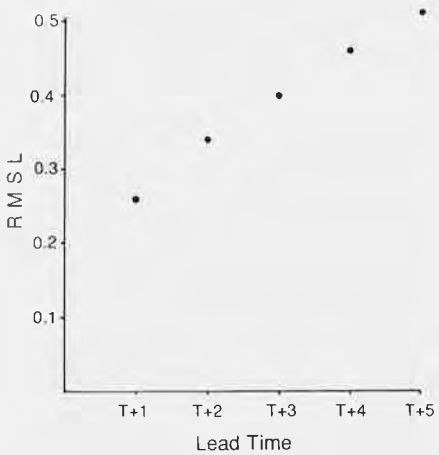


Figure 1. Average RMS error in log_{10} hourly rainfall accumulations for events in NRA Thames Region

An example using FRONTIERS accumulations and a rainfall-runoff model to forecast flows in the Silk Stream catchment shows that FRONTIERS performs well, on average, across all lead times. The quality of forecasts for individual lead times is more variable. Analysis of further events are planned, as well as an assessment of the IH high resolution Local Radar-Rainfall forecasting system.

Dawn Hotchkiss described briefly the IH Local Radar-Rainfall Forecasting System.This uses data from a single weather radar, at Chenies, to produce forecasts on a 2 km grid, updated automatically every 15 minutes and focusing on lead times up to 2 hours ahead. The Local Forecasting method infers a velocity for the whole 76 km radius field. The original radar field is advected forward with this velocity over all lead times, to produce the forecasts. Growth, decay, acceleration and rotation terms are not included. An evaluation on 15 events indicates that the simple advection method performs better than persistence and better than a more complex formulation, involving an acceleration term. A shrinking term which reduces the forecast field to its average value at high lead times has provided further improvement.

The overall pattern of rainfall forecasts are reasonable up to a lead time of about 60 minutes; after this time the forecast field becomes a lot smoother. Use of a single radar means that the area over which it is possible to find a forecast can diminish with increasing lead time. However, this is not often a serious problem up to 2 hours ahead. It is estimated that the method can construct forecasts up to 2 hours ahead in just over 10 seconds of CPU time on a VAX 4000-200. A comparison of 15-minute FRONTIERS accumulations with those produced by the Local Forecasting method, using the Critical Success Index, indicates a cross-over in performance, with FRONTIERS performing better at lead times greater than 2 hours.

Flood Channel Design — The Californian Experience

Joint BHS/IWEM Meeting
Imperial College, London
4 June 1991

A summary of a presentation given by Philip B. Williams to a joint meeting of the River Engineering Section of IWEM and the Southern Section of the British Hydrological Society.

All the case studies and practical examples at this meeting were taken from the West Coast of the USA, centred on San Francisco and nearby cities.

Climate in the region was described as Mediterranean: hot during the summer months and precipitous, primarily during the winter months. However, seasonal weather is highly variable from year to year.

Over the past 40 years there has been a large influx of population to the area and a corresponding increase in urbanisation. Hence channels built in the 1950s now need an increase in capacity because of the rise in runoff from storms. This increase is caused by additional impervious areas and by improved drainage systems.

Many of these channels were built by the UK Corps of Engineers to a standard trapezoidal concrete lined design. However, public attitude is changing: people no longer want concrete channels devoid of plant life running through their cities where once natural rivers used to flow. The Los Angeles river is an example of the former standard design.

Traditional Flood Control

The US Corps of Engineers have dictated design methods in the USA for the past 40 years. Their strategy was one of flood fighting as opposed to flood management.The main criticisms that the speaker had of traditional flood control methods were:

Channel design was single purpose and not multipurpose. It was solely to alleviate flooding, with no environmental enhancement considered.

Hydraulic engineering was not a multi-disciplinary expertise. Specialist areas of expertise such as geomorphology and hydrology needed more emphasis.

Rivers had been subjected to channelization, not management policies.

Planning problems with traditional flood control design

Most projects have been designed for a 100-200 year return period event, hence design floods have not yet been experienced on most schemes. However, smaller floods have occurred and they indicate that the adopted methods of flood protection may not operate as designed.These can be categorized under the following headings:

Factors affecting flood risk excluded

Failure mechanisms were not examined. An example of this is the Sacramento flood. A dam was being constructed upstream of a flood control reservoir within the protection of a cofferdam built to withstand a 10 year flood. The cofferdam rapidly overtopped and failed, spilling into the reservoir downstream. Due to the surge of water into the reservoir the control gates on the dam had to be opened to beyond its design limit, causing extensive flood damage downstream. One solution is to build yet another dam downstream of the existing one!

No monitoring and no feedback

Design of the capital works was divorced from maintenance. Maintenance did not receive the importance that is needed to ensure that flood alleviation schemes remain effective. This was largely due to the fact that the cost of regular maintenance is not included in local budgets. As an example, trapezoidal channel design often does not take vegetation growth into account. Hence there is a need for better total scheme life planning.

Technical problems with traditional flood control design

Many designs assume clear water flow, which is not necessarily valid, especially in times of flood. In many cases trapezoidal channels have silted up, causing a rise in flood levels. Roughness factors are increased by high sediment load and this can affect levels, especially where supercritical flow is required in the design.

Debris can also be a serious problem. The severity of this hazard can vary depending on local natural conditions. For example debris in moderate floods can easily consist of a forest of logs in certain parts of the USA, causing near-total blockage of some bridges.

Manning's equation is relied upon to represent open channel flow, yet it is not always applied properly. Factors affecting 'n' include sediment size, channel pattern, debris, turbulence, bed morphology, and vegetation. However, it is the vegetation that is used predominantly to determine the coefficient. It is also important to remember that the equation was based on results from tests carried out mainly in irrigation channels.

The emphasis on clearing vegetation can actually make matters worse. Where a local authority's maintenance budget does not allow clearance or waterways every year, but only every two to three years, the most usual state of vegetation gives the worst value of Manning's 'n'. If left to itself the channel could stabilise with acceptable vegetation growth, as in-channel vegetation would be shaded out by bankside growth.

Scour is another matter for conjecture. Because of the lack of knowledge, scour is protected against whenever possible. Certainly its effects on bridge foundations can be catastrophic, but, if conditions are possible, scour may be allowed to alter the bed morphology. Erosion of the bed could increase a river's capacity during a flood and the subsequent recession of flow would allow the sediment to be deposited into pools created by the erosion.

Paving the bed under such conditions could make matters worse, with sediment raining the channel bed during the receding flood, and hence reducing its capacity.

New Approach

The new approach to flood design suggested by the speaker can be summarized as follows:
Utilize an integrated flood protection design.
Clearly identify design objectives.
Understand the physical systems.
Devise maintenance programmes.

The method suggested for use to a greater extent in the USA is that of the two stage channel, where a small channel with a capacity for low flow is located within a large flood channel. Maintenance is kept to a minimum by encouraging a canopy of vegetation over the low flow channel, whilst design roughness values are used which take this vegetation into consideration. The majority of the flood channel would be planted with grass to ensure its appearance is acceptable for environmental and aesthetic reasons.

Discussion:

John Gardiner (NRA Thames Region) said that two-stage channels had been used in this country since the early 70s and were working very well. Nevertheless some improvements could still be made.

He suggested that more use could be made of grass swales and hydrobrakes in drainage systems, to reduce the time of concentration of residential development areas. This could reduce the rate of runoff to the receiving watercourse.

Phil Johnson (NRA Thames Region) asked what research had been carried out into two-stage channel conveyance and hydraulic assessment, and hence the basis of their design. Philip Williams admitted that because of a lack of knowledge in this area a conservative design had to be made.

Prof. Peter Wolf (City University) pointed out that Lindsay, Lacy, *et al.* had researched non-trapezoidal channels, including those with sediment deposits. John Francis had written many papers aboutManning's 'n'.

Jack Levy (NRA Thames Region) asked if the speaker believed that roughness is changed by sediment load due to changes in bed profile or due to the actual sediment load? Philip Williams responded that both of these affected Manning's 'n', with more emphasis on the effect that sediment has on the bed profile.

Peter Wyllie was concerned about the assumption that sediment would be washed away under high flows in natural channels. He felt that it could in fact bind together to form obstructions to flow.

BHS 'Rolling Programme' of future meetings

Date	Venue	Theme	Associated Organisation	Organiser
1991				
* 16-18 Sept	Southampton	3rd National Hydrology Symposium		Dr A Gurnell, Dept of Geography, Univ. of Southampton, SO9 5NH.
* 2 Dec (AGM)	ICE, London	Climatic change and the Hydrological cycle		Dr C Collier, HD(NS), Met. Office, Rm R322, London Road, Bracknell, RG12 2SZ
1992				
*+ Feb	ICE, London	Hydrology and water quality in development control	Instn Mun Engrs IWEM	Dr H Wheater, Dept of Civil Eng., Imperial College, London, SW7 2BU.
*+10-12 April	Newcastle	Third postgraduate hydrology symposium		Dr J Bathurst, Dept of Civil Eng., Cassie Building, Newcastle upon Tyne, NE1 7RU.
*+Early June	ICE, London	Consulting overseas - perils, problems and practicalities		Dr R Harpin, Sir Wm Halcrow & Ptnrs, Burderop Park, Swindon, SN4 0QD.
*+24-27 June	Stirling	Planning and development of Water Resources and Reservoir Engineering	British Dam Society/ Scottish Hydrological Group/IWEM	Dr S Walker, NRA NW Region, P O Box 12, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG.
+ 21 or 21 Sept	Leeds	Preferential transport of sediments and solutes from uplands to estuaries	ICE Pennines Group	Prof M J Kirkby, Dept of Geography, Univ. of Leeds, LS2 9JT.
*14 Dec (AGM)	Sheffield	Land use change impacts		Dr R Ferguson, Univ. of Sheffield & Dr J Bathurst, Dept of Civil Eng., Univ. of Newcastle, Cassie Building, NE1 7RU.

*National Meeting
+Meetings for which the programme is not yet confirmed; contributions are invited.

OBITUARY: John Pirt

Hydrology, Sunderland football Club, Cricket, Boddington's and Restaurants - themes that together remind me of John Pirt as we mourn his tragic death.

Born and brought up in the north-east, John crossed the national divide to study at Lancaster University before joining the water industry in which he rose to Principal Catchment Manager of the Lower Trent Area in the National Rivers Authority, Severn Trent Region.

I first met John in 1980 when he began a part-time research programme at Loughborough. His research was motivated by a desire to improve the application of hydrology within the water industry. I quote the Preface of his thesis:

"In the course of my duties as a hydrologist with a British Regional Water Authority, I am frequently required to derive river flow statistics for catchments for which there is little or no measured flow data. Whilst there are many existing methods by which flows may be estimated, my experience has been that the majority of these approaches are unreliable!"

The research was highly successful and his external examiner considered his thesis "the best he had seen for several years". John was my first PhD student and also the first in the new Geography Department at Loughborough. The Abstract of his thesis is reproduced below.

John played a very active role in the development of hydrology, especially its application within the water industry. Most recently he was a very effective Project Leader, and Chairman of the Advisory Group, of the NRA's R & D project on Low Flow Estimation in Artificially Influenced Catchments.

He was an active member of the BHS and meetings of the BHS Main Committee were strengthened by John's pragmatism, honesty and common sense! Over the years he served on several sub-committees, including those dealing with British Standards. He was instrumental in developing the Midlands Region of the British Hydrological Society and became a very effective coordinator of our regional activities. He had great vision, and was able to conceive of themes for our meetings that were both topical and of interest to the practitioner and academic alike.

John was a man's man - the evening after Main Committee meetings often involved a few pints of Boddi's or a meal at a new restaurant he had discovered. The conversation quickly turned to sport: the problems of English football and perhaps greater problems of English cricket were explored in great detail. His knowledge of most sports was excellent and he was a useful footballer before an injury terminated his career but he remained a very able

cricketer as a batsman-wicketkeeper.

In all aspects of his life John was a character: a man with strong personality but a great sense of humour. He will be missed by the water industry, the British Hydrological Society, and his home community of Gotham in Nottinghamshire where he was a well-known figure. He leaves a wife Sheila and two daughters.

The Estimation of River Flows in Ungauged Catchments
Doctoral Thesis by John Pirt. Loughborough University of Technology (1983). Abstract:

An appraisal of existing river flow estimation techniques shows many of the methods to have deficiencies. Low flow calculation procedures take insufficient account of the influences of mans activities and catchment geology on runoff, and high flow estimation techniques, which take the form of simple parametric equations or linear synthesis models, do not reflect the non-linear processes of natural catchments. As alternatives to the existing methods, a number of user orientated, conceptual estimation techniques are developed by analysis of measured runoff and precipitation data from the Trent basin. This is a catchment of 8200 km draining much of the Midlands of England. Catchment properties which cannot be measured directly: morphology, geology, surface deposits and land use, are represented by numerical indices in the computational procedures. for example, a quantification of catchment geology in terms of dry weather flow runoff yield is advocated. In all, six types of data can be calculated for the ungauged case: Dry Weather Flows, Average Flows, Flow duration Curves, Flow Frequency Curves and Forecasts and Predictions of the Hydrographs resulting from storm rainfalls. Several different analytical techniques are used in the derivation processes, including: maps, residual flow diagrams, dimensionless base curves, regression equations and a nine parameter conceptual computer model. The derived techniques are shown to be accurate and reliable for application both within the Trent basin and a number of other catchments in the North of England. The procedures are also superior to those advocated in the Institute of Hydrology's 'Low Flow Study' and 'Flood Studies Report' for flow duration curve, flow frequency curve and hydrograph simulation.

During his period of research John produced two Occasional Papers entitled 'Low Flow Estimation in Ungauged Catchments' and 'A Simple Model to Simulate Catchment Response to Rainfall'. I would be pleased to reproduce these if anyone would like a copy.

Geoff Petts

BHS in Vienna

All BHS members going to the IUGG Meeting in Vienna, 11-24 August, should note that the Society is sharing a stand with the Institute of Hydrology. You will find us on Stand number H2/9 in Halle H2 in the Messepalast, Vienna.

The display material on show by both BHS and IH will be self-explanatory but we hope to arrange an informal rota so that someone for the UK is on the stand for a set period each day. So if you are looking for a friendly face or need some compatriot help, do come along.

Further British support will also be available in the form of Penny Kisby and Sarah Cage who will be manning the bookstall at the IAHS Information Centre.

HYDROLOGIST
Information Systems

Peterborough

£17,436 - £19,350 pay award pending

NRA

Anglian Region

We need a Hydrologist to join a team working on information systems in relation to Water Resources. This involves the development of systems for the processing and analysis of hydrometric data, co-ordinating the water resources input to geographical information systems, and hydrological analysis for regional studies including the use of mathematical models. Based at our Regional Headquarters in Peterborough you will make an important contribution to the management of water resources throughout East Anglia.

We are looking for someone with qualifications and experience in surface water hydrology, computing and mathematics/statistics. This will be the equivalent of a further degree in hydrology plus at least 5 years' relevant experience. It is essential that you are familiar with large databases. You must be able to program in Fortran and demonstrate an aptitude for the use of mathematical models, hydrological and business applications packages. You must be able to work on your own initiative, communicate effectively both orally and in writing, and manage a small team.

The National Rivers Authority is Europe's largest environmental protection agency and the benefits are those you would associate with a large progressive organisation. These include 26 days' holiday and an optional contributory pension scheme.

Prospective applicants are welcome to contact Nigel Fawthrop on Peterborough (0733) 371811 to discuss the job further. Application forms and a full job description are available from the Personnel Department, National Rivers Authority, Anglian Region, Kingfisher House, Goldhay Way, Orton Goldhay, Peterborough PE2 0ZR. Telephone: 0733 371811 ext 4353. The closing date is Monday 9 September 1991.

NRA is an Equal Opportunities employer.

EGS Assembly

The newly-formed hydrological section of the Wiesbaden Assembly of the European Geophysical Society in April was a great success. **Prof. Enda O'Connell**'s report will appear in the next issue of *Circulation*.

The next EGS Assembly in Edinburgh (6 - 10 April 1992) will have a full hydrological programme; the Second BHS Postgraduate Symposium will follow it (10 - 12 April). Papers are invited for both meetings: the deadline for the receipt of abstracts for the EGS Assembly is **15 December 1991**.

Information is available from Prof. Enda O'Connell and Dr James Bathurst, both at the Department of Civil Engineering, Cassie Building, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU. Fax 091 222 6669.

UK International Hydrology Programme (IHP) Committee

Although the IHP is sponsored by UNESCO and the UK has not rejoined that body, it has been possible to negotiate a formal Memorandum of Understanding to set up the UK IHP Committee. If you would like details, please contact **Frank Law** at the Institute of Hydrology. He can also supply a copy of the many IHP Phase IV sub-programme descriptions.

For efficiency, the Inter-departmental Committee on Hydrology (see *Circulation 26*, May 1990) also now acts as the UK IHP Committee. However, when it next meets on 28 November, under the chairmanship of **Prof. Brian Wilkinson**, an agenda item proposes that the latter committee be expanded to include a representative of UK hydrological consultancies.

The immediate need is to locate any researchers in the UK who are already contributing to an IHP Phase IV project or intend to do so shortly. This will enable the committee to foster effective communications and (who knows?) perhaps aid the flow of funds in appropriate directions. Please write to Prof. Brian Wilkinson at IH before 28 November if you are an IHP participant.

News from members

Honours list

Congratulations to **David Rodda** who received an OBE in the Queen's Birthday honours. David is in DoE's Water Research section of the Water Directorate, often representing the UK at EC and UN meetings.

Treasurer on the move

Dr Susan Walker, the Hon. Treasurer of the British Hydrological Society, has just left North West Water Limited to become Regional Water Resources Manager for the North West Region of the National Rivers Authority.

Her address is now NRA North West Region, Richard Fairclough House, P.O. Box 12, Knutsford Road, Warrington, WA4 1HG. Tel.: 0925 53999; Fax: 0925 415961; Telex 628425.



Minister visits IH

Alan Howarth, MP, Minister for Science at the Department of Education and Science (above, centre), visited the Institute of Hydrology recently, providing a welcome opportunity for media coverage of the Institute's research overseas. Both Radio Oxford and Central News South gave 'prime time' exposure to the Minister's comments.

New Secretary of Scottish Hydrological Group

From 1 August 1991, the Secretary of the ICE Scottish Hydrological Group will be **Dr David Gilvear**, Department of Environmental Science, University of Stirling, Stirling, FK9 4LA. Telephone: 0786 731711.

Nepal programme launched

Sir Crispin Tickell and **Prof Brian Wilkinson** have officially launched a three-year programme on environmental research into water, erosion and land management in Nepal. This joint project between the Institute of Hydrology, the Royal Geographical Society and His Majesty's Government, Nepal, is sited in the Kikhu Khola catchment in the Middle Hills of Nepal, about 50 km from Kathmandu. Welcome support is being provided by the UK Overseas Development Administration (in the shape of funding) and by Landrover (in the useful shape of a vehicle).

New Members

We welcome the following new members to the Society:

Afolalu, J. ..... Rotterdam, The Netherlands
Bajabaa, S. ..... Geography & Geology Dept., St Andrews University
Blackall, R.M. ..... UK Meteorological Office
Cooper, D.M. ..... Institute of Hydrology
Curran, J.C. ..... Clyde River Purification Board, East Kilbride
Dunn, S.M. ..... Civil Eng. Dept., University of Newcastle upon Tyne
Dunthorne, S.J. ..... Tilehurst, Berkshire
El-Hames, A.S. ..... Geography Dept., Cambridge University
Grimes, D.I.F. ..... Meteorology Dept., Reading University
Riley, M. ..... North Shields, Tyne & Wear
Witton, K.E. ..... Chester

Hydrology and water power development

The report of the BHS/Scottish Hydrological Group's one-day meeting, held in Glasgow on 14th June, has been held over until the next issue of *Circulation* because of a lack of space in this issue.

Books

Applied Chemical and Isotopic Groundwater Hydrology. E Mazor. 1991. Open University Press, Milton Keynes. 274 pp, £37.50, hardback.

This is a very readable and well written book which outlines basic techniques of hydrochemistry and is packed with practical examples. It is written in a pleasant quizzical style, posing questions and supplying answers. The contents could be considered as a "two phase" system: the first phase consists of the first five chapters and a significant part of other chapters and is that of a teaching text book. Considering the specialist readers likely to use this book, it is at a rather basic level with over-emphasis on very simple arithmetic - several examples of determining the percentage components in a mixture of waters which, after the second example, rather insults the reader. The second phase is more meaty with logical explanations of techniques and field studies and how these can be applied to wider problems.

There are 14 chapters, the first five being a very simple introduction to groundwater hydrology and, as mentioned above, not totally appropriate to a specialist book. The most notable section in these chapters relates to groundwater temperature, a somewhat neglected subject which actually provides a very powerful (and inexpensive) tool in large scale studies.

The book starts to raise its profile in Chapter 6 on chemical parameters which gives a good outline, again with examples, of the techniques of "finger-printing". This involves plotting the relative concentration of some seven (or more) dissolved ions such as Ca, Na, K, Mg, HCO_3, Cl and SO_4. By comparing the patterns from different sampling points, water mixing becomes evident and anomalies provide further hydrological and geochemical information.

Chapters 7 and 8 revert to the teaching mode and the need for care in sample collection and measurement. A good chapter follows on the principles of stable deuterium and oxygen isotope variations and the following one deals with tritium with many examples. The principles of carbon-14 "dating" are given but the problems associated with the ^{13}C values and the input concentration of ^{14}C are not considered in detail. The interpretation of ^{14}C data in terms of 'age' of the water is rather side-stepped and the author sees carbon isotopes as "providing relative ages". Perhaps he is right in avoiding the detailed geochemistry and falling into the trap of over-interpreting the data.

The chapter on Noble Gases is excellent and deals with the Ne, Ar, Kr and Xe content of samples and the interpretation of this in terms of temperature/altitude of recharge. The use of ^4He of radiogenic origin (from uranium minerals) as an age indicator is dealt with very superficially with no examples.

A chapter on the monitoring of contaminants is primarily concerned with the value of industrial and agricultural chemicals as large-scale tracers. Eighteen case studies illustrate the information which pollutants can provide. The final chapter is on the need for the preparation of hydrochemists' reports, again reverting to a very simple teaching mode.

One is struck by two omissions from the book. The first is the almost total absence of the word 'computer' and there is never an emphasis on the need for modelling, most of the interpretation being graphical. The second is the lack of one or two more detailed examples which use all, or almost all, of the many techniques described. Such a chapter would have been a great improvement on the "hydrochemists' reports" dissertation with which to end the book on a highlight.

In spite of the criticism in this review, the book is very well written, a clear explanation of groundwater hydrochemistry and an up to date presentation of the subject with numerous examples and 130 useful references.

It is recommended for perusal before taking its place on the bookshelf to be available as required when groundwater problems have to be tackled.

D.B. Smith
Wantage

Hydrotitles. Geosystems, P.O. Box 40, Didcot, Oxon. Six issues per annum. £75.

For the hydrologist attempting to keep pace with the never-ending flood of new publications this may seem a valuable source of help in tracing useful references, as it has the stated aim of

helping to "keep pace with advances in hydrology and associated subjects".

As its name suggests, this periodical provides the titles (but not abstracts) of papers, together with authors' names, publication source and year. As such it is obviously less immediately useful than an abstracting journal, but it does provide a compact source of references (about 1000 in 18 pages) and might perhaps encourage writers to think more carefully about the choice of wording in their titles!

Hydrotitles has been published by Geosystems since 1988 and it follows that organisation's unique classification scheme, developed in the 1960s principally for the geological sciences. Therein lay some of the problems with the early issues of this publication, since hydrology did not immediately fit well into that system. There was, for example, no section devoted to the atmospheric components of the hydrological cycle.

Some of these problems were acknowledged by its compilers in late 1990 when, following comments in a draft review, they considerably improved the structure of the classification. Thus anyone familiar with the 'old' *Hydrotitles* should be pleased to see that there are now separate sections devoted to precipitation and evaporation, and a great deal of the former duplication and ambiguities have been removed.

The system still has a few 'rough edges': for example it is still necessary to search for items on instrumentation under both 'Hydrometry' and 'Hydrological equipment'. Similarly there are different sections in the classification for 'Suspended load' and 'Suspended solid content of water'. Thus, compared to some of the rival publications available, it is still a little messy to use.

Some of the shortcomings of the printed *Hydrotitles* and its indexing may be overcome by using the online computer database equivalent, *Geoarchive* (Dialog File 58). However, like *Hydrotitles* and its sister publication *Geotitles* (both of which go to make up *Geoarchive*), the database does not contain abstracts, so searching for meaningful subject terms still relies on titles and indexing terms. This places it at a disadvantage when compared to abstract-providing competitors such as *Aqualine* and *Water Resources Abstracts*, since natural language searching can often be very useful in picking out relevant references.

Geoarchive is a relatively large database, on a widely-used host, and in the expensive world of online searching it is reasonably priced. With its strong geological bias it is likely to prove most valuable for searches concerned with the groundwater element of the hydrological cycle.

Mark Robinson & Sue Wharton
Institute of Hydrology

FORTHCOMING EVENTS

Hydrogeology Research Group,
University of Birmingham

and

Centre for Groundwater Research,
University of Waterloo, Ontario

present a short course on

Organic pollution of groundwater

Grand Hotel, Birmingham, 21-24th October 1991

This four day course provides a detailed and up-to-date coverage of the processes controlling non-aqueous phase liquid (NAPL) and dissolved organic contaminant behaviour in the subsurface. The lecture and discussion sessions integrate field observations, laboratory experimentation and theory. They will emphasise implications for monitoring and remediation, and include critical reviews of selected case histories.

This course is designed for consultants, regulators and managers who are responsible for investigating and remediating pollution of groundwater by organic contaminants. No prior knowledge of organic contaminant behaviour is needed, although a basic knowledge of groundwater flow would be advantageous.

The fee is £550, excluding accommodation. For further details contact Vanessa Chesterton, School of Earth Sciences, University of Birmingham, Birmingham, B15 2TT, UK. Tel: 021 414 6751, Fax: 021 414 3971.

Meetings

Institution of Civil Engineers
Symposium on
ENGINEERING IN THE UNCERTAINTY OF CLIMATIC CHANGE
28 October 1992
ICE, London

Since the greenhouse effect and the resulting climatic change are now firmly on the national and international agenda, Governments are concerned about how best to limit the effects. As the consequences of climatic change for engineers could be far reaching for water resources and water supply, maritime engineering, energy production, stuructures and geotechnics, this symposium aims to clarify the implications for civil engineers and to discuss

what actions should be taken now.

Further details from: The Conference Office, ICE, 1 Great George Street, London SW1P 3AA.

International Symposium on SNOW and GLACIER HYDROLOGY 16-21 November 1992 Kathmandu, Nepal

Organised as part of the Snow and Glacier Hydrology Project, begun in 1987 by the Nepalese government's Department of Hydrology and Meteorology, this symposium will concentrate on snow glacier hydrology in mountainous areas. Papers are invited on topics such as design and operation of measuring services, data bases for water resource management, hydrometeorological processes, models for melt and runoff simulation/ forecasting, effects of climate change, regional and global comparisons and institutional cooperation.

Abstracts of about 300 words (with drafts of principal figures and tables) are required by 15 March 1992. Note that air mail letters may take three weeks to reach Nepal.

The secretary of the organising committee is Mr Adarsha P. Pokhrel, Dept of Hydrology and Meteorology, P.O. Box 406, Babar Mahal, Kathmandu, Nepal. Tel. +977 1 226374, Fax +977 1 521982, Telex NP 2334 GTZ KTM.

International Conference Technology Transfer THE BUSINESS OF WATER QUALITY - A GLOBAL PERSEPCTIVE 15-20 September 1991 Paris and Bath

Co-sponsored by Wessex Water, AWWA Research Foundation of America, Lyonnaise des Eaux-Dumez and WRc, the conference venue will span the English Channel with a one-day tour of research and water treatment facilities in Paris, followed by an intensive three-day technical conference based at Bath University.

It will provide an opportunity for speakers from the UK and France to discuss their experiences with water privatisation and for delegates from the United States to discuss similar opportunities in America.

Subjects on the agenda include: The business of supplying water; Post-treatment concerns and issues; Disinfection by-products; Advanced treatment processes.

For further details contact Carol Rodaway, Wessex Water, 0272 290611.

Diary

16-18 September 1991
BHS 3rd National Symposium
University of Southampton.
[further details on front page]

19th September 1991
Welsh Hydrological Group AGM
"The Lynmouth flood disaster 40 years on – what lessons have we learned?"
W. B. Harris
Venue: University College, Cardiff

19th September 1991
Hydraulics Research Ltd
Seminar on "Data collection for water quality models"
Contact: HRL, Wallingford, 0491 35381.

22-24 September 1991
IWEM/ICE/IAHR/Uniras Second International Conference:Hydraulic and Environmental Modelling of Coast, Estuarine and River Waters.
Dept of Civil Engineering, Bradford University.

23rd September 1991
Fellowship of Engineering/Royal Society Lecture by Dr Frank Press, originator of the International Decade for Natural Disaster Reduction.
Venue: Royal Society, London
Time: 5.30 p.m.

3rd October 1991
Hydraulics Research Ltd
Seminar on "Prediction and control of water quality". Tel. 0491 35381.

8th October 1991
Scottish Hydrological Group
"Risk, reliability and levels of service in water resources and water supply"
Prof. P. Jowitt, Heriot-Watt University
Time: 6.30 p.m. (tea at 6.00 p.m.)
Venue: Royal Society of Edinburgh

Copy Deadline for Issue No. 32 4th October 1991

16th October 1991
BHS Southern Section
"River sedimentation problems"
Time: 6.00 p.m. (tea at 5.30 p.m.)
Venue: Imperial College, London

6th November 1991
BHS Southern Section
"Hydrology & water-related diseases"
Time: 6.00 p.m. (tea at 5.30 p.m.)
Venue: Imperial College, London

19th November 1991
Welsh Hydrological Group
"The use of models in combating coastal pollution"
Prof. R. Falconer, Bradford University
Venue: NRA Head Office, St Mellons, Cardiff

2nd December 1991
BHS AGM followed by National Meeting: "Climate change and the Hydrological Cycle"
Instn Civil Engineers, London.
Contact: Dr C. Collier, Tel: 0344 856244

11th December 1991
BHS Southern Section
"Flood management in large river basins – an overseas view"
Time: 6.00 p.m. (tea at 5.30 p.m.)
Venue: Imperial College, London

11th December 1991
Scottish Hydrological Group
"Scotland's weather radar"
Visit to Glasgow Weather Centre
Time: 2.00 p.m. (lasting 2 - 2½ hours)
Booking necessary: 0786 731711.

8th – 9th January 1992
British Geomorphological Research Group/Biogeography Research Group Symposium on "The effects of environmental change on geomorphic processes and biota in arid and semi-arid regions".
Venue: University College, Swansea.
Contact: Andrew Millington, FAX 0734 755865

21st January 1992
Scottish Hydrological Group
"Regulated and low flows and their effects on fish movement and conservation".
N. W. Graesser, Fishery consultant
Time: 6.30 p.m. (tea at 6.00 p.m.)
Venue: Royal Society of Edinburgh

23rd January 1992
Welsh Hydrological Group
"Groundwater resource investigation".
A. Willis and R. Hawnt
Venue: University College, Cardiff

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 £17. All enquiries concerning membership should be made to Peter Bacos, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA. Telephone 071 222 7722. Please address all other correspondence to the Editor, Celia Kirby, Institute of Hydrology, Wallingford, OX10 8BB. Telephone: 0491-38800 extension 2360.