THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

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Flooding in Pakistan

The recent visit of Paul Webster to the Centre of Excellence in Water Resources Engineering in Lahore, Pakistan, coincided with some of the worst flooding experienced in parts of the Indus basin this century. The following notes have been compiled by him from a variety of sources including the *Pakistan Times*, *The Muslim*, Pakistan television and the BBC Radio World Service.

The disaster unfolds

Heavy showers had accompanied my arrival in Lahore on 10 September. The airport recorded 68 mm during the day, with 177 mm at Faisalabad, approximately 150 km to the west. Of greater significance was the fact that similar totals to those recorded at Faisalabad had fallen over the tributaries of the River Indus. The catchments of the Chenab and Jhelum rivers had experienced the heaviest rain.

The first reports of serious damage were received within 24 hours and government officials undertook an immediate tour, accompanied by senior army officials and press photographers. The television pictures revealed that in the disputed area of Jammu and Kashmir, on the India-Pakistan border, the rivers had cut a swathe through the valley bottoms, sweeping away roads and bridges in their path. River discharges had recessed rapidly to comparatively normal levels and could be seen as an angry, but diminutive flows in the enlarged flood channels.

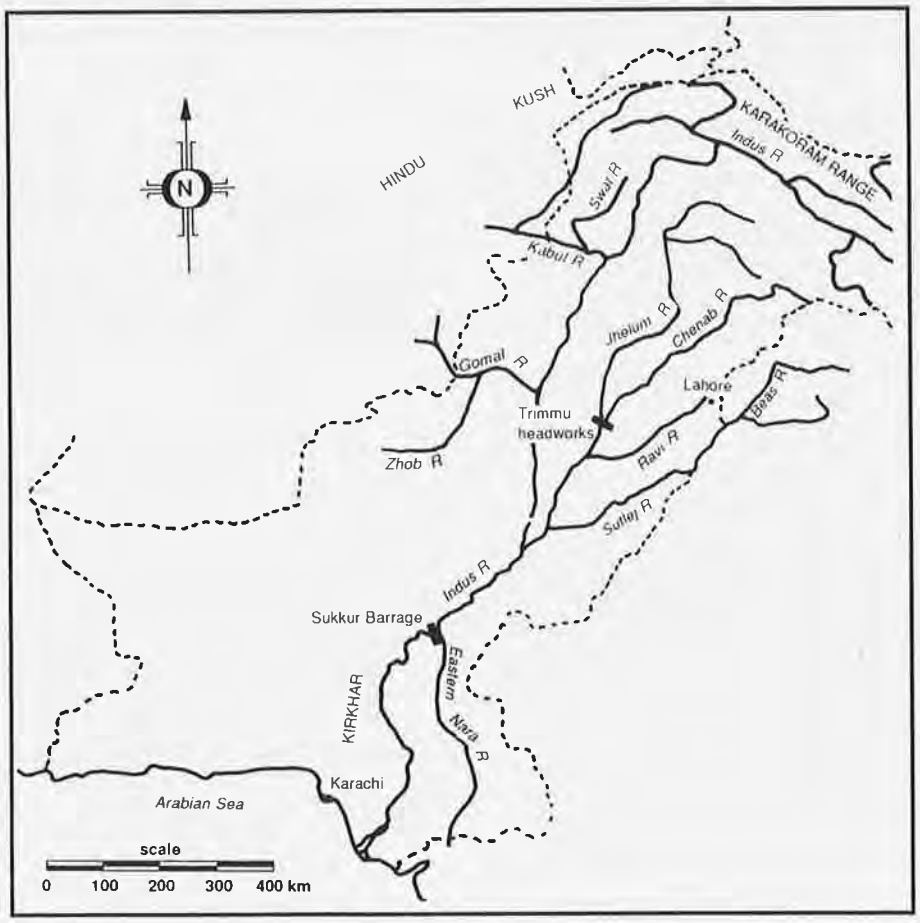
Although the threat of landslides and the plight of remote villages that remained cut off continued to dominate local interest in Kashmir, the downstream communities of the Indus Basin prepared themselves as best they could.

The agricultural regions of the Punjab lay next in the path of the flood waters. The greatest threat was posed by the Jhelum which had peaked at 28 000 m^3s^{-1} as it emerged from the mountainous part of its catchment. The peak of the Chenab at 11 000 m^3s^{-1} also posed a serious threat. The principal fear amongst officials was that although these peaks would be subject to attenuation as they flowed over the flatter flood plains of the Punjab, the coincidence of their peaks at the confluence would spell disaster for the Trimmu headworks.

The Government Response

The response of government officials comprised three principal actions:

- flood monitoring and river engineering;
- evacuation of villages at risk, and
- rescue and relief.



The National Flood Forecasting and Warning Centre of the Department of Meteorology plays a key role in the monitoring of floods and release of forecasts. Forecasts made by the Centre provided the basis for river engineers to take emergency measures.

In areas not yet affected by flood waters, the army and civilians worked with the assistance of bulldozers to strengthen and raise embankments at critical locations. In areas already subject to flooding, the risk of damage at key installations could be reduced by breaching flood embankments. Upstream of the Trimmu headworks, for example, explosive charges were detonated under both the left and right flood embankments. These led to the diversion of 5000 m^3s^{-1} around the works. The resultant peak discharge at the headworks was 17 300 m^3s^{-1}, just below the design discharge of 18 400 m^3s^{-1}.

Evacuation of villages at risk was undertaken in a massive army and civilian operation. In spite of the considerable efforts of the officials concerned, it proved impossible to evacuate all villages. Some residents did not wish to leave their homes, and others simply could not be reached. Television pictures taken from helicopters flying over the flood affected area illustrated the plight of these people as they strove to survive on roof tops and tiny island havens.

In areas already affected by flooding, the army was again active in mounting a massive rescue and relief operation. Health centres and food distribution centres were set up, and air force helicopters did their best to reach the stranded people.

The Damage Report

The summary statistics presented in this Section were compiled during the flooding. They are almost certainly under-estimates of the true picture, which will only emerge after a full analysis:

- 2000 persons dead or missing (400 in India)
- 100,000 villages flooded or partially inundated
- 500,000 people moved from their homes
- 0.6 million ha of crops flooded
- Rs 3 billion (£70 million) damage to crops

Although the immediate impact of the flooding was borne by those residing in the flood zone, the effects will in time be borne more evenly by the nation. Market prices of much produce had risen sharply in the days following the flooding in anticipation of shortages. Similarly, the crop damage, particularly to cotton, will do considerable damage to future export earnings.

At their height, the floods made the centre of the Punjab resemble an inland sea. Damage was particularly severe in this area, both to human life and property. The area downstream of Mangla Dam was exceptionally hard hit. Apparently, only small releases were made from the reservoir up to the commencement of the period of flooding. The sudden onset of flooding forced the operators to increase releases rapidly, without full warning to the downstream villages, resulting in serious loss of life. Newspaper reports indicated that the reservoir engineer had been arrested and that the matter was under detailed investigation.

A particularly harrowing story was recounted to me of one of the students at the Centre in Lahore. He had returned to his village to find no sign of his family, his home or even his village. His efforts to trace his parents or his friends through the relief centres had met with no success.

Mercifully for the people in Sind Province, the River Indus was not itself in high flood, and the main channel was able to accommodate the combined flows of the Indus and its tributaries with only limited damage. No emergency breaching of embankments was necessary at either the Kotri or Sukkur barrages.

An 'eye-witness' account

As a practical hydrologist who believes that one's hydrological experience is enhanced by witnessing major floods, I was understandably keen to visit the affected area, but the floods had caused massive disruption to the communication network. The chaotic transportation situation in the vicinity of the flood was a point not lost on my hosts, who sensibly recommended that we remain in the vicinity of Lahore.

However, in following up some leads at the Meteorological Department as part of my visit to Pakistan, I found myself inadvertently at the centre of the action. Accompanied by my host, Dr Saed Shah, I found myself being introduced to the Director, who in turn introduced us to the Officer in charge of Computing at the Flood Forecasting and Warning Centre. We were soon being shown around the Centre by officials, who seemed remarkably calm in spite of the mayhem caused by the floods.

We discussed the successes and failures of the different modules which make up the computer forecasting model. Significantly, in their experience the most robust and reliable routing models are those based on statistical procedures, rather than on conceptual or routing principles.

We inspected the visual display board which echoed the telemetered rainfall and water level data for approximately 40 sites in the Indus basin. The floods had resulted in damage to many of the gauges and attempts were being made to obtain the balance of the data by direct radio link.

Our visit was cut short by the appearance of an official who announced that the Prime Minister was on the hot-line and wanted information on flood peaks and timings at various locations. It was clearly time to leave, and we departed, leaving the staff of the forecasting centre free to concentrate on more important activities than our visit.

Paul Webster
Birmingham

Report of the Honorary Secretary for the year ending 30 September 1992

This, the report of the Honorary Secretary to the 9th AGM of the British Hydrological Society, records a year of continued consolidation and steady growth.

The Society has 586 paid-up members, although there is a significant number of additional members who have not yet paid their subscriptions. Efforts are being made by the Main Committee to establish a procedure which ensures that the exact status of our membership numbers is clear. In November 1990 the then Honorary Secretary reported a membership total of 589. It is clear that our Society presently loses as many members as it gains each year, and we must all work hard to encourage non-members in our community to join us.

In spite of static membership, the Society has continued to extend its activities. The new membership handbook was distributed, providing a list of members' addresses, our statutes and space for other Society information. The intention is to issue further useful information in the near future.

The August 1992 issue of *Circulation* contained the long-awaited analysis of the first membership survey, distributed in July 1991. **Rod Hawnt** did a magnificent job in collating the information and presenting it in an informative and stimulating way. It was interesting to discover that 14-20% of

our membership is under 30 years of age, and the main committee are taking steps to ensure that the views of this age group are fully represented in the future.

A difference in the qualifications held by our membership was noted: older members tend to have a background in Civil Engineering, whereas younger members tend to have a qualification in one of the Environmental or Earth Sciences including Geography. There is even the odd physicist! This is important information for the sub-groups of the Main Committee charged with organizing meetings, and considering the route to chartered status for our membership if they wish to pursue it.

In the former case we clearly need to develop a balanced programme of meetings; in the latter case we must recognize the difficulties facing those seeking such status, and attempt to identify clearly the most appropriate pathway. **Sue Walker** and her team continue to work hard on this matter.

Our programme of national meetings continues to be varied, including subjects ranging from climate change and radar hydrology to urban development, water quality and consulting overseas. Meetings have also been successfully arranged by the BHS sections in the South West and, particularly, the South. The Welsh and Scottish Hydrological groups have remained very active, and there has been a resurgence of activity by the Pennines Hydrological Group and the BHS Midlands Section.

A Drought Workshop, organised by **Geoff Petts** and **John Mawdsley** at the University of Loughborough, provided a forum to discuss the material to appear soon in the BHS Third Occasional Paper. National meetings have been planned for 1993 and are publicized in *Circulation*. The BHS continues to join with the ICE, IWEM and other organisations in sponsoring joint meetings. Our contacts with the European Geophysical Society and other overseas hydrological groups remain strong: the members of our international and IAHS sub-committees are **Des Walling, Enda O'Connell, Jim McCulloch** and our President, **Mike Lowing**.

The profile of the BHS has been raised by our contributions to government, most recently through our submission on the proposed Environment Agency. It is clear to me that, as the focal point for hydrology in the United Kingdom, the BHS should continue to collate the views of our community and be vigilant in making these views known when legislation is planned, which may be central to our professional activities.

The first decade of the BHS is now almost complete. The Main Committee feel that the time is now right to review the whole range of our activities and our aims as a society. The President, supported by the Main Committee, has begun work on a Plan for the Future. Eventually this document will be presented to the membership to seek their views.

I am sure that during the next decade the BHS will continue to develop and that membership will grow steadily. However, we all need to support in full the Society's activities and contribute whenever, and in what-ever way, we can. Next year, 1993, will see our Fourth National Hydrology Symposium in Cardiff. A call for papers appeared in the August issue of *Circulation*. I hope that you will all endeavour to make this the best symposium ever.

My term as Honorary Secretary, and member of the Main Committee, comes to an end at the 9th AGM and National Meeting on "Land-use change impacts" to be held at the University of Sheffield on 14 December 1992. I have enjoyed immensely my period on the Main Committee. Without the help of all those on that Committee my tasks would have been very difficult, particularly having, as I do, an unusual background in hydrology.

It is rather invidious to single out individuals, but special thanks are due to **Peter Bacos** and to the Presidents under whom I have served: **Peter Wolf, Allan Lambert** and **Mike Lowing**. To my successor, **Richard Harpin**: I hope he derives as much enjoyment from the job as I have. I hope that I will continue to be able to serve the Society in some capacity in the future. I am sure that the BHS will continue to go from strength to strength, and I look forward to the next decade.

Chris Collier
Hon. Secretary

Hydrology and Water-related Diseases

BHS Southern Section Meeting
Imperial College, London
6 November 1991

A large audience gathered last November to hear presentations by Peter Kolsky, a lecturer in Tropical Public Health Engineering at the London School of Hygiene and Tropical Medicine and Dr Peter Bolton, Section Manager of the Overseas Development Unit, Hydraulics Research, Wallingford and Chairman of the Environmental Impacts Working Group of the international Commission of Irrigation and Drainage. The meeting was chaired by Dr Nigel Arnell of the Institute of Hydrology who explained that the health implications of flooding in Bangladesh had provided the stimulus for the topic "Hydrology and Water-Related Diseases". Although a relationship clearly exists between poor drainage and disease, the speakers stressed that it is a complicated one and often difficult to translate into specific engineering recommendations.

Peter Kolsky's talk provided an introduction to the problem of "urban health and drainage in the tropics" before presenting some new design ideas for urban drainage schemes.

A fundamental problem faced by public health engineers in tropical urban areas is the removal of all unwanted water: stormwater runoff, external floodwaters, marsh or wetland water, sullage and toilet wastes. The urban drainage scheme therefore has to perform many functions. An integrated approach to design is needed to avoid problems such as the ineffective disposal of toilet wastes during periods of flooding, or destruction of urban stormwater-runoff with embankments built to contain external flood waters. Once installed, regular maintenance is vital to ensure continued operation of the scheme.

The health problems associated with poor drainage have different frequencies of occurrence which are important in assessing cumulative risk.

Large flood events and landslides cause catastrophic loss of life, but they are rare. However, insect vector diseases (e.g. malaria, filariasis and yellow fever), faecal-oral diseases (e.g. diarrhoeal disease and worm parasites) and Schistosomiasis pose severe public health problems because they occur more frequently.

Stagnant water is an important medium for disease transmission because mosquitos and insect vectors can breed in it. Poor drainage of faecally-contaminated water can also spread faecal-oral diseases. However, it is difficult to quantity the exact relationship between poor drainage and public health because stagnant water is not the only medium for disease transmission. Insects breed in many places, including rubbish and water tanks, and faecal contamination also occurs through food and poor hygiene.

Other complications arise from species sanitation: that is, different species like different conditions. For example, *Anopheles* mosquitoes (which transmit malaria) do not usually breed in heavily polluted water, but can multiply in swamps, pools, puddles, streams and stormwater canals where there is standing water. Research has also shown a lack of correspondence between the surface area occupied by wells, soakage pits, flooded plots, cement and kutcha drains and their percentage contribution of mosquitos. Whereas flooded plots comprise 41% of the total surface area they contribute only 2% of the mosquitoes. However, cement drains occupy less space (38% of the total) but contribute the greatest proportion of mosquitos (64%).

Such findings illustrate how the complexity of biological systems poses a real problem in attempts to define the nature of the relationship between poor drainage and health. To these complications must be added that of temporal variation in the conditions.

The performance of drainage schemes is determined by design, based on hydrological assessments, and the degree of maintenance. Consideration of health risks should be an integral part of the implementation of an urban drainage system. The performance measures which seem most relevant to health include area, duration, depth and frequency of flooding.

The traditional approach to urban drainage design has centred upon the calculation of return periods for storm events of different magnitudes. Predicting the exact area of flooding, the flood levels, and the length of time areas will remain inundated has been very difficult, particularly for large storms.

When average annual costs and benefits of drainage schemes for different design return period discharges were compared, the 2-year flood event gave the best benefit/cost ratio. Urban drainage schemes designed to cope with 5-year and 10-year events had much reduced benefit/cost ratios because costs increased much more than benefits with increasing return period. Thus, for purely economic reasons, it may be beneficial to consider designing urban drainage systems for events with return periods of less than one year, since the savings made would permit more schemes to be installed.

In addition to establishing the actual savings from such schemes and the health implications, research also needs to address two hydrological issues: firstly estimating the size of frequent events, such as the 3-month storm, and secondly assessing the performance of the drainage system under rarer events in terms of the area, depth and duration of flooding. It was concluded that the best return for investment, in public health terms, is likely to be in the most basic facilities.

Discussion

Anna Wesselink (Institute of Hydrology) asked how the benefits of drainage schemes have been quantified. Peter Kolsky replied that economic analysis using damage/costs curves had been used by the Flood Hazard Research Group, at Middlesex Polytechnic in the UK but not in less developed countries. Health benefits are difficult to quantify because their relationship to drainage improvement is not obvious. It is important to try to quantify benefits, however, because drainage works are competing with other resource demands (e.g. education) and in such competition quantifiable benefits can strengthen one's case.

Nigel Arnell (Institute of Hydrology) questioned the sensitivity of health impacts to the magnitude of the return period, asking whether the cost is per event regardless of its size or return period. Peter Kolsky responded that it was not simply a cost per event: the duration of flooding was important, e.g. for malarial vector breeding.

Graham Thompson (Binnie Beatty) commented that if one obtained a proper handle on 'true benefits' and 'correct costs' one might then persuade the client of the design. The speaker responded that the real argument is saving money to serve more people.

Paul Johnston (Imperial College, London) pointed out that the cost curve may also bottom out. Peter Kolsky agreed that this was probable but it would be interesting to test it on an actual case study.

Michael Moore (RMIT, Melbourne) questioned the validity of designing for low return periods in areas subject to monsoons. The speaker pointed out that the return period should not be taken too literaly: a 'three-month storm' is not only a storm equalled or exceeded four times a year; he agreed that the rainfall intensity distributions would differ between tropical and non-tropical climates. Drainage systems in Calcutta are now designed on the basis of the three-month event. He also said that the more interesting research would be in field observation, to see how different systems performed in practice, regardless of their nominal design return period.

Auberon Williams (Birkbeck College, London) asked for clarification of the term 'flooded plots'. Peter answered that in urban areas they are vacant plots not filled to the level of the surrounding area. They are not agriculturally worked and are often contaminated from houses.

Dr Peter Bolton then spoke about irrigation schemes in developing countries and their health implications. The main lesson, he said, was that predicting the effects on health of any given scheme was very complicated, as many factors were interrelated; the engineer must be wary of jumping to false conclusions about necessary responses by applying inappropriate experiences from other schemes. He illustrated his points by looking at the effects of a few examples of irrigation schemes on water-based and insect-vector diseases.

In the case of malaria and other mosquito-borne diseases, studies of the natural seasonal variations in mosquito populations in relation to variations in rainfall and runoff often show increases in mosquito breeding by changing the hydrological conditions. For example, reservoirs in the Tennessee Valley provided an ideal habitat for mosquito larvae but engineers were able to disrupt breeding by altering the water levels in the reservoir: weekly fluctuations of 0.3 m were adequate because the particular species of vector had a long breeding span. However, this may not be transferable to other mosquito species in different environments. Part of the success in the Tennessee Valley can also be explained by the large-scale alterations along the reservoir shoreline to reduce the areas where temporary ponds can form. The cost of such large-scale work often precludes its adoption in developing countries.

Irrigation may have a profound effect on mosquito population: compared to a natural situation of a single rainy season, irrigation introduces several peaks in the mosquito population. Draining the fields between each irrigation has led to some success in disrupting mosquito breeding. However, corresponding drainage of unlined canals to achieve this may lead to small pools of water remaining which are more effective breeding grounds for mosquitoes.

Engineers traditionally played a central role in all phases of irrigation design. Now the field is becoming more interdisciplinary with planners and other professionals becoming involved. Engineers must learn to work within this changing situation, by improving their education on health issues and by

learning correct biological and medical terms. Even more fundamental is the need to comprehend the biological and human systems involved so as to enable communication with other disciplines and avoid the dangers of generalisation. Every country seems to have a different matrix of vectors and there is no guarantee of transferability of vector control measures between countries.

Peter reported on three projects in which he had been involved. Firstly, a research project collaborating with the Anti-Malaria Campaign studying malaria transmission in the Kurunegala region of Sri Lanka. This illustrated some of the difficulties of specifying an appropriate data collection programme. Prior to the study experts believed that the paddy fields were unimportant for mosquito breeding in this area because of their shaded conditions and that breeding was most intense in very small pools and open unpolluted water. Preliminary results suggest that breeding is taking place in a wider variety of habitats than had originally been anticipated.

A second study of small irrigation schemes in Northern Nigeria focused upon developing simple risk assessment procedures for use by managers. A questionnaire was used to gather data from 'key' informants, such as the village leader and school teachers, about water-related vector-borne diseases and other environmental hazards. Biologists also gathered field data to verify the questionnaire findings. Although some health hazards, such as the guinea worm, are amenable to this risk assessment approach, others such as filariasis are cumulative and visible symptoms may only appear at advanced stages of infection.

The third study reported was the Mushandike Project conducted with the Blair Research Laboratory in Harare, Zimbabwe. The aim was to develop guidelines for the design of small dispersed irrigation schemes. More specifically, the aims were to discourage snails, reduce the contact of the human population with potential transmission sites, and reduce contamination of water by providing appropriate sanitation measures. Biologists suggested that a major problem is presented by the long weirs, installed to give steady flow in the off-take, because they never dry out. New off-take structures designed to prevent ponding were laboratory tested before installation in Mushandike. Of the three areas under study in Mushandike, preliminary results show one village area remaining infected but a decrease in the proportion of the population having S. haematobioum in the other two villages. Although the precise cause is unknown, location seems crucial: transmission is continuing in the village near the main canal, while the two villages showing an improvement are further away. Schistosomiasis is difficult to control because a single transmission site can infect a large number of people and without comprehensive action interventions may be ineffective.

The role for irrigation engineers in improving health appears to be promoting appropriate research, improving the operation of existing projects — especially since fewer new irrigation schemes are being built — and designing sustainable practical solutions, ongoing monitoring of schemes enabling dynamic responses to be made because environmental conditions and vector/species may change over time.

Discussion

Richard Wesson (Environmental Water Services) asked why malaria incidence peaked before the high point of irrigation. Peter Bolton suggested that it may relate to plant shading: breeding is reduced as plants grow and starve the larvae of light. Alternatively, it may be due to the natural rainfall pattern or other environmental factors. Further complications arise because different species peak at different times.

Howard Wheater (Imperial College) commented that malaria control in Sri Lanka was originally effective and asked if there had been changes in practice. Peter Bolton replied that the vectors had developed resistance to DDT and an element of complacency had crept in. The use of different insecticides is not a long-term solution since resistance to these is also likely to develop with time. A dynamic solution is required to reduce transmission because different primary vectors are adapting to changing environmental conditions.

Graham Thompson (Binnie and Partners) asked Peter to say something about future action, given the complexity of the problems. The speaker responded that research should start to identify principles. Multidisciplinary and local knowledge is vital and the implications of research findings need to be more widely discussed.

David Wardle (Balfour Beatty) remarked that a feasibility study in Swaziland produced the same findings about the off-take structures as the Zimbabwe study. The improved off-takes couldn't always be used but structures were designed to reduce the pondage in the canals. A further difficulty was persuading people to live in villages and not homesteads. Peter Bolton was asked whether this was a problem in Zimbabwe. He replied that the people in Zimbabwe were more accustomed to village life and were prepared to live together in villages to be near a suitable water source.

Geraldene Wharton
Queen Mary & Westfield College, London

The President's Piece

One of the topics which keeps returning in discussion at main committee meetings is how do we persuade more members to contribute to *Circulation*. No matter how fervently we appeal for letters and articles, nothing much is forthcoming except from those who are already captive (reporters of meetings, reviewers etc.). The editorial staff at the Institute of Hydrology would welcome the chance to expand the scope of the newsletter, but of course it depends entirely on there being sufficient contributors. If you are feeling guilty that you have never sent anything in why not have a go? One extra incentive to do so might be the BHS annual prize about which there is more below.

Useful rain

I chose the week of the mid-Anglian flooding to venture into Norfolk on a late summer bird-watching jaunt. We drove through some of the heavy stuff and wondered if this, at last, would be greeted happily by Water Industry spokespersons. Not a bit of it: 'It was the wrong kind of rain' someone was quoted as saying; or it 'did nothing to satisfy the soil moisture deficit'. The profession was beginning to sound like British Rail complaining about the type of snow. We all understand why summer rainfall has limited (often zero) potential for recharging underground reserves, but in late September heavy rainfall has got to be useful. OK, some is 'wasted' in flood runoff but what proportion exactly? My guess would be less than half of the 50+mm or so which fell on the Great Ouse catchment. That still leaves a fair amount to do some serious wetting of soils if not actual recharge.

If anyone should think that, by guessing the runoff and making provocative remarks concerning statements which may have come from fellow members, I am leaving myself open to more informed correction then I plead guilty - see previous paragraph! *(**Nigel Fawthrop** gives the more informed view - and more accurate figures - on p. 7)*

Prizes and awards

At the Southampton symposium last year we initiated the £200 BHS prize for the best paper presented to the meeting.

It was presented on that occasion in memory of John Pirt. The committee decided that the prize will be a regular feature of our biannual symposia and that, in the alternate years, it will be awarded for the best contribution (or series of contributions) to *Circulation* during the previous two years. A small committee, comprising the President, the Hon. Sec. and the Editor, has deliberated: the winner is revealed on p. 14.

Subscriptions

There is considerable confusion about the subscription rate and the year to which it is applicable. This confusion has affected everyone, not least the committee! Recent past practice has been for the subscription rate to be recommended by the Treasurer and decided by the committee at the July meeting, announced in the August *Circulation*, applied to renewals and joiners after 1st October, defended at the December AGM. The '1992' rate of £18 applied from Oct 1st 1991 to Oct 1st 1992. The '1993' rate will be £19 (as mentioned on p. 13) and will already have been lifted from the accounts of those paying by direct debit. We are sorry to have slipped up in not notifying members of the increase in the previous issue.

'Junior' representation

We are very pleased that, after voicing the concern that younger members should have a more focused representation on the committee, **Jennifer Taylor** - she works in NRA South West region - has been asked (and agreed) to attend committee meetings.

Coincidentally, one of our newly-elected committee members (see below) also qualifies as 'young' so the under-30s should be well served next year. Next problem - what to do about the really really old!

Committee for 1992-93

You will have received your voting papers for the post of President Elect. Three excellent candidates are standing and it will be hard for you to make a choice. But do please use your vote.

The other vacancies (Hon. Secretary and two ordinary committee members) were balanced by the nominations received so no election is necessary. We welcome **Richard Harpin** (finishing his spell as an elected committee member) as our new Hon. Secretary and we also welcome **Kevin Tilford** and **Timothy Wyatt** as committee members.

The committee recorded their sincere thanks to **David Boorman** for all his contributions during three years as a committee member. He will be remembered particularly for his convening of the Southampton Symposium, our best to date. We are also losing the services of **Chris Collier** as Hon. Secretary. Chris has impressed us all with his forward planning (he is widely believed to have set the date and location of his retirement AGM — 14th December 1992 in Sheffield — the day after he took over in December 1990!). His friendly sufferance of Presidents who ring him at all hours of the weekend has been much appreciated and his taking of the BHS message into Meteorological circles has been most beneficial. We thank him and we wish him well.

Tied to BHS

A number of members have asked whether there is a BHS tie. There isn't yet but of course there could be and I think it's rather a good idea. Apparently we could have a good quality polyester tie with the BHS logo woven thereon for sale at just under £8. The problem is, can we be confident that enough of you would buy to justify the initial outlay? If we meet or communicate over the next month or so, try to remember to tell me what you think. There are various ideas (e.g. brooch) as to a corresponding item for women but, again, it is difficult to assess the likely demand.

The AGM

For all of you who may find it difficult to reach Sheffield by 10.30 am, can I suggest treating it as a challenge? Hopefully we will not have snow and ice to contend with this time (remember Birmingham 1990?) so I look forward to seeing hordes of you there.

Mike Lowing

Rainfall and floods in Hubei Province, China

During a visit by the Hon. Secretary, Chris Collier, to China's Hubei Province in July this year several interesting facts emerged about rainfall and flooding of the River Yangtze.

Hubei Province (see map) is located in the middle Yangtze region. It has an area of about 18 000 km² and a population of about 80 million people; there are thousands of lakes and many rivers. Flood defence banks extend for some 6000 km along the rivers Han Shui and Yangtze. There are about 6000 reservoirs in total, of which some 48 can be described as large.

Rainfall can be very intense: around Yichang County 1072 mm of rain has been recorded in three days. Many places have rainfall exceeding 100 mm in a few hours. In addition, large flows are experienced in the River Yangtze as a result of rainfall to the west of Hubei Province. Hence the tasks of flood prevention and warning, hydro-electric power generation and water resources management are all regarded as of central importance.

Serious flooding occurs, particularly in Shishou City (see map) where the river meanders a great deal and its surface is 10 m above the surrounding land. In 1954 the floods were so bad that Wuhan was threatened. The last major flood was 29 June - 13 July 1991. On receipt of a flood warning around 500 000 people must be moved to safety: a lead time of at least two days is necessary to do this.

Yichang, a city of about 400 000 people, is the location of the Changjiang (Yangtze) Gezhouba multipurpose dam project. Parts of the city are very hilly and the Yangtze River flows on one side of it. Ten years ago Yichang's population was under 200 000: the rapid growth has been a result of the dam development.

This dam across the Yangtze, the third largest river in the world, contains the largest hydro-electric plant in China (the seventh largest in the world), with a capacity of 2.715 gigawatts producing 14 terawatt hours of power per year.

The river is divided into three channels by the dam construction. Figure 1 shows the flow through the central part of the dam with one of the large locks in the background. It was built by Chinese engineers, an achievement they are justifiably proud of. Construction began in 1970, and was finally completed in December 1988. The dam is 2606.5 m long, comprising three flood prevention gates, each capable of coping with a maximum

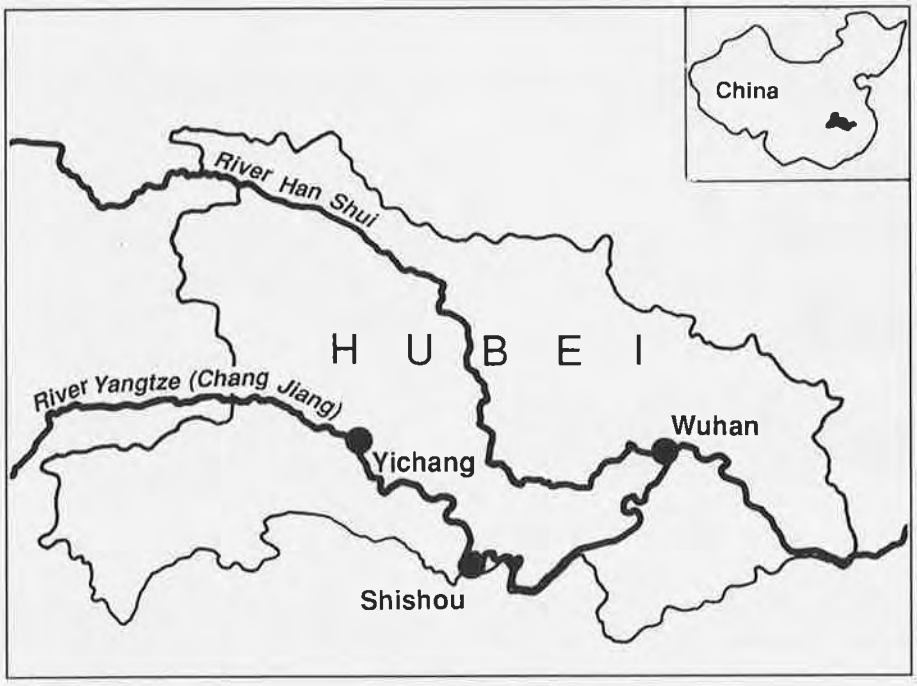




Figure 3 Mountainous area above Yichang, site of a proposed new dam

discharge of 3100 $m^3 s^{-1}$, two ship locks and the electric power plant.

In winter the river level upstream is 27 m higher than the level downstream. To date the maximum flow measured through the dam is 7200 $m^3 s^{-1}$.

Figure 2 shows a large multi-decked cruiser packed with people moving through one of the locks. These boats look very unstable, with a high centre of gravity! It takes about 50 minutes for the operation to be completed.

This dam is to be followed by a second, which is to be the main element of the *Three Gorges Project*, to be located some 40 km upstream on a very scenic part of the river. Figure 3 shows part of the mountainous area to the north of Yichang. The new dam is planned to be 185 m high with a hydroelectric power capacity of 17.68 gigawatts, almost six times the capacity of the existing dam.



Figure 2 Passenger ferry negotiating a lock at Yichang

Preparatory work has already begun: it will take three years, with completion in about 18 years time. Unfortunately this project will result in a very beautiful part of the River Yangtze being lost.

The storm forecasting problems in Hubei Province are severe. During the period 29 June 1991 to 13 July 1991, 778 mm of rain fell at Wuhan and more than 800 mm to the north east. This was a good example of rainfall from the Mau front which occurs from north-east to south-west during the summer months. On 14 August 1990 a Mesoscale Convective Complex produced a total of 418 mm of rain in the five hours between 1900 and 2400 in an area 70 km north-east of Yichang City. Clearly there is a real challenge in developing a reliable forecasting system for these events, particularly when they may lead to such damaging floods.

C G Collier
Meteorological Office



Figure 1 The waters of the Yangtze at the Changjiang Gezhouba dam

"The wrong kind of rain"

Media interest in hydrology turned from drought to floods in the Anglian region during September. How do you get the message across that the drought has not ended simply because half the region is under water? The NRA's best efforts, explaining that spatial distribution of rainfall, prevailing soil moisture deficit (SMD) and the underlying geology are all important considerations, sometimes fail to register.

On 22-23 September, 18 hours of rain fell on the relatively impermeable Bedford Ouse catchment, averaging about 50 mm, with over 80 mm in places. Antecedent SMDs were less than 10 mm and the rapid runoff resulted in severe flooding. Only 30 km to the east the soils overlying the chalk aquifer had average SMDs around 40 mm and the rainfall here was under 30 mm. In these areas the rain was most welcome, but the drought affecting the region's groundwater resources was by no means over.

"The wrong kind of rain" makes a good headline — to someone who understands hydrology it is actually quite meaningful — but to the British public it just seems like another excuse. The moral of this story? Do not believe everything you read in the paper — even if it is the *New Civil Engineer*!

Nigel Fawthrop
Peterborough

Consulting overseas - practicalities, problems and perils

BHS National Meeting
3 June 1992

The perils of consulting overseas caught up with this afternoon meeting at Great George Street: speaker Ron Manley was unavoidably delayed in Gaborone, Botswana, and Dr Robin Wardlaw was whisked abroad by his company. The day was saved by Dr Chris Kidd and Terry Evans who stepped in at the ninth hour.

The four speakers were introduced by **Dr Richard Harpin**, chairman for the afternoon. **Frank Farquharson** set the scene with his paper on Practical Hydrology Overseas. Frank gave two examples to illustrate the main problem in hydrology overseas: one was a flood study in Saudi Arabia and the other a compound weir rating in Botswana. Although the types of problem are similar to those encountered in British hydrology, overseas there is generally a lack of locally-calibrated models or methods and the data are, more often than not, very dubious.

The theme of data was extended to data analysis by the second speaker, **Dr Peter Adamson**, in typical incisive form with his paper "Never let the facts confuse a good model — ignore the data!" His main theme was the need for exploratory data analysis and the use of more robust analytical techniques. The hydrologist must look far more closely at the data. There is a inherent tendency to launder data through statistical techniques.

Any robust technique for analysis must have three properties: smoothness, resistance and breadth. Smoothness is obvious; resistance means insensitivity to a moderate number of "bad" data values (many statistical analyses are dominated by "bad" data values), and breadth means being applicable to a wide variety of situations. Dr Adamson implied, with reference to an earlier comment from the floor, that the Gumbel method was far from robust.

Next came **Terry Evans** on the problem of non-stationarity, with lots of examples from Africa, such as data for the Zambezi River, and from drought-stricken sub-sahelian Africa, and another example on changes in the sediment loads measured in the Chatra Canal in Nepal.

Apart from highlighting the difficulties, in water resources planning, of dealing with data which show large and abrupt changes in short-term averages, Terry made two pleas. The first was that hydrometric data in developing countries was undervalued and should received adequate funding; the second was for a big training effort in hydrometry in Africa.

Dr Chris Kidd deserved the prize for the paper with the shortest title: "Context" - the context being the Third World Environment. Chris focused his paper on Contextual Confusion, i.e. the application of techniques and technologies which may be largely inappropriate to the Third World.

Types of Contextual Confusion included:

A Confusion on the part of practitioners towards the Third World context

B Confusion between different types of practitioner

With respect to *B*, local hydrologists are far from immune from contextual confusion since they are trained by academics and work with expatriate hydrologists. Of the work carried out by local and expatriate hydrologists, data processing and preliminary analyses are not free from the opportunity for confusion, whereas data collection and advanced analyses are fraught with perils. Chris Kidd gave two "prizes" for overrated items of Third World hydrometric equipment: the first went to the Water Level Recorder (WLR) which is a labour-saving device appropriate where the cost of labour is high (i.e. *not* the Third World). WLR charts are of little interest for low flows, mean daily flows, or flood estimation on large catchments, but they are nevertheless inevitably installed there because of their perceived strategic importance. In practice two-thirds of WLRs are either missing from the site or not functioning. The second prize went to the Evaporation Pan, the "glorified birdbath": what is it for? Has anyone ever seriously used pan data? Dr Kidd's plea was for more fully-manned stations, as in India, Thailand and China, and for greater use of motorbikes for data collection.

In discussion **Dr Mike Tomms** gave several examples of stage measurement problems from around the world, such as uncorrected sloping staff readings in Kenya and a constant water level recorded in a Zambian flood when the water was above the top of the staff gauge. Dr Harpin asked if there was a way to get a sensible data set? Dr Adamson emphasised that there was no passing of raw or treated data between consultants and data were repeatedly re-analysed. **Henry Gunston** suggested that data should be published in yearbooks.

Terry Evans reiterated the need to drive home to the funding agencies the value of hydrometric data and the paramount importance of continuity. Chris Kidd thought that computer validation by plotting of data could be done manually: manual data process systems were highly developed in some places.

Frank Farquharson indicated that two papers from the World Flood Studies Report were shortly to be published, one for West Africa and one for Arid & Semi-arid Zones. Dr Adamson expressed his concern that the UK Flood Studies Report had led to "brain death" amongst hydrologists and that there was a danger that the World Flood Studies Report would do the same.

T G Davis expounded his faith in the simple Double Mass curve in data validation and said that some of the "non-stationarity" displayed by Terry Evans could be explained by variability in the quality of data, where rating curves had been applied retrospectively to historical level data, for example.

Most overseas hydrologists obviously have an instinct for locating watering holes and the lively debate was later taken down to the basement.

The main message of the day was that funding was needed for third world data collection at an appropriate technology level - so come on, funding agencies, give us the money!

Richard Harpin
Swindon

The Somerset levels and moors: aspects of conservation and land drainage

Joint Field Meeting of the Welsh Hydrological Group (ICE) and the South West Section of BHS 3rd July, 1992.

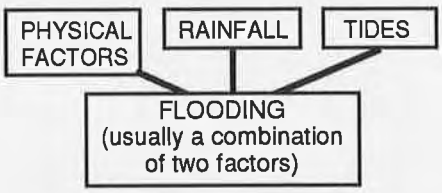
Almost 35 members attended this meeting, hosted by personnel from NRA Wessex Region, at Bridgwater. It began with three brief talks on aspects of geology, hydrology and the history of the area, conservation, land drainage and associated conflicts.

Geology and hydrology

Linda Aucott (Secretary Welsh Group, NRA Wessex) introduced the area, explaining the nature and extent of the Somerset Moors and Levels — a total area of 635 km² below mean high tides. The region is a complex one of generally flat, low land lying between the Quantock and Blackdown Hills to the south and the Mendips to the north. Bisecting the lower land is the ridge of the Polden Hills (see Figure 1). Strictly speaking, a distinction should be made between the Moors and the Levels. The Moors are the main areas of peatland, inland from the coast — areas of raised bog and peat accumulation on an impermeable base of Liassic clay. The Levels lie to seaward of the Moors and are areas of coastal silt and clay deposits overlying the main peat horizons (see Figure 2).

The rainfall for the area averages about 690 mm for low-lying areas and about 1200 mm on the surrounding uplands. Extreme rainfall events can reach intensities of 230mm per day (e.g. Bruton 1917, Cannington 1924) giving rise to high river flows which are in the range of 300 - 500 cumecs. Flooding has been and continues to be a serious problem in the area. Some 30% (20,000 ha) of the Moors was flooded in 1960; by 1990 this was reduced by drainage schemes to 15% (10,000 ha), thus enhancing agricultural productivity, especially in relation to cereal crops.

In general, flooding results from a combination of factors:



The physical factors include:
- flat low level land, rising slightly in altitude at the coast
- low gradients on drainage ways and rivers
- steep slopes and rapid runoff from surrounding uplands.

The tidal influences include:
- high tidal range in the Bristol Channel and in the tidal sections of the rivers.
- high silt content in all drainage ways
- tide 'lock' conditions during high tides, strong on-shore winds and high river discharge.

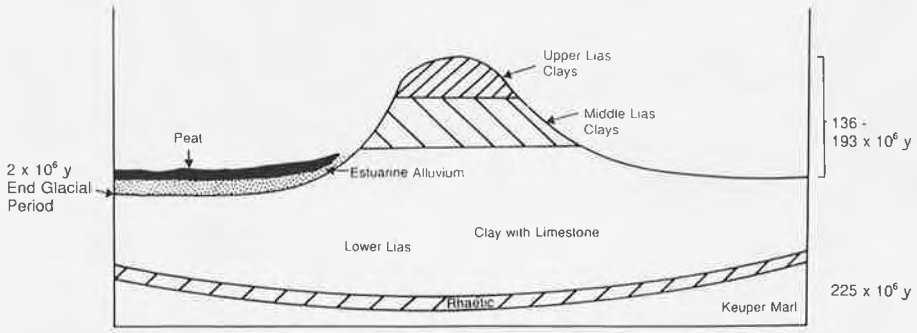


Figure 1 Moors geology

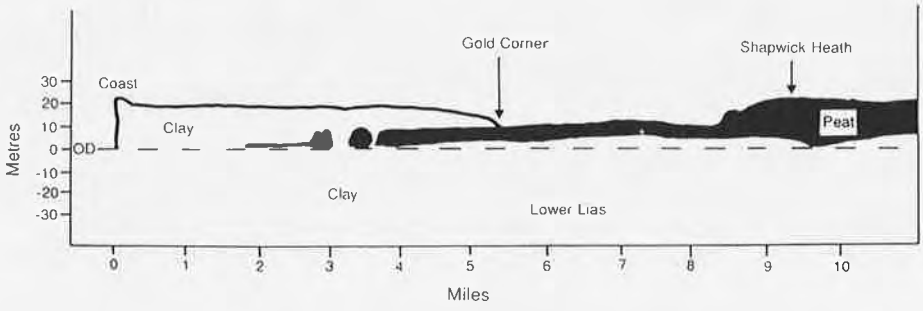


Figure 2 Schematic cross-section of the Somerset Moors and Levels

Water Level Management and Nature Conservation

Stewart MacFadyen (Conservation Officer, NRA Wessex) and **Ian Sturdy** (Land Drainage Officer/Moors and Levels Surveyor, NRA Wessex) introduced aspects of conservation, land use and drainage.

Up to the end of the eighteenth century much of the area consisted of open commons. Gradually drainage schemes were developed using ditches that can still be seen today throughout the area. Enclosing the small damp fields these 'wet fences' provide drinking water for cattle and act as drains in winter and irrigation channels in the summer. Traditionally grass was the main crop, with hay being cut in most years and cattle grazing in summer.

It is this system of low intensity farming combined with regular flooding and resulting damp conditions that has provided ideal habitats for wetland wildlife.

The Levels and Moors with their network of ditches and regular shallow flooding make the area attractive to many species of plants and animals. When they occur winter floods bring large flocks of birds into the area to feed and if fields stay damp into spring and early summer, the wading birds which find food in the soft damp soil, will settle and nest.

Thus the Somerset Levels and Moors are recognised as an internationally important wetland of exceptional wildlife, landscape and, because of their long human occupation, archaeological interest. In recent decades the modern demands of land drainage and changing agricultural practices threaten the continued existence of these wet-land habitats. Indeed in certain areas some species of wading birds have already become extinct. The present low water levels are unsuitable for the characteristic plants and animals of the Moors and also continue to jeopardise its archaeological interest and the unique moorland landscape.

NRA Wessex is undertaking a major review of water management on the Levels and Moors in order to safeguard these interests. The review focuses on the Environmentally Sensitive Areas (ESAs) and 16 Sites of Special Scientific Interest (SSSIs).

Basically, a major conflict exists in terms of a flood protection on the one hand and conservation of wildlife habitats on the other. In recognition of this conflict a special sub-committee of the Somerset Local Flood Defence Committee is also undertaking a review highlighting the high level of concern of the future of the Levels and Moors in relation to both local and national interests. The concept of a mosaic of nature reserves, extensive pastoral farming and intensive farmland is perceived as a viable approach.



Figure 3 The ancient Sweet Track at Shapwick Heath

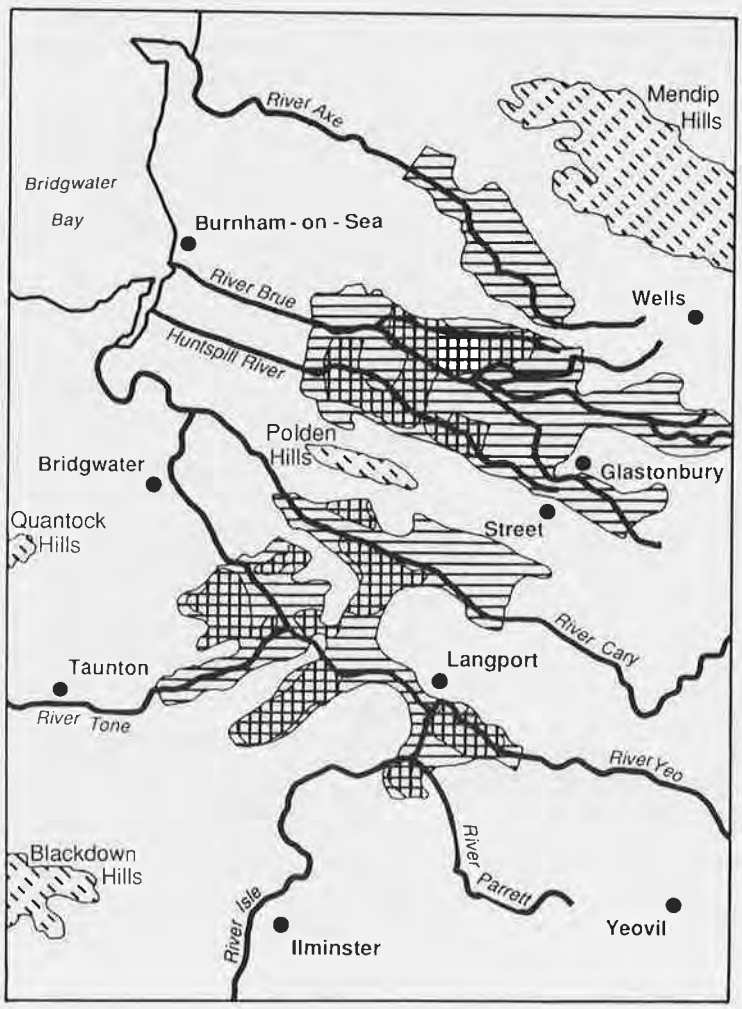
Bill Harris (President, Welsh Group ICE) thanked the various contributors for their authoritative and valuable introduction to the area. Members then proceeded to the 'field' with stops at Burrowbridge to view a typical patchwork of pasture fields, drainage ways and rivers from an excellent viewpoint above the lowland of Sedge Moor. We then went along the upper tidal section of the River Parrett to view traditional withy growing near Langport.

The coach then took us to a series of peat workings near Glastonbury and to a major stop at Shapwick Heath Nature Reserve. Here the party had the opportunity to observe various aspects of water management to achieve high water levels in the Reserve and also to view part of a reconstructed ancient wooden trackway, the Sweet Track (c. 4,000 BC), a part of the important archaeology of the area (Figure 3). Continued water-logging preserved these ancient relics.

Our final stop was at a notable pumping station on the Huntspill River at Gold Corner, an installation dating from the 1930 Land Drainage Act and the need for ample water supplies to the nearby Second World War Munitions Works at Puriton.

The party returned to the NRA offices at Bridgwater at about 6.30 pm, bringing an end to a most enjoyable and successful joint field meeting. Thanks are due to **Linda Aucott** (NRA Wessex) who organised the meeting.

Peter C. Sims
Secretary, South West Section



Some strategic aims for water level management by NRA Wessex

1. *Recognising the outstanding conservation interests of the Somerset Levels and Moors.*
2. *Maintaining wildlife and landscape in this internationally important wetland.*
3. *The control of water abstraction, water quality, drainage and water levels.*
4. *Reviewing flood defence arrangements in order to encourage appropriate management programmes within the ESAs.*
5. *Maintaining positive water level management for nature conservation on SSSIs and at other priority sites.*
6. *Supporting the introduction of water level premiums on ESA payments where raised water levels affect agricultural productivity.*

Water Resources and Reservoir Engineering

Joint British Hydrological Society/British Dam Society Conference, Stirling, 24-27 June 1992

The Stirling meeting was a great success: some 200 delegates attended, accompanied by around 30 visitors. Whilst the delegates enjoyed lively — and sometimes fiery — technical sessions, the visitors sampled the equally fiery local whisky! They also got very cold and wet on a lake steamer in the Trossachs but were well rewarded by being able to rub shoulders with royalty later in the day, and pay a visit to Stirling Castle.

The technical meeting began with a vigorously-discussed session on Reservoir Planning, Operation and Environmental Aspects. This was very timely in view of the current debate about the management of the drought in south-east Britain, low flow problems and their amelioration and the need for sustainable development of water resources into the next century. Both the chairpersons and the majority of speakers were BHS members. The discussion about methods of assessing reservoir yield and operation was lively, forming a tempting appetiser to the Loughborough workshop in September.

In the second session, papers presented by **Wyatt** and **Robinson** described methods involved in estimating river flows and the optimisation procedures used to determine release requirements to support hydropower generation in Cameroun. **Cole** described the policies used to operate some of the Tayside reservoirs. **Mosedale** described the conjunctive use of the South East Wales system. **Jack** and **Bunch** presented two different approaches to the management of risk in the operation of water resource systems.

Subsequent papers concentrated more on the use of yield assessments for reservoir planning. **La Touche** described the model used in Madras: **Hall** discussed the yield issues in the promotion of the Broad Oak reservoir. **Smithers** described methods used by North West Water and discussed the significance of the record length and the sensitivity of yield estimates in the light of potential climate change. Finally, **Hill** discussed the value of reservoir-based recreation and, in case studies, described how operating policies could be modified to take account of recreational requirements.

Session 3 was a special one, concentrating on potential revisions to the ICE Guide to Floods and Reservoir Safety and the Building Research Establishment database which is being developed to include all reservoirs under the 1975 Reservoirs Act.

Law and **Carlyle** gave an update of the work, funded by DoE, to revise the "Floods and Reservoir Safety Guide". So far the working party had identified the possible need for two new chapters in the guide to cover overtopping and bottom outlets. In their informative review of EC practice it was clear that the UK has the most earthfill dams and the few other countries look to design dams on the basis of PMF.

Anderson and **Reed** discussed the historical causes of dam failures. Even in cases of structural failure, rainfall is often a causal factor. They explained the reasons for the seasonal pattern of dam failures and especially antecedent wetness, discussed other factors such as wind and ice formation and suggested that further work was needed to look at joint probabilities in relation to dam safety. Since rainfall seems to have such a key role, Reed suggested using a trigger model which includes the antecedent wetness index and rainfall to produce an index of when dam failure is more likely to occur.

Further sessions covered reservoir design, construction and monitoring for reservoir safety purposes.

On Thursday evening, **Dr Pircher**, President of ICOLD, presented the Geoffrey Binnie Lecture. He emphasised the crucial role of civil engineers in project managing and coordinating the input of professionals from a wide variety of backgrounds — including landscape architecture, ecology and water science — to ensure that reservoir schemes which were developed were not only sympathetic to the environment where they were located, but where possible such schemes should actively enhance the environment.

He felt that reservoirs and dams had for too long had a bad name with environmentalists and the opportunity had been missed to portray their positive benefits. Dam engineers should stop being defensive and should take

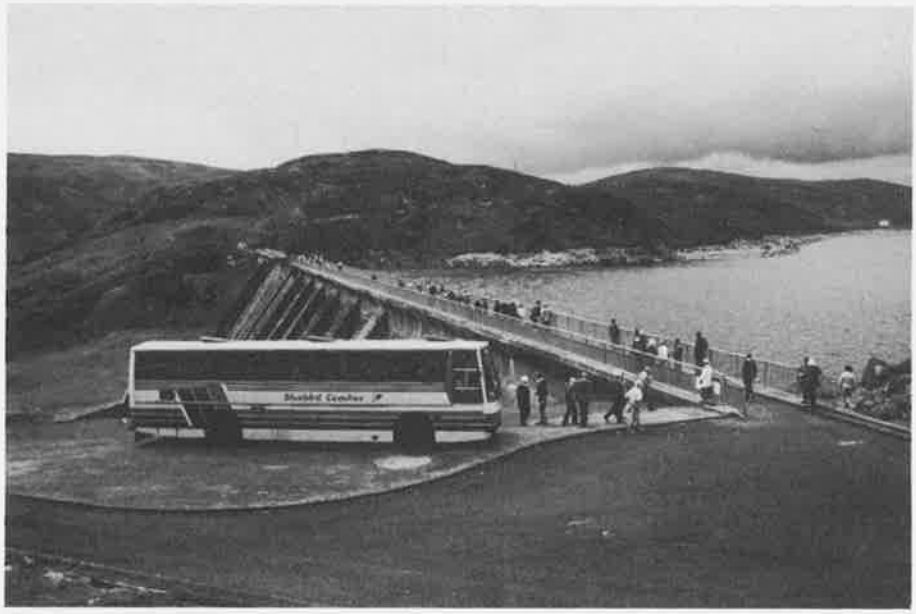


Figure 1 Field excursion to the Scottish Hydro dam in the Lednock Valley

up this challenge to ensure that the case for dams is actively pursued in the media, in discussions with local interest groups and with the public at large. The engineer is ideally placed to present the balance of needs between the technological sophistication of the design, architectural elegance and an understanding treatment of the environment.

A field trip was organised for the Friday afternoon. The first visit was to a Scottish Hydro concrete dam in the Lednock Valley (see Figure 1), which provided an excellent, if windy, location for a picnic lunch. This dam is believed to be the first major structure in the UK in which fly ash was used on a large scale. The reservoir, with aqueducts from other catchments, serves the 21 MW power station at St Fillans.

Following a sumptuous tea in the elegant surroundings of the Gleneagles Hotel, those who had the discipline to avoid the temptations of a round of golf and the willpower to resist seconds of the sticky chocolate cake made their way to the Fife Region dam at Upper Glendevon.

This dam was undergoing remedial works to overcome stability and seepage problems. Whilst work had only just started, it was interesting to see the sheer scale of construction which would be required. There has been a series of technical problems since the dam was first built in 1955. The reservoir is one of five operated conjunctively to provide water supply to Central and West Fife.

Water Resources and Reservoir Engineering edited by Parr, Charles and Walker, published by Thomas Telford, contains the preprinted papers. The discussion is to be published in a forthcoming issue of *Dams and Reservoirs*, the journal of the British Dam Society. Both publications can be obtained from the Thomas Telford bookshop at the ICE.

Susan Walker
NRA North West Region

Report on Nordic Hydrological Association Conference at Alta

3 - 6 August 1992

***Jim McCulloch* was nominated by the BHS and invited by the NHA (Nordic Hydrological Association) to attend their 1992 conference at Alta, just a few kilometres south of North Cape, often claimed to be the most northerly point in Europe.**

The Alta meeting was well supported, with some 280 participants. It was also very well organised, and commercial sponsorship resulted in all the arrangements for the meeting and the excursions being on a lavish scale. Catering for the barbecue grill party in the woods beside the River Alta, like that for the Conference Dinner was effected by the best hotel in Alta. White water power boating on the Alta left some participants with rather sodden posteriors, which they had to tolerate during the subsequent visit to a politically controversial (and hence uneconomic?) hydro-electric power station and dam and finally (still sodden, but in the pouring rain it didn't seem to make must difference!) to pre-historic rock carvings, sponsored (in historic times) by UNESCO as a World Heritage Site, near a recently completed museum.

The Proceedings of the Conference were pre-published and a copy is available for inspection by members of the BHS at the Institute of Hydrology, together with other relevant documentation including the programme of the meeting, which frequently involved two simultaneous sessions. The NHA has a language problem: in order to encourage youngsters to present papers (which may not yet be ready for presentation at a more international conference), the various Scandinavian languages are used by *all* the participants. On one occasion I attended a lecture, printed in English in the Proceedings, to find the oral presentation (and discussion) in Norwegian, although the (eminent) presenter speaks English as well as I! The victims of this nationalism are the English-speaking participants, among whom are the Finns and the Icelanders. As no other Scandinavian language has any resemblance to Finnish or Icelandic, English is their *lingua franca* for communication with Nordic colleagues.

Thus the BHS representative was hard pressed to contribute to most of the discussion of papers, although perusal of a paper printed in English but presented in one of the Scandinavian languages enables more personal contact with the author after the particular session is over. At a previous NHA meeting at Rovaniemi, in Finland, I had suggested a close link between the NHA and what eventually became the BHS, as an Anglo-Irish-Nordic Association; I had confidence in the international hydrological strength of these particular nations. However, following the creation of BHS and its links with the hydrology section of the EGS (European Geophysical Society), I now have greater hopes for the EGS as an international forum for discussion of hydrological ideas and advances.

In my own paper, printed on pages 13-24 of the Proceedings volume, I suggested that Nordic, as well as British hydrologists had contributed disproportionately highly (in terms of national populations) to effective studies of hydrological processes. However, during the meetings, there were numerous papers and presentations of applications of, and modifications to, the Nordic HBV model devised and elaborated by Bergstrom in Nordic Hydrology in the 1970s. It is gratifying to Anglo-Irish hydrological pride that Bergstrom always acknowledges the modelling principles laid down in 1970 by Nash and Sutcliffe in *J. Hydrol.* **10**, 282-290. There were also many complimentary references to FREND (Flow Regimes from Experimental and Network Data): this profitable and successful international cooperation, conceived and initiated at Wallingford, has been supported from the outset by Nordic hydrologists.

Inevitably, there is great competence in the Nordic countries in polar hydrology and glacier studies. One speaker lamented the possible melting of all the Nordic glaciers, and hence elimination of the requirement for glaciologists, if global warming occurs to the extent that some predict. No-one commented on the large number of glaciologists in the UK, a country in which the last glacier melted in pre-historic times! The only other Briton attending the meeting was **Dr Wilfred Threakstone**: his work on the Swartisen glaciers in Northern Norway is internationally acknowledged.

Included in the demonstration of instruments associated with the meeting was a new and potentially more fundamental rain-gauge than any present model. It incorporated a high quality load cell: the rain caught in the funnel is weighed, together with the funnel, so that wetting errors are almost completely eliminated. A patent anti-splash water-absorbing wind-shield, mounted level with the gauge orifice, is claimed to eliminate losses due to interference of the gauge with the trajectories of the raindrops. While the cost of such a gauge would prohibit its general adoption, it cannot but have considerable potential as a standard of comparison, against which the rather primitive bucket types of rain-gauge may be assessed.

Attending the NHA meeting was most enjoyable for me, as well as a useful opportunity for exchange of ideas and communication of potential developments. Few of the papers now published in the Proceedings will appear in their present form in the internationally refereed hydrological literature. However the biennial meetings provide a chance for young hydrologists to try out their theories and ideas before their peers in a relatively small regional grouping.

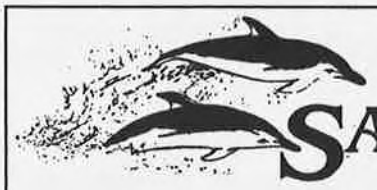
Nevertheless, there was a discouraging lack of meaningful and productive critical discussion following individual papers. This may reflect the language problems mentioned above and certainly delays the refinement of the ideas so that the work can be developed for presentation in the literature. At NHA meetings, more senior staff can also communicate news of possible (political?) changes of emphasis and direction: stress on time allocation to particular projects and on the necessity for government staff to be prepared to undertake commissioned work, either nationally or internationally, are relevant examples already familiar in the UK.

The importance of citation analysis was discussed by many individuals. Some excellent Scandinavian scientific journals of high academic standing and considerable editorial competence lack the circulation to secure an acceptable ranking in the international citation stakes. Hence, however excellent a paper in such a journal, its author will be at a disadvantage if his personal, departmental or institutional status is being assessed by citation analysis.

Finally, I commend the continuing relationship between NHA and BHS, despite the occasional difficulty of presentation of papers in Scandinavian languages. The next meeting of the NHA will be held in the Faroe Islands in 1994.

I hope that at future BHS conferences the representative of the NHA will be welcomed as enthusiastically as I was at Alta, from the platform, at the outset of the first plenary session. The ongoing collaboration between the competent hydrologists of both societies cannot but be advantageous to hydrology as a science and to its application internationally. Much aid money is available through the international development banks; this, if supplemented by Scandinavian and British bilateral aid funding, can enable substantial contributions to international hydrological and water resources investigations in less developed countries.

Jim McCulloch



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Subscription increase

At the Main Committee meeting on 7 *October* it was decided that the Society's annual subscription should be increased by only £1 to £19; the concessionary subscription for students and members over 60 goes up by just 50p to £9.50.

Members are reminded that they may pay their annual subscription by direct debit from their bank account. This method of payment is preferred by the Society — and by many members.

Pennines hydrologists regroup

The ICE Pennines Hydrological Group has gone through a rough patch recently. At an extraordinary General Meeting held in Warrington on 21st October, chairman **Tony Lewis** described it as 'moribund'.

Members present decided to reinvigorate the group and, at the same time, to reconfigure it as a regional section under the auspices of the British Hydrological Society. This decision will be subject to ratification of a new constitution at the AGM in May.

Although the change of affiliation will make little practical difference to existing members of the group (whether BHS members or not), it will allow for a more structured relationship with BHS nationally and will ensure even more support (including some financial support) and encouragement from the Main BHS Committee. A warm welcome, therefore, to the new Pennines Section.

For more information please contact **Sue Walker** (Pennines Rep. on the BHS Main Committee) or one of the following officers of the Pennine Section: Chairman: **Andy Bunch** (North West Water); Secretary: **Katherine Howard** (North West NRA); Treasurer: **John Ratcliffe** (Yorkshire NRA).

Hydrologists on the move

Four hydrologists have recently joined the North West Region of the NRA: **Hilary Smithers** (Hydrological systems manager), **John Adams** (Hydrometric information manager), **M Huband** and **O Wedgwood** (Assistant hydrologists).

IAHS Newsletter

Because of the increasing costs of printing and distribution and its need to economise, IAHS is no longer able to supply free copies of its newsletter to all BHS members. Distribution will cease after the next issue, No. 47, which members will receive in December 1992.

In order to publicise important and relevant information about IAHS activities after December, *Circulation* will include a regular section dealing with IAHS news. This will abstract selected material from the Newsletter, and Peter Bacos at the ICE will be pleased to provide, on request, a photocopy from the relevant Newsletter to any member who wishes to obtain further information about a particular item. Any member who wishes to continue to receive the whole Newsletter on a regular basis should contact Peter, who hopes to arrange for the mailing of photocopies (charge to be decided).

Individual membership of IAHS is free: an application form should be enclosed with this issue of *Circulation*. Information circulars and the IAHS Newsletter are distributed to subscribers to *Hydrological Sciences Journal*, which IAHS members may obtain at half the normal price.

Canadians form Society and establish links

The President has received the following letter from **W Edgar Wall**, President of the newly-formed Canadian Society for Hydrological Sciences:

Cambridge, Ontario, Canada
August 11, 1992

Dear Dr Lowing

Re: Links between BHS and CSHS

*My old and friend and colleague, **Milne Dick**, has forwarded your letter of July 16 as president of the newly formed Canadian Society for Hydrological Sciences (CSHS) which as been formed as an affiliated society of the Canadian Water Resources Association (CWRA). I can reiterate both Milne's and **Dave Daugherty**'s support for closer links between CSHS and BHS and, to that end, would ask that you take this letter as our application for reciprocal membership to the BHS Main Committee. I shall instruct our secretary, Jim Bauer, to add your name to the mailing list for Water News, the CWRA newsletter which also serves as the CSHS newsletter on an interim basis.**

Finally, I would like to offer an open invitation to any members of your society who may be visiting Canada to meet members of the CSHS either formally or informally. Our secretary can provide the names of provincial executive members and regional or city contact persons.

Yours sincerely
W Edgar Watt, President CSHS

* We will extract relevant items for *Circulation* when it seems sensible. *Ed.*

IAMAP - IAHS Scientific Assembly, Yokohama, Japan, July 11-23, 1993

It is hoped that the Royal Society will approve a block grant from its Parliamentary Grant-in-aid from which awards will be offered to non-Government scientists of post-doctoral status, and who are normally resident in the UK, who wish to attend the above meeting.

In addition, strictly limited funds, which at best may provide partial support for two or three hydrologists, may be available from the IAHS Exeter Fund. This fund is particularly aimed at providing support for young hydrologists and those who might otherwise be unable to attend IAHS Assemblies. Applications for support from this fund can be considered from final year PhD students.

Assessment applications for both sources of funds will probably be undertaken in late February/early March. Hydrologists who wish to apply for a grant should obtain the appropriate application form from Miss B M de Vere, Travel Grants Department, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG

BHS Prize for 1992

As described in the 'President's Piece' in this issue, the BHS prize for 1992 has been awarded for the best contributions to *Circulation* over the preceding two years.

The unanimous choice of the selecting sub-committee was **James Bathurst** for his contributions on 'Landslides in New Zealand' (*Circulation 29*) and his write-up of the Postgraduate Symposium in *Circulation 34*. In both articles, he managed to write authoritative scientific accounts in a highly readable and amusing style — just the kind of thing the Editor is looking for.

The presentation of the award (value £200) will be made at the Sheffield AGM where we understand James will outline his plans for spending it in connection with the next post graduate symposium.

Runner-up for the 1992 prize was **Mohammed Riaz Hasan** for his article in *Circulation 32* about the Aswan High Dam, with its memorable quotation from Napoleon.

Membership

BHS membership stands at 652. New members will be listed in the next issue of *Circulation*.

Research grants in hydrology

Here are titles of some more research projects grant-aided by the Natural Environment Research Council:

Sediment transport by desert flash floods (Prof Ian Reid, Birkbeck College, London; Dr Lynne Frostick, Reading)

Identification of natural & anthropogenic sources of sulphate in UK groundwaters using sulphur and oxygen isotope ratios (Dr JH Tellam & others, Birmingham)

Register of independent consultants

After so many of you expressed interest in the proposed register when the topic was introduced in last year's questionnaire, it has been puzzling to receive relatively few detailed replies after the notice in *Circulation 35* (page 13).

One theory is that the definition of an independent consultant must have appeared to tighten and that this had deterred a number of you. We suggest that, if you are in doubt for that reason, you send in your details anyway. The intention is simply to provide a service, both to individual members, who may benefit from a wider awareness of their skills, and also to agencies and larger firms who may occasionally have need of them.

Thanks to all those who have responded — please bear with us while we wait a little longer to make the register more truly representative.

Mike Lowing

HYDROLOGICAL DATA UK

Publication of the latest two volumes in the *Hydrological Data UK* series — the 1991 Yearbook and the 1986-90 Hydrometric Register and Statistics volume — comes at a time when the very protracted drought in the English lowlands has declined considerably in intensity. Nonetheless, the UK's continuing vulnerability to unusual weather patterns has come into clear focus over the last four years. An exceptionally persistent drought has afflicted much of eastern and southern England, whilst much of northern Scotland has been very wet and has had to cope with a number of notable flood events.

The possibility that such conditions may recur with greater frequency in the future underlines the need for authoritative documentation of the scope and magnitude of the hydrological stress recently experienced and an ongoing appraisal of the implications, particularly in relation to water management practices. The 1991 Yearbook and the complementary 'Stats' volume provide an essential backcloth to any scientific examination of the effects of the recent marked exaggeration in the west-to-east rainfall gradient across the United Kingdom.

The 1991 Yearbook

In common with its precursors, the 1991 Yearbook brings together the principal data sets relating to areal rainfall, river flow and groundwater levels in the United Kingdom. Water quality data are also featured for a representative network of monitoring sites. In response to the remarkable runoff and aquifer recharge conditions, over the latter half of the year especially, the amount of basic data has been increased and a comprehensive review of the year documents the drought's progress and assesses the regional variations in severity of an event which was still intensifying into the winter.

Following the very notable hydrological conditions which characterised much of the preceding two years, 1991 saw a return to somewhat more familiar weather patterns. It was a quiet year for floods and there was no repetition of the inordinate temporal variations in rates of runoff and aquifer recharge which were a feature of 1990 especially. However, although less clear-cut than in 1989 and 1990, a strong accentuation in the normal rainfall gradient across Britain was again evident in 1991. The general tendency for the normally wettest areas to receive abundant precipitation whilst meagre rainfall characterised the driest regions has been a persistent feature of the UK climate over much of the period beginning in summer 1988.

Generally, a significant amelioration in the drought conditions, which afflicted much of the English lowlands, occurred throughout the first half of 1991 although May was notably dry. From August, however, dry conditions again prevailed and the drought re-intensified. As a consequence, long term rainfall deficiencies across a large proportion of eastern and southern Britain — already substantial at the end of 1990 — increased over 1991 as a whole. As in 1989 and 1990, the drought achieved its greatest severity in those regions where rainfall, even in an average year, provides only a modest surplus over evaporation losses.

Annual runoff totals for 1991 in many eastern catchments were without recorded precedent and, by the late autumn, river flows were exceptionally depressed throughout much of the English lowlands.

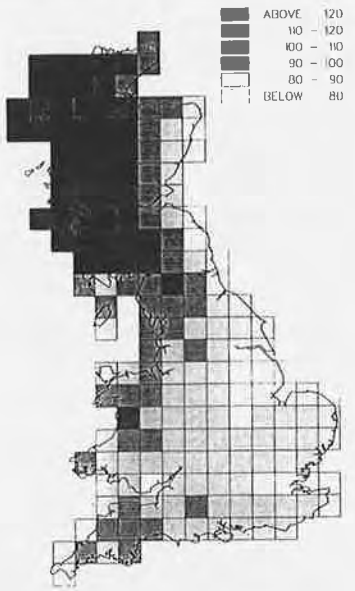
The drought was even more severe in groundwater terms. Near the eastern seaboard little substantial groundwater replenishment occurred over the period October 1990 to March 1991; the third successive winter with very meagre recharge in some parts of the Chalk outcrop. Following a sustained summer and autumn recession in 1991, groundwater levels were the lowest on record across the greater part of the English lowlands (and beyond).

Evidence from a number of observation boreholes indicates that, in parts of eastern England, the late-1991 water-table depression is unparalleled since at least the turn of the century. Consequently many spring sources failed in 1991 and river headwaters contracted further - representing a substantial loss of amenity and aquatic habitat. The ecological impact of the drought was most severe where concentrations of population, commercial activities and intensive agriculture generate the greatest water demand. This focuses attention on the requirement for new water management procedures which are better able to reconcile the needs of the human and wild life communities.

Hydrometric Register and Statistics 1986-90

UK rivers tend to be short, shallow and subject to considerable artificial disturbance. Water-tables, both locally and regionally, may also be heavily influenced by varying groundwater abstraction rates.

The effects of an evolving pattern of water utilisation together with more subtle influences resulting from, for instance, land use change, can greatly disturb the natural relationship between rainfall and rates of runoff and aquifer recharge. At the same time, the limited depth of UK rivers and the relatively narrow range in recorded annual minimum groundwater levels places a high premium on accurate field



Rainfall August 1988 - February 1992 as a percentage of the 1961-1990 mean

measurement and high standards of hydrometric practice. Changes in measurement techniques, and the priority afforded to hydrometric activities, imply considerable changes in data precision over time. All these factors are important in assessing the significance of contemporary droughts (and floods) and in making appropriate comparisons with notable hydrological events in the past.

The main objectives of the Hydrometric Register and Statistics 1986-90 is to document water resource variations during a notably volatile period and to serve as a reference source to assist data users in both the selection of monitoring sites for particular investigations and to allow more effective interpretations of analyses based upon the raw hydrological data.

Concise station gauging and station descriptions — drafted in collaboration with the measuring authorities — are given for around 1000 flow measurement sites; particular emphasis is placed on hydrometric performance, especially in the high and low flow ranges, and on the net effect of artificial influences on the natural flow regime; a thumbnail geographical description of the catchment is also provided. Summary hydrometric statistics, for each of the years 1986-90 are provided alongside the corresponding long-term average and extreme flows, to allow the recent variability in water resources to be considered in a full historical context. The groundwater section incorporates borehole and well details together with annual recharge assessments for about 170 wells in the national network contributing data to the British Geological Survey's archive.

The National Water Archive

The 1991 Yearbook and 'Stats' volumes are the first Hydrological data UK

publications released since the formation of the National Water Archive (NWA) in April 1992. The National Water Archive is the most recently established of the Natural Environment Research Council's Designated Data Centres. However, the Wallingford site has long been a natural focus for the acquisition and exploitation of major hydrological databases; for more than a decade stewardship of the National River Flow and National Groundwater Level Archives has rested with the Institute of Hydrology and British Geological Survey respectively. These databases form the kernel of the National Water Archive but a very broad range of hydrological and related data sets are being assimilated into the coordinated management that the NWA provides. Data holdings range from the catchment scale (e.g. detailed climatological and hydrological data for a network of experimental catchments) to national (flood event data) and international coverage (world floods archive). The utility of the archived time series data is enhanced by the availability of complementary spatial information (for example the digitised river network and UK soils hydrology map) and by the manipulative potential provided by modern data handling systems and analytical packages.

Orders for the 1991 Yearbook (price £20) and the Hydrometric Register and Statistics 1986-90 (£20) may be placed through The National Water Archive Office, Institute of Hydrology, Crowmarsh Gifford, Wallingford, Oxon, OX10 8BB, Tel: 0491 38800, Fax: 0491 32256.

Environment Agency

Following the news of the planned Environment Agency to incorporate the National Rivers Authority and HM Inspectorate of Pollution (see *Circulation 35*, page 16), the Government's provisional timetable has now been announced:

Bill introduced to parliament	November 1993
Agency organising committee set up	January 1994
Royal Assent expected	Summer 1994
Agency established	April 1995

Copy Deadline for Issue No. 37 8th January 1993

Report of the BHS Drought Workshop

Loughborough 15 - 16 September 1992

The first workshop BHS has organised was held in Loughborough on the 15th and 16th of September to consider how to assess the severity of droughts. A workshop format was chosen to help the authors of *BHS Occasional Paper 3* (OP3) to complete their task, and perhaps to yield enough information to produce a further Occasional Paper: but why did we need any help?

At the last national symposium I presented a short report on the OP3 stating that it would be published "shortly". However, as we were in the middle of a drought, the subject of drought assessment was of interest to a number of those present, and **Peter Wolf** suggested that before publishing a BHS paper on this topic we should give members a chance to contribute their thoughts on such an important topic.

The authors (**Sue Walker, Allan Lambert, Terry Marsh** and myself) were also finding the topic complicated with little published guidance on how to assess the severity and were delighted to be offered some assistance — hence the workshop.

It was decided to invite a number of hydrologists from the UK who had experience in some aspects of droughts, and these should be from all aspects of the water industry — principally water companies, the NRA, research establishments, universities and consultants. In addition there would be places for other members on request on a first-come-first-served basis, but the total number would be restricted to 30. In the end we had to turn members away, for which we would like to apologise, but we felt it was important for a workshop format that the numbers were limited.

The workshop was organised to answer a number of specific questions:

- what are good indicators of drought severity?
- how should these indicators be measured and analysed?
- how should the results be presented?

It was recognised that the answers to these questions may be different for hydrologists and for the public, and hydrologists' preferences may be influenced by where they work. This did indeed turn out to be the case and provoked lively debate.

After an introduction by Sue Walker, giving the background to OP3 and the rationale for the workshop, a number of contributors gave practical examples to show how difficult the topic of drought assessment can be: **Cameron Thomas** explained how effective rainfall was the important variable in East Anglia and not just rainfall; **Tim Wyatt** emphasised the importance of the management of the resources on drought impact; **Rob Wilby** rightly stressed the importance of a number of variables, and he argued that this could best be measured by a composite climatological index, and **Alan Gustard** introduced the "Gustard scale" of drought severity, which was to appear in discussions a number of times through the workshop.

For the rest of the first day the group was split into two to discuss the first question above: initially concentrating on possible indicators identified in the draft OP3, which had been circulated to participants earlier, and subsequently concentrating on the effectiveness of these indicators in communicating information about the drought to either professionals or the public.

In the first session one group considered indicators based on meteorological or hydrological variables, for example rainfall, effective rainfall, river flows, groundwater storage, temperature, SMD; and the other group concentrated on indicators more closely linked to the impact on water users, for example, abstractable quantities, reservoir levels, regulation releases, frequency and length of drought orders.

In the second session these indicators were ranked by voting on their usefulness in a number of areas: their clarity and unambiguous nature, directness of measure, data availability, and suitability for use during a drought. If you find these difficult to use as criteria for voting then you are not alone - so did the participants. I think we can say this session was the least successful, and I can say this freely as it was run at my suggestion!

Some results were obtained, however: rainfall was the most important variable (you might think this obvious and didn't require complicated voting to establish), but surprisingly

effective rainfall was scored one of the least useful indicators (probably because data records are thought to be very limited and dependent on the method of evaporation estimation); temperature was scored more highly than evaporation (why?), and river flow was scored highly (we got one right anyway).

Things improved in the evening with a dinner at a local Indian restaurant of some repute, at least in Loughborough, which was enjoyed by all. Unfortunately the chief organiser of this part of the evening, **Geoff Petts**, had his car broken into during the meal and *another* radio stolen - the fourth this year, he tells me.

On day two the intention was to move from identifying what are good indicators to the way these indicators could be measured and analysed. Therefore, it was important to conclude what were the good indicators. After some discussion on the previous day's voting it was agreed that five indicators were suitable for drought analysis - rainfall, SMD, river flows, reservoir storage, and groundwater levels.

Two particular aspects were to be considered:

- current best practice for categorising droughts and defining drought measures, and
- the best methods of presenting this information.

It was generally thought that guidelines for the analysis of droughts are not as widespread as for floods, and indeed many thought that in practice the chosen method of analysis was often tailored to the tools available, even if they may not be entirely appropriate. Therefore it was not thought possible to recommend the best practice at this time. However, it was thought that the measures should be continuous variables, which for rainfall could be the cumulative deficit below the mean (see Figure 1, taken from the paper by Bryant, Arnell and Law).

The discussions ranged widely over the issues related to these questions, e.g. what distributions should be used, are return periods suitable measures for public or even hydrological use given the rapid temporal and spatial variations that can be produced, should the percentage chance of refill be used; and over the issue of whether the drought indicator should show an impact on consumers of water rather than just the meteorological aspects of droughts. There was a view that a drought can only occur if someone or something is damaged in some way by the water shortage.

These wide ranging discussions presented the chairman of the last session with a serious problem - how to draw it all together to produce some firm conclusions to help the authors of OP3? **Frank Law** had been given this task and carried it out admirably (beyond what I at least thought possible). So what was concluded?

Conclusions

1. The large number of possible indicators could be reduced to five, but the most appropriate depends on whether the drought is impacting groundwater or reservoirs or both, and whether one is particularly interested in the impact on water supply or more generally on the environment.

2. The hydrological community does not at present feel able to recommend best practice for drought analysis: it was thought that more research is required and hopefully some organisation could be found to fund it.

3. For communicating the severity of a drought to the public the "Gustard scale" should be recommended (or perhaps the "BHS drought scale"). This classified drought severity into bands or categories: category 1 is moderate (return period of 5 to 20 years), category 2 is serious (return period 20 to 50 years) and category 3 is severe (return period greater than 50 years).

4. The main indicator chosen should be a continuous variable which could be

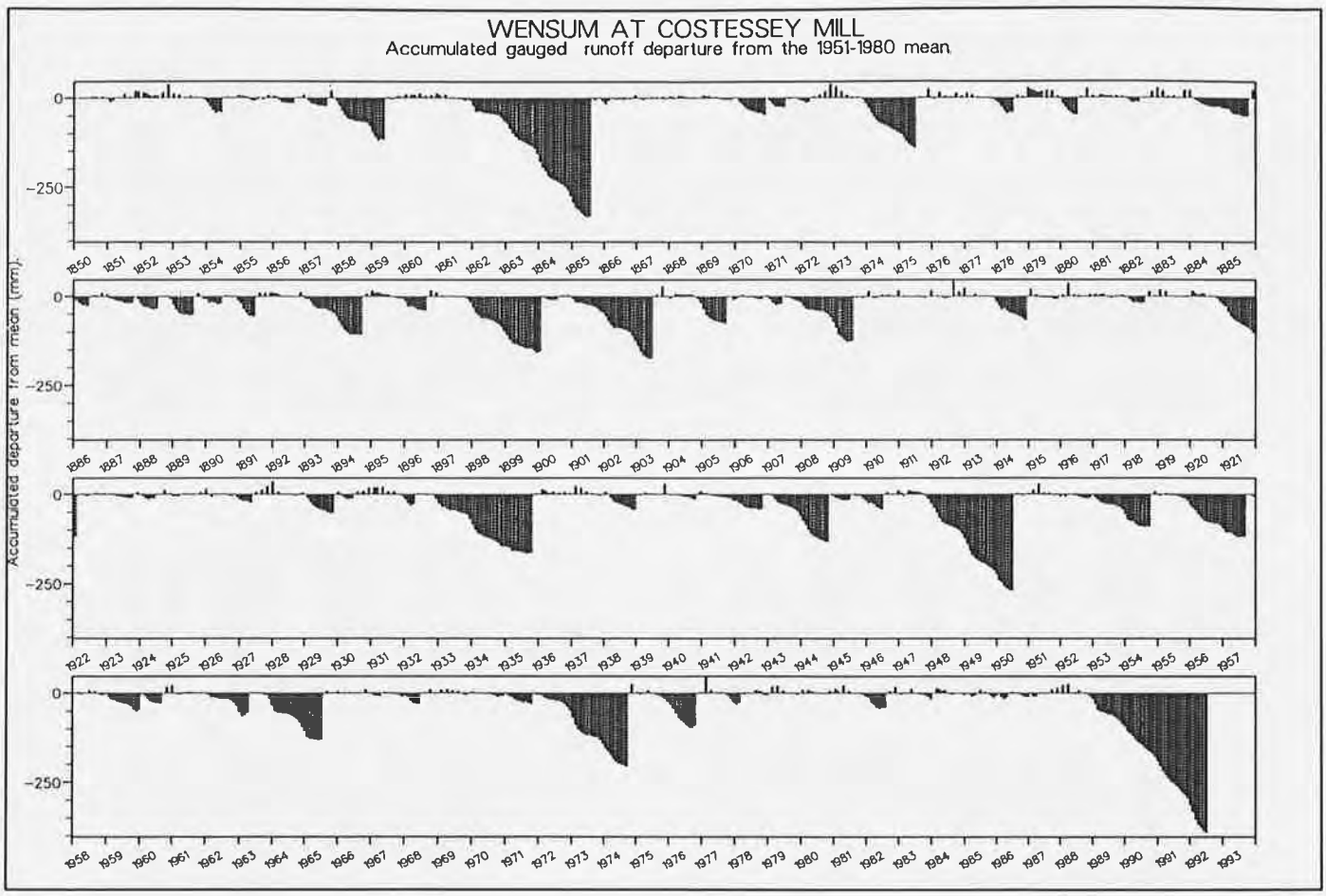


Figure 1 Runoff deficit index for the River Wensum at Costessey Mill, Norfolk

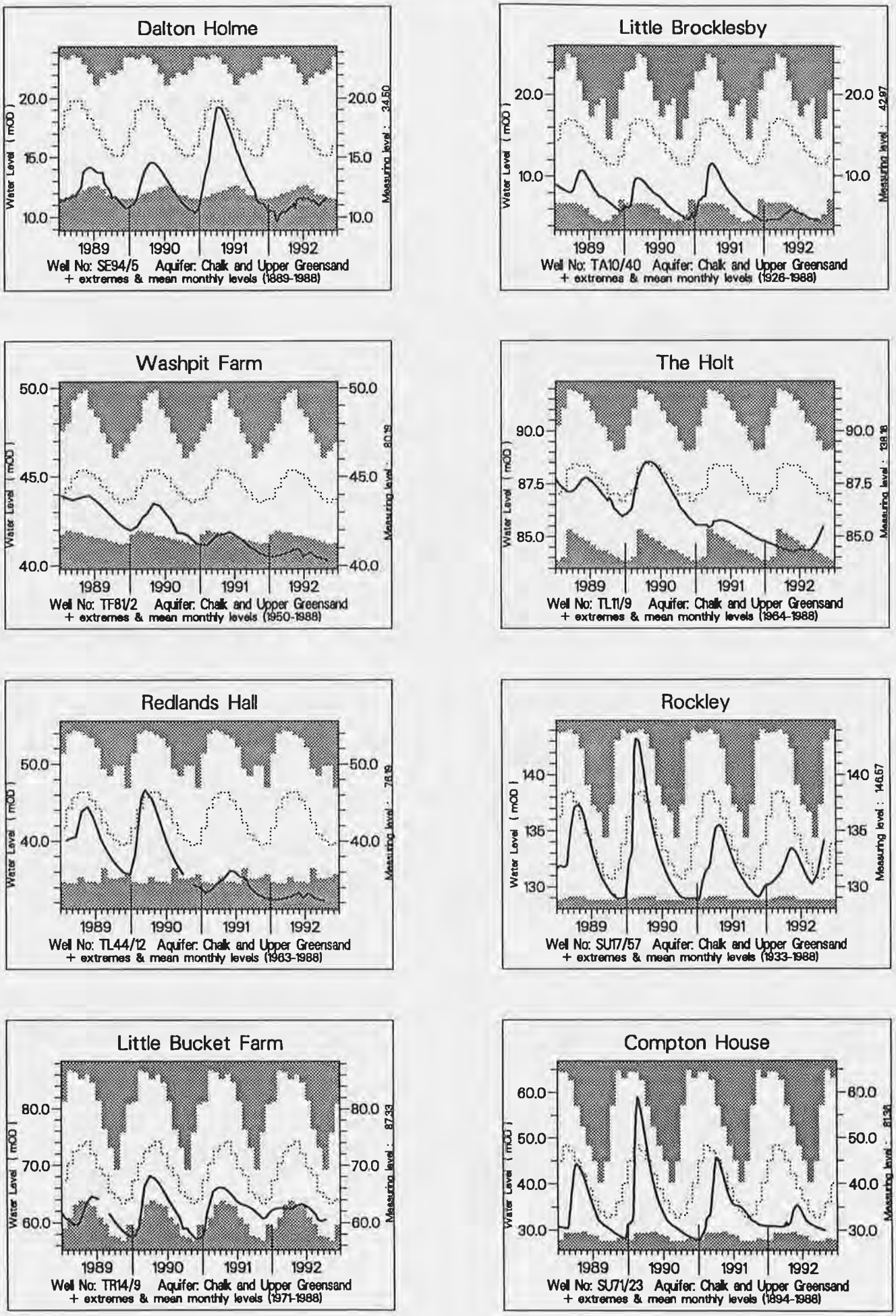


Figure 2 Groundwater level hydrographs in the Chalk and Upper Greensand, 1989-1992

calculated even when there is not a drought. This indicator could be calculated for MORECS squares and published by the Meteorological Office with their MORECS output. The indicator should be banded (as recommended in 3 above) and these bands colour-coded, so that when a drought is in progress they could be plotted for the UK.

5. In addition to the above, the graphical method of presenting information on the drought chosen by the Institute of Hydrology and some NRA regions was most appropriate for communicating information about particular sites or rivers to the public (see Figure 2).

6. The above indicators show that there is a meteorological (or environmental) drought but they do not necessarily show the impact on the public as a water consumer: the amount of developed resources and the way they have been managed are crucial for this. There was considerable support for a second type of indicator which gave the water resource impact, also categorised as in 3 above. However, there was a certain reluctance on the part of the water company representatives to agree to this, perhaps because of the problems this may cause with their levels of service agreements with OFWAT.

7. A number of the other issues raised in the workshop cannot be resolved at present and must await further work, workshops or conferences. We recommend that BHS consider incorporating in their programme of meetings within the next year or two drought analysis topics. A session at the next national symposium is one possible way of achieving this.

8. The OP3 authors will incorporate the conclusions from the workshop, as they see fit, and will produce this long awaited, or at least promised, report "shortly".

9. The workshop talked for two days about droughts without ever defining what one was — it was thought we could spend two days on this aspect alone.

John A. Mawdsley
Newcastle upon Tyne

IH Scotland

The Institute of Hydrology has established new Scottish headquarters in Stirling, headed by **Dick Johnson**, at Unit 2, Alpha Centre, Innovation Park, Stirling, FK9 4NF, *Telephone* (0786) 447612; *Fax* (0786) 447614

Midlands Section news

The BHS Midlands Section has recently co-opted **Richard Cross** onto its committee, which will help to satisfy the need for younger members on BHS Committees. Richard's presence should improve contact between the Section and those members who work for the NRA Severn Trent Region.

Water Board News

Sue Walker reports that the main activity of the ICE Water Board in recent months has been in preparing responses to consultation papers issued by Government departments and other organisations. Comments have been made on the following documents, among others: *Draft groundwater protection policy* (NRA), *Water resources development strategy* (NRA), *Using water wisely* (DoE), *Circular on development in flood risk areas* (DoE), *Policy guidance in planning and pollution controls* (DoE).

Software open day

On 29 January 1993 the Institute of Hydrology is holding an open day to demonstrate its range of hydrological computer software. A registration form is being circulated separately, but if you require further details please contact **Yvonne Parks** or **Neil Runnalls** at IH.

FORTHCOMING EVENTS

BHS AGM

14th December 1992
University of Sheffield
Land use change impacts

Fourth National Hydrology Symposium

Final call for papers

Jim Blackie awaits your contributions for the Fourth BHS Symposium in anticipation that their range and content will make for a lively three days in Cardiff next September.

If you have a problem with the closing date for **abstracts** (30 November, as announced in *Circulation 35*), please contact Jim as soon as possible at the Institute of Hydrology (Tel. 0491 38800, Fax 0491 32256).

Enquiries about exhibition space and offers of sponsorship will be welcomed by **Rob Drayton** at Wallace Evans Ltd, Plymouth House, Cardiff CF6 2YF (Tel. 0222 704321, Fax 0222 709793).

Courses

One-day workshop for
HYDROMETRIC PRACTITIONERS
Birmingham area
17 and 18 February 1993

This full day workshop and field demonstration for hydrometric technicians will be run on two days in or near Birmingham.

Details will be announced in a leaflet nearer the time. The contact for further information is Rod Hawnt, Hydro-Logic, The Annexe, West Lodge, Rainbow Street, Leominster, HR6 8DQ. (*Tel:* 0568 616847, *Fax:* 0568 616947)

Meetings

European Geophysical Society
XVIII General Assembly
6-10 April, 1993
Edinburgh

There are ten Hydrological Sciences sessions this time:
HS1: Open hydrology session;
HS2: Entering the era of distributed snow models;
HS3: Nutrient cycling and transport: from the plant to the catchment scale;
HS4: Impacts of environmental change on runoff, water quality and sediment regimes;

HS5: Sedimentation and circulation in lakes and reservoirs;
HS6: Water in the new Europe: scientific and management issues;
HS7: Fractals, scaling and nonlinear variability in hydrology;
HS8: Atmospheric and hydrological processes and models at the soil-vegetation-atmosphere interface;
HS9: Effective parameter estimation for flow and transport in the subsurface;
HS10: Data smpling and parameter estimation for spatially-distributed hydrological systems.

The **deadline** for submission of Abstracts is **1 January 1993.** Further details from Professor Enda O'Connell, Dept of Civil Engineering, University of Newcastle upon Tyne, Tel: 091 222 6405, Fax: 091 222 6669.

6th SOUTH AFRICAN NATIONAL HYDROLOGY SYMPOSIUM
Pietermaritzburg
8-10 September 1993

This symposium in Natal, South Africa, takes place just before the BHS National Hydrology Symposium in Cardiff (13-16 September).

For further information please contact Simon A Lorentz, Department of Agricultural Engineering, University of Natal, PO Box 375, Pietermaritzburg 3200, South Africa (*Tel:* +27 331 955178, *Fax:* +27 331 61896, *Email:* swan@aqua.ccwr.ac.za).

International Congress on MODELLING and SIMULATION
University of Western Australia
6-10 December 1993

The theme of this congress is Modelling Change in Environmental and Socio-economic Systems. It incorporates the 10th Biennial Conference of the Modelling & Simulation Society of Australia.

For further information contact Tony Jakeman, CRES, Institute of Advanced Studies, Australian National University, Canberra ACT 2601, Australia (*Tel:* 61 6 249 4742, *Fax:* 61 6 249 0757, *Email:* tony@cres.anu.edu.au)

International Conference on GROUNDWATER:
Drought, Pollution & Management
Brighton
1-3 February 1994

Papers are invited for an international conference on the long-term sustainability of groundwater resources.

The three broad themes are quantity constraints (including reduced recharge resulting from prolonged drought), quality constraints (diffuse and point-source pollution and management solutions (including groundwater protection and artificial recharge).

Abstracts of not more than **500** words should be submitted no later than **1 February 1993** on a form obtainable from the organiser, Jaqueline Watts, H R Wallingford Ltd, Howbery Park, Crowmarsh Gifford, Wallingford, OX10 8BA (*Tel. 0491 35381, Fax 32233*)

Diary

4th December 1992
Scottish Hydrological Group
"Mathematical modelling of solute transport in rivers" — Dr S Wallis
Venue: Strathclyde University
Time: 6.30 p.m. (tea at 6 p.m.)
Contact: Dr DJ Gilvear, Dept of Environ. Science, Stirling University, FK9 4LA *(Tel: 0786 731711; Fax 0786 67843)*

9th December 1992
BHS Southern Section Meeting
"Desert Island Diskettes"
Venue: Room 201, Civil Engineering Department, Imperial College, London
Time: 5.30 p.m. (tea at 5 p.m.)
Contact: Dr Howard Wheater, Dept of Civil Engineering, Imperial College, London, SW7 2BU.

14th December 1992
BHS **AGM** and National Meeting
"Land-use change impacts"
Venue: University of Sheffield
Contact: Dr James Bathurst, University of Newcastle upon Tyne (Tel: 091 222 6333, Fax: 091 222 6669)

5th -7th January 1993
Institute of British Geographers Biogeography Research Group / British Ecological Society / BHS Meeting
"Hydrology and hydrochemistry of British wetlands"
Venue: Royal Holloway & Bedford New College, University of London
Contact: J Hughes, Dept of Geography, Reading University, RG6 2AB (Tel. 0734 318733, Fax 0734 755865)

12th January 1993
Scottish Hydrological Group
"Orographic rainfall & weather radar" — Marjory Roy, Edinburgh University
Venue: Royal Society of Edinburgh
Time: 6.30 p.m. (tea at 6 p.m.)
Contact: Dr D J Gilvear, *address above*

20th January 1993
BHS Southern Section Meeting
"Water supply & demand in the south-east — recent drought experience"
Venue: Institute of Hydrology
Time: 11.00 a.m.
Contact: Dr Howard Wheater, *see above*

20th January 1993
Welsh Hydrological Group
"Acid rain" — A Gee, NRA
Venue: NRA, St Mellons, Cardiff
Time: 6.30 p.m. (tea at 6 p.m.)
Contact: Linda Aucott, NRA Wessex Region, Rivers House, East Quay, Bridgwater, TA6 4YS (*Tel:* 0278 457333)

27th January 1993
BHS Midlands Section Meeting
"Sediment & contaminant transport" — D Mitchell & I Foster
Venue: University of Coventry
Contact: Paul Webster, Dept of Civil Engineering, University of Birmingham, Birmingham, B15 2TT. (*Tel:* 021 414 5055, *Fax:* 021 414 3675)

17th & 18th February 1993
Hydrometric practitioners' workshops
Venue: Birmingham area
Contact: Rod Hawnt, Hydro-Logic Ltd, West Lodge, Leominster. (*Tel:* 0568 616847, *Fax:* 0568 616947)

3rd March 1993
BHS Southern Section Meeting
"Hydrology of the coastal zone"
Venue: Imperial College, London
Time: 5.30 p.m. (tea at 5 p.m.)
Contact: Dr Howard Wheater, *see above*

3rd March 1993
BHS Midlands Section Meeting / IWEM (East Midlands Section)
"The Derbyshire Derwent"
Venue: Loughborough University
Contact: Paul Webster, *address above*

12th January 1993
Scottish Hydrological Group
"Snowmelt runoff modelling" — Dr A Bennett, Clyde RPB
Venue: Strathclyde University
Time: 6.30 p.m. (tea at 6 p.m.)
Contact: Dr D J Gilvear, *address above*

6th-8th April 1993
Third BHS Postgraduate Symposium
Venue: University of Lancaster
Contact: Dr James Bathurst, *see above*

3rd-7th May 1993
EGS XVIII General Assembly
Venue: Wiesbaden, Germany
Contact: Professor P E O'Connell, University of Newcastle upon Tyne (Tel: 091 222 6405, Fax: 091 222 6669)

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 £19. 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. Fax: 0491 32256.