THE NEWSLETTER OF THE BRITISH HYDROLOGICAL SOCIETY

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UNIVERSITY RESEARCH ... Part V

Department of Geography, Southampton University

Six academic staff in the Department of Geography at Southampton University undertake research in physical geography. A group of this size cannot undertake substantive research across the full range of the subject and over the last ten years research has been deliberately concentrated upon specific themes, within which hydrology occupies a pivotal role. Since 1982, research has been focused upon four fundamental areas: the role of vegetation in hydrology and fluvial geomorphology; snow and ice hydrology and sediment transfer; palaeohydrology, and river and basin management. As a result of the strong overlap and interaction between these research areas, in 1987 they were formally combined into the single theme of *hydrogeomorphology and river management.* This is the primary concern of three members of the academic staff *(M J Clark, K J Gregory* and *A M Gurnell)* but is also related to some of the research interests of *K E Barber* (Palaeoecology), *E J Milton* (Remote sensing) and *R J Small* (Glacial sediment transfer).

Research in hydrogeomorphology and river management benefits from interdisciplinary links within the University. Such links arise firstly through research and postgraduate teaching with *Civil Engineering,* the *Institute of Irrigation Studies, Biology* and *Geology,* and secondly through the participation of four of the staff (M J Clark, K J Gregory, A M Gurnell and E J Milton) in the interdisciplinary contract research of the *GeoData Unit.* This is a Faculty of Science Advisory Unit, established in 1984. It provides a focus for research and contract investigations and for CASE research students with industry in the general field of environmental data collection, analysis and assessment.

The Role of Vegetation in Hydrology and Fluvial Geomorphology

The influence and significance of vegetation in relation to hydrology and fluvial geomorphology has long been one of the most active areas of research. Much of this research has been undertaken in the New Forest, where studies extending over some ten years and recently supported by an NERC research grant have investigated interactions between vegetation and runoff generation at a range of spatial scales (Gregory and Gurnell, 1988). The contrast in runoff from lowland woodland and heathland catchments has been found to be almost as great as that established by other researchers for the moorland and afforested areas of the British uplands (Gurnell and Gregory, 1987). Of even greater interest has been the demonstration of the close association between heathland vegetation composition and the near-surface water table regime and its potential for identifying runoff contributing areas (Gurnell and Gregory, 1986) and the impact of heathland management practices for the water balance of the heaths, particularly the dry heathland areas investigated by P A Hughes in her Ph.D. programme. Vegetation also has an impact on the stability, morphology and flood-routing characteristics of river channels within the New Forest (Gregory et.al., 1985). Vegetation debris dams, flush and mire vegetation all have a direct impact upon the way in which the drainage network stores and transmits flood flows and associated sediments. Clearance of such vegetation through channel management practices has a feedback influence on the flow and sediment regime and the subsequent evolution of the river channel. These links between channel vegetation and management, discharge, sediment



Val d'Herens, Switzerland

transfer and morphology have been addressed within the New Forest and also more widely through two CASE studentships with the FBA; the use of remote sensing to elaborate the relationship between channel vegetation and river discharge is being further developed (E J Milton, K J Gregory).

Snow and Ice Hydrology and Sediment Transfer

Studies of the relationships between sediment source areas, hydrology and sediment transfer have been undertaken in the nival, seasonal frost regime of northern Finland and the alpine glacial regime of southern Switzerland. Research in Finland has been based on links with the Geography Department, University of Helsinki and included a Ph.D. thesis by **J L Threlfall** on the discharge and sediment transfer characteristics of the Skirhasjohka catchment. Hydrological research in Switzerland developed out of early and continuing work on glacial sediment transfer by M J Clark and R J Small. **C R Fenn** submitted a Ph.D. thesis on the characteristics of proglacial streamflow time series and contributed to joint research on refining estimates of the suspended sediment load of proglacial streams through the traditional sediment rating curve approach and through the estimation of Box Jenkins transfer functions between suspended sediment concentration and discharge time series (Gurnell and Fenn, 1984a). Links between suspended sediment transport and the dissolved load of proglacial streams (Gurnell and Fenn, 1984b) suggest that studies of meltwater chemistry are likely to be helpful in establishing the supply characteristics of the suspended sediment, which form the fundamental problem when attempting to estimate suspended sediment concentration from discharge. More recently, M J Clark, A M Gurnell and J Warburton have studied the yield of bedload and suspended load from two alpine glaciated catchments and J Warburton has been attempting to establish the degree to which fluvial processes on the proglacial valley train contribute sediment to the proglacial stream in addition to that derived from the glaciated portion of the catchment. Empirical work carried out by researchers at Southampton and colleagues in other British, Swiss and Belgian research institutions has been summarised in a recent edited volume (Gurnell and Clark, 1987). Research in Finland and Switzerland continues and the Swiss research has recently been developed in a joint project with **K S Richards** and **M J Sharp**, University of Cambridge.

Palaeohydrology

Research in this area has become very strong, particularly in recent years during which K J Gregory has been UK national delegate to IGCP Project 158 'Palaeohydrology of the temperate zone in the last 15,000 years'. The British contribution to the fluvial part of this international project (1977-87) has been based on the Severn and Wye basins and included Ph.D. research by **A G Brown** which demonstrated the characteristics of adjusting fluvial systems in relation to the changing environments of the Severn basin. Subsequently as a postdoctoral research fellow, A G Brown investigated sediment storage in the Severn basin, and showed how it varied over the last 15,000 years and how it has been affected by human activity. Research within the field of palaeohydrology is illustrated by two recently published books (Gregory, 1983; Gregory et.al., 1987).

A workshop on global palaeohydrology was held in the department in March 1988 chaired by **Leszek Starkel** (Krakow) and discussed preliminary plans for future international palaeohydrological research. Such research may link to palaeoclimate research and have application to future hydrology. In future palaeohydrological research a refined river channel typology related to drainage basin processes could be useful and this could be one application of the typology being developed by M J Clark, K J Gregory and **Zhang Yu.**

River and Basin Management

Research interest in this area has developed from investigations of three main topics: river channel adjustments, the links between river channel morphology and process, and urban hydrology.

Research by K J Gregory and a number of research students has addressed the problem of river channel changes, the nature of the changes, their causes and their environmental impacts (Gregory, 1987). Studies have included those by **G E Petts** who considered the adjustments of river channels downstream of dams and reservoirs in Britain, **A Brookes** who undertook CASE research with the FBA on the downstream effects of river channelisation in England and Wales 1930-1980 (Brookes et al., 1983), and **W Mansfield** who investigated the impact of



Channelization in England and Wales 1930-1980 (Brookes et al., 1983)

bridges on downstream channel morphology. Investigations of river channel change have extended overseas to include joint work by K J Gregory and R Whitlow on channel change downstream of urban areas in Zimbabwe and a Ph.D. project by A Bullock on the influence of dambos on flood and low flows in Zimbabwe. Research on channel change is continuing with the development of a global data base on the character and magnitude of change and its association with river channel management.

The relationship between river channel morphology and process is focused on the impact of changing process rates on the river channel and also on the degree to which process can be inferred from morphology. G Wharton is undertaking CASE research with the Institute of Hydrology (N W Arnell) on the relation between channel morphology and flood discharge based on information derived partly from the Surface Water Archive and partly from field work. This research is establishing methods of estimating flood discharges in British rivers from river channel dimensions (Wharton et al., 1988).

Research in urban hydrology has centred on the Lordshill catchments. These three small, storm-sewered catchments were originally instrumented by Civil Engineering but were subsequently taken



Research on sediment production in proglacial areas, Val d'Herens, Switzerland

over by the Geography Department. Three research students have successfully undertaken Ph.D. programmes involving these and other catchments. **J. Buttle** demonstrated how dynamic contributing areas on the previous surfaces of the catchments contributed to storm sewer flows. This has been extended by **G Moys** who monitored changing soil moisture conditions in the catchments in order to assess the role of antecedent conditions in generating runoff to the storm sewer network. **C W Prowse** also utilised the Lordshill catchments with a large number of sampling sites in the Monks Brook catchment to study water quality variations and the impact of suburban housing development on the quality of runoff.

The Future

Several future research directions have been noted above and these are all based on the underlying aim of continued integration of research projects. The related projects are increasingly linked at the drainage basin scale and will benefit from database development in the GeoData Unit. A relatively small group of researchers has managed, by careful selection of research areas, by attention to interaction between individual research investigations and by investment of effort and resources underpinning this interaction, to establish a coherent research team under the single umbrella of 'Hydrogeomorphology and river management'. Under this theme the research team intends to continue research of a high quality.

References

Brookes A, Gregory K J and Dawson F H (1983) "An assessment of river channelization in England and Wales". The Science of the Total Environment 27,97-111.

Brown A G, Gregory K J and Milton E J (1987) "The use of Landsat multi-spectral scanner data for the analysis and management of flooding on the River Severn, England". Environmental Management 11, 695-701.

Gregory K J (Ed) (1983) *Background to Palaeohydrology.* Wiley, Chichester.

Gregory K J (1987) "Environmental effects of river channel changes". Regulated rivers: Research and Management 1, 358-363.

Gregory K J, Lewin J and Thornes J B (Eds.) (1987) *"Palaeohydrology in Practice: A river basin analysis"* Wiley 370pp.

Gregory K J and Gurnell AM (1988) Vegetation and river channel form and processes. In *Biogeomorphology,* Ed. H M Viles, Blackwell. In press.

Gregory K J, Gurnell A M and Hill C T (1985) "The permanence of debris dams related to river channel processes". Hydrological Sciences Journal, 30, 371-381.

Gurnell A M, Gregory K J, Hollis S and Hill C T (1985) "Detrended correspondence analysis of heathland vegetation: The identification of runoff contributing areas". Earth Surface Processes and Landforms, 10, 343-351.

Gurnell A M and Clark M J (Eds.) (1987) *Glacio-fluvial sediment transfer,* Wiley, Chichester.

Gurnell A M and Fenn C R (1984a) Box-Jenkins transfer function models applied to suspended sediment concentration - discharge relationships in a proglacial stream. Arctic and Alpine Research 16, 342-354.

Gurnell A M and Fenn C R (1984b) Flow separation, sediment source areas and suspended sediment transport in a proglacial stream. In A P Schick (Eds.) Catena supplement 5, 109-119.

Gurnell A M and Gregory K J (1986) Water table level and contributing area: the generation of runoff in a heathland catchment. International Association of Hydrological Sciences Publication 156, 87-95.

Gurnell A M and Gregory K J (1987) Vegetation characteristics and the prediction of runoff: analysis of an experiment in the New Forest, Hampshire. Hydrological Processes 1, 125-142.

Wharton G, Arnell N W, Gregory K J and Gurnell A M (1988) River discharge estimated from channel dimensions. Journal of Hydrology In press.

NEWS FROM MEMBERS

Congratulations to **Ian Cluckie**, moving from the Department of Civil Engineering at Birmingham University to take up the Chair of Water Resources at the University of Salford.

Congratulations also to our President **Peter Wolf** who is to receive the first *Ray K Linsley Award* of the American Institute of Hydrology. Prof Wolf will be travelling to Tampa, Florida, in November to present a lecture and receive his award.

CONSULTANTS

After more than 35 years working in the developing world and for the past 16 as a project manager of UNDP/FAO water resources and agricultural development projects in Africa, the Near East and South-East Asia, **John Pike** is now practicing as a freelance consultant specialising in agricultural hydrology from a base in Suffolk. He has recently completed work for Australian Aid in Thailand and for other clients in the Middle East.

Free Books!

I have a selection of books waiting for review. Many are on groundwater - are there really no new hydrology/hydraulics books being published at present? If you know of any others please let me know. The waiting list is:

Brassington, *Field hydrogeology*
Burget & Dubertret, *Hydrogeology of karstic terrains: case histories*
Clark, *The field guide to water wells and boreholes*
Lowing (Ed), *Casebook of methods for computing hydrological parameters for water projects*
Haimes and others, *The process of water resources project planning: a systems approach*
Hydrogeological mapping in Asia and the Pacific region
LaMoreaux, *Hydrology of limestone terraines*
Matthess, Foster & Skinner, *Groundwater protection zones*
Langguth, *List of terms of hydrogeology* (6 language dictionary and glossary)
Mijatovic, *Hydrogeology of the Dinaric karst*
Shaw, *Hydrology in practice* (2nd edition)
Developments in hydraulic engineering (vol 5) with sections on Low-head hydropower, Icy intakes, Estuary-sea interface, and Polders
Zekteser & Dzhamalov, *Role of groundwater in the hydrological cycle and in continental water balance*

Please contact me if you would like to join our team of reviewers:

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A Decade of The Indian Association of Hydrologists

The Indian Association of Hydrologists (IAH) was established in 1976, at the Department of Hydrology located in the University of Roorkee, Uttar Pradesh, as a scientific forum. In IAH, professionals in the field of hydrology interact with each other to exchange problems, knit their strategies and review the outcome of their efforts to solve national problems related to water resources. The Association also aims to honour individuals for their pioneering and meritorious contributions in the field of hydrology, by electing them as honorary life members, and inviting them to be patrons of the Association.

The IAH maintains close liaison with the national and international institutions working in the field of hydrology. The membership of the Association is open to all individuals and institutions dealing with hydrology. Recently, contact has been established with the British Hydrological Society based in London (UK).

Within the span of its existence, the Association has fulfilled most of its professional duties quite effectively and has been able to make a dent in the hydrological community in India and abroad, under the able Presidentships of Sri C C Patel, Ex-Secretary, Ministry of Irrigation, Government of India, Sri Pritam Singh, Ex-Chairman, Central Water Commission and Sri J F Mistry, Secretary, Irrigation, Government of Gujarat. Dr Satish Chandra, Director, National Institute of Hydrology, Roorkee has been a constant source of inspiration for the Association and has been its active Vice President. Over the years the Association has assumed a leading role as a mature institution engaged in dissemination of hydrological information through its publications and scientific get-togethers.

IAH Publications

The Association has been publishing a research magazine named "Hydrology Journal" with 2 to 4 issues every year. Over the years, the journal has grown into a mature academic effort, with each issue containing a wide spectrum of research contributions from different branches of hydrology. Recently, a new scheme of Best Paper Prizes has been introduced to encourage quality research contributions to the journal. A quarterly IAH Newsletter is also published regularly for circulation to all the members and selected nonmember institutions and individuals to cover hydrology news.

Regional Centres of IAH

The executive committee of IAH has resolved to form regional centres to cope with the increasing activities of the Association. In its first phase of regionalization, centres have been established at Delhi, Chandigarh, Roorkee, Annamalainagar (Tamil Nadu), Lucknow, Bangalore, Hyderabad, Bhubaneshwar (Orissa) and Ahmedabad. The executive committee of each regional centre consists of a Chairman, Vice-chairman,Secretary-cum-Treasurer, and two to four members.

Symposia, Seminars, Workshops

The Indian Association of Hydrologists has successfully hosted the following Seminars/Symposia/Workshops:

1. Symposium on hydrology of rivers with small and medium catchments, held at the School of Hydrology, University of Roorkee, in 1978.
2. Symposium on "Hydrologic Analysis of Catchment with Inadequate Data" (along with 54th Annual Session of CBIP) held at Vigyan Bhawan, New Delhi, in August, 1984.
3. National Seminar on "Estimation of Runoff for Surface and Subsurface Drainage", held at India International Centre, New Delhi, in December, 1985.
4. Workshop on Computer Applications in Ground Water Hydrology, held at School of Hydrology, University of Roorkee, in December, 1985.
5. Workshop on "Extreme Hydrological Trends in Gujarat" in Vadodara in November, 1986.

Besides the above, more events have been planned for the near future. One workshop is likely to be organised on 'Conservation of Surface Water Resources' by the Gujarat Centre of IAH. Another national symposium on Drought and Water Conservation is planned for 1988, with the venue at New Delhi.

Membership

The membership of the Association is open to all hydrologists, irrigation engineers, hydrogeologists, geophysicists and scientists working in the field of hydrology. At present there are 4 types of membership available to interested individuals/institutions:

(a) Individual (yearly)
(b) Individual (Life)
(c) Institution (yearly)
(d) Institution (Life), a recently created category.

The Association has recently introduced a standing discount (of 30%) to all Life members (Institution & Individual) on purchase of back volumes and other publications of the Association.

Since its establishment, the membership of the Association has recorded a steady rise. However, during the last one year, under the dynamic leadership of Sri J F Mistry, it showed a steep rise to over 600 members. IAH has also a sizable number of foreign members. The rates of membership subscription are nominal, starting from Rs. 50/- per year for individual (yearly) members.

The future plans of the Association include the creation of a category of Fellow members, and the inclusion of articles in Hindi for publication in its Hydrology Journal.

It may be seen that the IAH has emerged as a unique national forum of professional hydrologists in India having a pioneering role to play in combating the extreme hydrological problems and in the dissemination of hydrological knowledge.

NITRATES IN WATER - A CHALLENGE FOR THE HYDROLOGIST

Over seventy delegates attended the meeting on 'Nitrates in Water' held at the Institute of Hydrology on 13th April 1988. This BHS Southern Section meeting was held just two days after the Government announcement of the withdrawal of exemption licences for compliance with EEC Nitrate drinking water standards. It was an extremely appropriate time for hydrologists to re-examine the existing knowledge of nitrate movement within the water cycle, and to gain information on the developing research fronts.

Richard Williams (Institute of Hydrology) presented the first paper (on "Modelling of Nitrates in Surface Water") on behalf of **Dr Paul Whitehead.** He began by reminding conference delegates that rising nitrate levels in surface water was a problem faced not only by the UK but also by many other European countries.

The main thrust of the delivery was a description of the modelling of the nitrate dynamics of the River Thames as part of the Thames Nitrate Study. This was a collaborative study involving the Institute of Hydrology, the Water Research Centre and Thames Water. The study involved the production of water quality models for the soil zone, aquifers, rivers and reservoirs, all components of the Thames catchment.

The presentation focused on the description of the multi-reach, main channel water quality model developed by the Institute of Hydrology. The Thames Water mass balance water quantity model developed for resource evaluation provided the hydrological input for the water quality model. The twenty-two designated reaches of the River Thames were characterised by a number of cells. For each cell the water quality was modelled using a mass balance approach for a non-conservative variable. Although there are many nitrogen transformations which can occur in a river system, the model concentrated on denitrification (or more specifically nitrogen loss). Nitrification was not included as a variable since it was assumed that with efficient sewage treatment works most of the ammonia would be nitrified before reaching the river system.

The transport equation for nitrate in the river is based on the assumption that the reaction kinetics are first order. This assumption is supported by empirical evidence; modifications are made to the rate constants to take into account factors such as mud surface area and temperature. The selection of denitrification rates and the usefulness of laboratory derived denitrification constants using sediment-water systems were subjects of later discussion.

Use of the model illustrated that there was considerable seasonal variation in nitrogen losses in rivers. As might be expected from temperature differences, the summer nitrate losses are significantly higher. High nitrate losses also occurred in low flow periods. The 1976 nitrate losses in the Thames were higher than in the two preceding years: the long residence time associated with low flow rates in the reaches allowed more nitrate loss.

Graham Harris (Field Drainage Experimental Unit, ADAS) and **Dr Mike Goss** (Rothamsted) described the results of their experiments investigating the relationships between nitrate leaching, drainage type and cultivation practice. These were executed at the Brimstone Farm experimental site on the heavy clay soils of the Denchworth Series in Oxfordshire. The experimental design consisted of four treatments, each replicated five times:

undrained, direct drilled
undrained, ploughed
drained, direct drilled
drained, ploughed

These treatments were operated on plots of just under 0.2 ha each which could be managed individually.

Nitrate and other major nutrients were monitored through the surface runoff, interflow and pipe drains (on the drained plots). Water flow was monitored using FDEU V-notch weirs and collectors 35cm deep intercepting the interflow water at the plough layer or equivalent (Figure 1).

The total quantity of nitrogen lost in surface runoff and interflow drain systems did not differ significantly between drained and undrained plots. The losses of nitrogen via the surface runoff system were particularly small. However 10 times more nitrate-N was lost from the drained system via mole drains, giving total losses in the order of 30-60 kg N/ha. By comparing the different cultivation practices a marked change in runoff pattern and nitrate loss was noted. The drainage hydrograph for the direct drilled plots showed an enhanced response with more peaks, over 30% higher than from corresponding ploughed plots. This was related to the more developed soil structure with greater continuity of cracks associated with direct drilling. Loss of nitrate tended to be greater in the ploughed plots, primarily because of mineralisation caused by the greater soil disturbance and the more rapid water movement through the soil profile.

Judy Parker (British Geological Survey) gave a lively and informative account of 'Recent hydrogeological studies related to the nitrate problem'. The conclusions of the early work of the BGS were summarised briefly. Unsaturated zone research revealed high concentrations of nitrate beneath arable land but the downward movement of nitrate was no longer thought to be a straightforward process. The BGS work indicated that nitrate movement is a complex and spatially variable process involving the diffusion of solutes between mobile fissure water and static pore-water and a variable amount of dispersion.

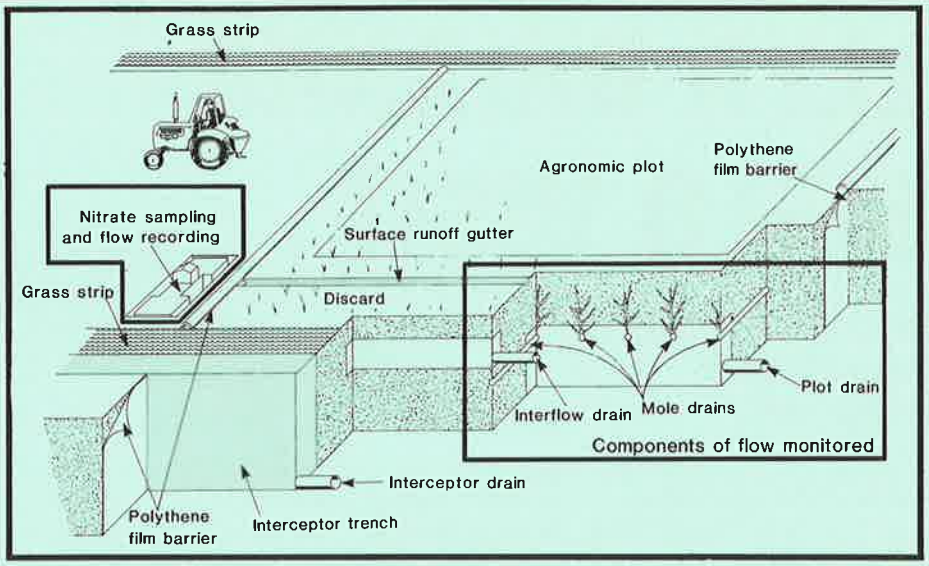
The principal results of the saturated zone research were:

Significant penetration of nitrate into unconfined aquifers,

Vertical stratification of groundwater quality with the highest nitrate concentrations occurring at shallow depths,

The quality of a groundwater sample was influenced by the type of sampling and depth/construction of the borehole.

Currently the BGS are looking at possible trends in nitrate levels in groundwater and are investigating solutions for the protection of groundwater quality. They are focusing on the investigation of natural *in situ* denitrification in confined aquifers and on the feasibility of aquifer protection on the outcrops. Studies of the three principal confined aquifers in Britain (Chalk, Triassic sandstone and Lincolnshire limestone) indicate that denitrifying bacteria are present. The next stage of the programme is to ascertain whether these bacteria have the ability to reduce nitrate in the aquifer environment, which has limited availability of organic carbon substrate.



Brimstone Farm - Flow and Nitrate Monitoring

Several aspects of aquifer protection are now being considered. In collaboration with the Soil Survey, BGS is involved in the preparation of groundwater vulnerability maps based on the characteristics of soils and geology. In areas where aquifers are vulnerable to nitrate pollution but where groundwater nitrate concentrations are still well below the EEC limit, the feasibility of establishing protection zones with fertilizer restrictions and/or land use changes is being assessed. Grassland is sometimes advocated as an alternative to cereal production in sensitive catchment areas but there is a shortage of data on nitrate leaching from grassland. Recent studies focused on this issue have demonstrated very high nitrate leaching from some intensively-managed, grazed grassland sites and further research is being carried out.

Aquifer Protection Zones was a theme returned to by the final speaker, **Colin Hayes**, Scientist for Water Supply at Anglian Water. In his paper 'Water resources implications of the nitrate problem' he gave an excellent review of the public health issues of rising nitratre levels and considered the options for operational control of nitrate in water. In his opinion, methaemoglobinaemia was not a problem in well run public municipal supplies. He also felt that there was no evidence to support a link between nitrate in drinking water and stomach cancer. The UK survey of health and drinking water revealed a lower incidence of stomach cancer in high nitrate areas.

The Water Authorities now have to face the fact that following withdrawal of derogations on the EEC standard in April 1988, they have to comply by supplying water with less than 50mg/l nitrate content. Reviewing the whole context of nitrate standards (WHO 1984, EEC, DOE/DHSS 1984/5) Colin Hayes felt that it was important not to confuse the UK municipal supplies, which are well operated, with the European and worldwide situation.

He reported the recent encouraging results of improvement in nitrate levels at Waneham Bridge on the Lincolnshire limestone. This improvement resulted from the beneficial effects of reduced spring planting and increased autumn planting. He was more cautious, however, about the possible impact of changing land-use practices on groundwater nitrate levels in the Eastern Counties as a whole. Given the fact that nitrate levels are already over 50mg/l in some aquifers he thought that it could require drastic changes in agriculture to achieve the desired quality standard of less than 50mg/l.

The Water Authorities' response to achieving the 50mg/l limit involves the consideration of a number of options. The most attractive is blending the high nitrate water with lower nitrate water. However, the scope for blending may be limited, since there may not be sufficient low nitrate water available. In addition, the distribution network may require substantial alteration, thereby increasing the expense. The options for water treatment, particularly ion exchange and microbiological treatment, were reviewed. Anglian Water is currently evaluating resins which are more selective to nitrate. Based on their experience Anglian Water are satisfied that they could introduce tertiary treatment plants for nitrate removal if required to do so.

The discussion covered a wide range of topics including the provision of bottled water supplies, the willingness of farmers to change cultivation practices and the viability of aquifer protection zones. It was acknowledged than an understanding of nitrate movement in the whole water cycle was essential if there was going to be successful control of nitrate in surface water, soil water and groundwater.

Kathleen Lacey
Kingston upon Thames

LLYN BRIANNE FIELD VISIT

Joint BHS/Welsh Hydrological Group Meeting 6 May 1988

A party of more than 30 individuals assembled in glorious sunshine by the top of the impressive LLyn Brianne dam and spillway (Fig.1), set in the magnificent mid-Wales countryside near Llandovery, at the start of a field visit devoted to catchment research and particularly to the Llyn Brianne Acid Waters Project.

BHS and WHG members were welcomed by the visit co-ordinator, **Dr Alistair Donald** (Welsh Water), who set the scene by pointing out the three main land-use types in the area: acid moorland, oak/scrub woodland and coniferous forest. He then asked **Jean Frost** (Welsh Water) to explain the basic features of the Llyn Brianne impoundment and the associated regulation scheme. The reservoir is fed by the headwaters of the Tywi and Camddwr rivers, draining an area of 88km^2; it was filled in 1972, has a total storage of 61 million m^3 and a live storage of 58.7 million m^3 above a single draw-off 62.4m below top water level. A river intake is located on the Tywi at Nantgaredig, 62km downstream from Llyn Brianne; summer regulating releases, which are made in such a way as to simulate the shape of a natural spate, take 16-24 hours to travel from dam to intake and may involve transmission losses of 12%. The relatively cold temperature of water released from Llyn Brianne is thought to affect downstream fisheries adversely. Licensed abstraction at 58 MGD is less than the potential yield of 75 MGD and there are further possibilities for increasing reservoir capacity by raising the dam. In response to questions, Jean Frost explained that the reservoir spilled for seven months of the year, that a 2% drought was the design drought for Llyn Brianne, and that there was hydropower potential at the dam site which could not easily be exploited because of the distance to demand centres and the high costs of reducing the environmental impact of such development.

Dr Donald then outlined the background to the Acid Waters Project at Llyn Brianne. Construction of the reservoir had drowned salmon spawning grounds in the Tywi headwaters and, to compensate, Welsh Water instigated a programme of 'trapping and trucking' fish which had met with limited success. Investigations in the early 1980s suggested that water acidification was responsible for spawning failures, and this problem was particularly acute in the Tywi inflow: this was more acidic than the adjacent Camddwr tributary, suffered from low pH episodes in high flows and was associated with increased dissolved Al^{3+} concentrations which are toxic to salmonids and to some invertebrates. The two headwater systems have broadly comparable geology and soil types, but the Tywi is 90% covered with coniferous forest whereas moorland dominates the Camddwr catchment. It was explained that the role of conifers in exacerbating streamwater acidification is linked to the

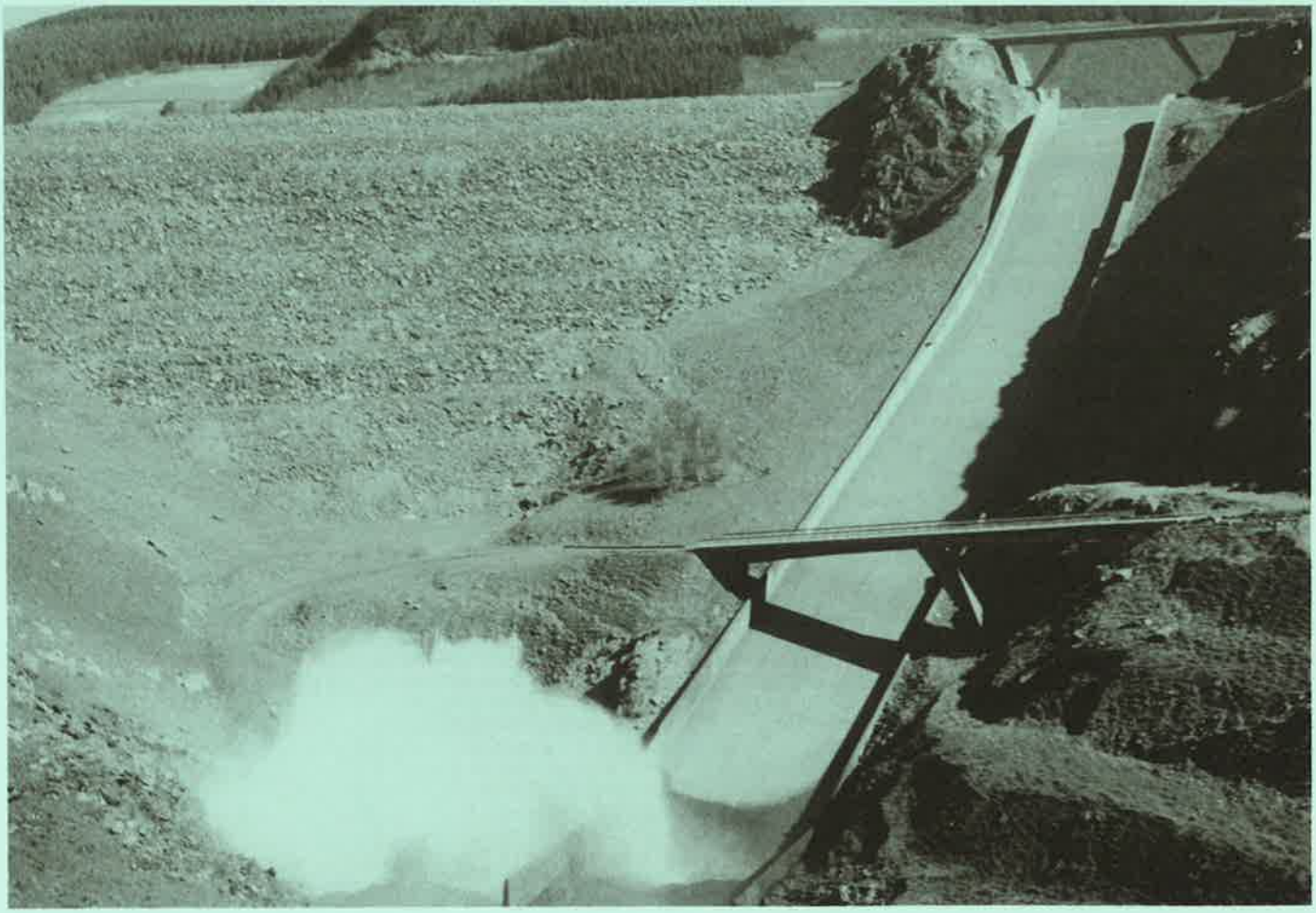


Fig. 1 Llyn Brianne Spillway and compensation release which is sprayed for oxygenation

considerable scavenging efficiency of conifer needles for air pollutants, particularly when the latter arrive as 'occult' deposition in the form of mists and fogs. Furthermore, the increased evapotranspiration of coniferous forest compared with heather moorland tends to concentrate H^+ ions in soil waters and baseflows; more subtle effects of conifer afforestation, such as the storage of divalent cations in the biomass and changes in storm runoff routes brought about by ditching, also promote acidification. The Acid Waters Project at Llyn Brianne was established in 1984 through a grant from the Department of the Environment: its aims have been to investigate the effects of acid deposition, afforestation and land management on stream acidity. The Project also involves detailed biological and fisheries studies and has focused particularly on experimental land treatments and the use of chemical and biological modelling techniques with a view to finding land-use policies and emission strategies which will ameliorate acidification problems in upland Wales. More than a dozen small catchments (Fig.2) have been equipped for continuous monitoring of flow, pH, conductivity and temperature with the object of identifying extreme as well as average water quality conditions. It has been found, for example, that the severest episodes of low pH (<4) are associated with snowmelt or follow a prolonged spell of easterly winds and cold dry conditions. The study has been set up to include control catchments draining the main land-use types in the area as well as a number of streams which have been subjected to various treatments (Table 1).

The party then travelled along the eastern side of the reservoir to view catchment L18, an open canopy conifer

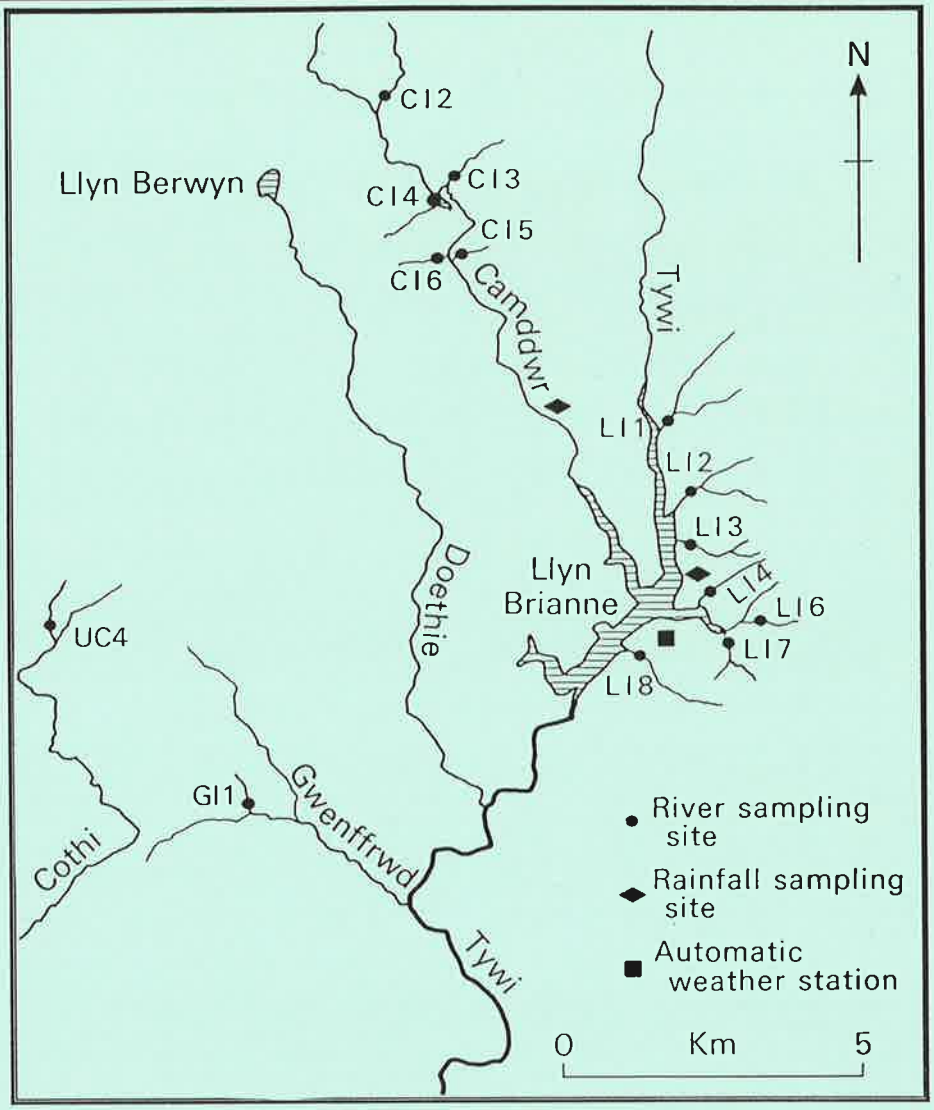


Fig. 2 Study Catchments in the Llyn Brianne Acid Waters Project

Table 1 Land-use and treatment in the Llyn Brianne study catchments

Site	Class	Land Use or Treatment	Treatment Date	Catchment Area (ha)	Treatment Area (ha)
LI1	IIIB	Control conifer forest	-	253	-
LI2	IIIB	Bankside clearance of conifer forest (30m width) plus liming at 10 t ha^{-1}	Summer 1986	105	6
LI3	IIB	Bankside clearance of conifer forest (20 m width)	1983	64	2
		Liming of water source areas with pelletised chalk (10 t ha^{-1})	Summer 1988		32
LI4	IIB	Liming of water source area in headwaters of conifer forest stream (30 t ha^{-1})	Autumn 1987	33	4
LI6	I	Unimproved, unacidified moorland control	-	68	-
LI7	I	Unimproved, unacidified moorland. Experimental acid pulses	1986,1987	68	-
LI8	IIB	Open canopy conifer forest control	-	66	-
CI2	IIIA	Water source liming of unimproved acidic moorland (15 t ha^{-1})	Summer 1988	59	4
CI3	IIIA	Standard agricultural improvement of acidic moorland	Summer 1986	84	20
CI4	IIIA	Contour ploughing of unimproved acidic moorland	Autumn 1986	49	8
CI5	IIIA	Surface liming of unimproved acidic moorland (9 t ha^{-1})	Autumn 1987	34	34
CI6	IIIA	Unimproved acidic moorland control	-	72	-
UC4	IIIA	Ploughing and planting of confers in unimproved acidic moorland	Summer 1988	237	50
GI1	-	Acid oak woodland control	-	18	-



Fig. 3 BHS/WHG Party making its way to the Trawsnant meteorological station

forest control. Tree stands of different but relatively young age (<12 years) cover this tributary, which quite surprisingly exhibits chemical behaviour similar to moorland streams, with mean pH levels above 5.0: streams draining mature coniferous forest typically have mean pH levels below this value. Results from Llyn Brianne suggest that stream acidification is intensified under conifers when they reach 15-16 years of age, a relatively young stage in the development of trees which take 40-50 years to reach full maturity. One problem in ascertaining trends in stream acidity over time, however, is the lack of long-term pH records at this and other sites, and it is hoped that evidence from the diatom floras of lake sediments will help in this context. **Dr Rory Walsh** (University of Swansea) explained that work in LI8 and other catchments at Llyn Brianne had revealed short-term fluctuations in pH which were strongly related to flow rate. Hysteresis effects do introduce some scatter into pH/discharge relationships, but pH response to flow can be well represented by fitting regression lines to data for individual years of record. It was also evident that afforestation has affected hydrological as well as chemical behaviour of streams, although the impact of conifers on runoff evolves through time. Initial effects associated with ditching result in an increased frequency of flooding, which in combination with erosion and channel dissection make flow measurement in the upper reaches of forested catchments at Llyn Brianne a difficult task. In maturing coniferous forest, however, hydrological response becomes more damped with the development of more permeable soil horizons under an established litter layer and of more pronounced macropore structures as soils dry out with increased evapotranspiration from the forest cover. In response to questions from the party at this site, it was suggested that acidification of the environment is a particular problem in areas of base-poor geology. In the Llyn Brianne district, the Silurian and Ordovician strata give rise to Ca^{2+} stream concentrations of approximately 1 mg l^{-1}, which are insufficient to buffer increases of acidity resulting from air pollution and land-use change.

The next part of the visit took the party to view the main meteorological station used in the Project, which is located at Trawsnant on the plateau above the reservoir (Fig.3). Dr Walsh described an IH automatic weather station in use in the enclosure and explained that a mean correction factor of 1.098 between raingauges at ground level and the conventional height had been obtained over a period of 18 months. This factor varied from 1.05 to 1.15 depending on wind conditions. A local orographic effect appears to influence precipitation at the meteorological station, and additional measurements suggest that 150 mm less rainfall is received annually over the Camddwr tributory. Equipment is also employed at this site to determine the quality of incoming precipitation, and Dr Donald explained that the volume-weighted mean pH of bulk precipitation received at Lynn Brianne is about 4.6, which is one of the most acidic values recorded in Wales. In combination with a mean annual rainfall of 1800 mm this leads to deposited acidity of 0.45 kg H^+ha^{-1} $year^{-1}$. In the prevailing westerly winds of the region, associated precipitation is usually well buffered by sea salts, but pH of bulk precipitation can fall to 3.5 when it is derived from air masses arriving from an easterly direction. Deposition of sulphur is recorded as 12 kg S $ha^{-1}year^{-1}$, of which 75% is industrially derived and the remainder comes from marine sources. Bulk and wet-only collectors are being employed at Llyn Brianne to determine the importance of both wet and dry deposition (by difference); the contribution of gaseous components to precipitation quality is being investigated using specially designed 'absorbing tubes' which, in the case of oxides of nitrogen, are based on the organic compound ethylamine.

A conifer catchment, LI4, was the first stop after lunch and provided the group with an opportunity to discuss the discharge monitoring techniques employed at Llyn Brianne. Dr Walsh explained that problems of vandalism, high bedload transport and a limited budget, constrained the approaches which could be used for flow measurement. Thin-plate rectangular weirs have been installed at four sites, including L14, but the use of rated sections is the only practical method in the remaining catchments, and an intensive programme of routine flow gauging has been crucial to obtaining good discharge measurements in the Project. Dr Donald further explained that catchment LI4 had been treated in autumn 1987 by liming the water source areas in the headwaters. Application at a rate of 30t ha^{-1} on hydrologically sensitive zones had proved successful in keeping pH levels higher



Fig. 4 Throughfall and stemflow sampling equipment in conifer forest of catchment L14

than those found in streams draining untreated coniferous forest.

A steep walk took the party to a site within the forest of catchment LI4 where an experiment has been set up to investigate the chemistry of throughfall, stemflow and soil water (Fig.4). Dr Donald reported that interaction of precipitation with the vegetation canopy tends to increase solute concentrations and that the acidity of stemflow is higher than that of throughfall. Research has also shown that the acidifying effect of larch was greater than that of spruce. The influence of the latter varies with tree age: it was absent in juvenile spruce, restricted to late winter and early spring for specimens 25 years old, and present throughout the year for trees 40 years of age. An increase in needle area as trees mature might be responsible for greater acidification with age, but further work is required to determine whether acidification is caused by the filtering effect of trees or by the leaching of chemicals from the vegetation canopy. Buffering at the ground surface tends to reduce acidity, and higher pH levels are typical of lower soil horizons. However, aluminium concentrations in the stagnopodzol B horizons of soils under mature spruce are higher than under other vegetation types because of greater cation exchange activity. In response to questions, it was pointed out that further studies of water and chemical fluxes are required at this site and at similar experiments on other land uses in the Project before it will be possible to extrapolate findings from the plot to the catchment scale.

The group next stopped at catchment LI3 where **Steve Thomas** (UWIST) demonstrated typical flow and water quality monitoring equipment installed in the Llyn Brianne catchments. Continuous signals from a flowmeter and from pH, conductivity and temperature probes are logged at 15-minute intervals. Further information on storm-period water chemistry is provided by an automatic water sampler, which is triggered by rainfall intensity and provides information every 15 minutes for the first six hours of a storm hydrograph and at one- or two-hourly intervals for the remainder of the event. Bankside clearance of conifer forest in a 20m wide strip has been undertaken in catchment LI3 in the hope of providing a zone to buffer acidity. However, Dr Donald explained that this treatment has had little effect on streamwater pH and has also reduced the nutrients reaching the watercourse with a consequent deleterious effect on stream invertebrates.

The last stop in the visit took the party into the Camddwr tributary and to a point with a view of catchments CI6, an unimproved acidic moorland control, and CI5, a stream draining acid moorland which had received surface liming at the rate of 9t ha^{-1}. Dr Walsh pointed out that flow gauging in the less flashy moorland catchments was a somewhat easier proposition but went on to explain that dilution gauging has been found to be the most appropriate technique for measuring discharge in the small upland streams of the Llyn Brianne area. Detailed research done for the Project by **Dr Ian Littlewood** had identified a sudden injection (relative) method as being the most suitable in this environment. Problems exist with this method in relation to a requirement for large quantities of salt when gauging high flows, to selection of mixing lengths which take account of dead zones and varying conditions at different stages and to unstable sections, although under favourable conditions the technique can be used to determine instantaneous discharge with an uncertainty of ±2% at the 95% level of confidence. Detailed investigation of pH/discharge relationships in moorland and forested streams has revealed hysteresis effects whereby pH levels at a given flow are lower on the recession than on the rising limb of a flood event. Dr Walsh proposed several mechanisms which could account for this hysteresis. These included kinematic wave movement of floods, pushout of old soil water in the early part of an event, a change in the dominant runoff production mechanism from saturated overland flow (pH the same as rainwater) to pipeflow and throughflow (pH lower than rainfall) as a storm proceeds, and arrival of runoff from different and spatially segregated source areas in a catchment. Further work, however, is required to evaluate the relative importance of these processes.

With reference to catchment C15, Dr Donald outlined modelling work done for the Project by **Dr Paul Whitehead** of the Institute of Hydrology. The Modelling of Acidification of Groundwater in Catchments (MAGIC) model has been employed to examine the impact of different land management and air pollution emission strategies on pH and Al levels (Fig.5), and preliminary results suggest that a 50% reduction in deposition would be required to prevent continued decline of stream pH and further adverse ecological effects. In conclusion to the visit, Dr Donald drew attention to three headwater catchments of the Camddwr where the effects of a range of land treatments were being examined in unimproved acidic moorland, including targeted source liming (CI2), contour ploughing (CI4) and standard agricultural improvement (CI3). He also stressed the role which moorland control catchments, such as C16, played in governmental long-term monitoring of the environment.

At the end of a very successful day, **Professor Peter Wolf**, on behalf of the Society, thanked the Welsh Water and Project Staff for providing such an interesting and enjoyable visit to Llyn Brianne and **Dr Robert Sellin** echoed his thanks on behalf of WHG.

Bruce Webb

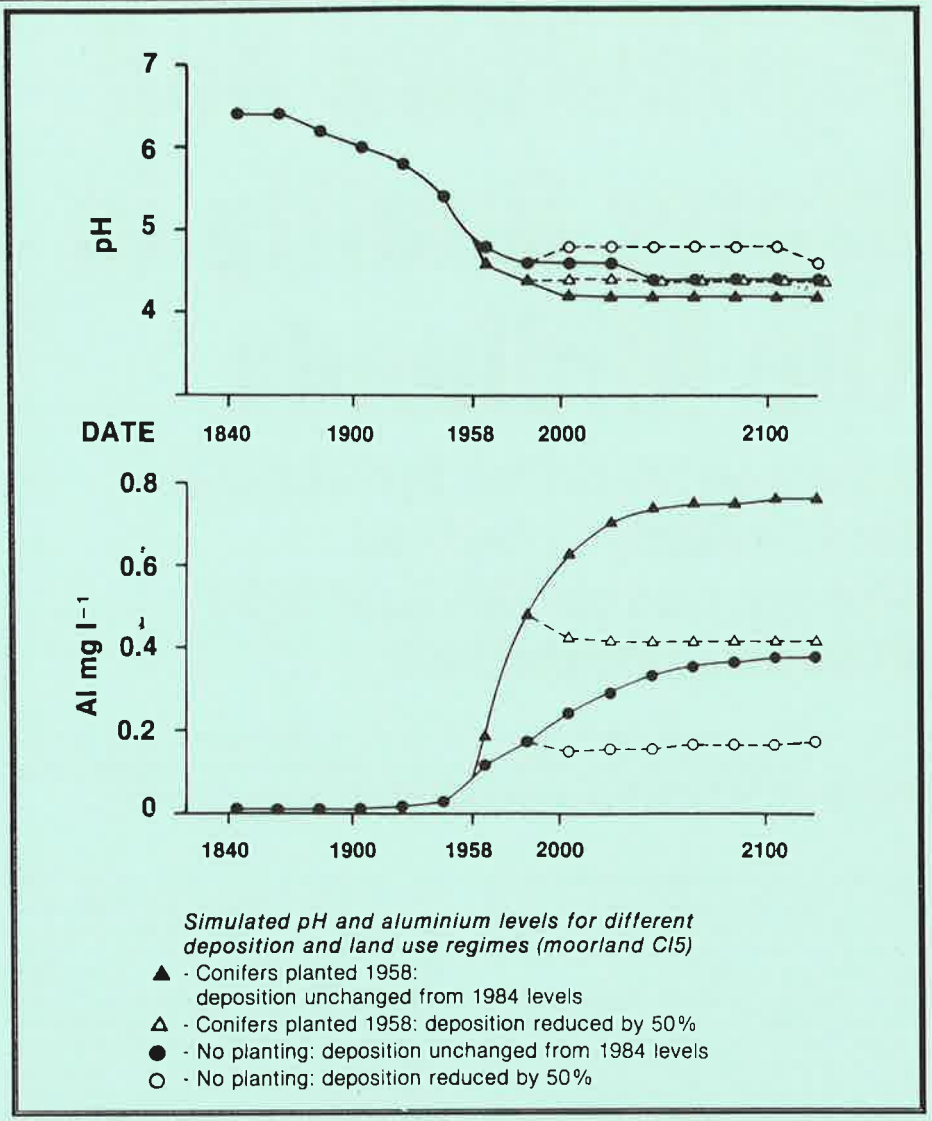


Fig. 5 Modelling of pH and Aluminium - work undertaken by P Whitehead (IH), forthcoming in Journal of Hydrology

Agriculture and Water Quality in the Midlands

Report on the British Hydrological Society (Midland Section) Meeting held on 20th April 1988 at Coventry Polytechnic

This topical meeting was attended by 35 hydrologists, and it was chaired by *Graham Sharp*, who has very recently retired as Regional Manager of Technical Services at Severn Trent Water Authority.

The first speaker was **Dr Andrew Skinner** from STWA, Birmingham, whose topic was "Agricultural impacts on water resources with particular reference to ground water quality."

Dr Skinner's particular interest was in nitrate pollution of ground water by current agricultural practices. This is a diffuse pollution problem in that the effect of a large number of minor events, spread over a large area, eventually concentrate in one area giving rise to a serious problem. It is difficult to apportion blame for the insidious long-term accumulation of nitrate in ground water from a large source area. Herbicides and pesticides also pose pollution threats, but more research needs to be done before management advice can be given. Nitrate leaching is of more urgent and primary concern.

More than one-third of the water supplied by STWA comes from groundwater and at present about 20 abstraction sites have been found to be above the EEC nitrate standard of 50mg/l, and this extrapolated to a disturbing 4 or 5 times as many sites by the year 2010.

On a regional basis, the levels of NO_3^- in groundwater in Nottinghamshire were shown to be increasing to over the 50mg/l standard; whilst also increasing in Staffordshire, the rise was not as steep. Confined aquifers showed the smallest rise, and it was possible to lower the high concentration of nitrates in Nottinghamshire water by blending with the other sources. The contrasts in nitrate levels were found to be related to precipitation and land use: less precipitation tended to concentrate nitrates leached off arable land and therefore concentrated them in groundwater aquifers.

Dr Skinner saw two possible pathways to deal with the problem in the future: prevention or cure. Cure would involve the blending of low and high concentration nitrate polluted water bringing it down to acceptable levels, or removal of nitrates by treatment. Both of these options are costly but blending is less so and much preferred to treatment. Prevention involves improved agricultural practice, voluntary restrictions on the use of fertilizers or statutorily enforceable protection zones. Only the last option would solve the problem, but it would have a major impact on a few farmers. The choice between the options outlined is not cut and dried: a combination of factors would probably be required.

Dr Skinner outlined a project he was involved in at Hatton, Staffordshire, with the Ministry of Agriculture and the Department of the Environment. In this recently published research project, prevention and cure proposals were carried out in the catchment in conjunction with computer modelling involving practical land use change. The results of the study give an indication of the viability of certain options and solutions.

With specific reference to nitrate pollution, the Water Authority has both regional and local responsibility to the consumer for minimising the effects of agricultural practices on water resources. Dr Skinner saw the importance of groundwater vulnerability maps increasing in the future, with areas directly above aquifers being constrained by law or binding agreement to keep nitrogen fertilizer applications within acceptable levels; areas directly around the most vulnerable areas would be regulated by a voluntary code of practice, and areas beyond this would be free of regulations.

Questions followed Dr Skinner's paper including why the present Control of Pollution Act was not brought into force more often. Dr Skinner replied that it was virtually unworkable because the controls necessary would be detrimental to the livelihood of the farmer who would be unable to claim compensation and the subsequent Public Enquiry would reach an impasse. Also, nitrate pollution is so diffuse that apportioning blame is impossible. On being asked how the coming reorganisation would affect policy, Dr Skinner replied that at present STWA's responsibility was twofold: that of supply and that of catchment management. On reorganisation, the latter would fall to the National Rivers Authority under whose auspices provision of protection zones would fall. A question regarding the faster rate of nitrate pollution in Nottinghamshire compared to Staffordshire revealed that the response time (because of its deeper water table and its porosity) was longer in Staffordshire, and mining in Nottinghamshire was also a contributory factor. STWA was spending £7m on blending and hoped that within a year all water supplies in the region would be below 50mg/l nitrate. In East Anglia, where sources were over the standards and no blending was possible, treatment plants would be on-stream within 5 years. The relative importance of nitrate pollution to that of pesticides and herbicides resulted from the complex nature of the chemistry of herbicides and pesticides which made legislation difficult. Nitrate is a single chemical species, whereas pesticides and herbicides are mixtures of compounds and more research needs to be done on their environmental impact, although STWA is pushing for some form of control.

The second speaker of the afternoon was **Roger Unwin** of MAFF whose paper was entitled "Farm Practice and Pollution Potential".

A series of slides illustrated the problems faced by the farmer on the one hand and the agricultural advisor on the other in attempting to optimise efficiency and income and minimise pollution and environmental damage.

The problems of agricultural pollution have increased with the increase of factory farming. With 39% of laying hens kept in units of 5,000 or more and 41% of pigs kept in units of 1,000 or more, disposal of wastes and storage of fodder becomes more problematic.

Mr Unwin showed several illustrations of safe means of slurry disposal, ranging from the traditional midden on the concrete yard to settling lagoons and washing weirs. Methods of disposal ranged from direct drainage into a water course, spraying crops with slurry supernatant and spreading with a tractor and tanker. The main causes for concern were when these methods were misused, containers not repaired, and when tractors damaged land by spreading onto wet or frosted ground. Research carried out showed that 10% of grass yield can be lost by over-application of slurry. Experiments were also carried out on injection of slurry into the soil which reduces odour and ammonia volatalization but requires careful, even application for full benefits.

In the 1970's there was a big increase in silage production and hence in the potential for pollution by effluent. This has a carry-over to the present day, as 15 years on most storage clamps need maintainence and repair to ensure no leakages occur. In fact spillages since

1979, apart from the wet spring in 1985, have shown no real increase.

In different countries, different emphases are placed on pollutants: in Holland, for example, it is believed that ammonia loss contributes over one third to the acid rain problem; therefore the prime concern to Dutch environmentalists is to control ammonia emissions.

Fertilizer usage has doubled since 1970, and yield has also gone up, resulting in relative self-sufficiency with a prudent amount in reserve. Reducing this fertilizer by 50% reduces yield by about 15% and reduces nitrate leaching, but this will negate the entire profit to the farmer and will therefore never be carried out.

A more accurate assessment is required of fertilizer needs using four factors affecting soil nitrogen supply. These are soil organic matter, previous crop residues, soil type, and leaching of previous cropping nitrogen. Nitrate leaching is seasonal and therefore only long-term averages should be used. Unusual weather conditions can change the whole overall picture.

Mr Unwin then looked towards the future and the steps which needed to be taken to reduce nitrate pollution. The farmer needs to match the nitrogen to the needs of the crop, apply it at the optimum time (but not in the Autumn). He must also not plough up grassland or leave land uncropped over winter. To this end various bodies including the DOE, MAFF and the WAA have produced a leaflet entitled "Nitrate and Water - The Farmers' Role" which gives guidelines to reduce leaching, information on how to get professional help and a notice of local meetings on the subject.

Mr Sharp then introduced the third and last speaker of the afternoon, **Dr Andrée Carter** from the Soil Survey and Land Research Centre, Shardlow, who talked on the "Vulnerability of groundwater to pollution from agricultural practice".

Dr Carter first outlined the importance of accuracy, methodology and presentation in decision making regarding risk to an aquifer. The three tools used in assessing risk are monitoring, modelling and mapping, and many parameters are necessary for assessing this risk, varying from soil type to vegetation. At the soil survey, the modelling is by LANDIS in which large numbers of soil properties are stored.

The current relevant research undertaken at the soil survey includes one project in its third year which utilizes suction devices to remove soil water which would have eventually leached to an aquifer. All the research sites lie over aquifers with varying soil covers, and these were illustrated with profiles of thin sandy soils over chalk and limestone. The results from 15 sites over the country showed that, after autumn leaching, grassland showed the lowest NO_3^- losses (2 kg/ha), a fallow plot after winter wheat lost 13 kg/ha, and wheat after peas lost the most at 26 kg/ha. Other research undertaken included permeability studies, particularly of the Cuckney and Salop series using a Dutch technique of taking large cores to measure saturated and unsaturated water conductivity.

All of the physical soil characteristics, plus the use of soil maps, give the basis for assessing leaching risk factors. These factors include the organic carbon content, the drainable porosity, its wetness class, the depth of soil and its lithology. Putting all this information together, Dr Carter outlined the four leaching classes as Extreme, High, Moderate and Low.

At Rothamsted the above scheme was tested against a leaching model by putting 100kg nitrate on each soil type, putting a crop on it, and increasing the soil porosity by the use of mole drains. The scheme is supported by the results of experiments still running at present.

As only the soil was investigated, the BGS was contacted to provide a similar classification for aquifers. Three simple classes were formulated for the type of drift covering an aquifer: permeable, less permeable and impermeable.

The Soil Survey and BGS classifications were amalgamated to give a matrix of groundwater vulnerability from which maps have been produced of soil aquifer risk. To date four have been produced: Stafford, Mansfield, Worcester and Lichfield. The Mansfield map was used to illustrate the use of such risk information.

These maps can only be used to assess risk from nitrate pollution and cannot be used for any other parameter. The maps produced are at a fairly small scale and therefore cannot be used in a field-scale advisory capacity. Looking to the future, Dr Carter saw the production of more actual risk maps and vulnerability maps, but only after far more detailed information has been obtained.

Mr Sharp then asked for any questions for the last two speakers. The first questioner was concerned with "set aside" leaving land uncropped and hence open to heavy leaching. Mr Unwin answered that Government policy seemed to be leaning towards green rather than bare fallow and was aiming at 20% "set aside" close to protected areas. On the possible extension of forestry into lowland areas, Mr Unwin explained that conifer planting could increase nitrate leaching: hence broad-leaved plantations would be preferable from an environmental point of view, but not from an economic one. Mr Unwin then replied to a question regarding the possibility of legislation regarding the construction of slurry pits and storage areas; he explained that there were moves to initiate a national campaign to advise on such matters, this was very resource demanding and expensive, but that lobbying continued. A question was then raised of taxation on nitrate fertilizers: it was difficult to tax only those who contribiuted to the problem and it was not only pelleted fertilizer that was to blame but also slurry and grassland ploughing which could not be taxed. The final question concerned vulnerability maps which appeared to be of use only on a gross scale. Dr Carter explained that their use was indeed for gross planning only and that they could not be used on a field scale. They were useful, however, in promoting public awareness.

Mr Sharp concluded the meeting by thanking the organiser, **Will Bradford**, and **Ian Foster** at Coventry Polytechnic for hosting the afternoon.

Sue Charlesworth
Coventry

PUBLICATIONS RECEIVED

A copy of the *Meteorological Office Annual Report 1987* arrived on the Editor's desk recently. She was so impressed by its attractive presentation and useful information (for example the section on the Use of Radar and Developments in Forecasting) she asked her Met Office contacts for permission to draw BHS members' attention to the publication. At £11.95 (from HMSO) most people will only seek out a copy from their own organisation library, but if you have time to browse, it is worth the effort.

Editor

NEWS FROM THE WORLD METEOROLOGICAL ORGANIZATION

The 1987 IMO Prize has been awarded to Professor M.I. Budyko, Head of the Climate Change and Atmospheric Water Cycle Research Department at the USSR State Hydrological Institute. Professor Budyko is an eminent climatologist who has contributed greatly to solar energy balance climate models, studies of anthropogenic warming processes and the implementation of the World Climate Programme.

The 1988 Norbert Gerbier - Mumm Award has been conferred on R.J. Charlson, J.E. Lovelock, M.O. Andreae and S.G. Warren for their multidisciplinary study entitled "Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate". The prize comprises 50,000 FFr and a medal in memory of Norbert Gerbier, late President of the WMO Commission for Agricultural Meteorology. The paper links meteorology to other sciences, proposing a biological mechanism of climate change by altering the reflectivity of the atmosphere to solar radiation.

A catalogue of WMO Publications, including a number on Hydrology and Water Resources, may be obtained free from WMO, Case postale 5, CH-1211 Geneva 20, Switzerland.

New Members

H J Colenbrander ..... Head, TNO Netherlands
R Cowdrey ..... Thames Water Authority
M Fisentzou (Miss) ..... Student
D K Hawkins (Miss) ..... Thames Water Authority
M T Waite ..... Haiste Group

International Conference: FRIENDS in Hydrology

FRIENDS - Flow Regimes from International Experimental and Network Data Sets

The Conference will include presentation of work carried out over the past three years by an international team of scientists from seven countries, based at the Institute of Hydrology, Wallingford. The FREND (Flow Regimes from Experimental and Network Data) project was initiated by the UNESCO IHP-III as a regional study to apply data from groups of research catchments in the project area of north west Europe to current problems in hydrology and water resources.

Papers are invited on the following themes:

Regional flood and low flow analysis.
Small research basin studies.
Human influences on the flow regime.
Managing international research programmes.

The conference is convened by the Norwegian National Committee for Hydrology in cooperation with the FREND project Steering Committee, UNESCO IHP and IAHS, and will take place in Bolkesjø, Norway, on April 1st-6th 1989.

Authors are invited to submit an original and one copy of an abstract in English of 600-800 words. The abstracts should include the name, affiliation and address of the author(s), and should be submitted as soon as possible. The deadline for final registration for the conference is 1st November 1988, and final papers for the Proceedings should be received by 1st December 1988.

Further details on the conference can be obtained from:

Dr Alan Gustard
Institute of Hydrology
Crowmarsh Gifford
Wallingford
Oxon OX10 8BB

BOOKS

Transactions of the Royal Society of Edinburgh: Earth Sciences 78, part 4.
HYDROLOGY IN SCOTLAND - (1987.) 180 pages.

Available from: The Publications Secretary, Royal Society of Edinburgh, 22, 24 George Street, Edinburgh EH2 2PQ. Price: £15 includes postage and packing.

This volume forms the somewhat belated proceedings of the two-day "Hydrology in Scotland" conference held jointly by the Royal Society and the British Hydrological Society in Edinburgh in October 1986. Most, but not all, of the papers presented at that conference are included to form a self-contained 180 page book, published to a high standard in A4 format.

The book forms an organised romp through Scottish research in hydrology with 19 invited papers from key workers. The papers are organised into eight groupings: research catchments, hydrometeorology, flood frequency analysis, engineering and applied hydrology, land use and water quality, sediment transport and surface water acidification. All the papers are routed firmly in Scottish hydrology, but most of them are applicable to hydrology in the UK as a whole and present findings which are of use to all.

The papers do not, and cannot, represent a complete overview but rather form a sample of the work in progress in the mid 1980's and in this way they manage to include papers of considerable depth despite the broad range of the collection. In some areas this works well and both the general and specific are represented. A paper on the ecohydrology of all Scottish peatlands is followed by one describing a detailed study of just 2.5 hectares of them, for instance.

The price paid for this combination of detail and range is the essential randomness of the collection. If you are looking for a particular aspect of Scottish hydrology you may find it here, but equally you may be unlucky. Nevertheless, although it may not be a complete guide to Scottish hydrology, the book does serve a useful function in showing the range of work being undertaken, and forming a source of the people involved and the available literature. Though many of the authors have published elsewhere, *Hydrology in Scotland* contains some papers which rarely get into print: a paper on the future of the Scottish hydrometric network is one such, and the opening section on research catchments is probably the best overview of the major experimental areas at Balquhidder, Loch Fleet and Loch Dee one is likely to find.

Overall, providing one is not expecting a comprehensive review, *Hydrology in Scotland* provides a good read in which most hydrologists should find plenty to interest them. Good holiday reading perhaps?

Bob Sargent
Edinburgh

Rainfall Measurement

The Royal Meteorological Society's Specialist Group on Observing Systems held an interesting discussion meeting on 'Measurement of Precipitation' at the Institute of Hydrology recently. The sessions included presentations on In situ Measurement of Precipitation, Recent Developments in Radar Processing and Quality Control, and Space Techniques. Copies of the material distributed at the meeting can be obtained from **Dr Ian Strangeways** at IH.

Among the many fascinating points raised during the discussions was the question of spatial variability in rainfall. Is it 'real' or a product of inaccurate measurement? Further, is spatial variability more important than point measurement? Some people advocated that until we invent a better system of measurement there will be no progress and certainly no point in developing super models. The thorny question remains: what accuracy *should* we aim for!

LIBRARY FACILITIES

We should like to remind members that the Library resources of the two sponsoring organisations of the Society, The Institution of Civil Engineers and the Institute of Hydrology, are available to the BHS. The following notes give an outline of what service is available.

The ICE Library

All members of the Associated Societies may use the library but, for the present, only members of the Institution may take books out.

The Institution's computerised library catalogue is on stream. The on-line catalogue currently contains references to over 35,000 books and conference proceedings and recent pamphlets. Staff are about to start putting the Proceedings index on to the catalogue which will eventually contain references to over 60,000 items on civil engineering and related sciences. Details of the latest publications on civil engineering added to the library are input on a daily basis.

There are three ways to access the new information system: via a terminal permanently connected to the system through datalines, by dial-up access or, for users with a small computer with a modem, the ordinary telephone network.

Potential users of the library catalogue need first to register with the ICE library who will issue them with an ID and password. Members of ICE and the societies will get three hours free use after which there will be a charge of £50 an hour.

The IH Library

The main collection of books and reports is arranged in a classified subject index using an IH-originated classification for hydrology. There is also a special report/symposia series and good reference section of dictionaries, directories, atlases and timetables. All told, this section of the library comprises some 10,000 items. In addition, the library holds 300+ journals, bulletins and newsletters, including a number of abstract journals, and Ordnance Survey maps (folded) of both 1:50,000 and 1" series.

The library lends material to other organisations - and this facility naturally includes BHS members - and is open during normal office hours to any bona fide researcher, student or practitioner. A telephone call beforehand is always recommended to check that staff will be available to assist, especially with historic items held in store because of space restrictions. Photocopying facilities are available.

Software Development

The Hydrologic Engineering Center (US Army Corps of Engineers, Davis, California) has announced* some improvements to the HEC-1 program:

Considerable effort has been put into improving **HEC-1's kinematic wave** runoff and routing capabilities. As with any numerical method (even the unit graph and Muskingum routing), the size of the time interval and the distance increment can affect the answer. Most engineers know rules of thumb for unit graphs (e.g. a time interval that provides three or four ordinates on the rising limb) and for Muskingum routing (select number of subreaches so the subreach travel time is about equal to the time interval). Not as much experience has been had with the kinematic wave method, and its more complex numerical solution makes the correct choice of spatial and temporal increments less obvious. HEC has been developing an algorithm that automatically checks the sensitivity of time and distance increments and determines the sizes that produce the best answer. This algorithm and other improvements will be in a new version of HEC-1 to be released this spring.

*Information Exchange Bulletin Vol. 9, No.1(March 1988)

FORTHCOMING EVENTS

Meetings

HYDROLOGY OF LANDFILL SITES
One-day Symposium organised by the Scottish Hydrological Group and BHS
3rd November 1988
Glasgow

Keynote address on 'Landfill and Water - a difficult mix' by Prof. George Fleming, Strathclyde University.
Papers on environmental and economic problems associated with water in waste-disposal landfill sites.
Further details from Dr J G Herbertson, Department of Civil Engineering, University of Glasgow, Glasgow G12 8LT, Scotland.

INTERNATIONAL CONFERENCE ON PUMPED STORAGE

*** Changed date and venue ***

2nd-4th April 1990
Imperial College, London

The three main themes will be:

- Operational experience, including maintenance of existing schemes.
- Latest developments in the design specification and construction of current or projected schemes.
- Evolving roles of pumped storage and its integration into power systems.

Offers of further papers are invited: a 200 word abstract should be submitted by 31st October 1988.
Workshops and visits are also being arranged.
Further information from the Conference Office, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA.

INTERNATIONAL CONFERENCE ON WATER RESOURCE CONSEQUENCES FOLLOWING A NUCLEAR EVENT
7th & 8th September 1989
Glasgow

The Chernobyl accident showed the vulnerability of the water cycle to radionuclide contamination. This forum for discussion will focus on accidental release of radionuclides into the soil/water system and its impact on water resources, with a view to developing strategies to deal with future events.

There will be sessions on:

- Present radiological standards relating to drinking water supply.
- Radiological monitoring requirements.
- Consequences of a nuclear event on water resources.
- Water resource management strategy.

Papers are being sought: synopses of 500 words are required by 15th August 1988. Details from the Conference Office, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA.

IAHS SYMPOSIUM ON GROUNDWATER MANAGEMENT: QUANTITY AND QUALITY
2nd-5th October 1989
Benidorm, Spain

Five themes:

- The role of groundwater quantity in the decision making process on water resources.
- The role of groundwater quality in the decision making process on water resources.
- Models for groundwater management.
- Aquifers as components of water resources systems.
- Applications and case studies.

Participants wishing to contribute papers should submit an abstract of up to 1000 words immediately to the Secretary, Dr J Andreu, E.T.S. de Ingenieros de Caminos, Universidad Politecnica, Camino de Vera, s/n., 46071 Valencia, Spain.

INTERNATIONAL CONFERENCE ON HYDRAULIC AND ENVIRONMENTAL MODELLING OF COASTAL, ESTUARINE AND RIVER WATERS
19th-21st September 1989
Bradford

Hosted by the Computational Hydraulics and Environmental Modelling Research Group at Bradford University, this forum for shared experiences will cover numerical and physical modelling approaches to management of the coastal, estuarine and river environment. Modelling applications considered will include:

- Interaction of pollutants and sediments, including modelling of solute distributions from long sea outfalls and offshore waste disposal sites.
- Estuarine and river hydraulics, including flood plain hydrodynamics, flood routing and flood alleviation schemes, density and salinity effects and sediment transport and water quality models.
- Physical and numerical model studies of flow processes and sediment and pollutant transport rates, including erosion, deposition, diffusion, dispersion and decay rates.
- Field and laboratory measuring techniques for model calibration and verification.
- Numerical techniques, solution algorithms and graphical presentation developments in the field, particularly with the aid of personal computers.

Papers are invited, abstracts to be submitted by 1st September 1988. Exhibition facilities will be available. Details from John Ayers, Department of Civil Engineering, University of Bradford, Bradford, West Yorks. BD7 1DP.

DRAINAGE AND WASTE MANAGEMENT INTO THE 1990's
9th-11th May 1989
Dundee

This conference covers six subject headings: Solid wastes, Sewerage, Sewage treatment, Instrumentation and control, River impact and Legislation and Management.
Offers of papers are invited: authors should submit a 200 word abstract by 30 September 1988.
Details from The Conference Secretary, Technology Transfer Centre, Dundee College of Technology, Bell Street, Dundee DD1 1HG, Scotland.

Courses

3-DAY COURSE ON FLOW AND WATER QUALITY MODELLING OF COASTAL WATERS, ESTUARIES, RIVERS, LAKES AND RESERVOIRS
20th-22nd September 1988
Bradford

The Aims of the Course are to provide practising engineers and scientists in industry, public authorities and academia involved in water quality modelling of free surface flows with an up-to-date review of:

coastal, estuarine, river, lake and reservoir hydraulics,
pollutant transport processes and water quality aspects, and
mathematical modelling techniques and model applications.

Further information from Prof. R A Falconer, Department of Civil Engineering, University of Bradford, Bradford, West Yorks. BD7 1DP.

Diary

8th September 1988
Welsh Hydrological Group AGM in Cardiff followed by:
"The floods in West Wales of October 1987". - Jean Frost (Welsh Water)

23rd September 1988
Welsh Hydrological Group/SW Branch of IWEM
"Reservoir safety work".
Further Information from Ray Jaquest, Engineering Department, West Glamorgan County Council, Swansea.

10th October 1988
BHS Southern Section Meeting
"Risk assessment for dam safety evaluation: principles and examples from practice" - Prof. David Bowles, Utah State University.
5.30 p.m. for 6.00 p.m., Imperial College, London.

5th December 1988
BHS AGM
Institution of Civil Engineers, followed by BHS National Meeting "Hydrology Overseas"

9th-11th May 1989
Conference - "Drainage and Waste Management into the 1990s"
Technology Transfer Centre, Dundee College of Technology, Bell Street, Dundee.
Deadline for abstracts: 30th September 1988 Further details: Vivien MacKinley, (0382) 28818.

Copy Deadline for Issue No. 20
5th September 1988

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