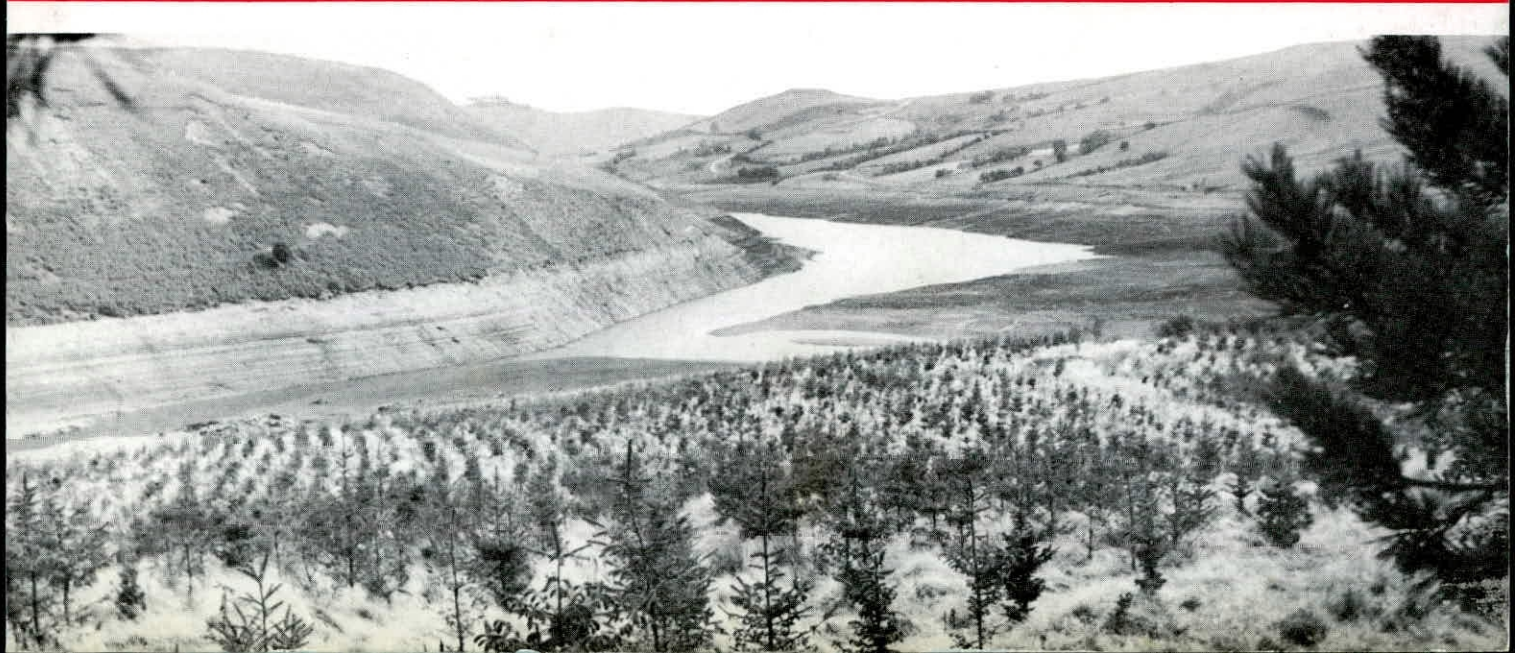
NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF HYDROLOGY

Hydrological Research in the United Kingdom (1975-1980)



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PREFACE

The Natural Environment Research Council includes hydrology among the subjects for which its Charter gives it powers to encourage, support and carry out appropriate research. Council also has a responsibility for research training which is provided by Research Grants and Training Awards to the universities for students reading for higher degrees. The first two editions of this booklet covered the period of the International Hydrological Decade (1965-74). International recognition for hydrology has been continued since 1975 through the International Hydrological Programme (IHP) whose remit is broadly the continuation of the subject areas and goals of the Decade with perhaps even more emphasis on the setting up of hydrometric networks and widely-available training facilities for hydrologists. NERC's responsibility for hydrological research makes it pertinent for the Institute of Hydrology to continue the collation of information relevant to current hydrological progress in the UK, as here presented in this third edition. Many people have co-operated in its compilation and their assistance is gratefully acknowledged.

July 1979

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V-notch weir monitoring flow from experimental catchment, Kenya

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TABLES

CHAPTER I

DEVELOPMENT AND ORGANISATION OF HYDROLOGICAL RESEARCH IN THE UNITED KINGDOM

As with every other commodity, consumer demand for water has increased rapidly in recent years. Stimulated by the upsurge in user requirement, Parliament passed the Water Resources Act of 1963 which created the River Authorities with responsibility for water conservation and the Water Resources Board to advise both them and central Government on such matters.

But providing and maintaining wholesome and adequate water supplies, coupled with looking after and cleaning up our rivers, is a complex and interrelated affair. It needs large-scale investment to budget the more than adequate national water income in such a way that it is in the right places at the right time and of the right quality. Recognition of the enormity of the task was reflected by the creation of the Department of the Environment in 1970 from the Ministries of Housing & Local Government, Transport, and Public Building & Works. This Department took over the responsibility for established research organisations such as the Hydraulics Research Station, the Water Pollution Research Laboratory and the Water Research Association and also set up a Directorate General Water Engineering to advise both Government and the industry on water supply, waste water treatment and disposal. The Directorate also sponsors research and development projects on these topics.

Next, the weakness in the organisation of the water industry itself, particularly the separation between quantity and quality, was corrected with the passing of the Water Act 1973. This provided for the creation of ten regional water authorities to take over the existing functions of river authorities, water undertakers, sewerage and sewage disposal authorities; these authorities now have responsibilities for water resources in the widest sense. The strategic research requirements of the industry are served by the Water Research Centre, formed from an amalgamation of the Water Research Association, the Water Pollution Research

Laboratory and parts of the old Water Resources Board and the Directorate General Water Engineering, and funded directly by the RWAs.

The influence of environmental factors affecting the natural water balance must be taken into account in regional planning, a need which had been recognized previously and resulted in the setting up of the Hydrological Research Unit in 1962 with the task of carrying out research into the effects of land use on the water balance within catchments. This Unit was transferred to the Natural Environment Research Council and became the Institute of Hydrology in 1968. Its research programme has since widened considerably to include studies of the physical processes of water movement, flow prediction, water resources surveys and operational studies.

The Natural Environment Research Council's expenditure on hydrological research has three divisions:

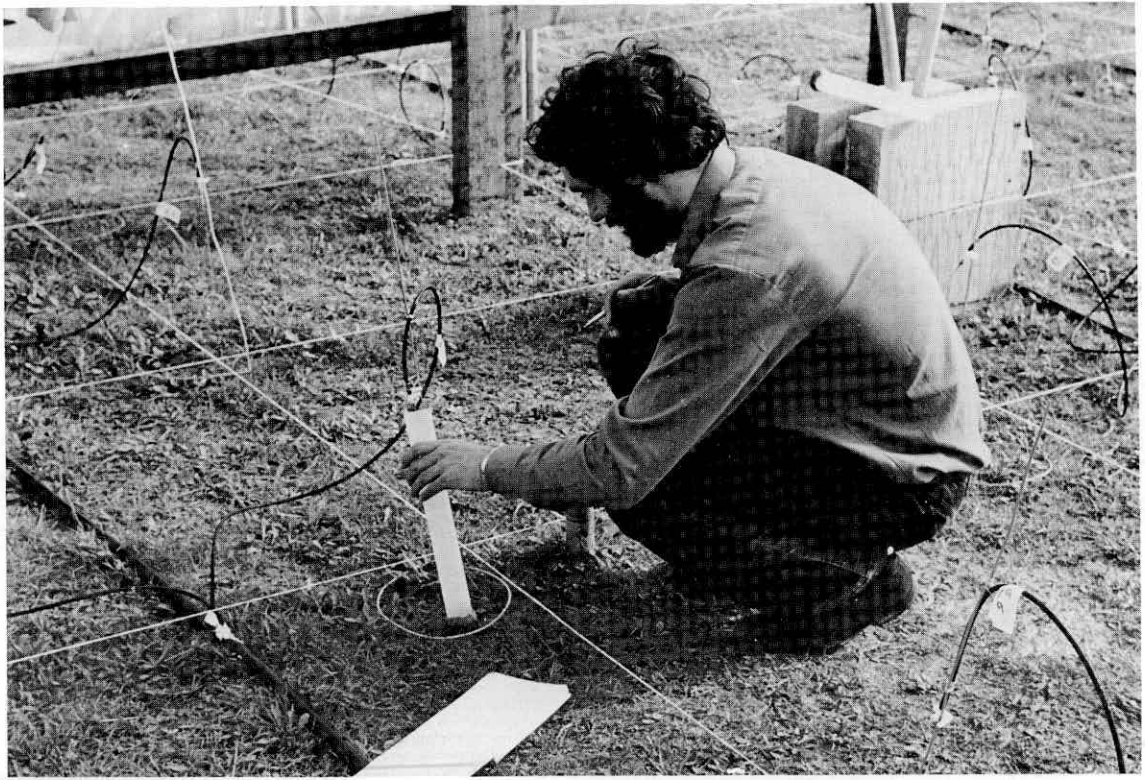
I The research programme of the Institute of Hydrology

II The research programme of the Hydrogeological Department of the Institute of Geological Sciences

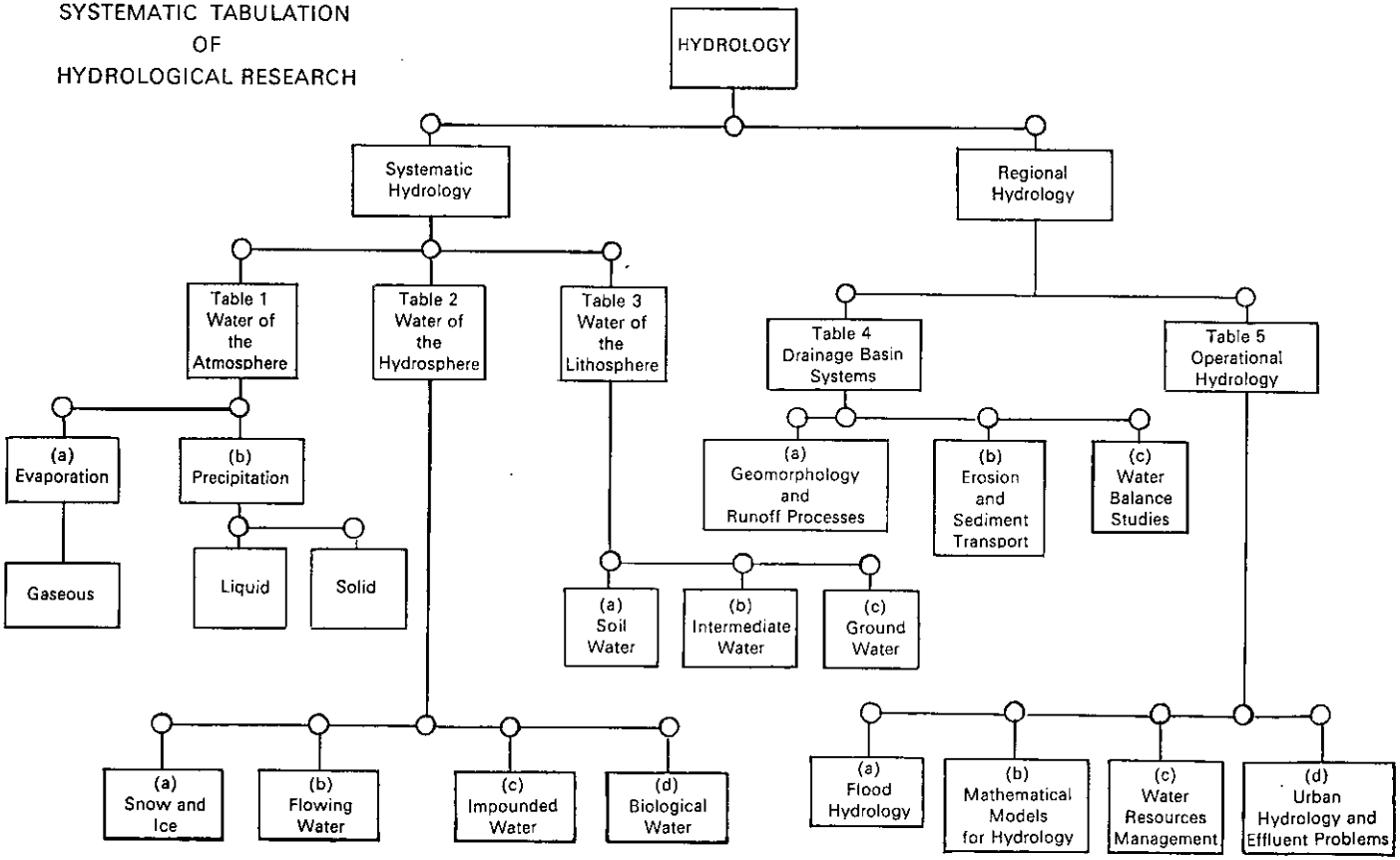
III Research grants and training awards for universities.

The expenditure in the year 1978/79 under these three heads was £2,020,000.

Setting up a steady-state infiltration study to measure the unsaturated conductivity of chalk soils



SYSTEMATIC TABULATION
OF
HYDROLOGICAL RESEARCH



CHAPTER II

TABULAR STATEMENT OF RESEARCH

The separations and sub-divisions of scientific hydrology used as a basis for classification of research topics are shown in the diagram opposite. There are two major groupings, namely: Systematic Hydrology and Regional Hydrology. The research projects in the first group have been assembled under general sub-headings within the tables where appropriate and, as in the previous editions, allocated to one of three columns describing the nature of the study, i.e. *Instruments and Techniques, Physical Hydrology a ıd Experimental Work* and *Theoretical Studies and Data Analysis.*

Every reserach project is labelled with the organisation or organisations responsible, using the abbreviations listed overleaf. Further information about any particular project can be obtained from Chapters III and IV where the research interests of government agencies and university departments are described in more detail.

KEY TO ABBREVIATIONS USED IN TABLES 1 – 5

Abbreviation	Organisation
ABDGG	Aberdeen University—Geography Department
ADAS	Agricultural Development and Advisory Service
AL	Appleton Laboratory
AERE	Atomic Energy Research Establishment, Harwell
ASTCE	Aston in Birmingham University—Civil Engineering Department
AWA	Anglian Water Authority
BAS	British Antarctic Survey
BSC	Bath University—School of Chemistry
BKLGG	London, Birkbeck College—Geography Department
BQUGG	Belfast, Queen's University—Geography Department
BQUGL	Belfast, Queen's University—Geology Department
BRE	Building Research Establishment
BRMCE	Birmingham University—Civil Engineering Department
BRMGG	Birmingham University—Geography Department
BRMGS	Birmingham University—Geology Department
BRMPH	Birmingham University—Physics Department
BTLGG	Bristol University—Geography Department
BTLGL	Bristol University—Geology Department
CAMAP	Cambridge University—Applied Mathematics and Theoretical Physics Department
CAMGG	Cambridge University—Geography Department
CAMPH	Cambridge University—Physics Department
CWPU	Central Water Planning Unit
DENI	Department of the Environment for Northern Ireland
DGWE	Directorate General Water Engineering
DUMBS	Dundee University—Biological Sciences Department
DUNGL	Dundee University—Geology Department
DURGG	Durham University—Geography Department
EANCR	East Anglia University—Climatic Research Unit
EANEV	East Anglia University—School of Environmental Sciences
EDGFN	Edinburgh University—Forestry and Natural Resources Department
EDGMT	Edinburgh University—Meteorology Department
EMRS	East Malling Research Station
EXEGG	Exeter University—Geography Department
FBA	Freshwater Biological Association
FC	Forestry Commission
GLACE	Glasgow University—Civil Engineering Department
GRI	Grassland Research Institute
HRS	Hydraulics Research Station
HULGG	Hull University—Geography Department
IGS	Institute of Geological Sciences
IH	Institute of Hydrology
ITE	Institute of Terrestrial Ecology
LANEV	Lancaster University—Environmental Sciences Department
LL	Letcombe Laboratory
LARS	Long Ashton Research Station
LDSS	Leeds University—School of Geography
LGC	Laboratory of the Government Chemist
LIVGG	Liverpool University—Geography Department
ICLBT	London, Imperial College—Botany Department
ICLCE	London, Imperial College—Civil Engineering Department
ICLGL	London, Imperial College—Geology Department
KCLCE	London, King's College—Civil Engineering Department
KCLGG	London, Kings College—Geography Department
MAFDU	Ministry of Agriculture Field Drainage Experimental Unit
MANCE	Manchester University—Civil Engineering Department
MANGG	Manchester University—Geography Department
MISR	Macaulay Institute for Soil Research
MNICE	Manchester University—Institute of Science and Technology—Civil and Structural Engineering Department
MO	Meteorological Office

KEY TO ABBREVIATIONS USED IN TABLES 1 – 5 *(continued)*

Abbreviation	Organisation
MIPGG	Middlesex Polytechnic—Geography and Planning Department
NCAFE	National College of Agriculural Engineering—Field Engineering Department
NEWCE	Newcastle upon Tyne University—Civil Engineering Department
NEWGG	Newcastle upon Tyne University—Geography Department
NOTSA	Nottingham University—School of Agriculture
NSHEB	North of Scotland Hydro-Electric Board
NVRS	National Vegetable Research Station
NWA	Northumbrian Water Authority
NWWA	North West Water Authority
OXFAS	Oxford University—Agricultural Science Department
OXFGG	Oxford University—Geography Department
PLPES	Plymouth Polytechnic—Environmental Science Department
QMCGG	London, Queen Mary College—Geography Department
RDGGG	Reading University—Geography Department
RES	Rothamsted Experimental Station
SALCE	Salford University—Civil Engineering Department
SHEGG	Sheffield Universoty—Geography Department
SHEGL	Sheffield University—Geology Department
SIAE	Scottish Institute of Agricultural Engineering
SOTCE	Southhampton University—Civil Engineering Department
SOTGG	Southhampton University—Geography Department
SSEW	Soil Survey of England and Wales
STAGG	St Andrews University—Geography Department
STRAP	Strathclyde University—Applied Physics Department
STRCE	Strathclyde University—Civil Engineering Department
STRGG	Strathclyde University—Geography Department
STWA	Severn-Trent Water Authority
SWA	Southern Water Authority
SWWA	South West Water Authority
TRECE	Trent Polytechnic—Civil and Structural Engineering Department
TRRL	Transport and Road Research Laboratory
TWA	Thames Water Authority
UCLGG	London, University College—Geography Department
UCLGL	London, University College—Geology Department
UWIST	Wales: Institute of Science and Technology, Cardiff
WABGG	Wales: University College, Aberystwyth—Geography Department
WDU	Water Data Unit
WEWA	Welsh Water Authority
WPBS	Welsh Plant Breeding Station
WRC	Water Research Centre
WSWGG	Wales: University College of Swansea—Geography Department
WWA	Wessex Water Authority
YWA	Yorkshire Water Authority

TABLE 1 WATER OF THE ATMOSPHERE – (a) EVAPORATION

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
MANCE Aero-diffusion method of evaporation estimation	**ICLBT IH** Plant physiological influences on evaporation from forests	**NEWCE** Relation between actual and potential evaporation
MO Experimental evaporimeter and simple irrigated lysimeter	**EDNFN** Boundary layer characteristics of coniferous shoots	**LIVGG** Regional and altitudinal variations in potential evapotranspiration
		LEEGG Computer models of evaporation from vegetated surfaces
		EDNMT Evapotranspiration models
	MISR Interception studies	**ITE** Analysis of UK meteorological data from woodland site classification
	IH Fog drip	
	LEEG IH Relation of actual evapotranspiration with soil moisture	
MO Transparent floating evaporimeter		
MO IH Development of Automatic Weather Stations	**IGS** Comparative studies of infiltration and evaporation losses using undisturbed drainage lysimeters isolated laterally	**CWPU** Evaluation of long term monthly catchment evaporation
		MO Testing and improvement of computer model for estimating evaporative losses

TABLE 1 WATER OF THE ATMOSPHERE – (a) EVAPORATION (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
MO Development of automatic climatological stations		**MO** Studies of estimates of potential evaporation from Penman and other equations
MO Revision of techniques used for wet and dry bulb psychrometer measurements	**MO** Comparison of various evaporimeters (Kew Observatory and other sites)	**MO HRS** Studies of the indirect measurement of lake/reservoir evaporation
IH Development, testing and use of evaporation detection apparatus	**EMRS IH LARS** Micrometeorological studies in estimating evaporation	**MO** Countrywide historical estimates of evaporation (eg London since 1697)
	EDNFN Evaporation from heathland	**MO** Studies of evaporative losses from a gravimetric raingauge
	NOTSA Catchment evaporation studies	

TABLE 1 WATER OF THE ATMOSPHERE – (b) PRECIPITATION

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
MO NWWA WRC CWPU MAFF Development of automatic, unmanned radar for operational rainfall forecasts for hydrology	**MO** Effect of orography on rainfall distribution	**MO IH WWA** Design of rationalized raingauge networks
MO Development of pilot networks of radars for short-period forecasts of area rainfall	**IH** Chemistry of iodine in rainfall	**MO** Optimisation of radar rainfall and raingauge data fields
	LGC MO KCLGG MISR ITE Rainwater chemistry	Extreme and probability analysis of rainfall (including droughts) on different time and space scales
		Forecasting quantitative rainfall using numerical models
	MO Redesign of gravimetric raingauge (Beaufort Park)	Mapping of rainfall by computer
	MO IH Development of automatic weather and climatological stations	**MO IH** Studies on raingauge exposure
NSHEB IH Remote recording of rainfall	**MO** Magnetic tape rainfall recorder network	**MO** Studies of recent important hydrometeorological events
IH AL MO Application of remote sensing techniques		Studies of storm movement for drainage design
		Studies of rainfall of overseas countries for hydrological design
		Effect of orography on rainfall distribution
		EDNFN Drought in Scotland

TABLE 1 WATER OF THE ATMOSPHERE – (b) PRECIPITATION (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	AL Drop-size distributions	**MO CWPU** Evaluation of long term catchment rainfall Relationship between historical weather information and river flows to augment river flow records Relative severity of historic dry periods
MO Trials of different raingauges	**BRMGL** Stable isotope concentrations in precipitation and soil moisture	
LL Rainfall simulation equipment	**ICLCE** Storm rainfall in Venezuela	**CWPU** Evaluation of long-term residual rainfall series (= rainfall – actual evaporation)
	IH Interception of precipitation by coniferous forest	**CWPU EANCR** Relating tree ring growth to rainfall and temperature
AL Rapid response raingauges		**BTLGG** Estimation and mapping from weather satellite data
		MO EANCR Homogenised rainfall records
		NSHEB Routing of storm rainfall through catchments
		ICLCE Principal component analysis of rainfalls, Nigeria
		BRMCE Spatial and temporal variation
		ICLCE Drought studies (from rainfall records)

TABLE 2 WATER OF THE HYDROSPHERE — (a) SNOW AND ICE

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
MO Measurement of snowfall using mixed radar and ground truth techniques	**BRMPH** Physics of ice	**MO** Studies of snowfall, water equivalent of snow and snow melt throughout UK
MO Measurement of water equivalent of snow	**CAMPH** Deformation mechanisms of ice	**WABGG** Snow assessment in Wales
	STRCE Surge characteristics of Robin Glacier, E. Greenland	**DURGG** Simulation of cirque glacier distribution
	MANGG Hydrology of alpine glaciers	

TABLE 2 WATER OF THE HYDROSPHERE – (b) FLOWING WATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
WRC Flow measurement by ultrasonic and electro-magnetic gauging	**FC** Changes in water regimes following afforestation	**IH** Real-time flow forecasting techniques
UWIST Methods of flow gauging	**SWA** River regulation using groundwater pumping	**IH SWWA** Low flow studies; estimation techniques
EANEV Secondary flows	**SOTGG** Preglacial stream hydrology	**UWIST** Finite element analysis of flow systems
EANEV Stable isotopes for flood hydrograph analysis in small streams	**ICLCE** Overland flow on urban surfaces	**STRCE** Low flow assessment
IH Diluting gauging	**ASTCE** Spatial and temporal variation	**LANEV** Intercomparison study of streamflow generating models
IH Magnetic tape and solid state loggers	**MANGG** Identification of runoff components in glacierised catchments	**BRMCE** 'No records' equations for estimating peak flows
AERE Radioactive tracers for flow measurement/ calibration of structures	**MDHD** Effect of river flow on tidal heights	**LANEV** Storm runoff volume in relation to rainfall and catchment conditions
WWA Tilting weirs	**UCLGG** Hydrology of urban rivers	**NEWCE** Effect of rainfall and evaporation data error on simulated mean daily river discharges
WEWA Quantitative study of interaction of freshwater and tidal flows, R. Dee	**ITE** Freshwater ecosystems	**CWPU BRMCE** Multi-site flow data generation
	CWPU Assessment of changes in river flow, such as effect of river regulation schemes	

TABLE 2 WATER OF THE HYDROSPHERE – (b) FLOWING WATER (Contd.)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	STWA Diurnal fluctuation of river flows	**CWPU** Generation and validation of synthetic flow sequences Flow prediction Optimization of monthly, pentas and daily catchment regression models
WWA Stream bed lining	**CAMGG** Downstream effects of river impoundments **TRPCE** Overland flows to urban stormwater drainage systems **HULGG** Channel geometry in gravel bed upland streams **EANEV** River regulation and channel stability **EANEV** Flow resistance **BOUGL** Flow and sedimentary processes **AWA** Variations of Manning's n with weed growth	**CAMAP** Buoyancy effects on dispersion **SOTCE** Circulation and dispersion in shallow water **STRCE** Regime of Scottish rivers **SOTGG** Hydrological mapping

TABLE 2 WATER OF THE HYDROSPHERE – (b) FLOWING WATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
ITE Chemistry of aquatic pollutants	**ITE** Monitoring pollutants in actual waters	**ICLGL** Interpretation of regional geochemical maps for water quality assessment
LGC Analytical methods for pollutants	**IH** Trace element chemistry of natural waters; stream temperature prediction	
WWA Fish monitors for raw water intakes	**ABDGG** Hydraulic aspects of pollution dispersion	**AWA** Use of flow recession data in planning fish stocks
	EANEV Nutrient budgets, Norfolk Broads	
	EXEGG Stream nitrate levels	
	SHFGG Spatial and temporal aspects of streamwater quality	
	STRGG Thermal characteristics of British rivers	
	WWA Abstraction effects on migrating fish	
	SHFGG Hillslope hydrology and water quality	
	TEPCE Minewater quality	
	FBA Effects of water transfers on fish populations	

TABLE 2 WATER OF THE HYDROSPHERE – (b) FLOWING WATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	TRPCE Pollutants from urban drainage	
	FBA Origin and variation of nitrate nitrogen	
	SHEFGG Solute mobility in relation to grazing management	
	SHFGG Hydrochemical investigation of the Isle of Man	
	EXEGG Interrelationship of streamflow and water quality	
	FBA Eutrophication studies	
	FBA Effects of flow and quality on the ecology of natural waters	
	SOTGL Water quality variation in an urbanising catchment	
	LIVGG Leaching of major cations through sand dune soils	
	FBA Bacterial studies of streams	
	FBA Cycling of chemical components through aquatic ecosystems	

TABLE 2 WATER OF THE HYDROSPHERE – (c) IMPOUNDED WATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	FBA Effect of sewage effluent on inorganic nitrogen transformations	**CAMGG** Late Quaternary lake levels
	WRC Destratification of reservoirs	**CMPU** Combined use of rivers, reservoirs and groundwater
	LEEGG Bacterial characteristics of upland reservoirs	Resource allocation studies
	UCLGG Hydrology of lakes	**MNICE** Probability aspects or reservoir operation
	ITE Freshwater ecosystems; biological surveillance of standing waters	
	WRC Effects of nutrient removal and zooplankton grazing on algal populations	

TABLE 2 WATER OF THE HYDROSPHERE – (d) BIOLOGICAL WATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
STRAP Gamma ray attenuation method for measurement of canopy mass and storage	**STRAP** Dynamic measurement of canopy storage **EDNFN IH** Behaviour of stomata in conifers **WPBS NVRS LL BMRS GRI LARS** Plant physiological studies of water stress **GRI LARS** Micrometeorological studies of crops **FC LARS IH** Moisture abstraction by trees **BMRS** Control of water loss by stomata and leaf-form development **GRI** Plant/atmosphere interchange of CO^2 and water vapour **ITE** Water level and vegetation changes	**IH ICLET** Modelling rainfall interception in forest canopies

TABLE 3 WATER OF THE LITHOSPHERE – (a) SOIL WATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	SHFGG Soil water flow in relation to soil moisture	**WPBS** Water deficit estimation from radiation balance measurements
	DUNBS Hydrology of mires	**ICLCE** Estimation of regional soil moisture deficit
	OXFSS N and P movement through soil into rural drainage water	**NVRS** Models of distribution of soil water from meteorological data and easily measurable soil properties
	EDNFN Hydrology of drained peat, southern Scotland	**NIAE/MO** Models of soil water deficits under arable crops
SSEW Field and laboratory measurements of soil physical attributes related to soil water	**EMRS** Micrometeorological studies in estimating soil moisture deficits	**KCLGG** Thermal regime of unsaturated zone of Chalk
NIAE Monitoring soil moisture regimes	**SHFGG** Soil water residence time and solute uptake	**MAFF** Models for prediction of soil water movement
LL LARS Lysimeter studies	**BKLGG** Seasonal changes and spatial distribution of soil water	
ITE Tracer studies of water in blanket peat	**IH OXFAS** Field drainage	
	BKLGG Drainage of agricultural soils	
	NIAE Effects of cultivation practices on movement and retention of soil water	

TABLE 3 WATER OF THE LITHOSPHERE – (a) SOIL WATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	ASTCE Soil moisture determination for irrigation	
	MISR Physical properties of soils related to soil moisture	
WPBS LL IH LARS Neutron probe techniques	**IH** Neutron probe and tensiometer use for vertical soil water fluxes in unsaturated zone	
RDGGG Discrimation of terrain properties, particularly soil moisture (remote sensing)	**GRI MISR** Relation between location of soil water and availablity of plant nutrients	
MAFF Design of drainage networks	**NEWGG** Crop and soil water relationships in agricultural catchment	
MISR Tritium-labelled water movement in peat	**EANEV** Soil water retention characteristics	
	SHFGL Porewater reactions, with reference to nitrates (unsat. zone)	
	GRI Irrigation studies related to grass and forage crops	
	IH Nitrate fluxes beneath grass treated with slurry; also fertilizer application in upland catchments	

TABLE 3 WATER OF THE LITHOSPHERE – (a) SOIL WATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
LEEGG Satellite thermal capacity measurements as indicators of soil moisture	**STWA** Landfill studies	**EANCR** Historcial review of soil moisture conditons
LL ^{15}N tracer studies of nitrates in soil and utilization by crops	**WRC** Nitrate leaching from different land uses	**IH** Soil moisture deficit data bank
SALCE Rate of recovery of infiltration capacity (weighable catchment)	**IH BTLGG** Soil water movement in hillslopes	**WRC** Predictive modelling of nitrate concentration; movement and degradation of poilutants underground
AERE/CWPU Recharge and movement using radio-active tracers	**SOTGG** Heathland vegetation patterns and soil moisture dynamics	
EANEV Fluorescent dye tracer techniques	**BKLGG** Surface depression storage and infiltration on ploughlands	

TABLE 3 WATER OF THE LITHOSPHERE – (b) INTERMEDIATE WATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
IH Zero flux plane methods for measurement of recharge through unsaturated zone	**EANEV** Washout of fertilizers from grassland	
	FC Effects of excess soil moisture on the physiology and development of root systems	**TEPCE** Evaluation of induced filtration
IGS Hydrochemical - mainly stable isotope and trace element - techniques	**GRI LL LARS** Uptake of water by plants	
	NEWGG Throughflow characteristics in slopes in upland catchments	
	NVRS LARS Movement of nutrients and herbicides in the soil and uptake by plants	
IGS Destructive and non-destructive in-situ moisture sampling techniques in unsaturated zone profiles	**IH** Hydrology of flood plains	**CWPU** Regional assessment of infiltration to groundwater storage to aid resource studies
	BRE Soil water/groundwater influences on ground stability;	
	SWA/WRC IGS Hydrogeology of nitrate transport in Chalk	
		IGS Analyses of rates of infiltration to permeable strata and theoretical relationships of infiltration to recharge and groundwater discharge

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
BRMGS Use of uranium-thorium series isotopes in groundwater studies	**LANEV** Recirculation between unequal recharge/ abstraction wells in uniform flow field	**BRMCE** Recharge estimates
BATSC Groundwater dating	**ICLGL** Underground waste disposal	**EANEV** Finite difference modelling of alluvial aquifers
EANEV Stable isotope composition of groundwater	**CWPU SWA WRC** Artificial recharge of lower Greensand and its development within a regional combined use system	**NEWCE** Dispersion in porous media
CWPU AERE Use of radioactive isotopes to study age and movement of groundwater	**SHFGL** Groundwater reactions involving trace elements	**LIVGG** Groundwater balance of sand dune area
EANCR Carbonate and isotopic geochemistry	**EANEV** Groundwater hydrology of south Lincolnshire limestone	**ICLCE** Analytical model for transient floods in presence of persistent base flow
BRMCE Pumping test analysis	**OXFGG** Solution and percolation rates of selected limestones	**MO** Effective rainfall and soil moisture deficits over catchments. Historical potential soil moisture deficits
AWA Small scale pumping tests in observation boreholes	**BTLGL** Hydraulic characteristics of Jurassic limestone aquifer	**CWPU IGS** Assessment of role of artificial recharge in regional and national groundwater development and management
BRE Field measurements of pore water pressure	**LANEV** Hydrogeology of Silverdale-Arnside area	**CWPU WRC** Assessment of role of artificial recharge in regional and national groundwater development
CWPU Groundwater conservation and variation in storage	**IGS** Development of unconventional techniques of increasing borehole yields	

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
IGS Development of lightweight portable logging systems	**BTGL** Groundwater flow patterns in Mesozoic clastic aquifers	**IGS WRC** Mathematical studies of well efficiencies
IGS Stable isotope studies of natural groundwater dating techniques using ^{14}C and ^{3}H	**EANEV** Hydrogeology of the Malham area	**CWPU IGS** Model studies of regional groundwater flows as inputs to regional systems studies of groundwater and combined use development, conservation and management
	BRMGS Hydrogeological assessment of central Lincolnshire limestone aquifer	
	BTLGL Hydrogeology of Chalk catchments, Dorset and Wiltshire	
	CWPU Mine drainage	
	KCLGG Hydrochemistry of chalk	
	SHFGL Hydrochemical investigation of the Askrigg Block	
	IH Groundwater recharge using zero flux plane technique	
	UCLGL Distribution of saline groundwaters	
	IH Chemistry of alkaline groundwater, Oman	

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
SWWA Automatic monitoring of small scale	**ICLGL** Hydrogeological studies in East Anglia	**WRC** Groundwater resource modelling
IGS Storage and retrieval of heat in permeable strata	**EANCR** Relationship of climate to groundwater in London basin	**CWPU** Chemical quality of groundwater and effect on water resource development
	BRMGS Hydrochemistry of some British aquifers	**IH** Comprehensive computer data handling system for groundwater resource studies
	TEPCE River and aquifer interconnection	**CWPU** Models for forecasting and projecting groundwater levels
	BTLGL Hydrogeology of Permian aquifer, central and east Devon	**AWA** Investigation into baseflow characteristics and groundwater component of Essex rivers
	BRMCE BRMGS Saline intrusion in aquifers	**UCLGL** Analogue and mathematical modelling of groundwater regimes
	BRMCE Regional groundwater flow	**SWA** Digital model study of patterns and rates of pumping
	IGS WRC Behaviour of nitrate in unsaturated and saturated zones of aquifers	
	AWA Hydrogeological investigation of toxic waste disposal sites	
	SWWA/IGS Hydrogeology and geochemistry of Triassic aquifer of east Devon	

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	WRC Geophysical studies	**IGS** Analysis of water level data for predictive purposes
	YWA Groundwater investigations in the Vale of York	
IGS Development of sectional lightweight shallow well linings and screens; field trials	**UCLGL** Hydrology of minor Mesozoic aquifers in Britain	
	WRC Hydrogeological surveys	
	UCLGL Groundwater resource studies in arid regions	
	YWA Saline water intrusion and management of Chalk aquifer, North Humberside	
	SWA · WRC Artificial recharge of groundwaters	
	IH Hydrogeology of Thames flood plain between Oxford and Wallingford	
	NWA Groundwater quality in Magnesian limestone	
	IGS WRC Behaviour of leachates beneath selected landfills by drilling and sampling	

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	SWA Geophysical logging of observation boreholes	
IGS BRMGL Application of geophysical methods (seismic and electrical)	**YWA** Groundwater investigations on Chalk of East Yorkshire	
IGS Physical properties of reservoir rocks - permeability, porosity and pore-size distribution	**AWA** Hydrogeological investigation of N. Essex chalk	**IGS** Groundwater studies in connection with underground oil storage, motorway drainage, new coalfields
IGS Multicapability modular wireline borehole logging equipment	**AWA** Studies of infiltration through boulder clay	
IGS Determination of physical properties of strata and column of water in a well (laboratory and field)	**AWA/BRMCE** Rapid recharge to a fissured aquifer	
IGS/HRS Assessment of simple inexpensive borehole screens for use overseas	**IGS** Groundwater resources of Scotland	
	IGS Geochemistry of UK groundwater - model and process studies, major and trace element occurrence	
	IGS Geochemistry of formation waters and brines	
	IGS Geochemical studies of interstitial waters and host rocks in UK aquifers, especially the Chalk	
	STWA Chloride pollution of groundwater	

TABLE 3 WATER OF THE LITHOSPHERE – (c) GROUNDWATER (Contd)

Instruments and Techniques	Physical Hydrology and Experimental Work	Theoretical Studies and Data Analysis
	IGS Variation in flow regimes with depth by determination of induced velocities in borehole water columns using various logging techniques including packers	**IGS** Study of naturally-occuring radioisotopes in groundwater
	IGS Field investigation of three-dimensional flow in major aquifers using pumping test, borehole wire-line logging and closed circuit TV	
	STWA Nitrates in groundwater	**IGS** Metric well inventories
	IGS Natural elemental geochemistry to investigate mass transport in induced recharge studies	National and regional hydrogeological maps Water supply contribution to IGS memoirs for one-inch geological maps
	STWA Regional groundwater studies	

TABLE 4 DRAINAGE BASIN SYSTEMS – (a) GEOMORPHOLOGY AND RUNOFF PROCESSES

WABGG
River channel changes

SOTGG
River channel adjustments downstream of reservoirs

BKLGG
Generation of desert floods and fluvial sediments

WABGG
Floods and floodplain geometry

EXEGG
Urbanisation effects on natural stream channel morphology

SOTGG
River channel morphology related to frequency of bank-full discharge

STAGG
Channel processes and bedload transport, R. Feshie

NEWCE
Runoff and channel morphology

SOTGG
Channel morphology in relation to river discharge

SOTGG
Changes in drainage networks in Britain

CAMGG
Drainage density and hydrological processes in humid environment

WABGG
Pipeflow contribution to stream discharge

EANEV
Alluvial channels: processes and form

EXEGG
Effects of urbanisation on natural stream morphology

ITE
Release of elements from parent materials to soil and freshwater

CAMGG
Drainage density in humid environments

SOTGG
Controls on extent, pattern of drainage work and density

IH
Morphometric variables in runoff generation

TABLE 4 DRAINAGE BASIN SYSTEMS – (b) EROSION AND SEDIMENT TRANSPORT

TRPCE
Transport and deposition of material in storm drainage systems

LIVGG
Runoff and sediment production on eroding gully slopes

BKLGG
Hydrological significance of clogging mechanisms in fluvial sediments

EDNFN
Accelerated erosion, Scotland

LIVGG
Identification by magnetic measurements of suspended stream sediment and lake sediment sources

LEEGG
Models for sediment production

SHFGG
Solute sources in a drainage basin

SHFGG
Solute loads and erosion rates on carboniferous limestone

DUNGL
Seasonal variations and agricultural practice effects on sediment transport

STAGG
Bedload transport

EANEV
Design equations for gravel bed rivers

PLPES
Karst water studies in Central Pennines (sediment, quality)

NEWCE
Sediment transport over fixed beds

EXEGG
Sediment and solute dynamics

SHFGG
Solute concentrations in karst percolation water

WABGG
Fluvial dispersal of mining sediments

BKLGG
Development of bedload trap

HULGG
Sediment production and moorland hydrology

IH
Land erosion and deposition by rivers

STRCE
Erosion-transport-deposition simulation

SOTGG
Bed material and bedload dynamics in small, mixed sand and gravel-bed streams

EXEGG
Climatic and physiographic controls of sediment and solute loads

EXEGG
Measurement of sediment and solute loads

LEEGG
Sensitivity of erosion to physical and hydrological variables

LIVGG
Magnetic tracing of stream bedload

MANGC
Solute and sediment dynamics in alpine glacierised catchments

EDNFN
Erosion and sediment yield - southern Scotland

EXEGG
Urbanisation effects on streamflow sediment and solute yield

NACAE
Soil erosin in UK

EXEGG
Erosion processes and sediment yield

BKLGG
Coarse grained sediments and bed topography

LEEGG
Relationship of solute loads with parent rock type

EXEGG
Sediment sources

TABLE 4 DRAINAGE BASIN SYSTEMS – (c) WATER BALANCE STUDIES

NOTSA
Water balance of Kingston Brook catchment

OXFAS
Studies of upland climate related to water balance

ICLCE
Hydrology of laboratory catchment

GLACE
Rainfall and runoff correlation for small catchments

UCLGG
Paleohydrology of Konya Basin, Turkey

LEESG
Water balance of Britain during Devensian and post-glacial periods

IH
Land use changes and water balance Plynlimon catchments

LANEV
Probability-distributed parameters within conceptual catchment models

LEEGG
Physically-based models for moderately-sized basins

NEWCE
Water balance in North Pennine catchment

LEEGG
Hydroclimatological models

OXFAS
Water balance studies

LANEV
Rainfall-runoff monitoring programme

IH/AWA
Water balance of the Cam catchment

WEWA
Effects of forestry on water yield (Usk valley)

HULGG
Catchwater catchment experiment

LANEV
Reliability of deterministic catchment models

NACAE
Water balance of gravel pits

PLPES
Integrated study of upland granite catchment

PLPES
Integrated study of upland granite catchment: Narrator Brook

SOTGG
Hydrological effects of heathland management

MNICE
Hydrology of the Cheshire Basin

TABLE 5 OPERATIONAL HYDROLOGY – (a) FLOOD HYDROLOGY

MIPGG
Flood hazard assessment

UCLGG
Environmental impact of flood alleviation works

AWA
Unit hydrograph studies to aid flood prediction in Essex rivers

BQUGG
River flood and water supply problems in Northern Ireland

STRGG
Water resource management, especially flood alleviation measures

MO
Computerisation, extension and improvement of rainfall studies - Flood Studies Report
Studies of heavy rainfall including probable maximum precipitation for overseas countries

EANEV
Flood alleviation feasibility studies

ICLCE
Flood modelling of River Lea

IH
Real-time flood forecasting

Physics-based distributed catchment models for flood prediction

Catchment response models for flood runoff design

Regional flood statistics

NWA
Hydrometric efficiency in relation to flood protection schemes

BRMCE
Regional flood analyiss

BRMCE
Real-time routing methods for operation forecasting of floods and regulation releases

WWA
Telemetry flood warning scheme

SWWA CWPU WRC
Flood warning procedures using radar-derived rainfall data

STWA
Flood forecasting-river regulation schemes

TABLE 5 OPERATIONAL HYDROLOGY – (b) MATHEMATICAL MODELS FOR HYDROLOGY

BRMCE
Time series, statistical and probabilistic methods in water resources assessment

KCLCE
Finite element modelling of hydrological systems

BRMCE
Multi-site data generation

ICLCE
Extremal statistics and rare hydrological events

BRMCE
Real-time rainfall runoff models

CWPU
Linear and semi-logarithmic catchment regression models, months, pentads and days. Accuracy of models related to catchment characteristics

NEWCE
Unit hydrograph

EANEV
Feedback mechanisms

IH
Lumped conceptual models
Distributed models
Time series analysis

ASTCE
Computer simulation of hydrological cycle

ASTCE
Data generation techniques

CWPU
Cross-correlation of river flows

TABLE 5 OPERATIONAL HYDROLOGY – (c) WATER RESOURCES MANAGEMENT

MO
Assessment of areal rainfall, evaporation and soil moisture

BRMCE
Optimal control rules for complex water resource systems

LANEV
Optimal design of water resource systems

YWA
Design of multi-resource operating procedures

SOTGG NOTGG
Drought atlas of Great Britain, 1975-6

AWA
Reliability of water resources in terms of level of service

AWA
Derivation of reservoir operating rules related to frequency of demand restrictions

WRC
Hydrological forecasting with weather radar (with RWAs)

EANEV
Irrigation scheduling

NEWCE
Hydrometric network design

CWPU WAs
Groundwater assessment, development and conservation Maps for EEC contract and other purposes

IH
Regional low flow characteristics

Reservoir operation - overseas applications

National data base for engineering hydrology

ICLCE
Operation of multi-objective resource systems

BRMCE
Optimal regional development

MO
Operational model for near-real time assessment of areal evaporation, soil moisture and rainfall

CWPU
Interaction between surface water and groundwater and influences on water resource development

AWA
Hydrological operation of Ely-Ouse-Essex Scheme

NWA
Optimal operation of regional water resources

Residual flows and constraints on abstractions

Real-time control of River Tees

LANEV
Simulation of reservoir operation

KCLCE
Optimization of water resources

NEWCE
Reservoir operating rules

AERE
Desalination research

CWPU WRC NWWA MO SWWA
Flow forecasting using weather radar

AWA
Optimisation of allocation of water sources to demands

SWWA
Water resources reliability/ operational studies

STWA
Conjunctive use studies

TABLE 5 OPERATIONAL HYDROLOGY – (d) URBAN HYDROLOGY AND EFFLUENT PROBLEMS

LANEV
Design of urban drainage systems

YWA
Residual flow and quality modelling of industrial river systems

WRC
Toxicity study on fish

MANGG NEWCE
Impact of urbanisation on hydrological systems

WRC
Leachate from domestic waste

IH
Design of river works to cater for urbanisation

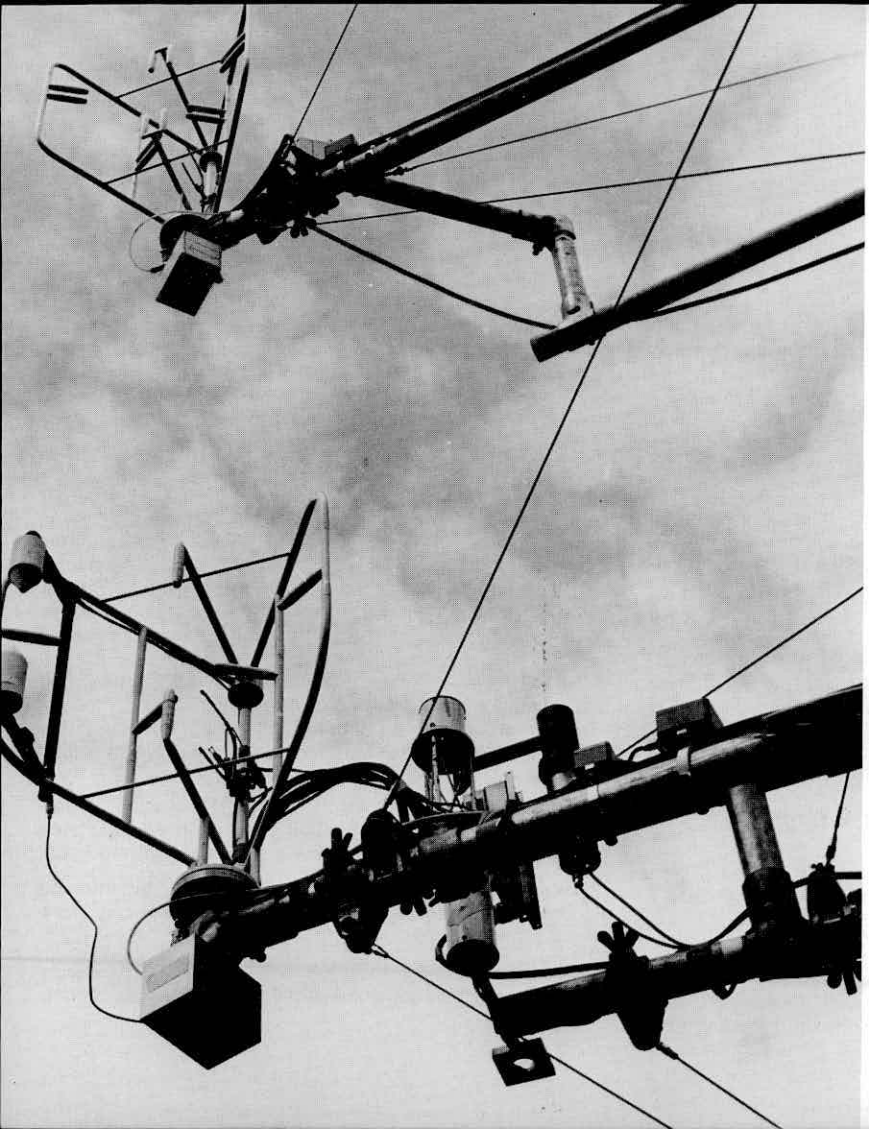
IH HRS
Storm sewer design

MO
Time series of minute-by-minute rainfall data for calibration of urban drainage models; characteristics of travelling storms relevant to urban drainage

NWA
Effects of urbanisation on drainage

WRC
Effect of urban runoff on quality of receiving water

WRC
Artificial oxygenation of rivers



Array of sensors to measure heat and water vapour fluxes for evaporation studies

CHAPTER III
HYDROLOGICAL RESEARCH BY GOVERNMENT AND OTHER AGENCIES

The study of hydrology in Britain has developed slowly and on an *ad hoc* basis; nevertheless much useful research has been done in certain fields such as precipitation, evaporation and groundwater, usually incidental to a research programme such as land drainage.

The diverse origins of hydrological research in the United Kingdom are reflected in the number and character of the agencies listed below. Interests range from the data accumulation and monitoring activities of various river and water authorities through applied project studies by such organisations as the Transport and Road Research Laboratory to the more fundamental research of the Institute of Hydrology.

The purpose of this chapter is to describe briefly the interest in hydrology of each agency. At the end of each entry is a selected bibliography of publications prepared since 1975.

DEPARTMENT OF EDUCATION AND SCIENCE

AGRICULTURAL RESEARCH COUNCIL

EAST MALLING RESEARCH STATION

East Malling, Maidstone, Kent

East Malling Research Station, grant-aided by the Agricultural Research Council, devotes most of its resources to studying the culture of deciduous fruit plants. Much of the research is of a fundamental nature to provide a better understanding of the factors limiting growth and cropping and relates to other applied studies providing more immediate practical answers to the problems of fruit growers. A water stress programme in the Nutrition Department determines the degree to which fruit trees can adapt to drought and the mechanisms involved. Physiological studies on the control of water loss both by stomata and leaf area development and shedding are undertaken in field and pot experiments where controlled water stresses are imposed through combinations of irrigation and soil covers affecting water inputs to the rooting zone.

Micrometeorological studies are involved in estimating evaporation and soil moisture deficits. These lines of study are aimed at defining tolerable limits of plant water stresses in the short term and growth and cropping of the tree in the longer term.

Goode, J.E. and Ingram, J., 1971. The effect of irrigation on the growth, cropping and nutrition of Cox's Orange Pippin apple trees. *J. hort. Sci.*, 46, 195-208.

Goode, J.E. and Higgs, K.H. 1973. Water, osmotic and pressure potential relationships in apple leaves. *J. Hort, Sci.*, 48, 203-15.

Goode, J.E., Higgs, K.H. and Hyrycz, K.J. 1979. Effects of water stress control in apple trees by misting. *J. hort. Sci.*, 54, 1-11.

Pereira, H.C. (Editor) 1975. Climate and the Orchard. Research Review No 5, Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent.

GRASSLAND RESEARCH INSTITUTE
Hurley, Maidenhead, Berkshire SL6 5LR

The Grassland Research Institute, grant-aided by the Council, is concerned with the growth and utilization of forage crops that make the maximum use of the radiant energy of the sun and the nutrients available in the soil.

The Agronomy Division undertakes research into irrigation and the efficiency of water use by grass and forage crops. Particular attention is given to the rate of uptake of soil water by different crops and from different soils and the effects of differences in water uptake on crop growth rate. The relationship between the location of water in the soil profile and the availability of plant nutrients is considered. Work is carried out in collaboration with the Plant and Crop Physiology Department on the loss of water from cut forage crops during field drying and the relationship between the swath micro-climate and the prevailing weather.

The Plant and Crop Physiology Department undertakes measurement of radiation, temperature, relative humidity wind speed and carbon dioxide content within and above the herbage crop and makes direct measurments of carbon dioxide and water with the relationship between the aerial environment, leaf diffusion resistance and leaf water status of grasses and with the relationship between crop transpiration, carbon dioxide exchange and crop growth.

Edelsten, P.R., 1976. A stochastic model of the weather at Hurley in south-east England. *Met. Mag.*, 105, 206-14.

Garwood, E.A. and Tyson, K.C., 1975. The response of S24 perennial ryegrass to irrigation. II Variation in soil and plant-water status. *J. Br. Grassld Soc.*, 30, 51-62..

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LETCOMBE LABORATORY
Wantage OX12 9JT

The Letcombe Laboratory is concerned with the growth of crops in relation to soil conditions, including drainage, and the long term influence of different methods of cultivation on soil structure and fertility. Detailed laboratory studies and field experiments are closely co-ordinated.

Work of hydrological interest arises mainly from work of the Drainage Section studying the influence of transient waterlogging on crop growth. Lysimeters containing

undisturbed columns of soil are installed in a substructure so that their surfaces are level with the surrounding soil which carries a guard crop. A mobile glasshouse with a traversing irrigation system allows a predetermined rainfall pattern to be simulated. Tunnels under the guard crop give access to the lysimeters for regulation of the water-tables, collection of drainage water, sampling the soil water and atmosphere, and monitoring soil temperature. Variations in moisture profiles are measured with a neutron probe. Nitrogen-15 is being used as a tracer to study the utilization of nitrogen fertilizer by the crop, and leaching through soil.

The effects of cultivation on soil water relations are being studied in field experiments, mainly on clay soils. Experiments are also in progress on effects of drought on water relations and yield of cereals.

In the laboratory, studies are in progress on the size and continuity of soil pores in relation to the movement of both water and gases. A small investigation is in progress into the relative movement of tritium-labelled water and nitrate down columns of undisturbed chalk; this is relevant to studies elsewhere of the leaching of fertilizers into aquifers.

The Electronics Section have adapted a cheap cassette tape recorder for use with a standard tipping bucket raingauge. It will run unattended for up to six weeks and provides hourly records of rainfall.

Agricultural Research Council Letcombe Laboratory Annual Report, 1976, 1977. Agricultural Research Council Letcombe Laboratory Annual Report 1977, 1978.

Goss, M.J., Howse, K.R. and Harris, W., 1978. Effects of cultivation on soil water retention and water use by cereals in clay soils. *J. Soil. Sci.*, 29, 475-488.

LONG ASHTON RESEARCH STATION
Long Ashton, Bristol BS18 9AF

Long Ashton Research Station is grant-aided by the Council.

A main hydrological interest at Long Ashton is in the area of transpiration and plant water relationships. Micrometeorological work on apple trees, over a number of years, has led to the formulation of equations for the calculation of transpiration from single trees or lengths of row. Several years' data on changes in soil moisture content in an orchard have been collected with a neutron probe, and further measurements are being made in association with studies on the effects of herbicides. Studies on water movement through trees and diurnal variation in plant water potential have been made.

Work of the type done on apples is now being carried out with cereals. Small hydraulic weighing lysimeters are being developed and large non-weighing lysimeters, in which neutron probe measurements are made, are in operation. Studies on the microclimate inside cereal crops, and on the water relations of diseased and disease-free crops, are proceeding.

Other soil moisture studies involving the use of a neutron probe are an important part of sward and soil management experiments in apple orchards. This project examines the effects of different ground covers - grass, clover or weed-free - and fertilizer treatments on fruit yield and storage quality. In separate work, the fate of pesticides and movement within and through the soil is also investigated.

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Powell, D.B.B. and Thorpe, M.R. 1977. Dynamic aspects of plant-water relations. In: *"Environmental Effects on Crop Physiology"* (Eds. J.J. Landsberg and C.V. Cutting), 259-279. Academic Press.

Thorpe, M.R. and Butler, D.R. 1976. Heat transfer coefficient for leaves on orchard apple trees. *Boundary Layer Meteorology, 12,* 61-73.

Thorpe, M.R. 1978. Net radiation and transpiration of apple trees in rows. *Agri. Meteorol. 19,* 41-57.

MACAULAY INSTITUTE FOR SOIL RESEARCH
Craigiebuckler, Aberdeen

The Macaulay Institute for Soil Research is grant-aided by the Department of Agriculture and Fisheries for Scotland on the advice of the Agricultural Research Council. Research is carried out on the fundamental properties of soil and soil-plant relationships, the object being to maintain and improve soil fertility.

Investigations into soil moisture characteristics are undertaken in relation to plant growth, particularly on the highly organic soils that cover considerable areas in northern and western Scotland. Water movement in peat has been traced using tritium-labelled water and work is in progress on moisure/aeration relationships with respect to conifer growth. The chemical composition of precipitation is being assessed with regard to nutrient input and soil acidification in forest stands; in studies of nutrient movement in these ecosystems the effects of interception by the canopy and of stemflow are also being measured. In relation to the drainage classes of soils as defined by the Soil Survey of Scotland, work on water table levels has been extended to include many of the more important soil series in the Midland Valley between Glasgow and Edinburgh.

Knight, A.H., Boggie, R. and Shepherd, H., 1972. The effect of groundwater level on water movement in peat: a study using tritiated water. *J. appl. Ecol.,* 9, 633-641.

Boggie, R., 1977. Water-table depth and oxygen content of deep peat in relation to root growth in *Pinus contorta. Pl. Soil,* 48, 447-454.

Miller, H.G. (In press). Throughfall, stemflow, crown leaching and wet deposition. *Proc. UNESCO/ITE Workshop on Methods Involved in Studies on Acid Precipitation to Forest Ecosystems, Edinburgh, 1977.*

Duncan, N.A. (In press). The moisture regimes of six soils of the Central Lowlands of Scotland. *J. Soil Sci.*

NATIONAL VEGETABLE RESEARCH STATION
Wellesbourne, Warwickshire

The National Vegetable Research Station studies methods of improving the yield and quality of vegetables.

Recent hydrological work has been concerned with the water balance of cropped and uncropped soil as it affects plant water stress, the movement of nutrients and herbicides in soil and their uptake by plants.

Computer models have been devised for calculating the distribution of water down fallow soils from standard meteorological data and easily measurable soil properties. They have been extended to cropped soils and calculating water-stress within plants. The models are being used to interpret results from field experiments on cultivation and seedling emergence.

Equations have been formulated for the movement of ions up and down the soil profile under field conditions. They enabled good predictions to be made of the movement of non-adsorbed ions in unstructured soils from rainfall evapotranspiration and soil texture.

More complicated models have been developed and tested experimentally for the daily increases of dry matter growth of field grown crops. These attempt to account for the fluctuating distributions of water, nutrients and roots down the soil profile and of the fluctuating requirements of the crops for water and nutrients during the growing season. They provide a theoretical framework for studies of the effects of weather conditions, especially rainfall, and the effects of soil type on crop yield.

Burns, I.G., 1976. Equations to predict the leeching of nitrate uniformly incorporated to a known depth of uniformly distributed throughout a soil profile. *J. Agric. Sci., Camb.*, 85, 305-313.

Rowse, H.R., 1975. Simulation of water balance of soil columns and fallow soils. *J. Soil Sci.*, 26, 337-349.

Rowse, H.R., Stone, D.A. and Gerwitz, A., 1978. Simulation of the water distribution in soil. II. The model for cropped soil and its comparison with experiment. *Plant and Soil*, 49, 533-550.

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ROTHAMSTED EXPERIMENTAL STATION
Harpenden, Hertfordshire

Rothamsted Experimental Station, grant-aided by the Agricultural Research Council, is the largest and oldest of the agricultural research centres. Most of the departments are biological, being concerned with the plant in health and disease. Of the non-biological sections, the Physics Department divides its interest between the root environment (soil physics) and the leaf environment (agricultural meteorology). Present research topics include measurements of the rate of water uptake of drought-stressed crops, and the effect of drought on the water status, photosynthesis, growth and development of the crop.

Following the death of its Honorary Director, Dr E. C. Childs, the Unit of Soil Physics was disbanded in October 1977 and its staff transferred from Cambridge to Rothamsted Experimental Station where they are continuing their studies on water movement both in the unsaturated zone and in the saturated groundwater zone. The former is of particular application to soil water profile development near the soil surface, while the latter gives a theoretical basis for groundwater movement and control.

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Poulovassilis, A. and Tzimas, E., 1975. The hysteretic in the relationship between hydraulic conductivity and soil water content. *Soil Sci.,* 120, 327-331.

Towner, G.D., 1976. A model for swelling soils and its application to the theory of the overburden potential. *Proc. Symp., "Water in heavy soils", Bratislava, ICID/ ISSS,* 1. 2-7

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Youngs, E.G. and Poulovassilis, A., 1976. The different forms of moisture profile development during the redistribution of soil water after infiltration. *Wat. Resour. Res.,* 12, 1007-1012.

SCOTTISH INSTITUTE OF AGRICULTURAL ENGINEERING

Bush Estate, Penicuik, Midlothian EH26 0PH

The Scottish Institute of Agricultural Engineering is grant-aided by the Department of Agriculture and Fisheries for Scotland on the advice of the Agricultural Research Council. The Institute has a small research team studying the effects on soil physical conditions of cultivation and traffic by agricultural machinery, with an emphasis on understanding and reducing the damage to soil structure caused by some modern farming practices.

Part of this work is concerned with monitoring soil moisture regimes and soil hydraulic properties in long-term cultivation experiments in Scotland, in which the cultivation techniques range from traditional deep ploughing through some of the more recent reduced

cultivation techniques to zero tillage. The effects of these practices on the movement and retention of soil water are being assessed.

A mathematical model for soil water deficits under arable crops throughout the year has been developed in co-operation with the Meteorological Office, Edinburgh.

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Soane, B.D., 1976. Review of gamma-ray transmission systems for the *in situ* measurement of soil packing state. *SIAE Biennial Report, 1974-76,* 58-86.

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Campbell, D.J. 1976. Plastic limit determination using a drop-cone penetrometer. *J. Soil Sci.,* 27 (3), 295-300.

SOIL SURVEY OF ENGLAND AND WALES

Rothamsted Experimental Station, Harpenden, Hertfordshire

The Soil Survey of England and Wales is grant-aided by the Agricultural Research Council and exists to organise information about soil variability in classifications, maps and explanatory texts. These are used to transfer results of research and experience in crop production and soil management from one tract of land to another, in planning land use, and in planning further research in soil science or allied fields.

Experience has shown that properties used to identify and map soils reflect infiltration rate and moisture storage capacity, and are relevant to investigation of the pathways of water movement. The Survey is involved in field and laboratory measurements of water levels, hydraulic conductivity, bulk density, moisture release characteristics and porosity, to characterise areally important soil series in hydrological terms and to increase the reliability of inferences derived from properties assessed in the field. Inferences and measurements provide relevant data for catchment research and studies of the component processes of the hydrological cycle.

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Farquharson, F.A.K., Mackney, D., Newson, M.D. and Thomasson, A.J. 1978. Estimation of run-off potential of river catchments from Soil Surveys. *Soil Surv. Spec. Surv., No. 11.*

WELSH PLANT BREEDING STATION
Plas Gogerddan, Aberystwyth, Dyfed.

The Welsh Plant Breeding Station, grant-aided by the Agricultural Research Council, is concerned with the breeding of herbage grasses, legumes and arable crop varieties.

The responses of grass and clover plants and swards to drought and irrigation in the field are studied to detect plant material with physiological and growth characters which contribute to increased productivity and survival during drought, and subsequent recovery. Water deficits are estimated from measurements of the radiation balance and by means of the Wallingford probe.

The Grassland Agronomy Department is studying the relations between sward productivity and survival and climatic data, recorded at a number of meteorological sites, forming an altitudinal transect across mid-Wales. At Pant-y-dwr Hill Centre, particular attention is paid to the effect of winter frost damage.

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NATURAL ENVIRONMENT RESEARCH COUNCIL

BRITISH ANTARCTIC SURVEY
Madingley Road, Cambridge, CB3 OET

The British Antarctic Survey is responsible for initiating and executing scientific research in British Antarctic Territory (BAT) and the Falkland Islands Dependencies. Research of hydrological interest is largely carried out by the Glaciology section. This work falls into four categories:

1. An inventory of contemporary snow and ice in BAT is built up from studies of the areal extent of ice revealed in satellite and high flying aircraft photographs. This information is converted into ice volumes using ice depths determined by airborne radio echo sounding over large areas. Long-term changes are revealed by repeated measurements of reference surface height profiles of representative glaciers. The distribution and variability of sea ice from year to year is recorded and analysed with the help of satellite pictures and ship observations.

2. Two glaciers which represent the polar and sub-polar environments have been selected for detailed studies of ice, heat, and water balance. This work is designed to shed light on the relationship between glaciers and climate and to isolate those factors most responsible for changes in ice volume.

3. The study of ice deformation in floating ice shelves leads to an understanding of the stability of ice shelves, calving from which represents the single most important source of ice loss from the Antarctic ice sheet. Bottom melting from the shelves is an important source of Antarctic Bottom Water.

4. Studies of the chemical properties of Antarctic snow and its included impurities gives information about
(a) chemical species which are related to climatic parameters and which may be sought in ice cores covering the past 1000 years to build up a picture of climatic changes during this period.
(b)the global atmospheric circulation of pollutants and the natural baseline levels of these materials in snow deposited prior to the industrial revolution.

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FRESHWATER BIOLOGICAL ASSOCIATION

The Ferry House, Far Sawrey, Ambleside, Cumbria

The Freshwater Biological Association, grant-aided by the Natural Environment Research Council, is an independent body, founded in 1929, to carry out and promote fundamental research into the biology of fresh waters.

The Association's involvement in hydrology is very broad and relates to the effects of water flow and quality on the ecology of natural waters. Research is carried out on both running and impounded waters. The role of catchments in defining particulate and dissolved loads of natural water is a growing area of interest. There is a particular interest in the cycling of chemical components through aquatic ecosystems. Biological productivity both controls and is controlled by these material cycles.

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INSTITUTE OF GEOLOGICAL SCIENCES

HYDROGEOLOGY UNIT

Exhibition Road, South Kensington, London SW7
Maclean Building, Crowmarsh Gifford, Wallingford, Oxon
Building 151, Harwell Laboratories, Harwell, Didcot, Oxon

The research remit of the Hydrogeology Unit of IGS embraces all physico-chemical aspects of the behaviour of water underground and its interaction with the rocks (mainly aquifers) in which it is stored or through which it passes whilst in the subsurface sector of the hydrological cycle. The Unit's research programme includes a number of long term projects, mainly in Britain, which evolve in response to discovery and understanding, and a much larger proportion of applied projects designed and implemented in response to the wishes of the 'customer' government departments, other national organisations or local authorities. A diminishing proportion of fundamental research (now about 20% of the Unit's effort) is still funded by the DES and much of the remainder (applied) research by the DoE and the ODA.

The Unit's work is carried out by seven Sections, as well as by regional representatives in Scotland and Northern Ireland. The work of each Section is briefly described below with its location – London (L), Wallingford (W), and Harwell (H).

Overseas Section (W) : Water resource and geothermal power investigations are carried out in developing countries as part of the Overseas Aid Programme. Current large-scale long-term projects include the Betwa Valley (India) study of river alluvial and Deccan volcanic trap aquifers and a methodological study of Botswanan aquifers and their groundwater resources with special emphasis on promising areas. Short term studies are taking place in Indonesia, Pakistan, Sri Lanka, Honduras, Fiji and Gibraltar.

Environmental Pollution Section (H) : mainly desk and field investigations into the suitability of crystalline rocks and argillaceous deposits for the geodisposal on land of highly-radioactive wastes. Field surveys of existing nuclear sites are also carried out. On a reducing scale, research is undertaken into the behaviour of effluents (synthesised to resemble those derived from landfills containing toxic materials), in the unsaturated zones of aquifers, as well as site investigations into actual groundwater pollution by landfills, and into a variety of natural materials for use as impermeable basal liners to landfills.

Infiltration, Modelling and Instrumentation Section. (W) : Measurements of natural infiltration to aquifers are made by means of IGS designed lysimeters, large

artifically enclosed 'undisturbed' blocks of aquifer which are fully instrumented. Results are compared with those obtained by the IH using tensiometric methods. IGS lysimeters are also in use in semi-arid zones overseas. Mathematical models are used to predict aquifer yields and responses to short and long term abstraction, particularly to support overseas groundwater resource studies. Various hydrogeological instruments are designed, modified or maintained.

Groundwater Hydraulics and Special Studies Section (L and W)
Better understanding of the three-dimensional behaviour of groundwater in aquifers is the aim of hydrogeological research within this Section. Boreholes are geophysically logged as opportunity permits, frequently in support of other (including commissioned) activities, and their fluid column characteristics as well as the levels of entry and temperatures of groundwater from the aquifer determined. Design research into the optimisation of geophysical waterwell logging equipment is also carried out. Amongst current Special Studies is a major investigation into the local and regional pollution of groundwater by nitrates derived from agricultural fertilizers.

Aquifer Properties Section (W) : The research of this section is to improve understanding of mechanisms of groundwater movement and storage in aquifers mainly by field (pumping test) methods, but also by the laboratory study of aquifer properties by means of rock samples. The DTI–commissioned studies concern the physical properties of North Sea borehole cores, as part of a larger contract placed elsewhere within IGS.

Hydrogeochemical Section (W) : Here the main research themes are the geochemical processes and major and minor trace element mobility within groundwater systems. Following exploratory reconnaissance studies of the principal British aquifers, more detailed research investigates specific geochemical processes as well as individual elements, paying special attention to interactions between water and aquifer minerals. Element mass balance studies of the unsaturated zone contribute to the NERC geochemical recycling programme. The Section operates a (water) stable isotope facility on behalf of NERC institutes and for universities and other organisations on repayment. Geochemical techniques are also applied to geothermal exploration in Britain and overseas.

Data Presentation Section (L) : The National Well Record Collection, collated statutorily under S.7 of the Water Act 1945, forms a comprehensive data base for British hydrogeological research; all non-confidential records are publicly available, and new records are geologically classified by IGS field staff and distributed to relevant government bodies and Water Authorities. Raw data is printed by automated methods and published in Metric Well Inventories; interpreted data is published in a series of regional hydrogeological maps designed to internationally agreed formats and planned to cover the main British aquifers within the current decade.

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Hydrogeological Map of Hampshire and the Isle of Wight (1:100,000).

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Metric well inventories

Marlborough (266) Sheet.

Alresford (300) Sheet.

Records of wells in the area around Aldershot. (Sheet 285).

INSTITUTE OF HYDROLOGY
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The Institute of Hydrology is a component body of the Natural Environment Research Council. It is responsible for a broad programme of basic research into all aspects of hydrology and also undertakes projects of an applied nature in Britain and overseas. The Institute's research programme is divided into some 60 projects, most of which are listed in Chapter II, Tables 1–5, under the general subject groupings as shown below.

Hydrological systems

The Institute was first established to study the rainfall/runoff relationships operating in natural drainage basins. Complete catchments were studied to reveal the influence of geomorphology, of geology and of land use on the response of a catchment to rainfall; mathematical models of catchment behaviour have been derived to improve existing methods of forecasting and prediction of water resources.

The Institute operates two catchment experiments: Plynlimon in central Wales with the two basins formed by the forested headwaters of the River Severn and the geologically-similar, grass-covered headwaters of the River Wye, and a small clay catchment at Underwood in north Bucks. In addition, data collected for the Institute from the catchment of the River Cam above Dernford Mill by the Anglian Water Authority and by the North-West Water Authority from a moorland catchment at Coalburn, Cumbria, newly planted with conifers by the Forestry Commission, both provide extra useful material for modelling purposes.

Mathematical modelling

Catchment systems

Various types of mathematical model are being used to analyse data from the experimental catchments. The two deterministic, distributed models (IHDDM and SHE) are based on the physical laws of water movement and have parameters which are determined *a priori* from the physical characteristics of the catchment. They provide detailed predictions of water flow within the catchment and are especially suitable for the analysis of the effect of land use change.

Lumped conceptual models (IH lumped conceptual

model, IH tank model) are based on a series of simple equations; they describe the flow of water in the catchment considered as a spatially uniform system. The parameters in the model must be evaluated by optimisation, using past records of rainfall, runoff and evaporation for comparison of the average properties of different catchments.

Stochastic models use both linear and non-linear systems equations to describe the state of a catchment. The expected catchment response at a given time is estimated using the systems equation and past observations of catchment behaviour. This type of model is especially useful for real-time forecasting.

Rainfall-runoff modelling for engineering applications

Since the publication of the Flood Studies Report in 1975 work with single event rainfall-runoff models has been concentrated on four aspects of engineering hydrology.

Flood runoff design The national flood event archive is being overhauled and extended to provide a firm base for revisions and improvements to the procedures recommended in the Flood Studies Report for estimating a flood hydrograph with a peak flow of specified return period. As part of the archive improvements, a representative network of UK catchments is being established to sample the range of sizes, soils, slopes and other variables of importance to the flood formation process.

Real-time forecasting In 1975/76 the Institute developed and implemented a hydrological model for use with a telemetry system and on-line small computer at the Bala control centre of the River Dee in north Wales; corrections and improvements to the model and its ancillary software were completed by December 1978. Further enhancements to the model are planned in conjunction with the Welsh Water Authority.

Storm sewer design The design, construction and maintenance of sewerage systems is an important area of Water Authority spending and design methods need to be updated in the light of improved knowledge of hydrological and hydraulic processes. The Institute has worked closely with the Hydraulics Research Station in developing new procedures and the Wallingford Urban Subcatchment Model has been calibrated from data obtained at a number of specially instrumented sites.

Design of river works to cater for urbanisation It is well known that urbanisation increases the volume and speed of runoff but the problem is to quantify the increase and to model it in terms of measurable catchment characteristics. Working mainly with the Flood Studies data, a procedure which is thought to comprise the best advice currently available has been devised for the Construction Industry Research & Information Association. An ongoing programme of research is exploring simple distributed models as well as the usual lumped unit hydrograph model.

Regional low flood studies

Procedures for estimating low flows at ungauged locations have been developed. Flow duration, flow frequency and storage yield curves may now be estimated from catchment characteristics for any river in the United Kingdom. Catchment geology was found to be the most important variable controlling low flows and this has been indexed by using the proportion of base flow. Final reports describing the research programme and estimation techniques are now available.

Advisory studies

The demand for detailed hydrological analysis for consulting engineers, especially on overseas projects in the more arid regions of the world, has led to the formation over the years of a specialised group of hydrologists and hydrogeologists available for such contract work. The range of work undertaken varies widely but always includes opportunities for originality so that research techniques developed by the Institute can be applied to provide a feedback and stimulus for further fundamental research.

Process studies

Evaporation

The Institute's research commitment to studies of the physical controls of evaporation go back many years. This work is now complemented by studies of the physiological controls of transpiration and extensive research into the interception process. All this has culminated in successful modelling techniques for estimating actual evaporation loss for a wide range of catchment conditions. Even so, actual measurements of evaporation would be invaluable in all water resources studies; hence considerable effort is now being devoted to the development of instrumentation for routine measurements of evaporation using the eddy correlation technique.

Erosion and sediment transport

The influence of forest drainage on bed-load yields has been studied in the Plynlimon catchments and at other sites in mid-Wales. The large increases in bed-load resulting from land-use changes have resulted in the study being extended down-river to the major catchments of mid-Wales to quantify artificial influences on the nature and quantity of sediment movement and the effects on hydraulic geometry.

The unsaturated zone

Measurements of soil water content and potential using neutron probes and tensiometers provides the means of determining soil water fluxes in the unsaturated zone. The 'soil' of principal interest at present is the unsaturated zone of the Chalk. Fluxes are being measured at two sites, one on the Upper Chalk near Winchester, the other on the lower Middle Chalk near Cambridge. From these measurements, evaporation and the recharge to the underlying aquifer are being determined at both sites. At the former site the measurements are used in conjunction with chemical analyses of cores taken from the top 3 m of the profile in an investigation of the physical processes controlling the distribution of nitrate in the unsaturated zone. At the latter site the principal objective is to provide a methodology for the determination of recharge independently of meteorological estimates of evaporation and to assess the areal representivity of such a point measurement.

Soil moisture deficits (SMD) measured *in situ* by neutron probes are being compared with values predicted by the Meteorological Office MORECS model. SMD data donated by neutron probe users throughout Britain are being compiled into a data bank containing as many soil/crop combinations as possible.

Methods of soil moisture measurement based on variations in the dielectric constant at microwave frequencies are also being investigated.

Groundwater

Field studies are aimed at improved understanding of

hydrogeological processes in flood plains of major rivers. An extensive subsurface exploration of the Thames Valley between Oxford and Wallingford is exploring the nature and distribution of the alluvial aquifers and the interrelationships between groundwater and surface waters in the area. Intensive laboratory studies are concerned with particle size distributions, analysis of fines, engineering tests and unconsolidated permeabilities. A supporting study into the fate of farm waste in gravels is also being conducted in cooperation with The National Institute for Research in Dairying at Shinfield.

Hydrochemical studies have concentrated on the origin of alkaline groundwaters (pH 11-12) from ultrabasic rocks in Oman. The geological controls determining the location and distribution of springs and the mineralogical tranformations and thermodynamic processes are being investigated.

Hydrochemistry

The speciation of silicon and iodine dissolved in natural waters, and the adsorption of major cations by clay minerals are being studied within the framework of a general study of hydrochemistry. The clay-mineral study has been extended to the estuarine environment where processes of aggregation are important.

Instrumentation

The continued emphasis on mathematical modelling of catchment behaviour means a constant pressure to improve data collection. Over the years, considerable effort has gone into refining existing equipment or to sponsoring the design and manufacture of improved devices. Both the Institute of Hydrology soil moisture neutron probe and the automatic weather station are known internationally.

The network of automatic weather stations has been extended and now collects data from sites in the UK. More generally, the trend is for data to be recorded on the solid state loggers developed by the Institute with increasing use of microprocessors for data processing and instrument control.

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Flood Studies Report. 1975. 5 vols.

Flood Studies Supplementary Reports. 1977 onwards

Low Flow Studies. 1979. Reports and estimation manuals.

INSTITUTE OF TERRESTRIAL ECOLOGY
68 Hills Road, Cambridge CB2 1LA

The Institute of Terrestrial Ecology is a component body of the Natural Environment Research Council. Its research is designed to improve understanding of the factors determining the structure, composition and processes of land and freshwater ecological systems and the abundance and performance of individual species and organisms. This research is intended to provide a sounder scientific basis than is presently available for predicting and modelling future environmental trends, and especially those resulting from man's activities, hence permitting a more critical assessment of the need for, and likely benefits of, specific measures to protect and manage the environment.

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Phillips, J. and Moss, R., 1977. Effects of subsoil draining on heather moors in Scotland. *J. Range Mgmt.,* 30, 27-29.

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SCIENCE RESEARCH COUNCIL

APPLETON LABORATORY
Ditton Park, Slough, SL3 9JX

The station has an interest in the characteristics of precipitation since they affect the absorption and scattering of radio and optical waves. Studies of the instantaneous local variations in rainfall over short distances and of drop-size distributions are of special importance. Such studies are in progress and are being combined with simultaneous measurements of radar back-scatter and of millimetre, sub-millimetre and infra-red transmissions. A rapid-response raingauge has been developed for this work, particularly for use in a network of gauges in a computer-controlled system linked by telemetry.

Radio and Space Research 1974/76 - published by SRC.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

LAND DRAINAGE, WATER AND MACHINERY DIVISION
Great Westminster House, Horseferry Road, London SW1P 2AE

FIELD DRAINAGE EXPERIMENTAL UNIT
Anstey Hall, Maris Lane, Trumpington, Cambridge, CB2 2LF

The Ministry of Agriculture, Fisheries and Food gives grant-aid to Regional Water Authorities, Drainage Boards and Local Authorities towards the cost of flood protection and land drainage schemes for rivers and other water courses. The Ministry also grant-aids schemes for field drainage of land and farm water supplies including the irrigation of agricultural crops.

The professional and technical matters involved in the work of this administrative division are dealt with by the Land Drainage service of the Agricultural Development and Advisory Service. This includes the Field Drainage Experimental Unit at Cambridge which is concerned with problems in field drainage and in particular with design standards. The hydrological interest of the Unit is in the movement of soil water, the behaviour of drainage installations and the development of mathematical models for predictive use. Most effort is on field scale hydrology but some work is done on large catchments. Hydrological data are collected from a number of experimental sites and extensive soil water regime studies are being made on sites throughout England and Wales. The Unit

does not undertake fundamental research but is in close contact with research centres in Britain and overseas.

FDEU Annual Report 1974, 1975, 1976, 1977, 1978.

MINISTRY OF DEFENCE

HYDROGRAPHIC DEPARTMENT
Taunton, Somerset, TA1 2DN

The Hydrographic Department carries out hydrographic surveys around the British Isles and British territories abroad. It produces charts to cover the whole world, for issue to the Royal Navy and for the sale to British, Commonwealth and foreign merchant fleets; it also publishes the necessary sailing directions, tide tables, radio and light lists to complement this world coverage; surveys may also be carried out in the open oceans and, as mutually arranged, in the waters around certain Commonwealth and foreign territories.

The Tidal Branch of the Hydrographic Department is responsible for the publication of the Admiralty Tide Tables which give world wide tidal predictions. For this reason it is interested in the effect of river water and seasonal variations on tidal heights.

The Storm Tide Warning Service, a branch of the Hydrographic Department, is responsible for issuing warnings to the appropriate authorities of abnormally high sea levels on the east coast of England. In order that it may provide the best possible service on the meteorological situation the office is situated within the Meteorological Office Headquarters, at Bracknell. Research into the improvements of the accuracy of the warnings of the service is continuously carried out by its staff officers.

In addition, an experimental 'Negative Surge Warning Service' has been started to forecast occasions when meteorological conditions produce tides far enough below the predicted values to constitute a navigational hazard. Initial empirical equations for this purpose were derived by the staff of the Storm Tide Warning Service.

METEOROLOGICAL OFFICE
London Road, Bracknell, Berks, RG12 2SZ

The Meteorological Office is responsible for providing a meteorological service to other government departments, aviation, shipping, agriculture, commerce, industry and the general public and for research in meteorology and in other related fields of geophysics. Its function also includes the collection, distribution and publication of meteorological information, mostly from the United Kingdom. In particular the hydrometeorological section of the Meteorological Office at Bracknell is concerned with problems of precipitation measurement and with the operation of systems for data collection, quality-control, dissemination and analysis of rainfall information, together with estimates of evaporative water losses and soil moisture deficits. Another section, based at Malvern, deals with the measurement of rainfull using radar. Five projects deserve special mention; two are concerned with radar.

The first, the Dee Weather Radar Project, ended in 1976. Its primary objectives were successfully accomplished. These were (1) to investigate the accuracy with which areal precipitation can be measured in a hilly area and (2) the development of a real-time system for the measurement of areal precipitation on the time scales required for water management and river regulation.

A second project concerns the development of a network of radars, supplemented by satellite observations, to develop improved methods of short-period (0-6h) precipitation forecasting (The Meteorological Office Short-Period Weather Forecasting Pilot Project.) Three radars have been installed and a further automatic radar is under construction. The project enjoys the active involvement of the water industry, certain of whose centres will have a direct, real-time access to the radar data (and to projections of the radar rainfall information) for operational purposes.

The Meteorological Office contribution to the United Kingdom Flood Studies Project has been computerised, and services using these programs have been made available to engineers and hydrologists. Techniques used in the work have also been applied to overseas engineering projects on repayment. The increasing availability of a large, new body of digitised autographic rainfall data (being put together in a parallel project) and data from a network of magnetic tape rainfall recorders is allowing work to be carried out both to improve the meteorological analysis (statistics) of short duration rainfall and to extend the scope of the original work. The work reported in the section on snowmelt in the Flood Studies Report has also been much extended and improved and the work published.

Fourthly, a major advance was introduced in 1978 in the service provided to hydrologists for the near-real time calculation of evaporation and soil deficit parameters throughout the UK. The new service is known as MORECS (Meteorological Office Rainfall and Evaporation Calculation System). It reflects a variety of improvements, notably in the combination equation for the calculation of evaporation; in addition to drawing on more extensive weather data, the calculation takes note of real land use and soil type.

Finally, the Synoptic Climatology Branch of the Meteorological Office is working, under contract, for the Department of the Environment, to carry out a comprehensive study of rainfall over Europe, including the UK, based on all available historical records. For the UK monthly rainfall totals for 700 stations over the period 1911-1970 and 2000 stations over the period 1941-1970 have been used to examine the spatial variability of rainfall. Homogenised series of monthly rainfalls for 185 stations in Europe have been produced for the period 1861-1970. Principal component analysis was used to identify the main patterns of European rainfall.

Other valuable additions to our knowledge have been made by the production of a statistical model of the relative frequency of droughts in UK. The completion of this work was very timely for assessing the severity of the 1975-6 drought. The further developments and trials of the gravimetric reference raingauge, now underway, promises to help with the difficult problem of assessing the quantity of rainfall reaching the ground.

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Multi-site flow data generation

The final report of the study showed that bi-variate auto-regressive models whilst possibly adequate for monthly time intervals, cannot operate with pentad or daily data. A method based upon dependency matrices was suggested and further development proposed.

Synthesis of river flows from weather data

The final report of this project was published in 1979. It describes a method of making full use of the long weather records in England and Wales to assist in the design and operation of water resource schemes. Mathematical relationships between river flows and weather information were derived for over 70 catchments.

River regulation losses

The final report of this study, which became available in 1979, describes the losses which can occur in a regulated river system due to various factors such as hydrological forecasting errors and operational efficiency.

Residual flows to estuaries

A preliminary report was completed in 1979 that provides a review of methods currently used to determine residual flows to estuaries and assesses the relationships between residual flows and water quality, sediments, salinity, temperature and migratory fish.

Groundwater resources

The Unit had a contract with the European Economic Community to coordinate returns from water authorities in England and Wales, regional councils in Scotland and the Department of the Environment in Northern Ireland to prepare an assessment of the groundwater resources of the United Kingdom.

Artificial recharge

Assistance to water authorities in promoting prototype artificial recharge schemes in the principal aquifers.

Groundwater quality

The analysis of information on nitrate concentrations in groundwater, together with problems associated with saline intrusion.

Optimum development of combined sources

A report was completed in 1979 on the benefits of using telemetry in the operational control of schemes involving the combined use of surface water and groundwater. Part I of this report reviews the equipment available and Part II is a case study of the Lancashire Conjunctive Use Scheme.

Reliability studies

In 1977 the Unit produced an interim report on the reliability of water supplies which showed that traditional methods of calculating the reliable yield were not ideal. Alternative methods of assessing reliability could be based upon factors such as the intensity, frequency and duration of expected restrictions in supply.

Weather radar

A jointly-financed prototype unmanned radar station was installed in 1979 in the area of the North West Water Authority to measure and forecast the intensity of preci-

pitation and thereby assist in forecasting river flows for flood warning and other real time operational purposes. The consortium funding this research included the Unit, MAFF, WRC, MO and NWWA.

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Birtles, A.B., 1977. River water quality models based on stream hydrograph components. CWPU Tech Note No. 23, 35 pp.

CWPU, 1976. The Wash water storage scheme: Report on the feasibility study. HMSO.

CWPU, 1976. Optimum development of combined sources. 1. Unconfined aquifer and surface storage. CWPU, Reading.

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Gibb, O. and Richards, H.J., 1978. Planning for development of groundwater and surface water resources. *Proc. R. Soc. London,* A363, 109-130.

Hamlin, M.J. and Wright, C.E., 1978. The effects of drought on the river systems. *Proc. R. Soc. London,* A363, 69-96.

Jackson, H.B. and Bailey, R.A., 1979. Some practical aspects of river regulation in England and Wales. *J. Instn. Wat. Engrs.,* 33, 183-199.

Kemp, J.B. and Wright, C.E., 1977. The assessment of river regulation losses. *Intern. Assn. Hydrogeologists,* Birmingham Congress, 24-30 July, *Memoires xiii,* part 1, D1-D19.

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Phillips, S., 1979. The prediction of groundwater levels. CWPU Tech. Note No. 21 (in press).

Rae, G., 1977. Computer analysis of information from mine drainage. *Intern. Ass. Hydrogeologists,* Birmingham Congress, 24-30 July, *Memoires xiii,* part 1, B39-49.

and Food, the Welsh Office, the National Water Council and the water authorities of England and Wales. Its ICL 1904S computer configuration allows the provision of certain computing services on a bureau basis to Government organisations and water authorities.

The major project at present in hand is the maintenance and joint development with water authorities of the Water Archive System. The system is designed to permit the storage and retrieval of technical water data with which to support the range of water management functions practised in the United Kingdom. A common suite of computer software is available for sustaining an archive of water features information and freshwater quality; the majority of water authorities have installed the package for their own use. The system will eventually be applied to the archiving of water quantity, biological, marine quality, recreation and amenity data. The archive of marine quality data should be operational this year at the Water Data Unit together with the first stage of the archiving of water quantity data.

Other existing computer systems support the work involved in managing the Unit's archives on surface water, groundwater, spillages and river quality harmonised monitoring. Future work includes the development of a computer mapping facility and the provision of graphical equipment.

In addition to the bibliography listed below, the Unit's main publications are Water Data. the Groundwater and Surface Water Yearbooks, and the River Pollution Survey.

WATER DATA UNIT TECHNICAL MEMORANDA

No. 1 (Revised) Computing and data processing services, February 1978

No. 2 Water demand in England and Wales 1973, August 1975

No. 3 A review of fish counter development, September 1975

No. 4 A guide to metric units in the water industry, May 1976, second edition December 1976

No. 5 Surface water data processing - a guide to practice, April 1976

No. 6 Punched tape river level recorders, May 1976

No. 7 An evaluation of the Braystoke current meter, May 1976

No. 8 The design of crump weirs, February 1977

No. 9 Water demand in England and Wales 1974, December 1976

No.10 The effect of pulsations on the accuracy of river flow measurement, September 1978

No.11 The water archive - phase 2. A functional description, January 1978

No.12 Method of flow computation in the river pollution survey (in preparation)

No.13 Autographic water level recorders, December 1976

No.14 A bibiliography of biological surveillance methodology for macro-invertebrates in running waters, July 1977

No.15 Weed growth on river flow measurement structures, August 1977

No.16 Interrogable devices, August 1977

No.17 Portable current meter cableways and winches, January 1978

WATER DATA UNIT, WATER ARCHIVE MANUAL SERIES

No. 1 Chemical determinand dictionary for use with the water quality archive system, June 1976

No. 2 Water archive user manual, May 1978

No. 3 A coded list of 1000 freshwater algae of the British Isles, May 1978

OTHER PUBLICATIONS

Herschy, R.W. 1976, New methods of river gauging. *Physics in Technology,* Institute of Physics, 7, (2) 54-48.

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Lees, M.L. 1979, DOE Water Data Unit processing for ultrasonic tapes. *WDU/WRC Seminar on ultrasonic river gauging,* Univeristy of Reading, 11 pp.

Marsh, T.J. and Littlewood, I.G. 1978, An estimate of annual runoff from England and Wales 1728-1926. *Hydr. Sci. Bull.* 3, 131-142.

Newsome, D.G. 1979, Archiving Data - An Archivist's Viewpoint, *WRC Conference on River Pollution Control,* Keble College, Oxford. 21 pp.

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Rodda, D.W.C. 1978, Water Resource Data Systems and their Development in Great Britain and Northern Ireland, *UN/ESCAP meeting of experts in Water Resources Data Systems,* Bangkok, Thailand.

Rodda, J.C., Sheckley, A. and Tan, P. 1978, Water resources and climatic change. *J. Inst. Wat. Eng. Sci.,* 32, 76-83.

Rowse, A. A. and Mullins, F. H. 1979, The feasibility of remotely monitoring snow and soil moisture in the United Kingdom. *WMO Workshop on Remote Sensing of snow and Soil Moisture by Nuclear Techniques,* Voss, Norway, 10pp.

FORESTRY COMMISSION

RESEARCH AND DEVELOPMENT DIVISION

Alice Holt Lodge, Farnham, Surrey
and
Roslin, Midlothian

The Forestry Commission acts as the national forest authority and as the national forest enterprise. The functions of the forest authority are to advance knowledge and understanding of forestry and trees in the countryside, to develop and ensure the best use of the country's timber resources and to promote efficiency and development in the home timber industry, to undertake research relevant to the needs of forestry, to combat forest and tree pests and diseases and to initiate Plant Health Orders when appropriate.

Boards in 1975 it was agreed that they should take over the Department's existing stations and complete the national network, with the aid of grant. This process is now under way. Although activity is orientated more towards data collection than fundamental research, periodic investigations have been carried out into various practical aspects of river flow measurement.

The Department co-operates with Universities and other authorities on schemes with a hydrological interest such as flood alleviation and control, flood warning, estuary surveys, effects of pollution on river and lochs and the monitoring of migratory fish. In addition, the Department is participating with Regional Authorites in investigating the potential of groundwater resources in various parts of Scotland.

The Department is jointly responsible with the Water Data Unit of the Department of the Environment, which provides processing facilities for Scottish river flow data, for publication in "Surface Water, UK".

RIVER PURIFICATION BOARDS

A restructuring of these boards became effective on 16 May 1975 when seven boards were formed to cover the whole of the mainland. As part of their function these boards undertake flow measurement in rivers and small streams, rainfall and other climatic measurements, analyses of hydrological data and hydrological and hydrographical surveys.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

Research and development work over the period has tended to centre on the problems of applying the NERC Flood Studies Report to the Board's area. This work has been greatly aided by a systems program which enables a design rain storm to be routed through the highly developed catchment areas incorporating explicitly the operation of the power generating headworks.

Because of the complexities of the catchments the NERC Flood Studies Report cannot be applied directly and careful attention has had to be given to the choice of design variables such as storm duration specification and the proportion of incident rainfall that is assumed to run off. Statistical aspects of the region's rainfall are also under review, in particular the degree to which spatial dependence among the data points may affect the assignment of return period to very large storms, and the manner in which rainfall depth reduces away from the areas of greatest intensity within rare and widespread rainfall events.

Reporting of results has been mainly internal and to regional meetings of hydrologists and engineers.

Reynolds, G., 1978. Maximum precipitation in Great Britain. *Weather*, 33, 162-6.

THE DEPARTMENT OF THE ENVIRONMENT FOR NOTHERN IRELAND

THE WATER SERVICE
Stormont, Belfast BT4 3SS

The Department is responsible for the management of all aspects of water in Northern Ireland excluding arterial and urban drainage and excluding certain provisons for water recreation. The Departmental emphasis is on water conservation, water supplies and sewage disposal.

The enabling legislation is contained in the Water Act (NI) 1972, the Water and Sewerage Services (NI) Order 1973 and the Water Regulations (NI) 1974. The Department is advised by the Northern Ireland Water Council.

The Department prepares regional reports on water supplies and water quality. A draft Water Management Programme for Lough Neagh has been prepared in accordance with the Water Act (NI) 1972.

The Department's hydrometric, meteorological, water quality and hydrogeological monitoring networks are used to provide the data on which water resource management is based. A rationalization of the meteorological network has been completed.

Although the Departmental emphasis is on its responsibilities as the Water Service for Northern Ireland, the Department actively supports water research by means of staff involvement and limited financial assistance. Much of this research supported directly or indirectly concerns hydrology, but no prime research in hydrology is undertaken directly by the Department.

WATER RESEARCH CENTRE

Registered Office:
45 Station Road,
Henley-on-Thames,
Oxon., 8G9 1BW

Medmenham Laboratory,
P.O. Box 16,
Henley Road,
Medmenham,
Marlow,
Buckinghamshire, SL7 2HD

Stevenage Laboratory,
Elder Way,
Stevenage,
Herfordshire,
SG1 1TH

The research programme of the Centre is principally designed to meet the needs of public water bodies in England, Wales, Scotland and Northern Ireland with the Medmenham Laboratory predominantly concerned with public water supply requirements and the Stevenage Laboratory with problems associated with the treatment and disposal of waste water. A newly-formed Engineering Directorate, centred at Henley, is controlling the Centre's increasing effort on sewers and water mains.

Hydrological topics included in the Centre's programme of work are as follows:

Resource development and management

Hydrogeological, geophysical and modelling assistance is being provided to Members undertaking advanced groundwater developments, including the use of artificial recharge.

Reservoir studies include further design work on destratification schemes and the assessment of the effect of nutrient removal and zooplankton grazing in algal populations, using the Lund tubes at Farmoor reservoir.

Groundwater pollution

Examination of nitrate release to aquifers from different land situations: predictive modelling of nitrate concentration and movement and degradation of pollutants underground.

Studies on composition, production and treatment of leachate from domestic waste and an examination of the

Monkhouse, R.A., and Fleet, M. 1975. A geophysical Investigation of Saline Water in the Chalk of the South Coast of England. *Q. J., Eng. Geol.*, 8, 291-302.

Naylor, J.A., Rowland, C.D., Young, C.P., and Barber, C. October 1978. The Investigation of Landfill Sites. *WRC Tech. Rep.* No. TR 91, 68 pp.

Oakes, D.B. and Skinner, A.C. 1975. The Lancashire Conjunctive use Scheme Groundwater Model. *WRC Tech. Rep.* No. TR 12, 40 pp.

Oakes, D.B., and Pontin, J.M.A. 1976. Mathematical Modelling of a Chalk Aquifer. *WRC Tech. Rep.* No. TR 24, 41 pp.

Price, R.K. and Mance, G. 1978. A suspended solids model for storm water runoff. *Proc. Conf. on Urban Storm Drainage, Southampton.*

Reeves, M.J., Skinner, A.C., and Wilkinson, W.B. 1975. The relevance of aquifer flow mechanisms to exploration and development of groundwater resources. *J. Hydrol.*, 25, 1-21.

Tolland, H.G. August 1977. Destratification/aeration in Reservoirs. A Literature review of the Techniques used for Water Quality Management. *WRC. Tech. Rep.* No. TR 50, 40 pp.

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Young, C.P., Oakes, D.B., and Wilkinson, W.B. 1976. Prediction of future nitrate concentrations in groundwater. *Groundwater*, 14 (6), 426-438.

Young, C.P. and Morgan-Jones, M., In press. Hydrogeochemical survey of the chalk of the Banstead area. *J. Inst. Wat. Eng. Sci.*

ANGLIAN WATER AUTHORITY,
Diploma House,
Grammar School Walk,
Huntingdon, Cambs.

Regional planning model

A mathematical model has been developed to select the least cost water resource development programme over a period of 30 years. As forecasts of demand change and possible new resource developments are considered, the model is now in frequent use to evaluate options. The model can be used to rapidly provide cost estimates for any potential strategy, for example dilution or treatment of high nitrate levels in particular areas.

Simulation studies

Several simulation models have been developed to investigate the performance of present and projected components of the water resource system, usually on a sub-regional scale, for example the Rutland Water-Grafham Water-Pitsford Reservoir system.

The water resource systems have been idealised on a series of nodes (reservoirs, demand centres etc.) and links (rivers and pipelines). The simulation consists of calculating the transfer of water along the links in response to hydrological inputs and constraints on the system such as link capacities and operating rules for the sources. The performance of the system is monitored by counting the number of events such as failure to meet a demand or target level in a reservoir.

The technique has been extended to include aspects of water quality, for example to predict future sulphate levels in the rivers Welland and Nene and to estimate the future levels of sulphate in Rutland Water.

Ground water resources are more difficult to integrate into such models, but a lumped ground water module is under development for inclusion in the simulation models.

Effluent quality

A method has been developed for calculating consent conditions for effluent discharges based on the probabilities of quality measures downstream. Using statistical properties of the flows and water qualities involved, water quality downstream (e.g. 95 percentile BOD) resulting from a given consent condition is calculated. The consent condition is then adjusted until the required downstream quality is obtained. A monte-carlo sampling method and also an analytical method have been developed and tested.

Operational models

Two models have been developed to assess the reliability of water resources. One simulates the operation of a reservoir, and by incorporating a forward look, assuming a drought is about to start, determines when restrictions on demand should be introduced. It is used to determine yields by matching reservoir output to an acceptable frequency of restrictions. The second model performs a similar function for a multi-reservoir system where demands may be met from more than one source. The forward look precedure uses linear programming to determine the least cost allocation of sources to demands such that, as before, the risk of failure is sufficiently low and the introduction of restrictions is properly staged.

Resource assessment

A number of resource assessment schemes have research aspects. Many of these are of ground water and include studies of infiltration through boulder clay, use of tracers to reveal flow paths and flow rates in a highly fissured aquifer and small scale pumping tests in observation boreholes.

Hydraulics

An experimental investigation of the effects of weed growth on channel roughness and in particular on Mannings 'n' has been carried out.

Fisheries

The possibility of using information on the recession rate of river flows to help fish farmers to decide on feasible stocking levels of trout for the coming seasons has been investigated.

NORTHUMBRIAN WATER AUTHORITY

Northumbria House
Regent Centre
Gosforth
Newcastle upon Tyne

Optimal operation of regional water resources

P Johnson/J Brady 1979-1981

This project is concerned with the development of control rules for Tees Reservoirs and the Kielder Scheme. The overall objective of the rules is to maintain the required level of reliability of supplies and the constraints are to minimise the operating costs, maintain an acceptable balance of drawdown in the region's reservoirs and provide benefit in the form of protected flows to the region's three major rivers below abstraction points.

Effects of urbanisation on drainage

P Johnson/J M Storey 1979-1980

The aim of this project is to identify the process of urban drainage and determine the increase in flood potential resulting from urbanisation. An overland flow model has been developed and calibrated and is being tested for for sensitivity to variations in rainfall and catchment area.

Hydrometric efficiency

P Johnson/J M Storey 1978-1979

This project was set up to determine the worth of a hydrometric data collection programme including stream flow, precipitation and climate. The application of cost-benefit analysis to flow data from a number of flood protection schemes is nearly complete.

Groundwater quality in the magnesian limestone

P Johnson/G M Kershaw 1978-1980

This project is concerned with the investigation of water quality in the Magnesian Limestone aquifer of South East Durham and possible effects on local water resources. Problems of saline intrusion in the Hartlepool area are under investigation. Sulphate contamination of the aquifer is also being examined. Water quality in the aquifer is also at risk from polluted rivers in the area and investigations are underway.

Residual flows to estuaries and constraints on river abstractions

C Drew 1979-1980

This project is to examine the criteria and objectives for determining flows to estuaries and abstraction conditions and their consequences for water quality, and their cost.

Real-time control of the river Tees

P Johnson/J Brady 1978-1980

The purpose of this project is to develop a computer model of the Tees catchment for use on the Tees telemetry system to control releases from upland reservoirs and minimise waste below the abstraction works at Broken Scar, Blackwell and Low Worsall.

SEVERN-TRENT WATER AUTHORITY

Abelson House, Coventry Road, Sheldon, Birmingham B26 3PR

Shropshire groundwater investigation 1971-78

An investigation of the groundwater resources of the Triassic sandstones of North Shropshire and their utillisation for river regulation. The investigation was completed in 1978 and a scheme for resource development is being promoted.

Nottinghamshire groundwater investigation 1974-77
(Dove Beck Scheme)

A study of the Triassic Sandstones in South Nottinghamshire involving evaluation of potential for conjunctive use. Project suspended at the end of the first phase.

Flood forecasting - river regulation

Development of rainfall-runoff and routing models and system support for flood forecasting and river regulation.

Agricultural runoff 1974-80

(Study still continuing). Measuring load of nitrate, phosphate and other nutrients in runoff from a small agricultural catchment in North Nottinghamshire. Intensive sampling at times of high flow.

Nitrates in groundwater in Severn-Trent catchment 1975 -

Field experiments are being carried out in three areas - South Staffordshire, East Shropshire and North Nottinghamshire to identify and monitor the extent of groundwater contamination. Particular emphasis is placed on processes in the saturated zone and on operationally practical techniques of controlling nitrate levels (in conjunction with WRC).

Groundwater resource evaluation 1978-79

A complete review has been undertaken of groundwater resource estimates for groundwater management purposes for the whole of the Triassic Sandstones of the Severn-Trent area.

Domestic waste disposal in river gravels 1979-82

Monitoring of strictly-controlled landfills in Trent Valley gravel excavations. Sites in a variety of hydrogeological situations and with a variety of site preparatory works, ranging from complete clay encapsulation to unprotected tipping below the water table, will be investigated.

Under an agreeement with the University of Aston in Birmingham, the attenuation of organic pollutants through gravels is also being studied.

Chloride pollution of groundwater 1976-78

Studies have been undertaken of chloride pollution of groundwater in Staffordshire and Nottinghamshire to identify the source of pollution and to suggest methods of control. The major study in Nottinghamshire had involved geophysical surveys (in association with Birmingham Universtiy Geological Sciences Department), drilling at selected sites and combined flow and water quality surveys of minor watercourses.

Implications of domestic refuse landfill for groundwater quality 1977-

Studies have been undertaken at three domestic refuse disposal sites on aquifer outcrop in Nottinghamshire to assess the impact of leachate on groundwater quality.

Radar

Co-operation with the Meteorological Office in trials of the Clee Hill radar installation providing areal rainfall estimates.

Hydrologic modelling 1975-

The use and continuing development of a hydrologic model, HYSIM, for the extension of flow data; long-term groundwater recharge data for the Shropshire Groundwater project; estimation of flood discharge for the Lower Severn and real time flow forecasting (floods and droughts).

Advanced flow gauging techniques 1974-

A multiple ultrasonic flow gauge was installed at Ashleworth on the River Severn in 1976. Early experiences have been promising at a site which tests both technique and installation very severly. This is a co-operative venture with WRC and WDU.

An experimental electromagnetic flow gauge is also under evaluation on a reclamation works outfall at Derby. This is a co-operative venture with WDU.

Diurnal fluctuation of river flows 1975-79

An investigation into the causes of the diurnal fluctuations of flow of rivers in the Severn catchment above Bewdley.

SOUTH WEST WATER AUTHORITY
Matford Lane
Exeter EX2 4QX

Development of procedures for the estimation of Q95 flows in ungauged catchments

E. Moyle, S. J. Booth 1978 -

To produce expressions relating Q95 flows to catchment characteristics for water quality/ pollution control purposes. A comparison with the procedures identified by the Institute of Hydrology has been made.

Water resource reliability/operational studies

S. J. Booth 1978 -

To study the effects of different restriction and Drought Order policies in water resources terms upon operational decision-making.

Camborne radar project

R. W. Hatton and W. MacGregor (Directorate of Operations) and S. J. Booth (Directorate of Resource Planning) in conjunction with CWPU and WRC 1976 -

To develop hydrological forecasting techniques using radar-derived rainfall data from the Camborne Radar Station in order to improve flood warning procedures in Cornwall.

Development of an automatic package for monitoring small scale pump tests

C. D. N. Tubb 1975 -

To provide a simple, compact package to monitor discharge and water level in boreholes during small scale pumping tests in order to improve supervision and data acquisition. The package is also being used to monitor short duration slug tests for the assessment of aquifer permeability.

SOUTHERN WATER AUTHORITY
Guildbourne House, Chatsworth Road,
Worthing, Sussex BN11 1LD

South downs groundwater project
SWA;
Water Research Centre;
Central Water Planning Unit;
Eastbourne Waterworks Company. 1970-82

Development of the chalk aquifer of the South Downs by the provision of additional point sources and extension of the controlled pumping system, thereby minimising the danger of increased saline intrusion from the coast and tidal waters. Programme includes extensive geophysical logging of deep coastal observation boreholes and a digital model study of the effects of different patterns and rates of pumping.

South Downs Groundwater Project
(Brighton and Worthing Chalk Blocks)
First Progress Report November 1972.
Sussex River Authority/Water Resources Board

South Downs Groundwater Project
(Brighton and Worthing Chalk Blocks)
Second Progress Report 1975
Third Progress Report 1979.

Hardham recharge investigation
SWA
Water Research Centre;
Central Water Planning Unit. 1966-81

The investigation aims to determine the feasibility of recharging with river water a natural groundwater basin in the Folkestone Sands near Pulborough, Sussex, with a view to evaluating the combined river and groundwater storage resource. The programme involves determination of the basin's hydrogeology, its relation to surface hydrology and the existing water quality; two series of recharge tests with raw and treated water through lagoons constructed in the aquifer; and trials of recharge via boreholes.

Fourth Progress Report 1976
Southern Water Authority

Final Report on Lagoon Recharge 1979
Southern Water Authority

R. Itchen groundwater regulation scheme 1973-79

The object is to study the feasibility and effects of regulating the flow of the Itchen by pumping groundwater from the Chalk into the headwaters of the three main branches, starting with the Candover stream. Particular stress is being laid upon the biological effects and on mathematical modelling to ensure the optimum use of the groundwater resources of the area. The Water Research Centre have prepared an independent water quality model of the Itchen estuary which has helped to define the minimum acceptable freshwater flow from which the extent of regulation needed can be calculated.

Final Report 1979
Southern Water Authority.

Tilmanstone Mine Drainage Study 1973-79
SWA;
Water Research Centre;
Central Water Planning Unit.

A large quantity of saline water has been pumped out of Tilmanstone coal mine into the Chalk aquifer in the past. The project is a hydrogeological and mathematical modelling study of the feasibility and economics of rehabilitating the aquifer by removal of the contaminated water by controlled pumping. Particular interest is centred on confirming the apparent confinement of much of the

contamination at a particular level, and exploiting this to remove the contamination in the most economical way. The mathematical model by WRC showed that artificial rehabilitation of the aquifer would be uneconomic.

Contamination of chalk aquifer by mine drainage at Tilmanstone, East Kent, UK, by Howard Headworth, S Puri and B Rampling. December 1978. (Paper submitted to technical journal for publication).

A numerical model of contamination by mine drainage water of a chalk aquifer, Tilmanstone, Kent, by Dr Robert Bibby (WRC Medmenham) March 1979

WELSH WATER AUTHORITY
Cambrian Way
Brecon
Powys LD3 7HP

Effects of Forestry on Water Yield

W L Jack 1979-

A study is being initiated to measure the runoff response of two adjacent catchments in the headwaters of the Usk Valley. One catchment is 100% forested and the other is upland grassland. The NERC studies at Plynlimon and Thetford were carried out for extremely high and low rainfall areas whereas the proposed study will be carried out on an area with an average rainfall in the region of 1600 mm per annum. One of the objectives of the study will be to identify the seasonal variation between the runoffs of the two catchments.

Interactive freshwater and tidal flows in the River Dee

The study indicates how a quantitative understanding of the relationship between tidal and freshwater flows in the lower Dee has been gained from simple but precise hydrometric observations and standard chemical sampling.
With the exception of an ultrasonic discharge meter, no large capital investment has been necessary. The results obtained in these studies provide a useful set of simple operational prediction methods which are extensively used in the Authority's day-to-day management of the Dee system. The work could also form a basis for the development and refinement of any mathematical model of the tidal section of the river.

Weston, A. E., 1979. The measurement of interactive freshwater and tidal flows in the river Dee, North Wales. Journ. IWES 33 No. 1.

WESSEX WATER AUTHORITY
Wessex House,
Passage Street,
Bristol,
BS2 0JQ

Gussage bed stream lining 1971-77

Various methods of sealing the bed of a bourne stream which, under natural conditions goes dry each year, were investigated. The use of puddled chalk, dry chalk, butyl and polythene sheeting for sealing the bed has been monitored by measuring flows over weirs along the channel. The overall performance of the bed lining is

highly satisfactory and enables flows in the stream to be maintained whilst continuing abstraction from the aquifer in that area. There was no measureable difference in the hydraulic performance of the different lining materials and costs were also comparable and compared favourably with the cost of a pipeline to take compensation flow.

Eastwood, J.C., Kenyon, W.J. and Wilkinson, W.B. 1977. Sealing river beds and its relevance to the development of ground water resources - with particular reference to the Gussage Stream. WRC Seminar on the Ecology and Management of Chalk Streams, March 1977.

Tilting weirs as permanent gauging structures 1975-79

Tilting weirs are used extensiveiy in lowland Somerset to maintain river levels and instrumentation has been developed and calibrated in a laboratory to obtain continuous records of river flows over these land drainage structures. Current meter gauging of a structure is in progress and once sufficient data have been collected, comparisons between laboratory and field data will be made.

Telemetry flood warning scheme 1975-78

A computer model has been developed to provide predicted flow rates within the Bristol Avon catchment using telemetered rainfall data as the prime input. This model is now being used as a prototype operating aid for flood forecasting.

Rationalisation of the rain gauge network 1977-79

The network of gauges measuring daily and monthly rainfall totals has been evaluated and user requirements for rainfall information established. The Institute of Hydrology and the Meteorological Office co-operated with the Authority in rationalising the existing network to produce a number of possible designs. The design network containing approximately two-thirds of the present number of gauges is being implemented and its performance will be monitored. Similar techniques were used to develop a network of recording gauges.

O'Connell, P.E., Gurney, R.J., Jones, D.A., Miller, J.B., Nicholass, C.A. and Senior M.R. 1978. Rationalisation of the Wessex Water Authority Rain Gauge Network. *Inst. Hydrol. Rep.* No 51.

Effects of abstractions on migrating fish 1976-95

A long term assessment of the effects of abstraction from two rivers in Dorset on the migration of salmonid fish has been commenced so that this information can be incorporated in the decision making process for the future development of water resources for public supply.

Fish monitors for raw water intakes 1978-81

Fish monitors are being developed to protect raw water intakes which are used for public water supply and are susceptible to pollution incidents. The first prototype fish monitor is being evaluated under laboratory conditions.

YORKSHIRE WATER AUTHORITY

West Riding House
67 Albion Street
Leeds LS1 5AA

Groundwater investigations in the vale of York 1975-80

Hydrogeological studies of the Triassic-Sandstone with a view to development for augmentation of the river Ouse to support increased abstraction in the York area. In particular to investigate the influence of groundwater development on farming and general ecology, and to carry out a programme of exploration to enable a scheme for full development of the aquifer to be prepared. The work includes investigations of soil moisture and of the temperature regime of streams to be augmented.

Groundwater investigations in the chalk of East Yorkshire 1975-80

Exploration and Pilot Scheme development of the Chalk aquifer in two areas near Driffield, to determine the feasibility of large scale development of the aquifer for augmentation of the river Hull to support increased abstraction at its tidal limit.

Saline water intrusion and management of the chalk aquifer of North Humberside 1975-80

Monitoring of groundwater quality and abstraction from the Chalk aquifer in the Hull area, and management of the aquifer to control saline intrusion from the Humber estuary.

Residual flow and quality modelling of industrial river systems 1976-80

Development and use of mass balance models to investigate the consequences of various river management options concerning effluent discharges, abstractions and reservoir compensation water.

Design of multi-resource operating procedures

Design of reservoir control curves and procedures for operation of the Yorkshire regional system of reservoir and river sources to maintain an even balance of security of supplies throughout the region and to minimise operating costs.

CHAPTER IV

HYDROLOGICAL RESEARCH IN UNIVERSITIES IN THE UNITED KINGDOM

Distribution of Hydrological Studies

University interest in hydrology is widespread but no specialist department of hydrology has yet been created. Hydrological research is carried out by individuals working in a variety of departments where hydrology is taught at undergraduate or postgraduate levels. Most first degree courses in civil engineering, environmental science or geography and many courses in agricultural science, biology and geology include some hydrology. At the postgraduate level, advanced courses in hydrological subjects are offered at several universities as listed in Table 6.

Layout

University research projects are listed below in alphabetical order of universities. Beside the name of each university department an abbreviation is given for ease of cross-reference from the tabular statement in Chapter II where the projects are classified according to subject.

A brief description of each project is given with the names of the research workers concerned. The names of the research students and research assistants are given in brackets following the names of the project supervisors. The length of each project is indicated by an approximate starting date and, when known or estimated, the date of completion. A bibliography is provided of key publications, or papers accepted for publication, arising from the projects since 1975.

UNIVERSITIES

ABERDEEN

Department of Geography (ABDGG)

Hydraulic geometry, sediment transport, coastal morphology and pollution dispersion studies in the Dee, Don and Ythan estuaries, Aberdeenshire, Scotland
Dr W. Ritchie
(G.C. Stove, P. Grant, P. Weatherill, N. Rose) 1978-82

Hydraulic aspects of pollution dispersion are being studied in Aberdeen Harbour before and after engineering works and attention is being given to the changing nature of a spit-bar shoreline at Donmouth. Research into the characteristics and movement of the Don sediment plume has just started, while the project relating sediment movement to hydraulic geometry has been completed. Freshwater water budgets are included in all these studies.

ASTON IN BIRMINGHAM

Department of Civil Engineering (ASTCE)

Spatial and temporal variation of monthly streamflow parameters
W.J. Walley (M. Elgusbi, Mrs P. Clulee) 1976-79

An extensive statistical analysis has been carried out on the available rainfall and streamflow data for the region containing the rivers, Teifi, Tywi, Usk, Wye, Tame and Upper Severn. Work is continuing on the development of relationships between the montly streamflow parameters (i.e. mean, standard deviation, skewness and correlation coefficients) and the meteorological variables and catchment characteristics influencing the rainfall-streamflow process.

Soil moisture monitoring with special reference to irrigation scheduling
W.J. Walley (D. Hussein, P. Hedges) 1975-79

Existing direct and indirect methods of soil moisture monitoring have been reviewed, and a study is being carried out into the causes and magnitude of the spatial and temporal variations of soil moisture. The influence of groundwater level variations on soil moisture are being investigated, and the development of a soil-water-plant model continues.

Computer simulation of the hydrological cycle
Dr T.R.E. Chidley 1979

An integrated simulation of surface and groundwater hydrology has been developed. Work is now current on implementing this system on the newly available microprocessors for use in teaching situations and in the offices of consulting engineers.

Chidley, T.R.E., Goodwill, I.M. 1975. A compact watershed model system. *J. Hydrol.* 24, 155-179

Stochastic hydrology
Dr J. Elgy 1978

Work is proceeding on data generation techniques for the multi-site problem and on the problem of filling in

missing data. Tests which can be applied to the generated data to ensure its validity are also being developed.

Elgy, J., Kottegoda, N.T. 1977. Infilling Missing Flow Data, *3rd Int. Symposium in Hydrology, Fort Collins.*

BATH

School of Chemistry (BASC)

Dissolved inert gases and natural radio elements in groundwater studies

Dr J.N. Andrews (R.L.F. Kay ('76-'78), I. Giles, D.J. Lee, Miss P. Towler, A. Zereshki) 1976

Groundwater dating using radiogenic ^{4}He and $^{234}U/^{238}U$ disequilibrium methods has been investigated in the Bunter Sandstone and in the Lincolnshire Limestone. Recharge temperatures derived from dissolved inert gas contents of the groundwaters determine the palaeoclimatic conditions at recharge and are used as a further constraint upon groundwater age. The dependence of the ^{22}Rn content of groundwaters on the extent of aquifer fracturing and upon the ratio of percolation/fissure flow in the Mendip karst is being studied. The evolution of low nitrate groundwaters is being investigated in collaboration with the Hydrogeological Unit of the Institute of Geological Sciences. The techniques outlined are being applied in assessing the age and flow pattern of deep groundwaters of possible geothermal potential and fracture flow in granitic intrusions in Cornwall and in Sweden.

Bath, A.H., Edmunds, W.M. and Andrews, J.N., 1979. Palaeoclimatic trends deduced from the hydrochemistry of a Triassic Sandstone aquifer. *Int. Symp. on Isotope Hydrology,* Neuherberg, June 1978, Proceedings, vol II, pp 545-568, IAEA, Vienna.

Andrews, J.N. and Lee, D.J. (In press). Inert gases in groundwater from the Bunter Sandstone of England as indicators of age and palaeoclimatic trends. *J. Hydrol.*

BELFAST, QUEEN'S

Department of Geography (BQUGG)

River flood and water supply problems in Northern Ireland

Dr R. Common 1975-80

Physical characteristics and social surveys form the basis for water resource appraisal in a number of troublesome catchments.

Department of Geology (BQUGL)

Flow and sedimentary processes in the River South Esk, Glen Clova, Scotland.

Dr J.S. Bridge, Dr J. Jarvis (D.M. Reay) 1976-80

The relationships between flow and sedimentation on several bends of the River South Esk is being investigated. Three-dimensional distribution of mean velocity vector, turbulence structure, bed sediment load, bed configuration and water surface topography are measured at different high-flow stages, using equipment operated from inflatables and stable scaffolding platforms. This is supplemented by low-flow studies of the sedimentology of the river deposits by coring, trenching and drilling. Results are being compared with theoretical models.

Bridge, J.S., 1976. Bed topography and grain size in open channel bends. *Sedimentology,* 23, 407-414.

Bridge, J.S., 1977. Flow, bed topography, grainsize and sedimentary structures in open channel bends: a three-dimensional model. *Earth Surface Processes,* 2, 401-416.

Bridge, J.S. and Jarvis, J., 1977. Velocity profiles and bed shear stress over various bed configurations in a river bend. *Earth Surface Processes, 2,* 281-294.

BIRMINGHAM

Department of Civil Engineering (BRMCE)

Multi-site data generation
Prof M.J. Hamlin and D. Henry 1975-1979

Work has been carried out for the Central Water Planning Unit on synthetic data generation models with particular reference to low flows and low flow sequences. This has led to the development of a Transitional Probability Matrix model which is used as the key station for a multi variate model generator. The synthetic data has been successfully tested using a complex multi-input system based on the river Severn.

Hamlin, M.J. and Wright, C.E. The effects of drought on the river system. *Proc. R. Soc. Lond. A.* 363, 69-96.

Hamlin, M.J., Fisher, R.G. and Cluckie, I.D. 1975. Multi-site data generation for large Water Resource Systems. *IAHS Symposium, Bratislava,* 1.

Flood hydrology
Prof M.J. Hamlin and R.J. Simpson 1976-1979

Research has been undertaken for the Severn Trent Water Authority on the applicability of 'no records' equations for estimating peak flows in the Authority area. This work was extended to develop simple self correcting models for forecasting flows on small catchments in real time for incorporation into the Authority's flood warning procedures.

Derivation of optimal control rules for complex water resource systems
Prof M.J. Hamlin (I.D. Cluckie; D. Harwood) 1976-1979

Following work by Cluckie in 1974 Harwood considered the modelling and control of the surface water component of a complex integrated resource system drawing on both surface water and groundwater sources. A model has been developed which determines the optimum control strategy for the system over the next six months based on forecasts of both river flow and groundwater recharge over the same period.

Hamlin, M.J., Kottegoda, N.T. and Kitson, T. 1976. Control of a river system with two storage reservoirs, *J. Hydrol.,* 28, 155.

Cluckie, I.D. (In press). A systems approach to the operational management of water resources. *IAHR Congress,* Cagliari.

Analysis of storm rainfall with particular reference to Northumbria
Prof M.J. Hamlin (J. Lister)

This study was undertaken in conjunction with the Northumbrian Water Authority under the CASE Studentship Scheme. A large number of storms have been analysed for spatial and temporal variation and a classification is proposed which is related to storm hydrograph shape.

An empirical approach is used to study the breakdown of storm pattern definition as gauge density decreases; of the statistical tests studied, the use of Semi-Variogram analysis was the most successful.

Regional flood analysis
Dr N.T. Kottegoda (M.A. Horder) 1975-

A probability model is formulated for the process of daily rainfall by considering the occurrence of wet and dry days. The relationship between rainfall and runoff is then examined, from which a rainfall runoff model is derived using pulses and a transfer function. The model is extended to the multisite case and the relationship between its parameters and catchment characteristics is investigated.

Application of time series, statistical and probabilistic methods in water resource assessments
Dr N.T. Kottegoda 1975-

Stochastic methods are being assessed so that improvements required to solve practical situations could be made. Probability distributions are under scrutiny particularly those applicable to closely spaced data. Time series models dealing with seasonal components are analysed. The effective and unbiased preservation of correlation matrices in multisite data is studied. Stochastic methods of infilling missing data are implemented. Tail behaviour of empirical probability densities is investigated as a pre-requisite to risk and reliability studies.

Lawrance, A.J., Kottegoda, N.T. 1977. Stochastic modelling of riverflow time series (with discussion). *J. Royal Stat. Soc., Series A (General)*, 140, 1-47.

Kottegoda, N.T., Yevjevich, V. 1977. Preservation of correlation through two station models. *J. Hydrol.*, 33, 99-121.

Kottegoda, N.T., Elgy, J. 1977. Infilling missing flow data. Invited paper, *3rd Int. Hydrol. Symp., Fort Collins.*

Kottegoda, N.T. 1978. Tail behaviour of riverflow probability densities. *Intern. Symp. on Risk and Reliability in Water Resources, Waterloo, Ontario.*

Optimal water resources regional development
Dr N.T. Kottegoda (X. Anastassiou) 1977-

Optimal water resources allocations are studied for various levels of regional development with domestic, agricultural and industrial demands. Concept of expected net benefits is used with stochastic programming methods. Refinements to geometric and other non linear programming are under way. Multi-objective methodology is proposed. Political and other uncertainties are considered.

Real-time routing methods for operational forecasting of floods and regulation releases
Dr I.D. Cluckie (R. Harpin) 1978-

The development of routing models suitable for real-time use in conjunction with existing or planned telemetry control systems is being carried out. Several rivers in the U.K. and in India are being used in the study.

Real-time rainfall runoff models
Dr I.D. Cluckie (D. Harwood) 1976-

Rainfall-runoff models specifically for use in real-time situations are being developed and tested. Various para-

meter estimation schemes, including Kalman filters, are being utilised and the emphasis is on the adaptability of the model to changing catchment conditions.

Tillotson, A., Cluckie, I.D. 1977. Linear models for flow estimation and prediction. *3rd Int. Symp. Hydrol., Fort Collins.*

Pumping test analysis

Dr K.R. Rushton, A.E.F. Spink (Y.K. Chan) 1972-

A numerical method of pumping test analysis has been devised which can include a wide range of variable parameters. It is particularly useful when the permeability varies with depth. The method can be used to analyse short term tests at existing borehole sites.

Rushton, K.R., Y.K. Chan. 1976. A numerical model for pumping test analysis. *Proc. Instn.. Civ. Engrs.* 61, 281-296.

Rushton, K.R., Y.K. Chan. 1976. Pumping test analysis when parameters vary with depth. *Ground Water,* 14, 82-87.

Rushton, K.R., Y.K. Chan. 1977. Numerical pumping test analysis in unconfined aquifers. *ASCE, 103,* No. IR1, 1-12.

Rushton, K.R. 1978. Estimating transmissivity and storage coefficient from abstraction well data. *Ground Water,* 16, 81-85.

Regional groundwater flow

Dr K.R. Rushton, A.E.F. Spink, Mrs L.M. Tomlinson, J. Miles, (K.S. Rathod) 1968-

Following a thorough examination of analogue and digital methods of pumping test analysis, attention has now turned to detailed studies of various aquifers. The importance of representing the historic behaviour has been highlighted in several studies. The influence of springs and rivers has been examined. Non-linear effects due to changing transmissivity of storage coefficient have also been studied.

Rushton K.R. 1975. Aquifer analysis of the Lincolnshire Limestone using mathematical models. *J. Inst. Wat. Engrs,* 29, 373-389.

Rushton K.R., I.A. Fox. 1976. Rapid recharge in a limestone aquifer. *Ground Water,* 14, 21-27.

Rushton K.R., Tomlinson, L.M. 1976.. Permissible mesh spacing in aquifer problems solved by finite differences. *J. Hydrol.* 34, 63-76.

Recharge estimates

Dr K.R. Rushton 1976-79

Methods of estimating recharge to aquifers have been re-examined to explain observed summer recharge. New methods of calculation have been proposed in which a proportion of the water enters the aquifer bypassing the soil zone.

Rushton, K.R., C. Ward (In press). The estimation of groundwater recharge. *J. Hydrol.*

Saline intrusion in aquifers

Dr K.R. Rushton (Dr A.N.S. Al-Niami) 1975-

Analytical and numerical methods of modelling saline intrusion in aquifers have been devised with special reference to the behaviour near to abstraction wells.

Al-Niami, A.N.S., Rushton, K.R. 1978. Radial dispersion to an abstraction well. *J. Hydrol.* 39, 287-300.

Al-Niami, A.N.S., Rushton, K.R. 1978. Finite-difference solutions for one-dimensional dispersion using an improved mesh design. *J. Hydrol.* 39, 301-310.

Department of Geological Sciences (BRMGS)

Hydrogeological assessment of the central Lincolnshire Limestone aquifer
Dr J.W. Lloyd (D.W. Peach) 1973

A variety of techniques are used to assess groundwater resources and the effects of development on saline water in the aquifer.

The hydrochemistry of some British aquifers with special reference to trace elements
Dr J.W. Lloyd (J.M. Marsh) 1975-78

Techniques have been developed using preconcentrations and x-ray fluorescence to determine a range of trace metals in groundwater.

The South Humberside salinity research project
Dr J.W. Lloyd, Dr K.R. Rushton (Dept of Civil Engineering) Dr R. Barker, K. Howard 1975-78

A multi-disciplinary study of the groundwater resources in the north Lincolnshire Chalk has been carried out including geophysics, hydrochemistry and digital modelling. The study was carried out under contract to the Anglian Water Authority.

The hydrochemistry of the Triassic Sandstones of the Birmingham area
Dr J.W. Lloyd (D. Jackson) 1976-79

The groundwater flow pattern in the Birmingham area is being investigated with respect to lithology and structure using major and minor ion chemistry, trace metals and isotopes.

The hydrochemistry of saline groundwaters in the area of Ipswich
Dr J.W. Lloyd (J. Heathcote) 1977-80

A multi-parameter hydrochemical study is being used to identify the origin of saline groundwater in the Chalk aquifer.

The use of uranium-thorium series isotopes in groundwater studies
Dr J.W. Lloyd (S. Webster) 1977-80

Uranium and thorium concentrations are being measured in groundwaters to provide base data in British aquifers and to study the use of such isotopes in groundwater dating. The study is being carried out under contract to the Harwell Research Laboratories.

The lower Mersey salinity research project
Dr J.W. Lloyd, Dr K.R. Rushton and K. Howard (Department of Civil Engineering), J. Tellam 1978-83

A multi-disciplinary study is being undertaken to identify the origin and distribution of saline groundwaters in the Lower Mersey valley. The aquifer is also being studied hydraulically to understand the response of the saline waters to groundwater abstraction. The study is being carried out under contract to the North West Water Authority.

A study of stable isotope concentrations in precipitation and soil mixture
Dr J.W. Lloyd, Dr M. Boast 1978-81

The concentrations of oxygen-18 and deuterium and their variations are being studied under direct recharge conditions.

Department of Physics (BRMPH)

Physics of ice
Dr J.W. Glen, Dr R.W. Whitworth (Dr J.G. Paren, Dr G. Noll, A. Wright) 1963-80

The effect of grain boundaries, preferred crystal orientation and impurities on the mechanical and electrical properties of ice is being studied to improve understanding of the mechanical response of ice to loading and to interpret electrical sounding of natural ice masses.

Glen, J.W., Paren, J.G., 1975. The electrical properties of snow and ice. *J. Glaciol.,* 15, 15-38.

Fitzgerald, W.J., Paren, J.G., 1975. The dielectric properties of Antarctic ice. *J. Glaciol.,* 15, 39-48.

Whitworth, R.W., Paren, J.G., Glen, J.W., 1976. The velocity of dislocations in ice - a theory based on proton disorder. *Phil. Mag.,* Ser. 8, 33, 409-26.

Camplin, G.C., Glen, J.W., Paren, J.G., 1978. Theoretical models for interpreting the dielectric behaviour of HF-doped ice. *J. Glaciol.,* 21, 123-41.

Homer, D.R., Glen, J.W., 1978. The creep activation energies of ice. *J. Glaciol,* 21, 429-44.

Riley, N.W., Noll, G., Glen, J.W., 1978. The creep of NaCl-doped ice monocrystals. *J. Glaciol.,* 21, 501-07.

BRISTOL

Department of Geography (BTLGG)

Estimation of mapping of rainfall from weather satellite data
Dr E.C. Barrett (M. Lounis, J.U. Hielkema) 1969-

Techniques for improving maps of rainfall especially in conventional data-remote regions through integrations of satellite visible and infra-red imagery with routine meteorological station data are being developed and implemented to operational status in various countries in Africa and the Middle East, in support of international and national desert locust control operations, water resource monitoring and agricultural prediction programmes.

Barrett, E.C., 1974. Estimates of daily and monthly rainfall from weather satellite data. In: *Environmental Remote Sensing: Applications and Achievements* (Eds: E.C. Barrett and L.F. Curtis), Edward Arnold, London, 241-65.

Barrett, E.C., 1977. Monitoring precipitation from meteorological satellites: a global strategy for the 1980s. In: *Monitoring Environmental Change by Remote Sensing* (Eds: J.L. Van Genederen and W.G. Collins), Remote Sensing Society, 53-58.

Barrett, E.C., 1979. The use of weather satellite data in the evaluation of national water resources with special reference to the Sultanate of Oman. *Space Research,* 19, 41-46.

Barrett, E.C., Howard, J.A., and Hielkema, J.U. 1978. The application of satellite remote sensing to monitoring of agricultural disasters. *Disasters,* 2, 280-294.

Soil water movement in hillslopes and the generation of river discharge peaks

Dr M.G. Anderson (P.E. Kneale) 1977-

Soil water potentials are being monitored continuously at a hillslope hollow site in a 2 km^2 study catchment. The role of soil water convergence in such topographic hollows and the relationship to flood peaks are being examined and modelled.

Anderson, M.G., Burt, T.P., 1977. A laboratory model to investigate the soil moisture conditions on a draining slope. *J. Hydrology,* 33, 383-390.

Anderson, M.G., Burt, T.P., 1978. Analysis of spatial water quality and stream networks in the southern Cotswolds during and after the drought of 1976. *Earth Surface Porcesses,* 3, 59-69.

Anderson, M.G., Burt, T.P., 1978. Time synchronised stage recorders for the monitoring of incremental discharge inputs in small streams. *J. Hydrology,* 37, 101-109.

Anderson, M.G., Burt, T.P., 1978. Experimental investigations concerning the topographic control of soil water movement on hillslopes. *Z. Geomorphologie,* 29, 52-63.

Department of Geology (BTLGL)

Hydraulic characteristics of Jurassic limestone aquifers of the Cotswolds

Dr B.P.J. Williams (Dr J. Bromley) 1974-80

Groundwater conditions including flow regimes, aquifer properties and aquiclude leakage are being evaluated through detailed pumping test analyses. Well loss and well efficiency are being considered in the context of fissured/fractured carbonate aquifers.

Bromley, J., Williams, B.P.J., 1976. Hydrogeological characteristics of the Great and Inferior Oolite Limestone aquifers in the southern Cotswolds. (Abstract). *Q.J. Eng. Geol.,* 9, 340.

Bromley, J., Williams, B.P.J. (In press). Hydraulic features of Jurassic limestone aquifers in the southern Cotswolds. *Q.J. Eng. Geol.*

Hydrogeology of the Permian Aquifer in Central and East Devon.

Dr B.P.J. Williams (J.C. Davey) 1975-79

Carried out in conjunction with the South West Water Authority, this regional study has involved the assessment of groundwater occurrence, the effect of lithofacies changes, variation in groundwater quality, and calculation of aquifer properties. The latter, in addition to conventional pumping test analyses, were evaluated from specific capacity tests, laboratory determinations on rock core, and from well response tests undertaken with a pressure transducer system. Several observation wells were subjected to depth chemical sampling and down-hole geophysics, both lithological and fluid column logs; and, in the absence of any fully penetrating wells, a geophysical

survey utilising gravity technique was undertaken to determine aquifer configuration. Finally, groundwater resources were estimated and areas of potential resource development outlined.

Davey, J.C. (In press). A hydrogeological study of part of the Permian aquifer in South West England. *Q.J. Eng. Geol.*

Hydrogeology of Chalk catchments in Dorset and Wiltshire
Dr B.P.J. Williams (Miss L.S. Alexander).

The hydrogeology of Chalk catchments in the Lulworth and North and South Winterbourne areas is being studied. The problems of development of both coastal and inland Chalk aquifers is evaluated by research on the geology and tectonics of the area and determination of aquifer properties via pumping test analyses and laboratory permeability testing. Variations in hydrochemistry are also being studied particularly of the groundwaters of the coastal catchment. This research programme involves close cooperation with Wessex W.A.

Ground water flow patterns in Mesozoic clastic aquifers
Dr B.P.J. Williams 1979-

A comparative study of intergranular and fracture flow patterns in three Mesozoic clastic aquifers in the West of England. Emphasis is being placed on the comparison of physical and hydrological properties of the sandstone aquifers, as determined by sediment size analyses, gas/liquid permeameter testing and mercury porosimetry, with the overall transmissive properties of the aquifers assessed via pumping tests and analysis of the well hydraulics.

CAMBRIDGE

Department of Applied Mathematics and Theoretical Physics (CAMAP)

Buoyancy effects on dispersion
Dr R.E. Britter, Dr J.C.R. Hunt, Dr H.E. Huppert, Mr J.E. Simpson, Dr R. Smith, Dr N. Thomas 1975-

Theoretical and experimental investigations of the way in which buoyancy effects modify the flow in channels and the dispersion of material in the water.

Britter, R.E. & Simpson, J.E. 1978. Experiments on the dynamics of a gravity current head. *J. Fluid Mech.* 88, 223-240.

Smith, R. 1978. Coriolis, curvature and buoyancy effects upon dispersion in a narrow channel. *Hydrodynamics of Estuaries and Fjords,* 217-232.

Smith, R. 1979. Buoyancy effects upon lateral dispersion in open channel flow. *J. Fluid Mech.* 90, 761-779

Department of Geography (CAMGG)

Late Quaternary lake levels
A.T. Grove (F.A. Street) 1973-79

Old strandlines and sediments are used to trace variations in lake levels in Ethiopia, Tanzania and Kenya in Late Quaternary times. The results are interpreted in terms of variations in rainfall, temperature and runoff. These studies are linked with others in Africa and elsewhere.

Grove, A.T., Street, F.A., Goudie, A.S. 1975. Former lake levels and climatic change in the rift valley of southern Ethiopia. *Geogr. J.* 141, 177-202.

Street, F.A., Grove, A.T. 1976. Late Quaternary lake level in Africa: Environmental and climatic implications. *Nature,* 261, 385-390.

Grove, A.T. 1978. Late Quaternary climatic change and the conditions for current erosion in Africa. *Geo-Eco-Trop.,* 291-300.

Downstream effects of river impoundments
A.T. Grove (W.B. Adams) 1978-

The downstream effects of river impoundments, especially in tropical Africa.

Drainage density and hydrological processes in a humid environment: the Windward Islands
Dr D.R. Stoddart (R.P.D. Walsh) 1972-78

The relations between rainfall, runoff, vegetation and drainage density in a humid tropical region.

Walsh, R.P.D., Voigt, P.J. 1977. Vegetation litter: An underestimated variable in hydrology and geomorphology. *J. Biogeog.* 4(3), 253-274.

Department of Physics (CAMPH)
(Cavendish Laboratory)

Creep and fracture of polycrystalline ice, and surface strain measurements on glaciers and sea ice
Dr D.J. Goodman, Prof D. Tabor, with Prof M.F. Ashby, Dr H.J. Frost (Dept. of Engineering) and Dr G.C.P. King, K.E. Evans (Dept. of Geodesy and Geophysics) 1973-79

Indentation and four point bend tests have been carried out between -4° and -38°C, to determine the critical stress intensity factor, K_{IC}, for polycrystalline ice. It is found that ice behaves as purely brittle solid for loading times faster than 10 s.

A new technique for continuous measurement of surface strain changes on glaciers and sea ice has been developed and successful trials carried out on fast ice in Bylot Sound, NW Greenland, and on the surface of the Roslin Glacier, E Greenland (in collaboration with the Scott Polar Research Institute, Cambridge). Subsequently the instrument has been used to monitor surface strain changes on the Barnes Ice Cap, Baffin Island and on the Erebus Glacier Tongue, McMurdo Sound, Antarctica (in collaboration with Dr G. Holdsworth, Environment, Canada), and to study the response of sea ice floes to the action of swell off the east Greenland coast (in collaboration with Dr P. Wadhams of the Scott Polar Research Institute).

Goodman, D.J., Allan, A., and Bilha, R.G. 1975. Wire strainmeters on ice. *Nature,* 255, (5503), 45-46.

Frost, H.J. Goodman, D.J., Ashby, M.F. 1976. Kink velocities on dislocations in ice. A comment on the Whitworth, Paren, and Glen Model. *Philosophical Magazine,* 33 (6), 951-961.

Goodman, D.J., Frost, H.J., and Ashby, M.F. 1977. The effects of impurities on the creep of ice, and their illustration by the construction of deformation maps. *Proc. IASH Symp. 1975, Grenoble, IASH Publication 118,* 17-22.

Goodman, D.J., and Tabor, D. 1978. Fracture toughness of ice; a preliminary account of some new experiments. *J. Glaciol.* 21, (85), 651-661.

Goodman, D.J., Holdsworth, R. (In press). Continuous surface strain measurements on the sea ice close to the

annual ice runway, and on Erebus Glacier Tongue, McMurdo Sound, Antarctica. *Antarctic Journal of the U.S.*

Goodman, D.J., King, G.C.P. Millar, D.H.M., and Robin, G.de Q. (In press). Pressure melting effects in basal ice of temperature glaciers. Laboratory studies and field observations under the Glacier d'Argentiere *J. Glaciol.*

DUNDEE

Department of Biological Sciences (DUNBS)
Dr H.A.P. Ingram (Olivia M. Bragg), with W. McNicoll, Dept. of Civil Engineering, and Dr J.M. Baxter Brown, Dept. of Mechanical Engineering

Hydrology of mires

The experimental catchment is centred on a raised bog of the saddle type in the southern Grampian foothills. Items of the water budget continue to be derived from stream gauging (now with improved instrumentation), lysimetry and ground-level rain gauging. Recently a set of small lysimeters with automatic water table control has been installed. Earlier work on water transmission of peat in the humified catotelm has been extended to the acrotelm. The water relations of this surface layer are being studied with piezometers, tensiometers and filtration flumes.

Rycroft, D.W., Williams, D.J.A., Ingram, H.A.P. 1975. The transmission of water through peat. II. Field experiments. *J. Ecol.*, 63, 557-568.

Ingram, H.A.P. 1978. Soil layers in mires: function and terminology. *J. Soil Sci.*, 29, 224-227.

Department of Geology (DUNGL)

Bed, suspended and solution load transport in the Tay and Teith river systems
Dr J. McManus (N.A. Al-Ansari, M.H. Al-Jabbari, M.J. Al-Kazwini, K. Al-Bayati, N. Asaad, R.F. Duck) 1973-83

Small catchments with specific geological or rain gauging attributes are used to estimate the significance of seasonal flow variations and the impact of agricultural practice on the materials in motion. The role of water movement in lake systems in relation to entrapment of silts, factors leading to flocculation in freshwater reservoirs, and detectable bathymetric changes form the nucleus of a second study mainly centred on the Tay basin. The internal shears in the water column, the physical and chemical variations in the water with season and the nature of settling and settled fine sediments are important aspects currently pursued.

Al-Ansari, N.A., Al-Jabbari, M.H., McManus, J. 1977. The effect of farming upon solid transport in the River Almond, Scotland. *Proc. Paris Symposium. IAHS Publ. 122,* 118-125.

McManus, J., Al-Ansari, N.A. 1975. Calculation of sediment discharge in the River Earn, Scotland. *Proc. 9th Inst. Congr. Sedimentology, Nice,* 113-118.

XRD modal analysis of estuarine suspended fine sediment
Dr F.H. Hubbard- 1979-

The methodology for routine XRD modal analysis of fine suspended sediment is being investigated and assessed. If a suitable method is developed it will be applied to sea-truth control work in connection with the CZ satellite remote-sensing programmes of EURASEP.

DURHAM

Department of Geography (DURGG)

Simulation of cirque glacier distribution
Dr I.S. Evans (Jasbir S. Gill) 1976-78

The development of a deterministic computer simulation model which, with given inputs of local topography and monthly climate, locates areas of positive mass balance and cirque glacier generation in mountainous ranges of temperate areas. Topographic parameters (slope, aspect, profile and plane convexity), calculated from an altitude matrix (100 m spacing), are generated for each grid intersection. The interaction of local topography with regional climate defines the local climate and modelling of mass balance processes leads to the simulation of snow and ice distribution at all points of the altitude matrix. Results of mass balance modelling, for an area in NW Iceland, are compared with field mapping of snowpatch distribution. Computer simulation experiments, with changed climate input, enable local glacier generation/climate relations to be examined.

EAST ANGLIA

Climatic Research Unit (School of Environmental Sciences) (EANCR)

Climate of southern Britain during the last 50,000 years with special reference to groundwater in the London Basin
Dr T.C. Atkinson, Dr T.M.L. Wigley 1978-80

Fossil insect and floral assemblages are being used to reconstruct past climatic conditions and hence recharge of the London Basin chalk aquifer. The results are to be compared with inferred recharge evidence from radiometric dates of cave calcite formations, and with isotopic data from the aquifer.

Atkinson, T.C. *et al.* 1978. Paleoclimatic and geomorphic implications of ^{230}Th ^{234}U dates on speleothems in Britain. *Nature,* 272, 23-28.

Homogenization of long rainfall records for different parts of England
J.M. Craddock 1975-79

Homogenized rainfall records representative of various regions in England extending back to the early 18th century are being constructed from original documents.

Craddock, J.M. 1976. Annual Rainfall in England since 1725. *Q.J. Roy Met. Soc.,* 102, 823-840.

Soil moisture conditions in England since 1698
Dr T.M.L. Wigley, Dr T.C. Atkinson 1976-77

The long precipitation and evaporation series for Kew have been used to reconstruct soil moisture deficits back to 1698 using the Penman approach. The series provides a useful drought record and shows non-stationary properties which require more detailed investigation.

Wigley, T.M.L., Atkinson, T.C. 1977. Dry years in south-east England since 1698. *Nature,* 265, 431-434.

Carbonate geochemistry and isotopic geochemistry of groundwaters
Dr T.M.L. Wigley 1974-79

This work is primarily concerned with explaining and

interpreting the chemical and isotopic composition of carbonate groundwaters. The main emphasis has centred on laboratory studies of the complex dissolution kinetics of calcite, resulting in a mechanistic explanation which is applicable to a wide variety of situations, and on modelling the carbon-isotope (^{13}C and ^{14}C) evolution of groundwaters and other natural waters. The latter work has been applied to the problem of the ^{14}C dating of groundwaters.

Drake, J.J., Wigley, T.M.L. 1975. The effect of climate on the chemistry of carbonate groundwater. *Wat. Res. Resrcs. Res.*, 11, 958-962.

Wigley, T.M.L., Plummer, L.N. 1976. Mixing of carbonate waters. *Geochim. Cosmochim. Acta*, 40, 989-995.

Wigley, T.M.L. 1977. Carbon-14 dating of groundwater: theory and principles. *Q.J. Engng. Geol., Geol.*, 10, 444.

Wigley, T.M.L., Plummer, L.N., Pearson, F.J., Jr., 1978. Mass transfer and carbon isotope in natural water-systems. *Geochim. Cosmochim. Acta*, 42, 1117-1139.

School of Environmental Sciences (EANEV)

Finite-difference modelling of alluvial aquifers
Dr T.C. Atkinson (J.R. Trillwood, D. Winfield) 1976-

A one-dimensional, single aquifer layer model of river bank storage has been programmed in FORTRAN, and calibrated on the River Tees during the 1976 test releases of water from Cow Green Reservoir. Volumes of bank storage over a 65 km reach computed from the model agreed satisfactorily with estimates made from measurements of the discharge of the river. A two layer model, incorporating recharge and evaporation from the flood plain is under development.

Groundwater hydrology of the southern Lincolnshire Limestone
Dr T.C. Atkinson (I.R. Booker) 1976-79

In cooperation with the Anglian Water Authority, the Lincolnshire Limestone aquifer in the region between Bourne and Colsterworth has been studied in detail, by means of water budgets and natural and artificial tracers. Three characteristic velocities of flow have been demonstrated, associated with voids of increasing size. Rapid groundwater movement via solution conduits from the recharge area to wells and artesian springs 12 km downdip has been demonstrated by tracers, while detailed maps of the transmissivity due to fissures and fractures have been produced.

Development of artificial tracer techniques using fluorescent dyes
Dr T.C. Atkinson 1979-

Development work on fluorescent dyes has mainly been undertaken by Mr P.L. Smart at Bristol University (q.v). Applications of fluorescent tracers have been developed in single-well dilution tests using two or more dyes simultaneously to determine the vertical distribution of groundwater velocity; and in evaluation of leachate movement and dispersion potential of landfill sites in chalk, limestones and fissured sandstones.

Atkinson, T.C., Smart, P.L. (In press). Artificial tracers in hydrogeology. *Bull. Bureau Recherches geol. et min.* (in French) and *Spec. Pub. Roy. Soc. Lond.*

Stable isotope composition of waters in a karstic limestone aquifer

Dr T. C. Atkinson with P.L. Smart,
University of Bristol 1977-80

Detailed studies of isotopic composition, carbonate chemistry and hydrological variables are being made in the catchments of two limestone springs in the Mendip Hills near Bristol. The Sherborne Spring is fed by diffuse flow, has few proven swallet feeders and shows negligible change in isotopic (δD) composition seasonally or in short term studies. The Cheddar spring is fed by major conduits and caves. The baseflow shows no seasonal variation indicating an isotopically well-mixed source.

Atkinson, T.C. 1977. Diffuse flow and conduit flow in limestone terrain in the Mendip Hills, Somerset (Great Britain). *J. Hydrol. 35,* 93-110.

Atkinson, T.C. 1977. Carbon dioxide in the atmosphere of the unsaturated zone; an important control of groundwater hardness in limestones. *J. Hydrol. 35,* 111-123.

Use of stable isotopes for flood hydrograph analysis in a small stream

Dr T.C. Atkinson, with P.L. Smart, 1977-80
University of Bristol.

A small (2.7 km^2) stream draining sandstones, shale and limestone near Bristol has been studied during baseflow and flood conditions. Major ion chemistry and δD (deuterium) have been measured at 2 hour intervals during storms. Stream water can be separated into four geographical components by applying simple mixing models to the major ion chemistry.

Hydrogeology of the Malham area, Yorkshire

Dr T.C. Atkinson 1973

A programme of water tracing has been carried out in the Carboniferous Limestone of the Malham area. This area was first studied in 1870 and papers published in 1879, 1891 and 1900 in the *Proc. Yorks, Geol. Polytech. Soc.* (14, 1-44). Work with modern tracers confirms the nineteenth century results and amplifies them. An interpretation of the unexplored conduit systems beneath Malham Moor has been published, and further experiments are planned in this area which is an ideal outdoor laboratory for karstic water tracing.

Washout of nitrogenous fertilizers from grassland

D.L. Dent, Dr P.S. Liss (D.A. Klessa) 1974-78

Loss of inorganic nitrogen and associated ions from a clay catchment under pasture, with different rates of anhydrous ammonia and ammonium nitrate fertilization has been monitored over a three year period by analysis of drainage and soil waters.

Irrigation scheduling

D.L. Dent, Dr R.D. Hey, R.P. Scammell 1974-78

A technique of irrigation scheduling has been developed combining the use of tensiometers with soil water retention curves determined on representative undistributed soil samples. A library of soil water retention curves is being compiled for the principle soil series mapped in East Anglia.

Dent, D.L., Hey, R.D., Scammell, R.P. 1978. Irrigation scheduling. *Soil and Water.* 6(2) 8-11;

Hey, R.D. (In press). Evaluation of optimum irrigation requirements under conditions of drought uncertainty. *Int. Jour. of Environmental Studies.*

Alluvial channels: processes and form
Dr R.D. Hey 1972-

Continuation of research to determine the physical principles governing river channel development.

(i) Flow resistance
Dr R.D. Hey (Dr J.C. Bathurst) 1974-77

Evaluation of the effect of non-uniform surface roughness, cross sectional shape, non uniform flow and secondary currents on the flow resistance and velocity of flow in gravel-bed rivers.

Hey, R.D. 1979. Flow resistance in gravel-bed rivers. *J. Hydraulics Div. Am. Soc. Civ. Eng. 105* No. HY3.

Bathurst, J.C. 1978. Flow resistance of large scale roughness. *J. Hydraulics Div. Am. Soc. Civ. Eng. 104,* No. HY12 1587-1603.

(ii) Bank erosion
Dr R.D. Hey (Dr C.R. Thorne) 1974-77

Investigation of the mechanical and hydraulic processes controlling the erosion of river banks composed of cohesive material.

(iii) Secondary flow
Dr R.D. Hey
(Dr C.R. Thorne, Dr J.C. Bathurst) 1974-

Measurement of secondary flows in straight and meandering channels using an electromagnetic flow meter. Analysis of the cause of secondary flows and the investigation of their effect on primary velocities, shear stress distributions and sediment transport.

Hey, R.K., Thorne, C.R. 1975. Secondary flows in river channels. *Area,* 7(3), 191-195. *Discussion* 8(3), 234-235.

Hey, R.D. 1976. Geometry of river meanders. *Nature, 262,* 484-848.

Bathurst, J.C., Thorne, C.R., Hey, R.D. 1977. Direct measurement of secondary currents in river bends. *Nature, 269,* 504-506.

(iv) Feedback mechanisms
Dr R.D. Hey 1974-

The operation of channel feedback mechanisms both upstream, through drawdown and backwater effects, and downstream, through sediment discharge, control erosional and depositional activity. A preliminary theoretical model has been developed and this is being calibrated using flume and field data.

Hey, R.D. 1979. Dynamic process-response model of river channel development. *Earth Surface Processes 4*(1), 59-72.

(v) Design equations for gravel bed rivers
Dr R.D. Hey 1977-

Field data from approximately a hundred sites in the UK will be used to develop empirical design equations for gravel-bed rivers. These will enable the three dimensional bankfull shape of gravel-bed rivers to be derived given information on the discharge, sediment

load, bed and bank material size and characteristics and valley slope.

Hey, R.D. 1975. Design discharge for natural channels. In: *Science, Technology and Environmental Management* (Eds: R.D. Hey, T.D. Davies). Saxon House, 73-88.

Hey, R.D. 1978. Determinate hydraulic geometry of river channels. *J. Hydraulics Div. Am. Soc. Civ. Eng. 104* (HY6) 869-885.

River regulation and channel stability
Dr R.D. Hey 1975-

River regulation, by altering the flow regime and sediment transport characteristics of a river, can be responsible for erosion and deposition. Given information on threshold discharges for bed material transport and bank erosion, it is possible to define a regulation strategy which will preserve the natural stability of the channel or identify the sections of channel which will require maintenance and protection if regulation is responsible for instability.

Hey, R.D. 1975. Response of alluvial channels to river regulation. *Proc. 2nd World Congress, Int. Water Resources Assoc. 5,* 183-188.

Hey, R.D. 1976. Impact prediction in the physical environment. In: *Environmental Impact Assessment* (Eds. T. O'Riordan and R.D. Hey).

Hey, R.D. 1979. River regulation and channel stability. *Proc. 18th World Congress, Int. Assoc. Of Hydraulics Research.*

Flood alleviation feasibility studies
Dr R.D. Hey with Dr J.C. Chatterton
(Severn-Trent Water Authority) 1979

Sensitivity analysis to determine the effect of different methods of calculating the costs and benefits of flood alleviation on cost/benefit ratios.

Study of the River Bure, Norfolk Broads
Dr B. Moss (I. Booker, H. Manning, K. Manson) 1979-81

Synoptic studies on the phytoplankton, key major and nutrient ions and water movements of the River Bure and its Broads, between Little Haubois and Thurne Mouth are being made in an attempt to construct nutrient budgets for sections of the river and each Broad. The consequences of the present degree of eutrophication are being assessed and placed in perspective by extensive palaeolimnological studies.

Broadland research
Dr B. Moss (Dr R.T. Leah) 1976-79

Nutrient, algal, aquatic plant, migratory bird and water movement interrelations are being studied at Hickling Broad and at Brundall Broads. Practical management techniques for reversing the present degree of enrichment of the Norfolk Broads are being studied.

Moss, B., Leah, R.T., Forrest, D.E. 1978. Ecosystem experimentation in the management of a system of shallow lakes. *Verh. int. Verein theor. angew Limnol. 20,* 649-653.

Leah, R.T., Moss, B. Forrest, D.E. 1978. Experiments with large enclosures in a fertile, shallow, brackish lake,

Hickling Broad, Norfolk, United Kingdom. *Int. Rev. ges. Hydrobiol. 63,* 291-310.

Hoveton Great Broad
Dr B. Moss (R.M. Timms) 1978-81

A study of the relationship of Hoveton Great Broad, Hudsons Bay and the R. Bure to assess the consequences and efficacy of potential management to restore aquatic plant populations to the Broad.

Soil water retention characteristics
D.L. Dent, Dr R.D. Hey 1978-

Continuation of research on the water retention characteristics of soils, with particular reference to low water tensions and the definition of field capacity. Experimental works on large soil cores in the laboratory to simulate field conditions.

EDINBURGH

Department of Forestry & Natural Resources (EDNFN)

Stomatal conductance of coniferous forest
Prof P.G. Jarvis, Dr D. Whitehead, Dr J Leverenz, Mrs H. Talbot 1978-

Diffusion porometers are being used to measure stomatal conductance in forest canopies of different species. Changes in conductance are being related to the weather and the calculated canopy conductance is being used in models of evaporation.

Behaviour of stomata in conifers
Prof P.G. Jarvis, Dr Ai Peng Ng, (J. Morison) 1978-

The physiology of stomatal action in conifers is being investigated using a controlled environment wind tunnel, curettes and porometers. The responses to environmental variables are being used in models of stomatal behaviour to assist in the interpretation of field data.

Boundary layer characteristics of coniferous shoots
Prof P.G. Jarvis (J. Follan) 1978-

The boundary layer properties of single needles are being studied with respect to windspeed turbulence, and the effects of aggregation into shoots are being investigated in a controlled environment wind tunnel.

Evapotranspiration from heathland
Prof P.G. Jarvis, Dr J. Grace (A. Miranda) 1978-

An energy budget approach is being used to determine evapotranspiration from heathland in relation to weather conditions.

Erosion and sediment-yield studies in southern Scotland
Dr D.C. Ledger, Dr J.P.B. Lovell 1970-

Periodic surveys of gullies, stream channels and reservoirs have been made to determine rates of erosion and sedimentation in upland areas in southern Scotland. More detailed studies of erosion processes and their relation to land use are planned.

Lovell, J.P.B., Ledger, D.C., Davies, I.M., Tipper, J.C. 1973. Rate of sedimentation in the North Esk Reservoir, Midlothian. *Scot. J. Geol., 9* (1), 57-61.

Ledger, D.C., Lovell, J.P.B., McDonald, A.T. 1974. Sediment yield studies in upland catchments areas in South-East Scotland. *J. appl. Ecol., 11.* (1), 201-206.

The hydrology of a drained peat area in Southern Scotland
Dr D.C. Ledger (J.S. David) 1978-

Lysimeters and isolated drain sections are being used to determine the water balance and other characteristics of the component parts of a drained peat area.

Accelerated erosion in Scotland
Dr D.C. Ledger (I. Jennings) 1975-79

The incidence of accelerated erosion features in the Lammermuir Hills, south-east Scotland, has been determined, and studies carried out on the rate of erosion occurring in key areas. An attempt has been made to relate erosion to land use.

Drought in Scotland
Dr D.C. Ledger, Dr A.S. Thom 1975-
(K.J. Edwardson, R. Fleming)

A number of long term rainfall and other records have been, and are being, analysed to determine the nature and incidence of severe drought events in Scotland. Detailed study is being made of the impact and implications of the succession of dry years occurring during the early and middle 1970s.

Thom, A.S., and Ledger, D.C. 1976. Rainfall, runoff and climatic change. *Proc. Instn. Civ. Engrs.*, 61, 633-652.

Ledger, D.C., and Thom, A.S. 1977. 200 years of potential moisture deficit in south-east Scotland. *Weather* 32, 342-349.

Department of Meteorology (EDGMT)

Evapotranspiration
Dr A.S. Thom 1975-

Simple, physically based models of regional evaporation are being considered for describing gross interception losses and predicting net interception losses from contrasting vegetation types (e.g. grass and forest) in different climates.

A close link is retained with the work of the Institute of Hydrology, Wallingford.

Thom, A.S. and Oliver, H.R. 1977. On Penman's equation for estimating regional evaporation. *Quart. J. roy. met. Soc.*; 103, 345-357.

EXETER

Department of Geography (EXEGG)

Sediment and solute dynamics of Devon catchments
Dr D.E. Walling, B.W. Webb 1968

The processes of sediment and solute production in Devon catchments are being investigated by detailed study of a number of small instrumented catchments on contrasting terrain and by a large scale investigation on the River Exe and its tributaries.

Walling, D.E., Webb, B.W. 1975. Spatial variations of river water quality: A survey of the River Exe. *Trans. Inst. Brit. Geogr.* 65, 155-171.

Walling, D.E., Foster, I.D.L. 1978. The 1976 drought and nitrate levels in the River Exe Basin. *J. Inst. Water Engrs. Sci.* 32, 341-52.

Walling, D.E. 1978. Suspended sediment and solute response characteristics of the River Exe, Devon, England. In: *Research in Fluvial Geomorphology. Proceedings of the 5th Guelph Symposium on Geomorphology, 1977* (Eds. R. Davidson-Arnott, W. Nickling), Geo Abstracts, 1969-197.

Foster, I.D.L. and Walling, D.E. 1978. The effects of the 1976 drought and autumn rainfall on stream solute levels. *Earth Surface Processes,* 3 393-406.

Oldfield, F., Rummery, T.A., Thompson, R. and Walling, D.E. (In press). Identification of suspended sediment sources by means of magnetic measurements: some preliminary results. *Wat. Resrs. Res.*

Hydrology of the catchment area of Slapton Ley
Dr D.E. Walling with R.P. Troake (Slapton Ley Field Centre) 1970-76

As part of a wider study of the freshwater biology of Slapton Ley, work has been undertaken to document the runoff and sediment and solute dynamics of the streams draining into the lake. Particular attention has been given to the input of nutrients.

Troake, R.P., Walling, D.E. 1975. Some observations on stream nitrate levels and fertilizer application at Slapton, South Devon. *Trans. Devon Ass.,* 107, 77-90.

Effects of building activity and urbanisation upon streamflow, sediment and solute yield
Dr D.E. Walling, Prof K.J. Gregory (now University of Southampton) 1968-76

The progressive effects of building construction and urbanisation on the runoff, suspended sediment and solute dynamics of a small catchment on the margins of Exeter have been monitored.

Walling, D.E. 1979. The hydrological impact of building activity. In: *Man's impact on the hydrological cycle in the United Kingdom* (Ed. G.E. Hollis) Geobooks, 135-152.

Problems of measuring sediment and solute loads
Dr D.E. Walling 1975-

Attention is being given to the problems involved in measuring and calculating sediment and solute loads, to the reliability of various commonly used techniques and to the development of effective procedures.

Walling, D.E. 1977. Assessing the accuracy of suspended sediment rating curves for a small basin. *Wat. Resrcs. Res.,* 13, 531-538.

Walling, D.E. 1977. Limitations of the rating curve technique for estimating suspended sediment loads, with particular reference to British Rivers. In: *Erosion and Solid Matter Transport in Inland Waters, Proceedings of the Paris Symposium.* IAHS Publication No. 122, 34-48.

Interrelationship of streamflow and water quality in a small catchment
Dr D.E. Walling (D I.D.L. Foster) 1973-77

An intensive scheme of instrumentation was installed in a small (1.4 km^2) catchment to evaluate the interrelationships of runoff and water quality dynamics. The concentrations of individual cations and anions were

monitored using automatic sampling apparatus, and the processes controlling the water quality response were evaluated.

Foster, I.D.L. 1978. A multivariate model of storm period-solute behaviour. *J. Hydrol.* 39, 339-353.

Erosion processes and sediment yield in a small upland catchment

Dr D.E. Walling (Dr C. Clark) 1974-77

A detailed investigation of the processes of erosion and sediment yield operating within a small upland catchment to develop a physically-based model of sediment yield.

Sediment and solute loads of world rivers and their relation to climatic and physiographic controls

Dr D.E. Walling (A.H.A. Kleo) 1975-

An extensive data compilation of the sediment and solute loads of world rivers has been undertaken. Analysis is being carried out to evaluate spatial patterns of sediment and solute yield and the influence of climatic and physiographic controls.

D.E. Walling and A.H.A. Kleo (In press). The sediment yields of rivers in areas of low precipitation: a global view. *Proceedings Canberra Symposium on the Hydrology of Areas of Low Precipitation,* IAHS.

Sediment sources in small instrumented catchments

Dr D.E. Walling (M. Peart) 1977-

A study is being undertaken in two small instrumented catchments to determine the sources of the suspended sediment yield, and more particularly the relative importance of channel and slope source areas. Traditional techniques, including the use of erosion pins, are being combined with the use of various sediment properties as a means of assessing source material. The time-variant nature of sediment yield from the various source areas is being assessed.

Design of sampling programmes for water quality surveillance

Dr D.E. Walling (J. Dowd) 1978-

This work is being undertaken in cooperation with the Water Data Unit. Detailed records of 16 water quality determinands are being collected at the Thorverton gauging station on the River Exe and these will be used to evaluate the adequacy of various sampling strategies for determining time- and discharge- weighted mean concentrations and for estimating load values.

Sediment sources in the Corston Brook

Dr D.E. Walling, B.W. Webb (R.H.F. Curr) 1977-

Sediment sources are being investigated in a small catchment near Bath by evaluating continuous records of downstream sediment concentrations and discharge, in relation to upstream processes and conditions. Measurements of erosion pins, soil moisture, particle size and sediment quality are used to assess the relative importance of bank erosion, surface erosion and other sediment sources.

The effects of urbanisation on natural stream channel morphology

Mrs C.R. Roberts 1975-

Changes in natural stream channel morphology resulting

from urban-induced alterations to the hydrological and sedimentological regimes of catchments are being investigated at a number of sites in England and Scotland. Channel change is inferred from statistical techniques and from the analysis of historical material.

Knight, C.R. 1979. Urbanisation and natural stream channel morphology: the case of two English new towns. In: *Man's Impact on the Hydrological Cycle in the United Kingdom,* (Ed. G.E. Hollis) Geobooks, 181-198.

GLASGOW

Department of Civil Engineering (GLACE)

Rainfall and run-off correlations for small catchments
Dr J.G. Herbertson, with Dundee College of Technology 1970-

Two catchments, one highland and one semi-coastal, are being instrumented to provide continuous rainfall and streamflow records. The object is to obtain a detailed picture of the run-off from individual sections of the catchments and to use the data to calibrate run-off models.

HULL

Department of Geography (HULGG)

Sediment production and moorland hydrology in the North Yorkshire Moors National Park
Dr R.R. Arnett (M. Fullen) 1974

A determination of the source areas for run-off and sediment (suspended and dissolved). The effects of heather burning on run-off, water quality and soil erosion.

Arnett, R.R. 1976. Some pedological features affecting the permeability of hillside soils in Caydale, Yorkshire. *Earth Surface Processes* 1, 3-16.

Arnett, R.R. 1978. Regional disparities in the denudation rate of organic sediments. *Z. Geomorphologie* Suppl. Band 20, 169-179.

Arnett, R.R. 1979. Soil erosion and heather burning. *Drought Atlas of Great Britain.* Institute of British Geographers.

Catchwater catchment experiment
Dr R.C. Ward 1965-85

To study its hydrology, a small boulder-clay catchment has been comprehensively instrumented to measure a wide range of variables. A computerised data storage and retrieval system is being developed in collaboration with the Institute of Hydrology.

Richard, K.S. 1979. Channel adjustment to sediment pollution by the china clay industry in Cornwall, England. In: *Adjustments of the Fluvial System,* (Eds: D.D. Rhodes, and G.P. Williams, 19th Annual Geomorphology Symposium, State Univ. of New York at Binghamton.

Investigations of channel geometry in upland streams with gravel bed material
Dr K.S. Richards (J.A. Milne) 1970-

Studies of regular and random (environmental) components of variation in properties of river channel cross-

sections in upland gravel bed streams with riffle-pool bed topography, particularly with regard to the relationships between bedforms and channel pattern.

Richards, K.S. 1976. The morphology of riffle-pool sequences, *Earth Surface Processes,* 1, 71-88.

Richards, K.S. 1978. Simulation of flow geometry in a riffle-pool stream. *Earth Surface Processes,* 3, 345-354.

LANCASTER

Department of Environmental Sciences (LANEV)

Probability-distributed parameters within conceptual catchment models
Prof T. O'Donnell (D Machado-Olive) 1973-76

By allowing the parameters of a conceptual model to vary in a probability sense, the resulting variability of the outflow in terms of the variability of the parameters was examined. A criterion for terminating parameter optimisation based on outflow deviations was explored.

Machado, D. and O'Donnell, T., 1977. A stochastic interpretation of a lumped overland flow model. *Proc. 3rd Int. Hydr. Symp., Fort Collins.*

Optimal design of water resources systems
Prof T. O'Donnell, J.C. Wilkinson., Dept. of Operational Research
(D.K. Smith) 1973-76

The problems of optimising the components of large simulation models of water supply systems were studied and techniques developed for guiding planners on the size of system components to meet a vector of demands at minimal cost while satisfying reliability and other constraints.

Reliability of deterministic catchment models
Prof T. O'Donnell (P. Canedo) 1976-79

Catchment models are generally fitted with several years of rainfall, runoff and other data. Very long and/or extreme synthetic runoff records may then be generated from the fitted model and design studies based thereon. This study aims to put quantitative estimates on the reliability of such usage, in particular in relation to the length of the fitting period.

Storm runoff volume in relation to rainfall and catchment conditions
Prof T. O'Donnell (Miss J.E. Groves) 1977-79

An investigation (supported by WRC) has been made of storm runoff in NWWA catchments in relation to the rainfall hyetogram and catchment wetness conditions. A storm forecasting model to be used with the NWWA weather radar scheme is to be developed. Unit hydrograph methods have been used and new techniques studied; an isolated event model may also be used.

Recirculation between unequal recharge/abstraction wells in a uniform flow field
Prof T. O'Donnell 1977-79

The amount of well-recharged groundwater being abstracted in a nearby pumping well is a function of the relative strengths of the two (unequal) wells, the strength of any ambient uniform flow in the aquifer, and the direction of the latter flow relative to the line joining the wells.

An algebraic solution of this general problem has been established. General design curves relating the recirculation to the three controlling parameters are being prepared.

Intercomparison study of streamflow generating models
D.M. Sargent (Miss A. Hope) 1978-

This study is an attempt to produce guidelines on the choice of model to be used in the evaluation of a variety of water resource systems (e.g. direct supply reservoirs, river regulating reservoirs). Each chosen system will be subjected to analysis using a wide range of historic and synthetic streamflow data and the overall model performance assessed by statistical analysis.

Simulation of reservoir operation
D.M. Sargent 1976-78

Various computer simulations are used to study a variety of techniques for analysis of water resources systems. Two recently developed programs are now being tested in collaboration with the NWWA; one for reservoir operation and one for the generation of synthetic data.

Rainfall-runoff monitoring program
D.M. Sargent 1979-

Modern computer data logging techniques will be used to record rainfall and runoff on an experimental catchment to provide data for modelling studies. Additional parameters which can be used to separate components of the runoff hydrograph, such as turbidity, pH and conductivity, will be added to the monitoring system. At present magnetic tape data logging devices and an ultrasonic stage recording device are being developed.

Design of urban drainage systems
D.M. Sargent 1978

The effects of storm movement in urban drainage design is being studied using a computer program to simulate runoff from a hypothetical catchment.

Investigations of groundwater in the Silverdale-Arnside area
C.K. Patrick 1972-79

Observations of water quality and discharge at risings and in streams are being used to investigate the relationships between natural groundwater, infiltrated septic tank effluent and seawater.

LEEDS

School of Geography (LEESG)

Development of a physically based hydrograph model for moderate sized basins
Prof M.J. Kirkby 1975-79
(Dr N. Schofield, Dr K.J. Beven)

Field measurements and computer modelling have been carried out on catchments of about 10km^2 at Crimple Beck, near Harrogate, Hodge Beck (N. York Moors) and the Upper Wye (Plynlimon) to test and develop a forecasting model for ungauged catchments. Measurements are mainly of soil and topography within a number of small subcatchments, which are linked by hillslope and channel routing procedures.

Beven, K.J. and Kirkby, M.J., 1977. Considerations in the development and validation of a simple physically

based, variable contributing area model of catchment hydrology. *Int. Hydrol. Symp., Fort Collins.*

Evaluation of satellite thermal capacity measurements as indicators of soil moisture
Prof M.J. Kirkby and Prof R.A.G. Savigear (Reading University), (Dr J. Hogg, Dr A.T. McDonald, Dr K. Atkinson, Dr J.G. Lockwood, Dr S. Jagger, M. Elkington) 1978-81

Groundwater instrumentation of one or more sites to calibrate TEGRA and Rosema soil moisture models and compare with satellite (HCMM) day and night thermal measurements (May 78 - 79). Use of standard meteorological data to interpret satellite data.

Rates of chemical denudation of non-calcareous rocks in Yorkshire
Prof M.J. Kirkby (Miss E. Sutton) 1978-81

Variations in solute loads will be primarily related to differences in rock type using a simple hydrological model for stage variations, which will separate overland and subsurface flow contributions to the hydrograph. Initial testing will make use of the Crimple Beck and other catchments in Yorkshire.

Channel patterns and the equilibrium form of streams in Upland Britain
Prof M.J. Kirkby (Miss P. Naden) 1977-80

Necessary and sufficient conditions for the development of midchannel islands, and thence braiding, are being explored using computer simulation models and field techniques. In the context of the potential flow variability of selected streams, an attempt is being made to examine explicitly the sediment transfers involved in the production and maintenance of divided channels.

Erosion from stream head hollows
Prof M.J. Kirkby (M. McCaig) 1978-79

Field measurements of runoff and erosion have been made in two very small (0.04 km^2) Pennine catchments. The data is coupled with a simple computer model to examine the sensitivity of erosion to physical and hydrological variables. The results are felt to have relevance at the scale of drainage density.

Hydroclimatological models of the Central Pennines
Dr J.G. Lockwood 1975-80

Models relating relief, precipitation, evaporation and runoff in the Central Pennines.

Lockwood, J.G., 1979. *Causes of Climate,* London, Edward Arnold.

Water balance of Britain during the Devensian and postglacial periods
Dr J.G. Lockwood 1978-80

Estimates are made of precipitation and evaporation in lowland Britain for periods up to 50,000 years ago.

Lockwood, J.G. (In press). Water balance of Britain, 50,000 BP to the present day. *Quarternary Research.*

Computer models of evaporation from vegetated surfaces
Dr J.G. Lockwood (P. Sellers). 1976-79

An attempt to model evaporation from various types of vegetated surface.

Bacterial characteristics of upland reservoirs in relation to reservoir limnology and catchment use
Dr A. McDonald (D. Kay) 1975-79

An examination of *E. coli* distribution in two reservoirs are related to reservoir and inflow conditions. The inflow conditions are related to inflow hydrology and this relationship is being further investigated with the cooperation of the Yorkshire Water Authority.

Models for sediment production
M. Robinson 1976-79

Analysis of existing UK and US stream sediment records, together with fieldwork in the Coalburn catchment, to establish and test a lumped sediment model requiring minimal parameter calibration. The model is to provide short and long term sediment forecasts, and to be applicable in catchments undergoing land use changes, for example afforestation or urbanisation.

LIVERPOOL

Department of Geography (LIVGG)

Runoff and sediment production on eroding gully slopes
Dr A.M. Harvey 1970-

Runoff and sediment production are monitored on eroding gully slopes in the Howgill Fells, Cumbria, over a range of time-scales. Storm rainfall intensity and duration thresholds for sediment production have been identified and longer term event frequency considered. Within-storm variations of runoff rates and sediment production rates are also being studied.

Harvey, A.M., 1974. Gully erosion and sediment yield in the Howgill Fells, Westmoreland, Ch. 5 in *Fluvial Processes in Instrumented Watersheds,* (Eds: K.J. Gregory, and D.E. Walling), *Inst. Brit. Geogr. Sp. Publ.* 6,45-58.

Harvey, A.M., 1977. Event frequency in sediment production and channel change. Ch. 20 in *River Channel Changes* (Ed: K.J. Gregory,), London, 301-315.

Leaching of major cations through sand dune soils
P.A. James 1978-

A project has been initiated into the leaching of major cations through sand dune soils in the Ainsdale National Nature Reserve. It involves determinations of Na, Ca, K and Mg in leachate from laboratory simulated and field leaching. Rain water chemistry of the area is also being monitored.

The ground water balance of the Ainsdale National Nature Reserve
Dr R.K. Pegg (D. Clarke) 1975-

The basic components of the hydrological system in a coastal sand dune area are being evaluated and simulation models developed of the groundwater regime.

Regional and altitudinal variations in potential evapotranspiration
Dr R.K. Pegg and D. Ovadia (Institute of Oceangraphic Sciences, Bidston) 1972-

Regional and altitudinal variations in potential evapotranspiration, in North Wales, are being compared with a central station. The feasibility of producing prediction models is being examined and data derived from radio-

sonde ascents and published in the Daily Aerological Records proves to be beneficial in the analysis.

Ovadia, D. and Pegg, P.K., 1979. An approach to calculating evaporation rates at remote sites. *Nordic Hydrol.*, 10 (1).

Identification of suspended stream sediment and lake sediment sources by means of magnetic measurements
Prof F. Oldfield (J. Dearing, T.A. Rummery, J. Bloemendal, J.P. Smith) 1975-

Collaborative studies are in progress in a variety of instrumented catchments where measurement of magnetic parameters such as susceptibility (χ), Saturation Isothermal Remanent Magnetization (SIRM) and coercivity of SIRM (B_{CR}) allow identification of dominant suspended sediment sources.

Thompson, R., Battarbee, R.W., O'Sullivan, P.E., Oldfield, F. 1975. Magnetic susceptibility of lake sediments. *Limnol. Oceanogr. 20* (5), 687.

Oldfield, F., Dearing, J., Thompson, R., Garrett-Jones, S.E. 1978. Some magnetic properties of lake sediments and their possible links with erosion rates. *Pol. Arch. Hydrobiol.*, 25, 321.

Oldfield, F., Rummery, T.A., Thompson, E., Walling, D.E. (In press). Identification of suspended sediment sources by means of magnetic measurements. *Wat. Resrs. Res.*

Magnetic tracing of stream bedload
Prof F. Oldfield (T.A. Rummery) 1977-

Natural bedload is magnetically 'tagged' by heating, then returned to the stream for recovery in bedload traps downstream. Pilot studies are in progress in the Institute of Hydrology's experimental catchments, Plynlimon, in collaboration with Dr M.D. Newson.

Rummery, T.A., Oldfield, F., Newson, M.D., Thompson, R., 1979. Magnestic tracing of stream bedload. *Geophys. J.R. astra. Soc.*, 57, 279 (abs.).

LONDON

Birkbeck College

Department of Geography (BKLGG)

Seasonal changes in soil water disposal and its spatial distribution
Dr I. Reid 1969-72

Soil water redistribution mechanisms regulated by rainfall character, evapotranspiration losses, and antecedent soil conditions differentiated microclimatically by slope aspect.

Reid, I., 1975. Seasonal variability of rainwater distribution by field soils. *J. Hydrol.* 25, 71-80.

Reid, I., 1977. Soil environment and the hydrometeorological mosaic. *Agric. Meteorol.*, 18, 425-433.

Changing surface-depression storage and infiltration opportunity in ploughlands
Dr I Reid 1973-75

A microscale examination of soil-surface configuration change under the influence of weather and its pertinence

to depression storage, infiltration, and surface-runoff in ploughlands.

Reid, I., 1979. Seasonal changes in microtopography and surface depression storage of arable soils. In: *Man's impact on the hydrological cycle in the U.K.* (Ed: G.E. Hollis), 19-30, *Geobooks*, Norwich

Soil water redistribution in an agricultural clay soil with and without underdrainage
Dr I. Reid 1975-

A composite study of water dispersal in problem soils. Resident water is measured using a neutron probe, with particular interest in the advance of wetting and drying fronts. Two tile drainage networks are being monitored for response to rainfall, while the influence of land slope upon the catchment of individual tile drains is being investigated.

Recognition and exploitation of benefits to agriculture derived from improvements in arterial drainage
Dr I. Reid (S.H. Salvin) 1974-

Commonly held views of farming community response to major land drainage schemes are questioned. The Rother catchment is the setting for an investigation of both the rate at which changes are effected by landowners once a scheme has been installed (e.g. improved underdrainage, alterations in land management), and the agricultural benefits reflected in changing gross margin.

Development of a recording bedload trap for coarse-grained alluvial channels
Dr I. Reid, J.T. Layman, Dr L. Frostick 1977-

A continuous recording device for unattended field installation. Six units are at present being evaluated on two reaches of Turkey Brook, Enfield.

Coarse-grained sediments and bed topography in natural channels
Dr I. Reid, Dr L. Frostick (J.T. Layman) 1976-

A dynamic study of the interaction of bedform, fluid, and entrained sediment in coarse alluvial channels. A mobile relief meter spans Turkey Brook on horizontal rails and gives instantaneous record of bed-relief. A laboratory scale-model successfully simulates changing bed configuration.

Mechanics of fine matrix emplacement in gravel bodies
Dr I. Reid, Dr L. Frostick (P.M. Lucas) 1978-

An analysis of clogging mechanisms in fluvial sediments and their hydrological significance.

Generation of desert-floods and fluvial sediments
Dr I. Reid, Dr L. Frostick 1976

Part of a larger research programme investigating the sedimentology and geomorphology of the Lake Turkhana Basin, N. Kenya. Surface run-off and wash-erosion, stream flow and suspended sediment complement examination of fluvial sediments in discrete catchments of Kenya's arid zone.

Frostick, L.E. and Reid, I., 1977. The origin of horizontal laminae in ephemeral stream channel-fill. *Sedimentology,* 24, 1-9.

IMPERIAL COLLEGE

Department of Botany (ICLBT)

Modelling rainfall interception in forest canopies
Prof. A.J. Rutter, Prof. K.A. Kershaw (until 1970), Dr A.J. Morton, Dr P. C. Robins (until 1975) 1968-1977

Work on a predictive computer model has been completed by validation against published records of interception loss and investigation of the sensitivity of the model to meteorological variables and parameters describing forest stands.

Rutter, A.J., Kershaw, K.A., Robins, P.C. and Morton, A.J., 1971. A predictive model of rainfall interception in forests. 1. Derivation of the model. *Agric. Meteorol.,* 9, 367-384.

Rutter, A.J., Morton, A.J. and Robins, P.C., 1975. 2. Generalization of the model and comparison with observations in some coniferous and hardwood stands. *J. Appl. Ecol.,* 12, 367-380.

Rutter, A.J. and Morton, A.J., 1977. Sensitivity of the model to stand parameters and meteorological variables. *J. Appl. Ecol.,* 14, 567-588.

Plant physiological influences on evaporation from forests
Prof A.J. Rutter (Dr P.C. Robins, Dr J.M. Roberts) 1968-1975

In co-operation with the Institute of Hydrology, a quantitative investigation was made of diurnal and seasonal changes of the stomatal resistance to transpiration in Scots pine in relation to environmental factors (now about to be reported) and of various aspects of the pathway of water from the soil to the leaves of the same species.

Roberts, J, 1976. A study of root distribution and growth in a *Pinus sylvestris* plantation in East Anglia. *Plant and soil,* 44, 607-21.

Roberts, J., 1977. The use of tree-cutting techniques in the study of the water relations of mature *Pinus sylvestris. J. exp. Bot.* 28, 751-767.

Department of Civil Engineering (ICLCE)

Droughts in England and Wales
Miss E.M. Shaw 1976-

The occurrences of droughts as defined from monthly rainfall records by the Herbst method have been determined for the long periods of the Kew, Manchester and Edinburgh rainfall data and their intensities and severities compared. Similarly, the regional variations of notable droughts are demonstrated from analyses of 72 stations over England and Wales from 1911.

Shaw, E.M. (In press). The 1975/76 drought in England and Wales in perspective. *Disasters.*

Extremal statistics and rare hydrological events
Dr P.W. Jowitt 1978-

Some aspects of the statistics of extreme events are being investigated using Bayesian techniques of probability theory. In the realm of low flows, comparisons are being

made between existing reservoir rule curves and those suggested by the findings of the research for various levels of reliability.

Jowitt, P.W. (In press). The extreme value Type I distribution and the principle of maximum entropy. *J. Hydrol.*

Analytical model for transient floods in the presence of persistent baseflow
F.V. Appleby 1965-

An explicit non-linear analytical model is being constructed for total streamflow runoff in terms of jointly acting subsystems of persistent and transient components with physically significant parameters (time variation or not) as behavioural indicators in the mean for varying catchment conditions and types.

Operation of water resource systems to meet multiple objectives
Dr P.W. Jowitt 1979-

The operation of a water resource system to meet several objectives is being studied in collaboration with the Severn Trent Water Authority. Emphasis is being placed on the disbenefits of temporary inability to meet demand and how to incorporate such effects within operational techniques or resource utilisation.

Principal component analysis of rainfall in Nigeria
Dr P.W. Jowitt,
Miss E.M. Shaw (J.B.O. Adewumi) 1979-

As part of a future study of the operation and performance of water resource systems in Nigeria, the characterisation of regional rainfall using the techniques of principal component analysis is being undertaken.

Overland flow on urban surfaces
Miss E.M. Shaw (P.M. Johnston, R. Pavlov, Dr R.D. Wing) 1976-78

As part of a programme of research by the Institute of Hydrology into the factors determining the form of the inlet hydrograph to storm sewers, a contract was undertaken to conduct rainfall-runoff experiments on prototype plane concrete road surfaces under the laboratory rainfall simulator. Different catchment areas up to 48 m^2 were used with a selection of longitudinal and cross slopes. Rectangular and triangular rainfall profiles of various durations and intensities were recorded and processed with the corresponding hydrographs.

The soil moisture component of regional actual evapotranspiration models
Dr H.S. Wheater 1979-

In collaboration with the Institute of Hydrology, an experimental and theoretical study of soil moisture response to rainfall and actual evapotranspiration is being made to calibrate and extend models currently used to estimate regional Soil Moisture Deficit.

Hydrology of laboratory catchments
Prof J.R.D. Francis
(P.M. Johnston, Dr R.D. Eing) 1968-79

A rainfall simulator with a working area of approximately 11 x 7 m was commissioned with the object of studying rainfall-runoff relationships using small artificial catchment areas in the laboratory. The apparatus was programmed to produce a variety of time and spatially varying rainfall patterns on two impervious catchments: a 1 x 10 m plane strip and a channel and valley configuration

with independently variable slopes. All experimental data were recorded directly on magnetic tape for subsequent analysis on a mainframe computer.

Flood modelling of the River Lea
Dr H.S. Wheater (J.G.L. Conejo) 1978-79

In a study of flood propagation in the Lea Valley, in conjunction with the Lea division of the Thames Water Authority, the performance of linear and non-linear rainfall excess-runoff models for urban and rural inflows and the application of hydrological and hydraulic routing methods to complex river reaches are being investigated.

Storm rainfall in Venezuela
Miss E.M. Shaw (R. Ponte) 1978-

The hydrometeorological causes of heavy rainfall are being studied for the flood stricken regions of Venezuela. The significant synoptic situations will be identified and their influence on the distribution of heavy rainfall within the serious flood producing storms assessed. The study may extend to relate rainfall patterns to flood hydrographs.

Department of Geology (ICLGL)

Groundwater studies in East Anglia
M.H. de Freitas, with members of Anglian Water Authority (A.C. Scerri, F. Parvizi, E.H. Alabo, P.A.Waldron) 1975-

Hydrogeological and groundwater resource studies have been made of catchments around Norwich, in particular the Tas catchment. Studies of the natural concentration and origin of Fe and Mn from wells are underway.

Underground disposal of waste with special reference to the UK
M.H. de Freitas, J.L. Knill, (Miss M McKinlay, Miss E.B. Cullsard) 1973-

Study of the hydrogeological problems associated with the disposal of fluid waste underground in the UK.

Influence of reservoirs on groundwater flow
Prof. J.L. Knill 1964-

Collation of data on the influence of reservoir impounding on groundwater conditions, based on reservoirs in UK, Australia and Iran.

The interpretation of regional geochemical maps for water quality assessment
Dr I. Thornton and Dr L.T. Thorne 1977-

Studies on the input and dispersion of trace elements, including heavy metals, in tributaries of the rivers Gannel, Hayle, Tean, Ecclebourne, Tawe Hamps, Bradbourne and Minsterley Brook (Shropshire). Investigations into factors controlling relationships between trace elements in sediments and the dissolved and particulate phases of waters. Assessment of on-site filtration methods.

KING'S COLLEGE

Department of Civil Engineering (KCLCE)

Modelling of hydrological systems by the finite element method
Dr J.K. White 1973-

The finite element method is applied to the response to rainfall of surface drainage and groundwater flows by a

model both distributed and deterministic with parameters identifiable as properties of the catchment. The model has been applied to real catchments.

White, J.K., Jayawardena, A.W., 1977. A finite element distributed catchment model. Part I - Analytical Basis; Part 11 - Application to real catchments. *J. Hydrol.*

Optimization of Water Resources
Dr J.K. White 1975-

A new optimization technique has been specially developed for dealing with water resource systems having a large number of decision variables, and has been applied to the system that is being proposed for the southern part of Cyprus.

White, J.K., Christodoulou, C.A., 1979. The simulation and optimization of a multi-basin water resource scheme in Cyprus *Proc. Inst. Civil Engrs., Part 2,* 67 (Mar), 111-132

Department of Geography (KCLGG)

Mass movement in Dorset
Dr D. Brunsden with D.K.C. Jones (London School of Economics) 1978-

Continuing studies of landslide activity in relation to groundwater movements.

Brunsden, D., Jones, D.K.C. (In press). Relative time scales and formative events in coastal landslide systems. *Zeit. fur Geom.*

Applied geomorphology including mapping of surface water conditions for highway engineering design
Dr D. Brunsden (with D.K.C. Jones, J.C. Doornkamp) 1975-

Brunsden, D., Doornkamp J.C., Fookes, P.G., Jones, D.K.C., Kelly, J.M.H., 1975. Large scale geomorphological mapping and highway engineering design . *Eng. Geol.* 8, 227-253.

Chemical processes and equilibria in the unsaturated and saturated zone of the Yorkshire Chalk
Dr J.I. Pitman 1967-

The investigation is centred on the hydrogeochemistry of a small chalk outlier at Givendale. The water carbonate chemistry is directly related to whether the groundwater system is open or closed to soil CO2.

Carbonate chemistry of groundwater from Chalk at Givendale, East Yorkshire. *Geochima et Cosmochimica Acta,* 42, 1885-1897.

The chemistry and mineralogy of some Lower and Middle Chalks, Givendale, East Yorkshire. *Clay Minerals,*13 (1), 93-100

Oxidation - reduction processes in the confined Chalk aquifers of East Yorkshire and East Anglia, with particular reference to iron
Dr J.I. Pitman 1976-

Detailed investigation of pH, Eh, Fe^{++}, Fe^{+++}, sulphide, indicate that sulphate reduction is the major process taking place.

Thermal regime of the unsaturated zone of the Chalk, and its relationship to infiltration and percolation rates
Dr J.I. Pitman 1977-

Seasonal temperature variation is recorded to a depth of 20 metres. Mathematical modelling of the temperature regime, given measured thermal properties of the overlying soil and bedrock, suggest that the conductive transport of heat is modified by convective heat flow.

UNIVERSITY COLLEGE

Department of Geography (UCLGG)

The hydrology of urban rivers
Dr G.E. Hollis

The hydrology of London's rivers. Flood hydrology of G.L.C. streams (W.S. Eyre). Water balances of urban rivers (H.A. Hall). Studies of the River Brent to include Manning's n (G. Richards), temperature (T. Gibson) and water quality (J. Riley). The derivation of equations to predict unit hydrographs for urbanising and highly urban basins under different storm conditions.

Hollis, G.E., 1975. The effect of urbanization on floods of different recurrence interval. *Wat. Resrcs. Res.,* 11 (3), 431-435.

Hollis, G.E. and Luckett, J.K., 1976. The response of natural river channels to urbanization: Two case studies from south east England. *J. Hydrol.,* 30, 351-363.

Hollis, G.E. (Editor), 1979. Man's impact on the hydrological cycle in the U.K. *Geo. Books.*

Environmental impact of flood alleviation works
Dr G.E. Hollis and Lea Division, Thames Water Authority.

Monitoring the effects of the R. Stort (D. Kite) and R. Roding improvement schemes; modelling the ecological recovery of disturbed rivers and preparation of management plans.

Hydrological aspects of lakes
(i) Dr G.E. Hollis

The hydrology of the marshland and open water at Garaet El Ichkeul and Sebkha Kelbia is being modelled as part of the preparation of ecological management plans for these Tunisian wetland parks.

Hollis, G.E., 1979. The impact of water diversion schemes on the hydrology of Garaet El Ichkeul, Tunisia. *Proc. Int. Symp. Specific Aspects of Hydrological Computations for Water Projects.* Leningrad, Sept. 1979.

(ii) Dr C. Vita-Finzi, (N. Roberts)

Paleohydrology of the Konya Basin, Turkey. Chronology and implications of late Quaternary lake level fluctuations.

Department of Geology (UCLGL)

Hydrogeology of minor Mesozoic aquifers in Britain

G.P. Jones (M.J. O'Shea, P.J. Shaw, S. Beeson) 1975-

Hydrogeological investigations of parts of Dorset and Somerset (M.J. O'Shea); parts of Oxfordshire (P.J. Shaw); parts of the Weald (S. Beeson).

Groundwater resource studies in arid regions 1975-78

G.P. Jones (F. Al Sawaf - northern Iraq; S. Tohami - western Sudan; Sh. Marrei - northern United Arab Emirates).

Analogue and mathematical modelling of groundwater regimes

G.P. Jones (Hele Shaw model studies in Triassic aquifer - B. Memon; brackish water wellfield in southern Iraq - R. Haddad; Sulibiya wellfield in Kuwait - F. Al Ruwaih) 1976-

Distribution of saline ground waters

G.P. Jones (detection of saline water by surface resistivity methods A. Oteri).

MANCHESTER

Department of Engineering (MANCE)

Aero-diffusion method of evaporation estimation
Dr H.S. Takhar (M.A. Halim) 1975-

Turbulent equations for momentum and water vapour diffusion are solved simultaneously for meteorological conditions of a thermally unstratified and stratified atmosphere respectively. It is now envisaged to develop models which will take care of all stratifications of the atmosphere in a single formulation. A fully automatic weather station and an accurately monitored evaporation pool at Arley are ued to test this theory..

Takar, H.S., Liddament, M.V., 1978. Aero-diffusion a method of estimating evaporation in a non-stratified atmosphere. *Proc. Recent Advances in Applied Mathematic and Applications.* Indian Institute of Technology, Kharagpur, India.

Takhar, H.S., Liddament, M.W., 1978. Estimating evaporation in a stratified atmosphere. *Proc. Recent Advances in Applied Mathematics and Applications.* Indian Institute of Technology, Kharagpur, India.

Department of Geography (MANGE)

Runoff components in glacierised Rocky Mountain catchments
D.N. Collins, with G.J. Young (Glaciology Division, Environment Canada) 1978-80

Components of flow arising from snowmelt, icemelt, precipitation and from springwaters are separated using hydrograph and water quality techniques. Hydrochemical and isotopic determinations of component sources and runoff are investigated at four limestone based catchments around Wapta Icefield, Rocky Mountains, Alberta, Canada. Models of mountain runoff systems are being constructed, and subglacial Karstic linkages assessed.

Collins, D.N. and Young, G.J., (In press). Separation of runoff components in glacierised watersheds by hydrochemical techniques. *Proceedings of Symposium on Cold Climate Hydrology,* Vancouver, National Research Council of Canada.

Collins, D.N. and Young, G.J., (In press). Hydrochemistry of runoff portions in Alpine catchments. *Proceedings of Western Snow Conference,* Vol. 42.

Hydrology of Alpine glaciers
D.N.Collins 1972-

Internal hydrological systems of Gornergletscher and Findelergletscher, Canton Wallis, Switzerland are investigated using temporal variations of meltwater chemical composition. Contrasting basal regimes and englacial flow patterns are under evaluation using mass-balance mixing model techniques. Summer and winter observations are in progress, with a view to identifying the role of groundwater beneath temperate valley glaciers.

Collins, D.N., 1977. Hydrology of an Alpine glacier as indicated by the chemical composition of meltwaters. *A. Gletscherkunde Glazialgeologie, 13,* (1-2) 219-238.

Collins, D.N., 1977. Hydrology of an Alpine glacier. *Eos, Transactions of the American Geophysical Union, 36,* 979.

Impact of urbanisation on hydrological systems
Prof. I. Douglas 1979-

Analysis of techniques of land evaluation and flood plain mapping to assess the effect of urban development on hillslope hydrology and river systems. Areas of new urban development in SE Greater Manchester are being monitored.

Douglas, I., 1976. Urban hydrology. *Geogr. J., 142,* 65-72.

Solute and sediment dynamics in Alpine glacierised catchments
D.N. Collins —— —— 1974-

Sediment concentration and solute transport are monitored at short intervals or continuously in meltwater streams draining from Alpine glaciers in Switzerland. Samples have been collected at about hourly intervals between July and September, and infrequently at other times. Yields and rates are evaluated and models of subglacial interaction of sediment/solute/water are currently being investigated.

Collins, D.N., 1979. Hydrochemistry of meltwaters draining from an Alpine glacier, *Arctic and Alpine Research, 11,* (3).

Collins, D.N., (In press). Sediment concentration in meltwater as an indicator of subglacial erosional processes. Symposium on Glacier Beds: the ice-bedrock interface, Ottawa, 1978. *J. Glaciol.*

Investigations of Basal Ice at Austre Okstindbreen (Okstindan) and Austerdalsisen (Svartisen), Norway
W.H. Theakstone

Studies of the various types of basal ice, and their mode of formation, at two Norwegian glaciers include collection and laboratory analysis of samples of glacier ice, regelation ice and ice accretions within natural cavities at the glacier beds. Fabric, structure and debris content of basal ice are investigated.

Theakstone, W.H. (In press). Observations within cavities at the bed of the glacier Østerdalsisen, Norway. *Symp. Glacier Beds: the Ice-Rook Interface, Ottawa,* August 1978. *J. Glaciol.*

Glacio-hydrological studies at Okstindan, Norway (Joint project with Geologisk Institut/Laboratoriet for fysisk geografi, Aarhus Universitet, Denmark)
W.H. Theakstone, with N.T. Knudsen
(University of Aarhus, Denmark) 1970-

Observations of (i) water discharge from the glaciers Austre Okstindbreen and Charles Rabots Bre, (ii) throughflow velocities of water entering crevasses and moulkns at the glacier surface (dye tracer studies), (iii) annual drainage of a glacier-dammed lake, (iv) supraglacial streamflow, (v) micrometeorology above glacier surfaces (datalogging).

Hambrey, M.J., 1975. The origin of foliation in glaciers: evidence from some Norwegian examples. *J. Glaciol.* 14, 181-185.

Hambrey, M.J., 1976. Debris, bubble and crystal fabric characteristics of foliated glacier ice, Charles Rabots Bre, Okstindan, Norway. *Arctic and Alpine Research* 8, 49-60.

Knudsen, N.T., 1976. Glaciologisk undersogelser i Nordland, Norge, 1973-74. *Licentiat thesis, University of Aarhus.*

Knighton, A.D. and Theakstone, W.H., 1978. Throughflow water velocities in Austre Okstindbreen, Norway. *J. Glaciol. 20,* 598-599.

Hydrometeorological studies of a small glacial catchment, Storbreen, Norway
M.G. Read

Development of models to stimulate run-off from a glacial catchment at daily, hourly and ten minute intervals. Determination of time lags and water movement velocites from any point on the glacier. Development of empirical models to predict discharge at different times in the melt season for differing weather conditions.

Glacio-hydrological studies in Norway and Switzerland
W.H. Theakstone, D.N. Collins *et al.* 1979-82

Studies of glacier river hydrographs from areas of contrasting radiation regime, temporal variations of chemical and isotopic composition of water discharging from glaciers, seasonal evolution of glacier drainage systems, variations of thermal structure of glacial lakes and drainage mechanisms of glacier-dammed lakes.

Studies of glacial lake sediments at Austerdalsisen, Norway
W.H. Theakstone 1978-

Investigations of a 70 m thick sequence of glacial lake sediments are aimed at clarifying the nature of the glacial lake sedimentary environment. Observations are made of re-working of sediments by ephemeral (snow melt) streams. Bedforms in predominantly fine-grained ephemeral stream channels are studied.

Theakstone, W.H., 1976. Glacial lake sedimentation, Austerdalsisen, Norway. *Sedimentology* 23, 671-688.

MANCHESTER TECHNOLOGY

Department of Civil and Structural Engineering (MNICE)

Hydrogeology of the Cheshire Basin
F.T. Howell (P.L. Jenkins, G. Walters) 1975-80

Investigations made into the nature and magnitude of

flow of fresh and saline groundwaters in the Permian and Triassic rocks of the Cheshire basin and the distribution of bodies of fresh and saline groundwaters. The use of stable isotopes has enabled origins of groundwaters to be postulated. The affinities between migration of protective saline interfaces in rocksalt districts and surface subsidences have been identified. The mechanisms of migration of pollutants in the strata of the region has been evaluated.

Probability aspects of reservoir operations
J.B. White (Hilary A. Smithers) 1978-80

Transition probability matrix methods are being applied to cases where multiple reservoirs are used for river regulation and where there is some element of pumped re-fill. Though general results are being sought, current work is concentrating on regulation of the River Dee with use of Llyn Tegid, Llyn Celyn and Llyn Brenig.

MIDDLESEX POLYTECHNIC

Department of Geography and Planning (MIPGG)

Flood hazard research project
Dr E.C. Penning-Rowsell, D.J. Parker 1970-80

The damage resulting from flooding is being investigated, as an input to evaluations of flood alleviation measures to secure maximum use of flood plain areas, by land use survey. Flood damage potential surveys for different land uses, correlations with published data on land use and correlations with flood extent and frequency data. The effects of flooding of agricultural land is being investigated, as is the damage-reducing effects of flood warnings.

Penning-Rowsell, E.C., Parker, D.J. 1974. Improving flood plain development control. *J. roy. Town Planning Inst., 60,* 2, 540-544;

Penning-Rowsell, E.C. and Chatterton, J.B. 1977. The benefits of flood alleviation: a manual of assessment techniques. Saxon House.

NATIONAL COLLEGE OF AGRICULTURAL ENGINEERING , SILSOE

Cranfield Institute of Technology (NCAFE)

Soil Erosion in UK
Dr R.P.C. Morgan, L. Martin

Erosion by rainsplash, overland flow and rill wash is monitored in the field under a range of soil and landuse types. Measurements are being made of surface roughness and the effects of this on erosion rates are being investigated both in the field and through controlled laboratory experiments simulating field conditons. These detailed field studies are being supported by regional surveys and assessments of erosion hazard over the whole country.

Morgan, R.P.C., 1977. Soil erosion in the United Kingdom: field studies in the Silsoe area, 1973-75. *Nat. Coll. Agr. Engng. Occasional Paper* No. 4, 41 pp.

Morgan, R.P.C., 1978. Field studies of rainsplash erosion. *Earth Surface Processes,* 3 (3), 295-299.

Water balance of gravel pits
Dr D.W. Rycroft, M. Street

Investigations are being carried out to establish the water

balance of a recently formed gravel pit lake in the valley of the River Ouse, Buckinghamshire. Information obtained will be used to formulate a policy for water management of the lake which is being developed as a wetland nature reserve by the Game Conservancy on behalf of Amey Roadstone Ltd.

NEWCASTLE UPON TYNE

Department of Civil Engineering (NEWCE)

Frictional resistance in conduits with large roughness
Prof P. Novak (J.R. Pyle) 1974-77

An experimental and theoretical study of the effect of roughness concentration, its spatial distribution and shape on the frictional head loss coefficient in fully turbulent flow in conduits has been completed. The overall aim of the study was to establish design equations enabling the computation of frictional head loss from the conduit surface characteristics without hydraulic experiments. Particular attention was paid to large relative roughness and the study was supplemented by the measurement and analysis of turbulence intensities. A mathematical model incoporating all the studied parameters for the prediction of the frictional resistance was developed and tested.

The frictional resistance of conduits with surfaces covered by random roughness was studied both at the Newcastle Laboratory and in co-operation with the Osker v. Miller Institute of the Technical University at Munich in the Institute's Obernach Laboratory. The developed mathematical model was applied to these results.

Runoff and channel morphology
Prof P. Novak (F.G. Crane) 1976-

A study of the relationship between channel morphology and various aspects of runoff with emphasis on the effect of significant discharges and of their variability and rate of change is in progress. Several field sites were chosen for observations where Water Authority flow records were available and a small scale laboratory study was carried out with the aim of improving the definition and understanding of 'dominant discharge'. A wide ranging set of experiments (for a sand bed with a uniform grain diameter) with different hydrograph shapes and sizes has been carried out. The resulting morphological changes have been correlated with the flow parameters and resulting regime equations are being developed. The study will be continued with different sediment sizes and grading.

Sediment transport over fixed beds
Prof P. Novak (S.I.A. Ojo) 1975-78

During the last years sediment transport studies over fixed smooth beds have been completed both for the incipient motion of single particles as well as for bed load transport without depositon. This study was continued for single and grouped particles on fixed beds of different roughness, smaller than the particle size.

Experiments with incipient motion of grouped particles on a smooth bed and single as well as grouped particles on fixed rough beds have been completed. The results analysed in the form of critical values of particle Froude and Reynolds numbers, critical sheer stress and critical velocity are being compared with corresponding published results for fixed smooth and movable beds.

Novak, P., Nalluri, C. Sediment transport in smooth fixed bed channels. *Proc. ASCE, 101, No. HY9,* 1139-45.

Turbulence in open channel flow
Prof P. Novak, Dr C. Nalluri (F.M. Phillipson) 1975-

The relationship between hydraulic parameters, channel shape and turbulence characteristics is being studied for uniform flow in smooth channels. Hot film anemometry was used in circular and rectangular channels and turbulence intensities, energy spectra, macroscales, microscales and Reynolds stresses were recorded and analysed. The scope of the study is now being extended to incorporate similar measurements in non-uniform and unsteady flows using a Laser Doppler Anemometer. Comparisons have been made between results obtained using LDA and those previously obtained with hot film anemometry. This work has demonstrated the advantages of using LDA in open channel flows but also the need for more advanced LDA techniques in low velocity flows in positons very close to the bed and in channels with curved boundaries. The study is continuing and turbulence characteristics both in rectangular and circular channels with non-uniform flow are being analysed. Results for non-uniform flow are being compared with corresponding results for uniform flow to evaluate the effect of non-uniformity on turbulence characteristics.

Nalluri, C. and Novak P., 1977. Turbulence characteristics in smooth open channel flow. Fifth biennial symposium on turbulence, Univeristy of Missouri, Rolla (USA).

Hydrological models
(a) Conceptual Models
P. Johnson, Prof P. Novak, (P.D. Jones) 1972-77

The investigaton of the effect of rainfall and evaporation data error on simulated mean daily river discharges in the river Tyne basin was completed. A spatially distributed model, incorporating the nonlinear unit hydrograph method, for flood forecasting and river regulation in the Tyne basin, based on three-hourly inputs has been developed and tested.

(b) Unit hydrograph
Dr J.A. Mawdsley 1976-

A technique for identifying the unit hydrograph which gives the best fit for 6 storms analysed simultaneously has been programmed and is being compared with methods with have identified the UHs separately. The solution of the six storms simultaneously presents some numerical problems so that several solution techniques are being investigated.

(c) Tyne catchment model
Dr J.A. Mawdsley 1976-

The Tyne catchment model is being tested for its sensitivity to data input errors with particular reference to the potential evaporation input. The results from this study should indicate whether more accurate PET estimates would help the model performance. The snow subroutine is again receiving attention in an attempt to improve the runoff prediction at times of snow melt. Preliminary results obtained using wind speed information in the Degree Day index suggested that some improvement is possible, but not consistently so.

Evapotranspiration
Dr J.A. Mawdsley (M.F. Ali) 1977-

The relationship between actual and potential evaporation continues to receive attention. At present a non-weighing lysimeter has been installed at Nafferton farm to measure the actual evapotranspiration from a field of grass. The results will be used to test a modification of the equilibrium equation; a proportionality constant will be made a function of the catchment wetness (preliminary results suggest either the antecedent precipitation or the soil moisture deficit). Further data are being obtained from catchments in Britain or abroad where suitable data are available. It is hoped that at the end of the research a method will be available for calculating weekly actual evapotranspiration from net radiation, air temperature and precipitation data only.

Hydrometric networks
Dr J.A. Mawdsley (D.B. Smith) 1977-

Research is continuing on the design of hydrometric networks based on maximising the net benefits obtained from the data: the benefits are evaluated from the reduction in uncertainty of hydraulic structure design produced by more data. This uncertainty is produced by temporal and spatial uncertainty in the design parameters. We chose to analyse two cases: first when only temporal uncertainty exists, and second, the more difficult case, when both temporal and spatial uncertainty are present due to data being transferred, by some method, to an adjacent site or sites. The techniques developed are being tested on the hydrometric networks of the Northumbrian Water Authority.

The uncertainty in the 2% drought flow estimate is being investigated for several durations of drought as a function of the length of record. A record in excess of 100 years has been extended to 500 years, then subdivided into shorter lengths so that the variance of the estimate of the 2% drought can be determined as a function of the length of record. This variance has been compared with the variance from a standard empirical method, based on rainfall, and the length of record required to improve on the empirical estimate has been determined as approximately 15 years.

Urban hydrology
R.E. Featherstone (P.R. Solway) 1976-

(a) The hydrological effects of urbanisation are being investigated on three partly urbanised catchments within the Northumbrian Water Authority region. Rainfall-runoff response is being monitored and the data will be used to extend knowledge of storm profiles and frequency and to evaluate urban catchment models.

(b) In conjunction with one of the above catchments at Cramlington suspended sediment loads during storms have been monitored. This work is supported by the Water Research Centre.

Mathematical modelling of estuarial flows
R.E. Featherstone (S. Shoben) 1975-78

The study of mathematical simulation of unsteady flows in a tidal reach has been completed. A two-dimensional hydrodynamic model incorporating the effects of density stratification has been incorporated in this model and simpler one-dimensional water quality models have also been developed.

Dispersion in porous media
R.E. Featherstone (A.M. Hussain) 1978-

Dispersion coefficients for the movement of solutes in groundwater flow are being determined using a physical model. By introducing a continuous source of tracer in various modes and determining the time and areal distribution of solute concentration the longitudinal and transverse dispersion coefficients can be obtained by use of solutions to the mass transport equation. The coefficient will be related to the flow velocity components and characteristics of the porous media.

Reservoir operating rules
P. Johnson, Dr C. Nalluri, (A.A. Mohammed Ali) 1974-78

The problem studied is that of finding the optimal monthly/daily operating rule for a single multiple reservoir system having an objective function associated with each release and storage. The solution consists of three steps: streamflow synthesis, deterministic optimization and regression analysis. The sequential generating of monthly flow data is based on the Thomas and Fiering model and Kirby's modification of Wilson-Milferty's transformation to avoid a high skew. This model has been tested for four English rivers and gave satisfactory results when compared with historical data. The discrete differential dynamic programming (DDDP) technique is used as the deterministic optimization model. This technique is believed to be the most efficient method, because it requires less computer memory and time and also gives more accurate results than the common Dynamic Programming (DP) technique. The multiple regression analysis is used to relate optimum decisions (release) with other independent variables (inflow, storage, past inflow, past storage and the time of year). The results from this operating rule method show an improvement over the common operating rule methods (e.g. Queuing theory, Bandwidth policy) used for a single reservoir of any capacity and the operating rule technique applied to the Teesdale reservoirs system shows an improvement over the existing operating rule as used by the Northumbrian Water Authority.

Department of Geography (NEWGG)

Crop and soil water relationships in an agricultural catchment, Northumberland
Dr L.W. Hanna (N. Siam) 1973-79

Meteorological recordings in the catchment allow estimation of daily Penman Eo and rainfall. Soil water is measured by neutron probe calibrated by field sampling. Runoff is monitored by steam gauging. Several crops (currently Italian rye grass and winter wheat) will be studied for water use and an attempt will be made to assess the influence of crop type on the hydrology of the catchment. The results will be used for a more general land use model for water resource management.

Throughflow characteristics in slopes in an upland catchment
Dr L.W. Hanna (R. Bevan) 1977-80

Soil moisture is monitored by a series of access tubes using the Wallingford neutron probe. Continuous recording of throughflow from boxes at different level in the profile are compared with soil moisture changes on the slope and discharges from the catchment.

Water balance in a North Pennine catchment
Dr H. Lister 1976-79

Measurements are made of climatic data for calculation of evaporation with occasional micro meteorological measurements to evaluate the vertical flux of water vapour over short periods. Effective rainfall is compared with stream discharge, continuously recorded at two depth gauges 1 km apart on the same stream, for interpretation of geomorphological control in the catchment.

NOTTINGHAM

School of Agriculture

Department of Physiology and Environmental Studies (NOTSA)

Evaporation from a catchment
Dr M. McGowan, Prof J.L. Monteith, Dr G. Russell 1975-80

Study of the water balance of the Kingston Brook catchment was completed. For 1969-73 estimates of annual evaporation, based upon soil water measurements in the summer, together with Penman values in the winter, were in close agreement with the annual differences between rainfall and runoff confirming that the catchment is essentially water-tight. A linear relationship between annual rainfall and annual runoff for 1969-76 was interpreted in terms of (i) a fixed catchment storage (125 mm), (ii) a small and nearly constant winter evaporation (ca 49 mm) and (iii) a summer evaporation from storage plus a constant fraction of contemporary rainfall.

During the winter, monthly evaporation estimates were consistenly less than the corresponding differences between rainfall and runoff mainly because of a gradual increase in catchment storage due to gradual swelling of the clay soils. During the spring, storage in the catchment declined in response to both increasing evaporation losses and the continued high drainage rates from the soil.

Analysis for the years 1970-73 showed that the minimum canopy resistance of barley and pasture was about 40 s/m. The resistance increased when soil water deficit exceeded 30 mm (barley) and about 50 mm (pasture).

OXFORD

Department of Agricultural Science (OXFAS)

A study of N and P movement through soil into rural drainage water
R.E. White 1976-

Measurements are made of stream flow, sediment movement and N and P loads from a catchment of mixed land use on permeable limestone over Oxford Clay; detailed studies of nitrate leaching through arable soil during autumn and spring when appreciable SMDs exist; direct measurements of soil moisture to check the water balance of the catchment.

Studies of field drainage

Green, F.H.W. 1979. Field drainage and the hydrological cycle. In: *Man's Impact on the hydrological cycle in the U.K.* (Ed: G.E. Hollis), Geo Books, Norwich.

Green. F.H.W. (In press). Field drainage in Britain in the nineteenth century. *Ag. Hist. Review.*

Studies of various aspects of the water-balance

Green. F.H.W. 1979. Observation of potential evapotranspiration by a network of simple irrigated lysimeters. In: Symposium on Lysimeters. Inst. Geol. Sci. (in press).

Studies of field drainage

Greeen F.H.W., 1976. Recent changes in land use and treatment. *Geog. Jnl.,* 142, 12-26.

Green, F.H.W., 1976. Current trends in field drainage practice. *Jnl. Env. Mgmt.,* 5, 207-213.

Studies of various aspects of the water-balance

Green, F.H.W., 1975. The transient snow-line in the Scottish Highlands. Weather, 30, 226-235.

Green, F.H.W., 1976. Mid-winter temperatures in north west Europe (with reference to snowfall). *Jnl. of Met.* 1, 353-354.

Studies of upland climate, related to the water balance

Harding, R.J., 1978. The altitudinal gradient of temperature within the British Isles. *Geografiska Annaler,* Series A, 60, 43-49.

Harding, R.J., 1979. Radiation in the British uplands. *J. App. Ecol.*

Harding, R.J., 1979. The effect of the Cow Green reservoir on the local climate. *J. Inst. Wat. Eng. and Sci.*

Harding, R.J., 1979. Climatological data analysis using a five-day week. J. Met. 4, 73-76.

Department of Geography (OXFGG)

Solution and percolation rates of selected limestones
Dr M.M. Sweeting

Variations in karst landscapes (particularly in the tropics) are being studied especially in relation to the diagenesis of limestones. Isotopic examinations of limestones and of tufa are being made in conjunction with UKAEA Harwell; the effects of these results upon the hydrology of limestone terrains are being investigated.

Sweeting, M.M., 1978. New developments in limestone hydrology. *Progress in Physical Geography.*

PLYMOUTH POLYTECHNIC

School of Environmental Sciences (Geography) (PLPES)

Integrated study of an upland granite catchment in S.W. Dartmoor - the Narrator Brook
Dr L. Ternan, P. Sims, M. Kent, A. Williams 1974-

A long-term integrated study of the hydrology, geomorphology, soils, ecology and microclimatology of a small upland catchment. Instrumentation includes two automatic weather stations (Wallingford type), four stream gauging stations - one with Crump Weir, raingauge network, and data logging system for monitoring of soil interflow.

Ternan, J.L., Williams, A. (In press). Hydrological pathways and granite weathering on Dartmoor. *Geographical Approaches to Fluvial Processes. (Ed:* A.F. Pitty) Geo-Books.

Karst water studies in the Central Pennines
Dr J.L. Ternan

The role of hydrological and hydro-meteorological variables in influencing spatial and temporal variations in limestone solution in the Malham area.

Pitty, A.F., *et al.,* (In press). The range of water temperature fluctuations in the limestone waters of the central and southern Pennines. *J. Hydrol.*

READING

Department of Geography (RDGGG)

The discrimination of terrain properties, particularly soil moisture, using ground and remotely sensed thermal data
Dr J.R. Hardy, Dr S.F. Jagger and others 1977-1980

Test areas have been selected. Ground data and multispectral scanner data from aircraft have been used to date. It is intended to analyse Heat Capacity Mapping Mission (HCMM) satellite data when available.

This project is being carried out in co-operation with Institute of Hydrology, University of Leeds, the Joint Research Centre of the EEC, Ispra, Italy and a number of institutions in Europe.

ST. ANDREWS

Department of Geography (STAGG)

Hydraulics and morphology of braided reaches on the R. Feshie, Inverness-shire
Dr A. Werritty, with Dr R.I. Ferguson,
University of Stirling 1976-

Channel processes in a divided reach on the R. Feshie have been examined over timescales of 1, 30 and 200 years using large scale maps, sequential aerial photography and repeated field survey. A temporary gauging station has been installed and measurements of velocity distribution, and wetted channel dimensions are being undertaken over as wide a range of discharges as possible in divided and undivided reaches. Bedload transport is being monitored indirectly via tracers, and the emplacement internal structure and evolution of channel bars is recorded by detailed field survey.

Werritty, A., Ferguson, R.I. (In press). Pattern changes in a Scottish braided river over 1, 3 and 200 years. In: *Timescales in Geomorphology* (Ed. J. Lewin *et al.)* John Wiley.

Hydraulics and sedimentation in the South Esk (Glen Clova, Angus)
Dr J. Jarvis with Dr J.S. Bridge (Queen's University)

A hydraulic and sedimentary survey including bedload transport is being carried out in a meander bend of the South Esk. Observations have been made from scaffolding bridges erected across the river. The relationships between bedload, bedform, bed calibre and velocity profiles, energy slopes are being investigated.

SALFORD

Department of Civil Engineering (SALCE)

The rate of recovery of infiltration capacity
Prof E.M. Wilson (R. Jacob) 1975-79

The Salford weighable sloping catchment has been completely automated and controlled by computer. The equipment has been used to study the rate of change of infiltration capacity of a variety of soil surfaces under a wide range of rainfall intensities and durations and at various slopes.

SHEFFIELD

Department of Geography (SHFGG)

Spatial and temporal aspects of the evolution of streamwater quality
Dr R. Cryer 1979-

Investigation of spatial and temporal water quality variations within a 10 km^2 catchment, particularly during storm events, may indicate the sources of streamflow and solutes and their interaction.

Cryer, R., 1979. The chemical quality of some pipeflow waters in upland Mid-Wales and its implications. *Cambria* 6 (2).

The distribution of energy in natural stream systems
Dr A.D. Knighton 1977-

Study of the spatial and temporal distribution of the energy available to perform work in natural stream systems, and of the relation between that distribution and the ability of a stream to modify its channel form.

Spatial variation of river channel form
Dr A.D. Knighton 1978-

A river is considered to have four degrees of freedom in adjusting its channel form to external constraints. The nature and extent of the variation in these four degrees of freedom at different spatial scales are being examined to determine the relationships between them.

The influence of tributaries in river systems
Dr A.D. Knighton 1977-79

Study of changes in channel morphology at tributary junctions and of tributary influence on the longitudinal distribution of stream bed material.

Knighton, A.D. (In press). Longitudinal changes in size and sorting of stream bed material in four English rivers. *Bull. Geol. Soc. Am.*

Soil water residence time and solute uptake
Dr S.T. Trudgill and A.M. Pickles 1978-

To assess soil water residence times using fluorescent dyes and to relate solute uptake to contact times between soil water and dissolvable soil minerals. Laboratory leaching/displacement experiments in soil columns monitoring solute load in relation to flushing times and dye breakthrough curves. Field work in a Magnesian Limestone catchment.

Trudgill, S.T., Smart, P.L. and Laidlaw, I.M.S. (In press). Soil water residence time and solute uptake on a dolomite bedrock. *Earth Surface Processes.*

Solute sources in a drainage basin
Dr S.T. Trudgill (R. Crabtree) 1978-

To assess solute sources from atmospheric, vegetation, soil and bedrock components and to relate spatial disposition of erosion rates at the soil/bedrock interface to throughflow regimes. Use of weight loss erosion rock tablets, solute, soil moisture and streamflow monitoring. Field work in a Magnesian Limestone catchment.

Hillslope hydrology and water quality
Dr S.T. Trudgill (I.M.S. Laidlaw) 1975-78

Monitoring of solute loads in soil throughflow water on a gritstone catchment in relation to (a) spatial variation in soil type, vegetation and topography and (b) temporal responses to rainfall inputs. Soil water dye tracing.

Solute mobility in relation to grazing management
Dr S.T. Trudgill (G. Ulmanis) 1976-79

Measurement of solute loads in soil drainage waters from plots (a) ungrazed for 40 years (b) temporarily enclosed for two years and (c) grazed. Field site at Moor House National Nature Reserve, Teesdale.

Soil water flow in relation to soil structure
Dr S.T. Trudgill (P. Walker) 1976-79

Use of soil leaching columns from the Nordrach (carboniferous Limestone) soil; measurement of dye breakthrough curves under saturated conditons and thin section analysis of soil structure using resin impregnation and quantimet analysis of pore size distribution and connectivity.

Solute loads and erosion rates on Carboniferous Limestone
Dr S.T. Trudgill, Miss M. Calloway, Malham Tarn Field Centre
(Field Studies Council) 1975-

Measurement of solutional erosion weight loss of rock tablets in (a) carbonate rich soil hillslope and (b) carbonate poor soil hillslope in relation to throughflow regime. Field work in Malham Tarn region.

Solute concentrations in karst percolation water
P. Smart, H. Friederich, D. Braidwood (University of Bristol, Geography) Dr S.T. Trudgill, R.W. Crabtree 1977-78

Measurement of solute concentrations in percolation water springs in relation to vegetation and soil cover characteristics. Tracing of soil percolation water to cave systems; monitoring of percolation/swallet water in karst risings. Field work in Co. Clare, Eire.

Department of Geology (SHEGG)

Porewater reactions in the unsaturated zone with particular reference to nitrates
Dr D.A. Spears (Mrs S.M. Rhodes) 1975-

Porewaters are extracted from borehole samples and analysed for major ions. The whole rock composition and mineralogy are also determined. Reactions taking place during infiltration are thus established. Infiltration into the Chalk and the Bunter Sandstone have been investigated. This work is currently supported by the Water Research Centre.

Spears, D.A., 1976. Information on groundwater composition obtained from a laboratory study of sediment-water interaction. *Q. J. Engng. Geol.* 9, 25-36.

Spears, D.A. and Reeves, M.J., 1975. The influence of superficial deposits on groundwater quality in the Vale of York. *Q. J. Engng. Geol.*, 8, 255-269.

Spears, D.A., (In press). Porewater compositon in the unsaturated zone of the Chalk, with particular reference to nitrates. *Q. J. Engng. Geol.*

Groundwater reactions involving trace elements in the unsaturated zone
Dr D.A. Spears (A. Midgley) 1979-

This project will study porewater reactions involving trace elements in the unsaturated zone. Natural background concentrations will be established for both the Bunter Sandstone and the Chalk. Potential extraction of pollutants in the unsaturated zone during infiltration will be investigated.

A hydrogeochemical investigation of the Askrigg Block (Northern Pennine Orefield)
Dr P.R. Ineson (A.S. Al-Badri) 1974-77

A regional hydrogeochemical survey of the trace element and selected major element content of waters (±stream sediments and bedrock) within the Asrigg Block. Atomic adsorption, wet chemical, specific ion, colourimetric and x-ray fluorescence etc. analytical techniques are employed and computer interpretation and graphical output is via ICL 1907S.

A hydrogeochemical survey of the Isle of Man
Dr P.R. Ineson (S. Gaciri) 1977

A regional hydrogeochemical survey of the trace element and selected major elements content of waters on the island. Atomic adsorption is the principle analytical technique employed. Computer interpretation and graphical output is via ICL 1907S.

SOUTHAMPTON

Department of Civil Engineering (SOTCE)

Mathematical models for circulation and dispersion studies in shallow waters
Dr C.A. Brebbia 1975-

Numerical methods, in particular finite and boundary elements, are being used to build computer models for shallow water circulation and dispersion problems. Work on the use of microprocessors for engineering calculations is also being carried out.

Brebbia, C.A., 1976. Introduction to finite elements in fluid flow. Butterworths, London.

Brebbia, C.A., 1978. The boundary element method for engineers. Pentech Press, London.

Department of Geography (SOTGG)

Channel morphometry in relation to river discharge in British catchments
Prof K.J. Gregory 1976-78

A method of expressing an index of the three-dimensional

character of drainage networks has been developed so that the index could be related to precipitation characteristics and to indices of flood discharge. Field surveys of channel geometry in 24 basins throughout Britain which were used in the NERC's Flood Studies Report have been related to drainage network extent and the index of stream network volume has been related to flood discharge parameters. Ancillary studies of controls upon, and changes in, channel morphology have been undertaken.

Gregory, K.J., 1976. Changing drainage basins. *Geographical Journal,* 142, 237-247.

Gregory, K.J. and Walling, D.E., 1976. *Drainage Basin Forms and Process: a geomorphological approach.* Arnold, Paperback, 456 pp.

Gregory, K.J., 1977. Stream network volume: an index of channel morphometry. *Bulletin of the Geological Society of America,* 88, 1075-1080.

Gregory, K.J. and Ovenden, J.C. (In press). Drainage network volumes and precipitation. *Trans. Inst. Brit. Geographers.*

Gregory, K.J. (In press). Drainage network power. *Wat. Resrs. Res.*

Drought atlas of Great Britain 1975-76

Prof K.J. Gregory and Dr J.C. Doornkamp (see NOTGG) 1976-79

An atlas devoted to the expression of the drought conditions in 1975 and 1976 in Great Britain is to be published by the Institute of British Geographers. The atlas contains maps and text detailing general aspects of the drought, its impact, and its effects in specific areas.

Doornkamp, J.C. and Gregory, K.J. (editors) 1979. *Atlas of Drought in Britain 1975-76.* Institute of British Geographers. 88 pp.

River channel adjustments including changes downstream of reservoirs

Prof K.J. Gregory (Dr G.E. Petts) 1975-

Studies have been undertaken for several areas in Britain, the nature and magnitude of river channel adjustments are studied including surveys of channel geometry downstream of twenty reservoirs and analysis of the channel changes which have succeeded reservoir construction. A contribution to IGCP project 158 Palaeohydrology of the Temperate Zone during the last 15000 yeas was initiated in 1978.

Gregory, K.J. (editor) 1977. *River Channel Changes,* Wiley, 450 pp.

Bed material and bedload dynamics in small, mixed sand and gravel-bed streams

Prof K.J. Gregory, Dr R.J. Small (B. Gomez) 1977-

Streams in which segregation of the coarse and fine material occurs on the surface of the bed allow opportunities for relationships between the particle size of the stationary and mobile bed material and the flow velocity to be defined. Existing morphology - discharge relationships are being refined to allow them to be used for the interpretation of both contemporary and palaeohydrologic flow conditions. Field measurements are being made on reaches in the New Forest and Dartmoor.

Gomez, B. (In press). A method for sampling bed material

in mixed sand and gravel-bed streams. *Brit. Geomorph. Res. Group Tech. Bull.*

River channel morphology in England and Wales related to frequency of bank-full discharge
Prof K.J. Gregory (J.R. Madew) 1976-

The frequency of bankfull discharge has been investigated at 34 gauging stations in England and Wales and related to measurements of channel size and morphology to provide an improved understanding of spatial variations in bankfull discharge and to facilitate the estimation of discharges at ungauged sites.

Recent changes of drainage networks in Britain
Prof K.J. Gregory (J.C. Ovenden) 1977-

Comparisons of differnt editions of Ordnance Survey 1:10560 and 1:10000 series maps, for a variety of drainage networks. These changes have been evaluated in relation to Ordnance Survey surveyors conventions and fieldwork in the basins confirms the changes and indicates reasons for the extension and contraction of streams in British networks. Detailed field investigations in the catchments of Highland Water (New Forest) and the River Wye (Institute of Hydrology, Plynlimon) are being used to identify the mechanics of network extension.

Ovenden, J.C. and Gregory, K.J. (In press). The permanence of drainage networks in Britain. *Earth Surface Processes.*

Water quality variation in an urbanising catchment
Prof K.J. Gregory, Dr M. Cosgrove (SOTGL) (C.W. Prowse) 1978-

Spatial and temporal variations in the dissolved and suspended loads of the Monks Brook between Southampton and Winchester are being analysed in relation to present variations in rock type and urban influence. A model of catchment response is being developed as a basis for estimation of the implications of future urbanisation of the catchment which was initiated in 1979.

Influence of vegetation upon river channel morphology
Prof K.J. Gregory (T.M. Wahnsiedler) 1977-

The way in which woodland and other vegetation types influence river channel morphology and size is investigated along reaches of rivers in south central and south west England. Identification of the precise influence of vegetation is a basis for interpretation of recent river channel adjustments and for indicating the significance of further vegetation changes for adjustments of channel morphology.

Hydrological mapping
Dr Angela M. Gurnell 1970-76

A technique for mapping evapotranspiration and runoff has been devised using a grid base for data extrapolation and storage. The method can be applied to varying scales of study area and it uses simple physiographic and climatological information to generate the resulting maps.

Foyster, A.M. Mapping runoff by the grid square technique 1975, *Nordic Hydrol.* 6, 207-221.

Controls on the extent, pattern and density of the drainage network
Dr Angela M. Gurnell 1973-

An instrumented catchment in the New Forest allows

detailed evaluation of both spatial and temporal variations of precipitation as well as runoff amount and composition to clarify some of the relationships between precipitation, runoff and the dynamic drainage network. Patterns of rock type, vegetation and soils have proved to be reflected in local variations in the ephemeral drainage network and its density.

Gurnell, A.M., 1978. The dynamics of a drainage network. *Nordic Hydrol.* 9, 293-306.

Gurnell, A.M. Variations in streamflow during periods of no measureable precipitation. *Weather* 32, 149-151.

Heathland vegetation patterns and soil moisture dynamics
Dr Angela M. Gurnell 1977-

Detailed monitoring of piezometric load at the base of the soil profile over a smooth slope in the New Forest is revealing not only simple meso-scale relationships between the water table and discharge, but also micro-scale variations corresponding to changes in local permeability which are indicated by the patterns of vegetation on the slope.

Proglacial stream hydrology
Dr A.M. Gurnell, Dr R.J. Small (C.R. Fenn) 1976-

Continuous hydrologic series have been obtained from Tsidjiore Nouve glacier basin in the Val d'Herens, Switzerland, for the 1977 and 1978 ablation seasons. Research is being directed towards the use of relational methods for the analysis and interpretation of proglacial discharge and sediment (suspended and dissolved) series. In this analysis, the nature of discharge as a control variable and the problems posed by sediment supply indeterminancy are investigated. The serial structures and patterns evident in the dynamic hydrological regime of the proglacial zone are being evaluated.

Heathland management in the New Forest and its effect on the hydrological cycle
Dr A.M. Gurnell, Dr P.J. Edwards (SOTBT)
(P. Ann Hughes) 1977-

A slope in an experimental catchment in the New Forest has been instrumented to evaluate the effects of burning on overland flow, throughflow, solute load, and water table fluctuations. Additional studies are being undertaken of associated variations in soil properties, infiltration characteristics and interception on heathland sites of different ages.

STRATHCLYDE

Department of Applied Physics (STRAP)

The dynamic measurement of canopy storage for a coniferous forest
Dr J.M. Crowther, (N.H. Hancock) 1974-79

A continuous measurement of canopy storage provides a means for studying in detail the interception of rain, fog, and low cloud. Very little is yet know about the last two processes. A further application is the direct measurement of evaporation from wet vegetation. A technique for measuring the mass of water intercepted by conifer foliage has been developed, using a linear displacement transducer to monitor the cantilever deflection of a living branch. Nine such transducers have been installed in

Hafren Forest, Powys, Wales, and measurements have been made for two years. Analysis of these data have validated the method and demonstrated that the technique represents a powerful tool for the forest hydrologist.

Hancock, N.H. and Crowther, J.M., 1979. A technique for the direct measurement of water storage on a forest canopy. *J. Hydrol.* 41, 105-122.

A gamma ray attenuation method for the measurement of canopy mass and canopy storage
Dr J.M. Crowther, (B. Olszyczka) 1975-79

A method of measuring intercepted water has been based on gamma ray attenuation. This technique has the advantage that the mass of water is given in terms of the mass attenuation coefficient of water which has been measured to a high accuracy, and which is understood theoretically.

An experimental rig has been built and has been tested at Kielder, Northumberland. A vertical scan allows the distribution of both canopy mass and stored water to be determined.

Department of Civil Engineering (STRCE)

Testing and development of mathematical models in erosion - transport - deposition simulation
Dr G. Fleming (A. Alkedimi) 1972-

Work continues with the further testing and development of sediment models.

Fleming, G., 1977. Development of mathematical models for erosion and solid matter transport. General Report, UNESCO, IHP - Paris 4-8, July.

Fleming, G., 1977. Total river basin assessment of sediment erosion - transport - deposition processes by mathematical model. UN/WHO Seminar on Pilot Zones for Water Quality Management, Budapest, 30th Nov-2nd Dec.

Fleming, G. and Walker, R., 1977. Digital simulation of soil erosion from the land surface. Paper presented to the I.A.H.R. Symposium, Baden-Baden, Germany, Aug.

Developing and testing mathematical models in hydrology
Dr G. Fleming (S. Moustafa).

Development and testing of practical mathematical modelling techniques in hydrology continues including the SACRAMENTO model and HSP. Integration of deterministic with stochastic techniques is under way for low flow assessment.

Fleming, G., 1975. *Computer simulation techniques in hydrology.* American Elsevier, N.Y.

Fleming, G., 1978. Deterministic models applied to hydrology. UN/FAO.

Fleming, G., 1975. An example of real time flood forecasting in Southern California. *Symp. Weather Radar and Water Management,* Water Research Centre and Royal Radar Establishment, Chester.

Fleming, G. and Wardlaw, R., 1977. An integrated surface/subsurface hydrological response model. *Symp. Optimal Development and Management of Groundwater,* International Assoc. of Hydrogeology, Birmingham, July.

Hydraulic geometry of tidal and non-tidal water courses
D.I.H. Barr (A. Nishat) 1975-

The work reported for 1965/1970 on sediment transportation data and that reported in 1970/75 for hydraulic geometry of tidal water courses, has been amalgamated. New flume data on sediment transport and channel geometry has been combined with the existing laboratory and field data, and definitive rules are sought which will allow the prediction of the normal river configuration given data on flow and land slope, and soil and sediment properties.

Regime of Scottish rivers
Dr J.F. Riddell 1978-79

Application of regime theory to natural watercourses requires the identification of the dominant discharge. This is considered to be the bankful discharge and field data allowing channel geometry to be related to this flow is being collected from a number of rivers in the Scottish Highlands and Lowlands.

The optimum breadth of a gravity dam spillway
Dr J.M. Townson

The total cost variation of a geometrically simplified gravity dam is related to the cost of its spillway component. By combining level pool routing and gradient search techniques, the optimum value of spillway breadth which minimises total cost has been investigated. It exhibits a sensitive variation with cost ratio over a wide range of flood sizes and durations, represented by dimensionless quantities. Four specific cases of existing dams have been included.

Department of Geography (STRGG)

Thermal characteristics of British rivers
Dr K. Smith (Miss A.L. Morgan) 1975-80

A continuing investigation into river water temperature variations in relation to drainage basin variables and dynamics. Recent emphasis has been placed on the implications of changing land use for stream temperatures and current activity is centred on the effects of afforestation on water temperatures in the Plynlimon catchments.

Smith, K., 1975. Water temperature variations within a major river system. *Nordic Hydrology,* 6, 155-169.

Smith, K., 1979. Temperature characteristics of British rivers and the effects of thermal modification. In: *Man's Impact on the Hydrological Cycle in Britain* (Ed: G.E. Hollis) Geo Books Ltd., 229-242.

Water resource management
Dr K. Smith 1975-80

A long-term study of water management strategies with particular reference to changing priorities in Britain. Specific attention has been given (with G.A. Tobin) to flood hazard and the efficiency of various flood alleviation measures including forecasting and warning systems.

Smith K., 1977. Water resource management in Scotland. *Scottish Geogrl. Magazine,* 93, 66-79.

Water resource management
Dr K. Smith 1975-80

A long-term study of water management strategies with particular reference to changing priorities in Britain.

Specific attention has been given (with G.A. Tobin) to flood hazard and the efficiency of various flood alleviation measures including forecasting and warning systems.

Smith K., 1977. Water resource management in Scotland. *Scottish Geogrl. Magazine,* 93, 66-79.

Smith, K., 1977. Recreation and water supply: the example of Longdendale. *Town and Country Planning,* 45, 494-499.

Smith, K. (In press). Trends in water resource management. *Progress in Physical Geography.*

Agricultural land use and water quality of the Watstone Burn

Dr K. Smith (P.J. Back) 1977-80

A project funded by the Scottish Development Department to investigate the effects of diffuse agricultural pollution sources on the water quality of a 5.4 km^2 drainage basin near Glasgow. Particular weight has been placed on the monitoring of spatial variations in nitrate, phosphate, ammonia and BOD levels in relation to farming practices and hydrological events.

Surge characteristics of Roslin Glacier, E. Greenland

V. Haynes 1975-

A study of the surge characteristics of Roslin Glacier, including water tracing (dyes) and chemistry of surface and subsurface waters.

TEESSIDE POLYTECHNIC

Department of Civil Engineering (TWPCE)

The nature of coal mine drainage in the South Durham area

Dr T. Cairney, Dr F.G. Buttler, Dr R.C. Frost 1973-77

An investigation of the processes causing the deterioration of groundwater with length of storage in disused collieries.

Cairney, T. and Frost, R.C. 1975. A case study of mine-water quality deterioration, Mainsforth Colliery, County Durham. *J. Hydrol.,* 25, 275-293.

Frost, R.C., 1979. Evaluation of the rate of decrease in the iron content of water pumped from a flooded shaft mine in County Durham, England. *J. Hydrol.,* 40, 101-111.

Interconnection of the River Skerne and the Magnesian Limestone aquifer in South East Durham

Dr T. Cairney and Dr L. Hamill 1975-78

The interconnection of the River Skerne and the underlying Magnesian Limestone aquifer is proved and evaluated using river discharge analysis, groundwater level analysis and mathematical modelling.

Cairney, T. and Hamill L., 1977. Interconnection of surface and underground water resources in South East Durham. *J. Hydrol.,* 33, 73-86.

Cairney, T. and Hamill L. (In press). The value of engineering geology maps in locating interconnection of surface and groundwater.

Evaluation of induced infiltration between the River Skerne and the Magnesian Limestone in South East Durham
Dr L. Hamill 1979-

Methods of locating areas of river leakage and evaluating induced infiltration are being reviewed, with special reference to the River Skerne and Magnesian Limestone aquifer.

TRENT

Department of Civil and Structural Engineering (TRECE)

Study in bed-forms in alluvial channels
Dr C.J. Pratt 1975-

Longitudinal profiles of bed-forms produced in 0.48 mm sand of near-uniform grading by the flow of water in a laboratory channel are being analysed. The research attempts to develop relationships between bedform dimensions, sediment transport rates and flow parameters.

Pollutants in an urban drainage catchment
Dr C.J. Pratt (I.J. Fletcher, J.R.W. Adams) 1975-

Systematic sampling of roadside gulley pot liquors, trapping of road surface sediments at entry to gulleys, and the monitoring of aerial deposition are being undertaken to assess the relative importance of roof and road surfaces are collectors of pollutants affecting the quality of storm water runoff and small urban catchments. Runoff from the total catchment of 11 ha, as well as from roof-only sub-catchments and road-only sub-catchments are being sampled during storm events.

Fletcher, I.J., Pratt, C.J., Elliott, G.E.P., 1978. An assessment of the importance of roadside gulley pots in determining the quality of stormwater runoff. *Proc. Inst. Conf. on Urban Storm Drainage,* Southampton.

Roof and paved surface overland flows to an urban stormwater drainage system
Dr C.J. Pratt (R.J. Henderson) 1978-

Storm runoff from roof and road surfaces is being measured and recorded on data logging equipment with the corresponding autographic rainfall records. Road sub-catchments of different sizes and slope are being monitored on an urban catchment: roof sub-catchments of between five and fifteen houses on the same catchment are being instrumented and this aspect is being extended by laboratory studies with a rainfall simulator over a specimen roof area with different concrete tile finishes, such as smooth, granular and acrylic.

Transport and deposition of material in storm drainage systems in pedestrian precinct areas
Dr C.J. Pratt (M.C. Wilson) 1976-

Rates of material transport and deposition within the longitudinal slot-type drainage units in a pedestrian-only area of Nottingham are being measured to determine relationships between material movement and stormwater runoff. Observations at a second site with limited pedestrian access are giving comparision results for the performance of this type of drainage system. Autographic raingauges and storm drainage flow meters allow the importance of storm characteristics to be assessed in determining material transport in storm runoff.

WALES: INSTITUTE OF SCIENCE AND TECHNOLOGY CARDIFF

Department of Civil Rngineering and Building Technology (UWIST)

Finite element analysis of flow systems
Dr P.W. France 1974-

Investigation into methods of river flow gauging
Dr F.A. Johnson (now at SHFCE), P.H. John, P. Sutcliffe

An experimental investigation with particular reference to less conventional methods of river flow gauging.

John, P.H., Johnson, F.A. and Sutcliffe, P., 1976. A conductivity flow meter, *J. Hydraul. Res.*, 14.

John, P.H., Johnson, F.A. and Sutcliffe, P., 1978. An intregating float method of discharge measurement. *Inst. Civ. Engrs. Proceedings, Part* 2, 65.

John, P.H., Johnson, F.A. and Sutcliffe, P., 1976. Float calibration in integrating float techniques, *A. S. C. E., J. Hydraul. Div.*, 102 HYB.

Water economy of Great Britain
P. Sutcliffe 1968-

An overall review involving aspects of water occurrence, conservation, use and abuse, government.

WALES: UNIVERSITY COLLEGE ABERYSTWYTH

Department of Geography (WAGGG)

Assessment of snow fall and snowcover in Wales
Dr J.A.A. Jones (E.A. Waring) 1976-

Improved methods of point measurement and areal extrapolation are being developed.

Contribution of pipeflow to stream discharge
Dr J.A.A. Jones, F.G. Crane 1979-

A study of the relationship between pipeflow and streamflow and of the factors responsible for generating pipeflow.

Jones, J.A.A., 1978. Soil pipe networks: distribution and discharge. *Cambria,* 5 (1), 1-21.

River channel changes
Dr J. Lewin, Dr D.A. Hughes (C. Blacknell) 1968-

Historical and observational data on channel forms and changes and sedimentation patterns have been analysed. Sedimentation in point bars, and forecasting rates of meander development are being studied in particular.

Lewin, J., 1978. Meander development and floodplain sedimentation: a case study from mid-Wales. *Geol. Journ.* 13, 25-36.

Lewin, J., Hughes, D., Blacknell, C., 1977. Incidence of river erosion. *Area,* 9, 177-180.

Lewin, J., and Weir, M.J.C., 1977. Morphology and recent history of the lower Spey. *Scott. Geogr. Mag.,* 93, 45-51.

Floods and floodplain geometry
Dr J. Lewin, R.L. Collin, N.W.T. Chisholm
(D.A. Hughes) 1969-

Photogrammetric and field surveys of selected floodplains have been undertaken, both to establish the nature of floodplain geometry in different sedimentological environments and to explore the field relationships between geometry and inundating waters.

Lewin, J., and Manton, M.M.M., 1975. Welsh floodplain studies: the nature of floodplain geometry. *J. Hydrol.* 25, 37-50.

Lewin, J., Collin, R.L. and Hughes, D., 1979. Floods on modified floodplains. In: *Man's impact on the Hydrological cycle in the U.K.* (Ed: G.E. Hollis).

Fluvial dispersal of mining sediments
Dr J. Lewin, Dr B.E. Davies
(Dr P.J. Wolfenden) 1972-

Heavy metals in selected environments are analysed to establish the nature and extent of pollution produced by river action in association with mining processes.

Lewin, J., Davies, B.E. and Wolfenden, P.J., 1977. Interactions between channel change and historic mining sediments. In: *River Channel Changes* (Ed: K.J. Gregory).

Wolfenden, P.J., and Lewin, J., 1977. Distribution of metal pollutants in floodplain sediments. *Catena* 4, 309-317.

Wolfenden, P.J. and Lewin, J., 1978. Distribution of metal pollutants in active stream sediments. *Catena* 5, 67-78.

UNIVERSITY COLLEGE OF SWANSEA

Department of Geography (WSWGG)

Studies of the atmospheric circulation during the 1975-6 drought

The effects of persistent abnormal sea surface temperature in the North Atlantic on the maintenance of drought-type circulations near the British Isles.

Perry, A.H., 1976. The long drought of 1975-76. *Weather 31,* 328-34.

Perry, A.H., 1977. Meteorological aspects of the 1975-76 droughts on the effects of the drought on animals and plants. *Bristol Naturalist Assoc.,* 5-12.

Perry, A.H. (In press). Circulation patterns during the drought in Atlas of the Drought. *Inst. of Br. Geographers Special publication.*

Precipitation in Wales in relation to different synoptic situations

Precipitation patterns occurring under different Lamb synoptic weather types are being investigated, with particular reference to the occurrence of heavy daily falls in particular locations.

Faulkner, R. and Perry, A.H., 1974. A synoptic precipitation climatology of South Wales, *Cambria,* I, 127-138.

TABLE 6
ADVANCED COURSES IN HYDROLOGY AND RELATED SUBJECTS IN U.K. UNIVERSITIES

1. COURSES PREDOMINANTLY CONCERNED WITH HYDROLOGY

University and Department	*Title of Course*	*Qualification to which course leads*
BIRMINGHAM Civil Engineering	a. Water Resources Technology (with 3 options)	MSc
Geology	b. Hydrogeology	
LONDON – IMPERIAL COLLEGE Civil Engineering	Engineering Hydrology	Diploma/MSc
LONDON – UNIVERSITY COLLEGE Geology	Hydrogeology and Ground-water Resources	Diploma/MSc
NEWCASTLE Civil Engineering	a. Engineering Hydrology	Diploma/MSc
	b. Water Resources	

2. COURSES WITH SOME HYDROLOGICAL CONTENT

ASTON Biological Sciences	Biology of Water Management	MSc
CITY Civil Engineering	Hydraulics and Hydrology	MSc
BIRMINGHAM Geography	Climatology and Applied Meteorology	MSc
LONDON – CHELSEA Applied Biology	Applied Hydrobiology	MSc
LONDON – IMPERIAL COLLEGE Geology	Engineering Geology	Diploma/MSc
MANCHESTER – UMIST Civil Engineering	Water Resources	Diploma/MSc
NEWCASTLE Civil Engineering	Public Health Engineering	Diploma/MSc
READING Agriculture (in conjunction with the National College of Agricultural Engineering, Silsoe, Beds)	Agricultural Engineering	
Geophysics	Meteorology	MSc
SALFORD Biology	Environmental Resources	MSc
SOUTHAMPTON Civil Engineering	Irrigation Engineering	MSc
STRATHCLYDE Civil Engineering	a. Environmental Control and Resources Utilisation	Diploma/MSc
	b. Hydraulics, Hydrology and Coastal Dynamics	

Ponding test site (right), Kaudulla irrigation water management study, Sri Lanka

APPENDIX I

SELECTED PUBLICATIONS

PERIODICALS

Agricultural Meteorology *(Elsevier. 6 p.a.)*

Aqua *(International Water Supply Association, quarterly)*

Boundary Layer Meteorology *(D. Reider, 8 p.a.)*

Earth Surface Processes *(Wiley, quarterly)*

Geographical Journal *(Royal Geographical Society, quarterly)*

Groundwater *(National Water Well Association of U.S., 6 p.a.)*

Hydrological Sciences Bulletin *(International Association of Hydrological Sciences, quarterly)*

Journal of Hydrology *(North Holland, 8 p.a.)*

Journal of the Institution of Water Engineers and Sciences *(6 p.a.)*

Journal of Soil Science *(Oxford University Press, quarterly)*

Nature and Resources *(Unesco, quarterly)*

Meteorological Magazine *(Meteorological Office, monthly)*

Proceedings of the Institution of Civil Engineers *(quarterly, in two parts)*

Quarterly Journal of the Royal Meteorological Society

Soil Science *(Williams and Wilkins, monthly)*

Water *(National Water Council, 6 p.a.)*

Water Research *(International Association on Water Pollution Research, monthly)*

Water Resources Bulletin *(American Water Resources Association, 6 p.a.)*

Water Resources Research *(American Geophysical Union, 6 p.a.)*

Water Services *(Fuel and Metallurgical Journals Ltd., monthly)*

Weather *(Royal Meteorological Society, monthly)*

WMO Bulletin *(World Meteorological Organisation, quarterly)*

ANNUAL REPORTS AND YEAR BOOKS

Groundwater *(formerly Groundwater Yearbook, Water Data Unit)*

Institute of Geological Sciences Annual Report

Institute of Hydrology Research Report

National Water Council Annual Report

Surface Water: U.K. *(formerly Surface Water Yearbook, Water Data Unit)*

Water Data *(Water Data Unit)*

Water Services Yearbook

Water Research Centre Annual Report

Who's Who in the Water Industry *(National Water Council)*

ABSTRACTING AND INDEXING JOURNALS

Aquatic Sciences and Fisheries Abstracts *(FAO, monthly)*

GEO Abstracts B : Climatology and Hydrology *(GEO Abstracts Ltd., 6 p.a.)*

Irrigation and Drainage Abstracts *(Commonwealth Agricultural Bureax, 4 p.a.)*

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National Water Council Bulletin *(weekly)*

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Soils and Fertilizers *(Commonwealth Bureau of Soils, monthly)*

WRC Information *(Water Research Centre, weekly)*

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Central Water Planning Unit - *Technical Notes*

Institute of Geological Sciences - *British Regional Geology; Memoirs fo the Geological Survey; Well Inventory Series*

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