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Appendix "E"

CURRENT RESEARCH IN THE UNITED STATES APPLICABLE TO SYSTEMS ANALYSIS OF WATERSHED MANAGEMENT

Prepared Under Grant No. AID/211d

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For

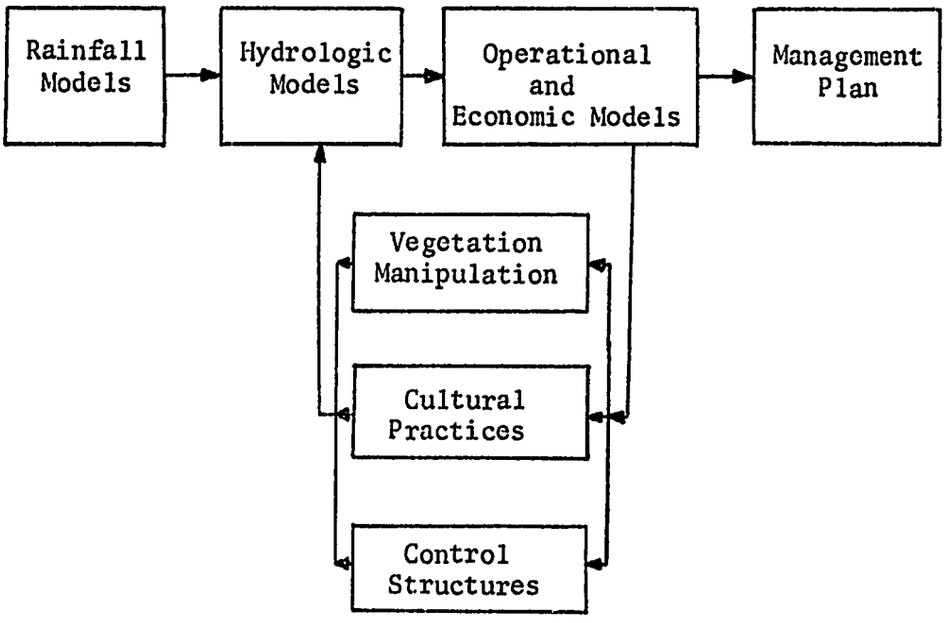
Agency for International Development

FOREWARD

The purpose of this compilation is to summarize current research projects being carried out by federal and state agencies and universities in the United States that may be pertinent to the objectives of AID Institutional Grant 211d, "Optimum Utilization of Water Resources for Agriculture with Social Emphasis on Systems Analysis of Watershed Management." The science information exchange was the primary source of information supplemented by correspondence, telephone communication and personal visits with the organizations involved.

Systems analysis of watershed management implies integrating hydrologic, ecologic and economic principles into operational models that will provide quantitative guides for the management of land for the optimum yields of water for: (1) on-site use in the production of timber, forage or crops; (2) use further downstream for irrigation, municipal needs or power production; (3) control of erosion, sedimentation and floods; and (4) all or any combination of these uses.

The objectives of a myriad of research and operational programs presently in progress in this country could be construed to fall under such an all encompassing definition. Therefore, only those projects falling within a clearly defined plan for research and training have been included in the compilation. The plan is shown in the following figure.



SYSTEMS ANALYSIS OF WATERSHED MANAGEMENT

Rainfall Models

Precipitation is the major input to the system. Stochastic models which employ such data as may be available from less developed countries can be used to synthesize rainfall characteristics and generate long-term storm sequences to provide this input. Familiarity with their development and operation will be necessary.

Hydrologic Models

Hydrologic models, synthesis of the hydrologic behavior of watersheds, are the central concept of the program. Their development is the fastest growing field in hydrology today. As they become more refined and better capable of simulating the real world they will undoubtedly become the primary means of predicting the effects of land management on the distribution, quantity and quality of water on and from watersheds. Although knowledge of both parametric and stochastic approaches to hydrologic modeling is necessary to the program, particular emphasis will be placed on parametric modeling, the extent to which it is presently developed, modifications possible to meet specific objectives, and the direction of further developments and improvements. Hydrologic modeling applies to urban, agricultural and non-cultivated watersheds and includes flood routing, erosion and sedimentation.

Operational and Economic Models

These models are the most powerful tool of the land manager. They combine technology and economics subject to the constraints of the physical system, social patterns, politics, and money available. They employ either cost-benefit or marginal analysis to determine the optimum combination of

management treatments that could be implemented. Feedback from the models is used both for selecting the most appropriate hydrologic model and for parameter adjustment within the selected model. The operational model uses the output from the hydrologic model to predict maximum water benefits for developing watershed management plans.

The following summaries are classified into (1) Hydrologic models of non-cultivated watersheds, (2) Hydrologic models of agricultural watersheds, (3) Hydrologic models of urban watersheds, (4) Erosion and sedimentation, (5) Land treatments for improving watershed values, (6) Economics of water management, and (7) Planning and Operational models. These categories include 152 selected from more than 1000 research projects currently in progress that could have some relation to the project. It is hoped that only a few pertinent projects have been overlooked in making the selection.

HYDROLOGIC MODELS OF AGRICULTURAL WATERSHEDS

Maletic, J. T. and Dutt, G. R.

"Predicting nitrate content of agricultural drain water", U.S. Department of Interior, Bureau of Reclamation, Denver, Colorado.

OBJECTIVE: To determine chemical reactions and movement of nitrogen from various sources using conceptual model systems involving lysimeters and greenhouse work.

APPROACH: Soils of different origin and mineral composition will be used. Data from the model systems, plus data on nitrogen uptake of various irrigated crops secured from a search of the literature, will be used to develop a computer program for predicting the nitrogen transformations taking place in soil-water systems, under variations of time, moisture content of the soil, temperature, oxygen in soil-air, source of nitrogen, or other factors. The computer program will be applied in deriving estimates of nitrogen content drainage effluent from the San Luis unit, Central Valley Project, California.

Speir, W. H.

"Runoff and steamflow regimes in South Florida", U.S. Dept. of Agriculture, Plantation Field Laboratory, Fort Lauderdale, Florida.

OBJECTIVE: Relate steamflow to climate, basin characteristics, and cover conditions of small agricultural watersheds. Develop techniques for separating total runoff into components of surface runoff, interflow, and baseflow. Evaluate the effects of land management and conservation practices on steamflow regimes.

APPROACH: Establish maximum and minimum flow rates and their frequencies on experimental watersheds. Correlate parameter values of distribution graphs with rainfall, antecedent conditions, water size and other geomorphic indices, land management practices, and watershed improvement measures.

Cobb, C.

"Factors affecting water yields from small watersheds", University of Georgia, Agricultural Experiment Station, Athens, Georgia.

OBJECTIVE: Correlate rates and yields of runoff watershed characteristics and climatic conditions.

APPROACH: Watersheds representative of physiographic and climatic conditions will be selected and studied. Initially, two watersheds of approximately 100 and 1000 acres with respresentative Piedmont conditions will be studied. Each watershed will be characterized as to soils, geology, topography, land use, conservation practices, and management. Base flows, peak rates, and total yields of runoff will be measured. Precipitation will be measured. Precipitation and runoff characteristics will be interpreted in terms of causative factors including soil moisture properties, watershed characteristics, climatic conditions, and management.

Yates, P.

"Runoff and streamflow regimes of agricultural watersheds in the southeast", U.S. Dept. of Agriculture, Soil & Water Conservation Research Division, Athens, Georgia.

OBJECTIVE: Relate streamflow regime to climate, cover, and basin characteristics for small agricultural watersheds. Develop methods to compute the water budget for agricultural watersheds. Develop methods for predicting the effect of watershed protection and flood prevention programs on streamflow rates and volumes.

APPROACH: Studies carried out on suitable watersheds in the Southern Coastal Plains of Georgia, North Carolina, Mississippi, and Florida but centered in Little River Experimental Watershed, Tifton, Georgia, where 18 watersheds from 1 to 145 square miles in size are being instrumented. Use analog and digital recorders to obtain records of precipitation, streamflow, ground water, and various parameters of climate. Maintain records of vegetative cover and land use and land management practices. Map and establish hydrologic properties of soils, geology, and topography of the pertinent watersheds. Develop mathematical expressions of relations between hydrologic inputs and outputs and devise methodology for predicting impacts upon streamflow rates, volumes, and duration associated with watershed protection measures.

Rosa, J. M.

"Hydrology of cropland in the palouse prairie", University of Idaho Agriculture Experiment Station, Moscow, Idaho.

OBJECTIVE: To study the water balance on an 8-acre watershed to determine distribution of precipitation to runoff, evapotranspiration and soil storage as affected by crop rotations, and sediment yield due to variations in soil-cover conditions.

APPROACH: Use hydrologic records to derive predictive equations for separate hydrologic components with intention of using the derived method for analyzing previous data from the other gages in the palouse river basin. Use the variance of separate hydrologic components as dependent variables for the development of predictive equations in terms of independent variables represented by soil, cover, climatic, and geologic factors. The relationship between sediment-runoff-soil moisture-temperature-cover will be determined from sediment concentration measurements for each storm event.

Chow, B. T., and Prasad, T.

"Stochastic analysis of watershed systems", University of Illinois, School of Engineering, Urbana, Illinois.

OBJECTIVES: To investigate the stochastic behavior of the rainfall-runoff relationship for 28 annual storms in the French Branch River Basin at Bent Creek, North Carolina.

APPROACH: Stochastic process will be formulated by Markov-Genes and Monte Carlo Method assuming deterministic watershed system. A watershed system itself, in addition to the stochastic input rainfall and stochastic output runoff, will be considered as stochastic in the analysis.

Jones, B. A.

"Hydrologic characterization of small watersheds", Agricultural Experiment Station, Urbana, Illinois.

OBJECTIVE: Investigate the use of a mathematical model to study hydrologic phenomena of watersheds.

APPROACH: Solve nonlinear differential equations expressing the continuity and momentum relationships for a single channel with unsteady flow to determine the temporal and spatial distribution of depth and discharge within channel.

Chow, B. T. and Rao, A. R.

"System analysis of rainfall-runoff relationship", University of Illinois, School of Engineering, Urbana, Illinois.

OBJECTIVE: To formulate a differential equation for a watershed which is treated as a lumped hydrologic system.

APPROACH: Assuming a general non-linear equation for the basin storage and combining it with the equation of continuity, a differential equation for the system will be formulated. This equation will be quasi-linearized by assuming that the coefficients or functions of the average inflow and outflow of the system. Without resorting to the quasi-linear procedure the non-linear equations will be solved on digital computers.

Chow, B. T. and Gareliotis, S. J.

"Stochastic analysis of hydrologic systems", University of Illinois, School of Engineering, Urbana, Illinois.

OBJECTIVE: To develop a practical procedure by which the stochastic behavior of the hydrologic characteristics of a watershed can be

APPROACH: The procedure involves four steps: to formulate a mathematical model to simulate the stochastic behavior of watersheds; to analyze and improve the model by numerical analysis and computer technology; to verify and apply the approved model to actual watershed systems; and to develop a practical procedure for applying the model to hydrologic design and planning. Emphasis is given to application of the procedure to the development of rural and urban watershed projects in Illinois.

Delleur, J. W.

"Estimation of runoff of small watersheds in Indiana", School of Engineering, Purdue University, Lafayette, Indiana.

OBJECTIVE: To develop more reliable and practical methods of estimation of runoff from small watersheds in Indiana.

APPROACH: The proposed work will attempt to eliminate the limitations of the unit hydrograph approach by developing a new conceptual model of the watershed system. This system will be adapted to markedly non-linear systems as are found both in Northern and Southern Indiana.

Huggins, L. F.

"Mathematical simulation of hydrologic events on ungaged watersheds", Purdue University, Agriculture Experiment Station, Lafayette- West Lafayette, Indiana.

OBJECTIVE: To develop mathematical relations describing mechanics of surface runoff within a watershed and digital computer programs to produce a complete runoff hydrograph.

APPROACH: To develop relationships describing dynamic components of runoff processes for small elemental variants within a watershed. Hydrodynamic equations will be utilized in high speed computers to integrate the spacially varied, time dependent outputs from all elements within the watershed to obtain the composite runoff hydrograph.

Huggins, L. F., Monke, E.J., Wiersma, D. N., Zachariah, G. L.

"Mathematical simulation of hydrologic events on ungaged watershed", Purdue University, Water Resources Research Center, Lafayette-West Lafayette, Indiana.

OBJECTIVE: To develop relationships describing the dynamics of the various components of the runoff process for small elemental areas within a watershed.

APPROACH: Fundamental hydro-dynamic equations will be utilized in high-speed computers to integrate the spacially varied, time dependent outputs from all of the many elements within the watershed to obtain a composite runoff hydrograph. After the hydrograph has been developed, the adequacy of the mathematical model will be tested by applying the model to several small gaged watersheds from which records are currently available in comparing the predicted observed hydrographs. The sensitivity of the predicted hydrographs to variations in parameter radius for the various hydrologic components will then be investigated. On the basis of this investigation, it is anticipated that a laboratory model will be constructed for investigating shallow flow over erodable surfaces where detention and retention are apt to pronounced. Upon refining one or more of the sensitive parameters in the model, the model will then be applied to larger, more complex aids to watersheds for a comparison between the predicted and natural runoff.

Huggins, L. F. and Monke, E. J.

"Simulation of the hydrology of ungaged watersheds", Purdue University, School of Agricultural, LaFayette-West LaFayette, Indiana.

OBJECTIVE: To develop the general mathematical model capable of simulating the hydrologic behavior of ungaged watersheds.

APPROACH: The model involves the subdivision of the watershed into a grid of elemental areas, a mathematical description of the various physical processes occurring within each element and the numerical integration of these individual responses into a composite runoff hydrograph from the entire watershed. The input parameters of the model will be correlated with known or easily measured watershed characteristics. Simulation of stochastic intercedent watershed conditions and of rainfall intensity-time distribution is also planned.

Monke, E. J.

"Hydrologic characterization of small watersheds", Purdue University, Agricultural Experiment Station, LaFayette-West LaFayette, Indiana.

OBJECTIVE: Investigate use of mathematical, electrical and hydraulic models to study hydrologic phenomena of watersheds.

APPROACH: To acquire historical runoff data from the University of Illinois concerning two small gaged agricultural watersheds. These data will allow the testing of the mathematical watershed model described in last year's annual report for larger areas and under a greater variety of cultural conditions than that previously investigated.

Johnson, H. P.

"Hydrologic characterization of small watersheds", Iowa State University, Agricultural Experiment Station, Ames, Iowa.

OBJECTIVE: Investigate use of mathematical, electrical and hydraulic models to study hydrologic phenomena of watersheds.

APPROACH: Work will be conducted in two steps, namely, (1) develop parameters for quantitatively describing watersheds, and (2) quantitatively describe watersheds which have been gaged and relate parameters describing watershed to surface runoff and, if possible water yield. For step 1, physiographic information such as contour maps, stream cross section, profiles and aerial photos of small watersheds in several physiographic areas will be collected. From these watersheds parameters as area and drainage density will be defined. The interdependence of variables will be determined. In step 2 gaged watershed will be studied. All known flow characterizing variables as mean annual discharge, unit graph, rainfall, peak flows and low flows will be defined. The relationship of watershed parameters and flow characterizing parameters will be studied.

Johnson, H. P., and Deboer, D. W.

"Development of a mathematical model for the simulation of flat-land watershed hydraulics", Iowa State University, School of Agriculture, Ames, Iowa.

OBJECTIVE: To develop a mathetical model to simulate the flow of water from an area which is characterized by shallow surface depressions and artificial (man-made) during each facilities. To use the model to investigate effect of the degree of drainage on watershed outlet flow. To use the model to investigate the economics of agricultural drainage.

APPROACH: A mathematical model will be developed which will provide a more complete knowledge of flat-land hydraulics. Such a model will be of value to water-resources planners and engineers. The mathematical model will be developed on a digital computer.

Haan, C. T.

"Mathematical model of the hydrologic cycle on agricultural watersheds", University of Kentucky, Agricultural Experiment Station, Lexington, Kentucky.

OBJECTIVE: Develop mathematical models for predicting the hydrologic regime of small watersheds using basic physical relationships that govern water movement and rainfall records. Measure water movement on a 5 or 6 acre watershed so that it can be quantitatively described.

APPROACH: Hydrodynamic equations describing overland flow will be combined with basic relationships governing infiltration, evapotranspiration and subsurface flow to produce a mathematical model of small watershed hydrology. The model will be programmed for a digital computer. A small homogeneous watershed will be instrumented and used to check the validity of the various components of the Mathematical model.

Haan, C. T.

"Factors affecting water yields from small watersheds and shallow ground aquifers", University of Kentucky, Agricultural Experiment Station, Lexington, Kentucky.

OBJECTIVE: Correlate runoff rates and yields to watershed characteristics and climatic conditions. Correlate shallow ground-water yields to site and climatic conditions.

APPROACH: Topographic, climatic and streamflow data for 15 small watersheds (less than 10 square miles) in Kentucky will be collected. Stream flow records will be analyzed to determine the frequency distribution of flood flows, low flows and total yearly runoff. The parameters of these distributions will be correlated with climatic and topographic variables. Runoff hydrographs from the watersheds will be studied and unit hydrographs derived. The unit hydrographs will be fit to functional relationships and the parameters of these relationships will be correlated with climatic and topographic variables.

Chesness, J. L.

"Runoff of small watersheds", Louisiana State University, Agricultural Experiment Station, Baton Rouge, Louisiana.

OBJECTIVE: Correlate runoff rates and yield to watershed characteristics and conditions.

APPROACH: Digital computer programs have been written to process the soil moisture, rainfall and runoff data that have been recorded. The process data from the computer programs is inprinted in graphical form. Twenty-four rainfall events have been processed to data. A prediction equation for the watersheds soil infiltration as a function of time and antecedent soil moisture has been derived through the employment of four large basin infiltratrometers.

Holton, H. N.

"Aquifer--streamflow relations in agricultural watersheds", U.S. Dept. of Agriculture, Soil & Water Conservation Research Division, Beltsville, Maryland.

OBJECTIVE: Develop theories and principles for the interpretation and application of geophysical data in the solution of engineering and hydrologic problems encountered in watershed engineering, including return flow, stream loss, and grown water recharge as affected by geologic, mechanical treatment of agronomic patterns within the watershed.

APPROACH: Information published by various agencies, including CP data annually compiled by ARS, is solicited for these analyses. In addition, geologic characteristics of selected watersheds are made by special surveys, portable equipment, and/or photogrammetric techniques to study the feasibility of concepts. Contracts and cooperative agreements are entered into with Federal, State, and private agencies, or field projects in ARS. Analyses are designed to evaluate the effects of geology, soils, and land use treatments, on ground water recharge, base flow, and stream loss and water yields, in general.

Brakensiek, D. L.

"Hydrodynamics of channel systems in agricultural watersheds", U.S. Dept. of Agriculture, Soil & Water Conservation Research Division, Beltsville, Maryland.

OBJECTIVE: Develop methods for obtaining solutions of free surface hydrodynamic equations for overland flows and channel flows, and integrate them into the surface flow aspects of mathematical models of watershed performance.

APPROACH: A continuous program of research in hydrodynamics is maintained to develop solutions for problems in surface water flows.

Information published by various agencies and ARS are used in analyses, and special types of data are obtained as needed for testing concepts and mathematical formulations of overland and channel flow phenomena. Research contracts and cooperative agreements are entered into where feasible and desirable.

Allen, J. B.

"Water Yields from small agricultural watersheds", Mississippi State University, Agricultural Experiment Station, State College, Mississippi.

OBJECTIVE: Correlate the rate and quantity of runoff with the hydrological characteristics of the watershed. Determine the relationship of water yields from the shallow wells to the hydrologic characteristics of the area.

APPROACH: Typical agricultural watershed of acres will be used. Maps showing soil types, slopes, and land use will be developed. Instrumentation includes rainfall amount and intensity, stream gaging for runoff measurements. Interpretation of precipitation-runoff relationship will include correlation of runoff yields to watershed characteristics. Shallow well studies are similar to surface water yields. Wells will be pumped and records ot yields analyzed in relationship to rainfall characteristics and character of the aquifers. Recharge rates will be determined.

Douglass, J. E.

"Improvement of quanity-quality, and timing of water yields in the Southern Appalachians--Piedmont. US Dept. of Agriculture, S.E. Forest Experiment Station, Franklin, North Carolina.

OBJECTIVE: Develop principles, prediction methods, and techniques for managing watershed lands for improved water yield and other purposes.

APPROACH: Available are more than 20 calibrated experimental forested watersheds for empirical studies and for testing hypothesis. Basic research is organized under four interdisciplinary fields: (1) hydrometerology, in which the staff is studying precipitation variation, the radiant energy budget, and evapotranspiration; (2) plant-water relations including interception effects; (3) soil-water relations, including unsaturated flow studies; and (4) streamflow.

Wiser, E. H.

"Water supply for irrigation", Agricultural Experiment Station, University of North Carolina, Raleigh, North Carolina.

OBJECTIVE: Develop methods for predicting water yields from small agricultural watersheds; obtain probability of occurrence of drought days and of days having excessive moisture; use approximate methods to solve moisture flow patterns in irrigation.

APPROACH: An analysis will be made of records of runoff, rainfall and other pertinent factors to develop methods of predicting probability of occurrence of soil moisture deficits, days with moisture deficits, soil moisture excesses, runoff and of predicting amounts of these deficits and excesses. These factors will be related to irrigation managem nt. Machine techniques will be developed for studying flow patterns for water through unsaturated soil in order to evaluate water movement under irrigation and drainage.

Schwab, G. O.

"Hydrologic characterization of small watersheds", Ohio Agricultural Research & Development Center, Columbus, Ohio.

OBJECTIVE: The behavior of small watersheds will be investigated to identify the pertinent variables using the statistical theory. These variables will be combined with the underlying physical and biological phenomena to develop a mathematical model which will permit statements to be made about prob.ble watershed behavior. Data from existing watersheds and runoff plots will be used to test the validity of the model.

APPROACH: The behavior of small watersheds will be investigated to identify the pertinent variables using the statistical theory. These variables will be combined with the underlying physical and biological phenomena to develop a mathematical model which will permit statements to be made about probable watershed behavior. Data from existing watersheds and runoff plots will be used to test the validity of the model.

Harrold, L. L.

"Runoff and streamflow regimes of agricultural watersheds in North Appalachian Region", U.S. Dept. of Agriculture, Soil & Water Conservation Research Division, Coshocton, Ohio.

OBJECTIVE: Determine how flows from incremental areas combine to produce hydrographs of streamflow on complex watersheds, how watershed characteristics affect rates and amounts of runoff, and how to predict the magnitude and frequency of flows from ungaged watersheds.

APPROACH: Rates and amounts of surface flow from incremental areas of simple coil-cover-slope combinations, representative of the major units of a complex watershed, is related to climatic and watershed characteristics. Quick return subsurface storm flow from these areas is also quantified and related to climate, characteristics of soils and geology, and soil water movement through porous media are coordinated. Flow from surface and subsurface sources and from aquifers provides values of total flood volume, and through watershed models, flow prediction techniques having meaningful parameters are developed.

Harrold, L. L.

"Hydrology of agricultural lands in North Appalachian Region", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Coshocton, Ohio.

OBJECTIVE: Relate precipitation, soil moisture, vegetation, and land treatment to storm runoff totals and hydrographs of surface runoff and interflow; develop techniques for quantifying and predicting watershed soil moisture and runoff.

APPROACH: Natural field watersheds are instrumented to provide data for defining the relationships between climate, watershed characteristics, land treatment, and surface and subsurface flow of upstream unit-source areas. Soil moisture storage and changes therein are related to influencing factors thereon and prediction techniques developed. Soil moisture potentials, hydraulic conductivities, and moisture characteristics are measured for the investigation and application of physical laws of flow to the porous media flow systems of complex watersheds.

Taiganides, E. T. and Ricca, B. P.

"Hydrologic investigations of watershed in Ohio", Ohio State University, School of Agriculture, Columbus, Ohio.

OBJECTIVE: To acquire the knowledge necessary in the development and application of mathematical models to simulate the hydrologic phenomenon associated with small agricultural watersheds in Ohio.

APPROACH: A review of the current mathematical watershed models and a selection of the more successful models to apply to Ohio watersheds will be done.Both analog and digital computer versions will be considered. The Stanford.stream flow simulation model will be modified, through the use of the excellent collection of data available at the Coshocton Ohio Hydrologic Station, in order to predict small watershed response. The cuminulation of the study will be a mathematical model, that would predict water yield peak runoff, outflow hydrographs, and residual soil moisture conditions, for inputs consisting of readily obtained basin characteristics and given precipitation sequence. Use will be made of the analog computer in the Agricultural Engineering Department as well as the University's 7094/360 Digital Computer facilities.

Schoof, R. R.

"Streamflow regimes of agricultural watersheds in the southern plains", U.S. Dept. of Agriculture, Soil & Water Conservation Research Division, Chickasha, Oklahoma.

OBJECTIVE: Determine response of streamflow to varying land use and climatic conditions, channel abstraction and gains, and devise mathematical models and others means for predicting impacts of watershed conservation improvements upon streamflow regimes.

APPROACH: Select the 78-river-mile, 1, 130-square-mile, Anadarko to Alex reach of the Washita River Basin for study. Hydrologically instrument it before flood-retarding structures are built. Measure the flow into and out of the reach and measure the contribution of each major tributary. Continue flow measurements after flood-retarding structures are built. Obtain a complete land use inventory every fifth year and a ten percent sample in other years. Relate the observed changes in flow regimen to causative factors. Publish mean daily flows, monthly and annual flow summaries, maximum and minimum volumes for selected time intervals, annual peak flows, and flow duration data.

Decoursey, D. G.
Synthesis of streamflow regimes in the southern plains", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Chickasha, Oklahoma.

OBJECTIVE: Develop mathematical models describing the hydraulic and hydrologic behavior of complex watersheds based on unit source data. The effects of changes in land use and treatment will be incorporated in the models and used to show changes in the flow regime of a large river.

APPROACH: Runoff, rainfall, soil moisture, ground water levels, meterological data, soils, land use, geology, and topography will be documented and/or recorded continuously on a subdivided watershed of 34 square miles with 8 subwatersheds of decreasing size upstream. Rational, empirical, and semiempirical methods utilizing linear and non-linear least squares and multivariate analysis techniques will be used to relate the runoff rate and volumetric characteristics of the watersheds to the physical watershed and climatic characteristics. Use past records of rainfall and runoff to reproduce a ten-year history of river flows at six stations along the Washita River by developing all the flood hydrographs for the ten-year period at each of the seventy subwatersheds in the basin and routing them down the river. Change the flood hydrographs to show the effect of land treatment measures and rerun the period. Difference between the two runs will show the change in flow regime of the rivers.

Garton, J. F., Crow, F. R. and Ree, W. O.
"The mechanism of direct surface runoff from rainfall," Oklahoma State University, Stillwater, Oklahoma.

OBJECTIVE: To develop prediction equations for water-surface profiles of overland flow from rainfall by finite increment computer solutions of the partial differential equations of momentum and continuity for spacially varied unsteady sheet flow. To measure actual water surface profiles for unsteady spacially varied sheet flow of water over various natural and synthetic ground surfaces and make comparisons with predicted profiles. To develop procedures of routing various rainfall rates through the sheet flow phase and into channel flow phase of surface runoff from rainfall using rational equations.

Engman, E. T.
"Groundwater in relation to land use of agricultural watersheds in the Northeast", Penn. State University, Agricultural Experiment Station, University Park, Pennsylvania.

OBJECTIVE: Relate the effects of geology, hydraulic conductivity, and transmissivity to acquifer capacity and yield and determine relation of ground water amounts and movement for use and management of agricultural lands.

APPROACH: Geologic subdivisions are established, water level contour maps are constructed, pumping tests are conducted, and results are correlated with major rock types, joints and fractures, and storm influence on water levels in the wells. Gains or losses of streamflow in channels are observed and related to geology, channel characters and other relevant watershed features.

Engman, E. T. and W. J. Gburek
"Streamflow regimes of agricultural watersheds of the Northeast", Penn. State University, Agricultural Experiment Station, University Park, Pennsylvania.

OBJECTIVE: Determine physically and analytically how the runoff process occurs, and use these data as a basis for developing a method of hydrograph synthesis.

APPROACH: Establish and operate a basic network of hydrologic instrumentation on the Mahantango Creek Experimental Watershed, including precipitation gages, meteorological stations, and streamflow measuring stations. Characterize soils, geology, and land forms relative to basin hydrology. Measure the amounts of water occurring as surface flow, interflow, and ground water. Hydrograph synthesis will be based on finite difference calculations of the water budget data.

Ligon, J. T., Law, A. G., and Nowack, R. F.
"Development and evaluation of hydrologic simulation models", Clemson University, Water Resources Research Institute, Clemson, South Carolina.

OBJECTIVE: To adapt the Stanford watershed model or a version of it and evaluate that model on existing experimental watershed data from Upper Peidmont Region of South Carolina. To develop new watershed simulation models.

APPROACH: The Stanford watershed model will be adapted for use on computing equipment available to the researchers. Subprocedures of this model will be checked against extensive field data available from a 561-acre experimental watershed in the Upper Peidmont. Where possible improved procedures will be developed to simulate more faithfully their existing conditions in this physiography region. The data from this experimental watershed and others within the region will be utilized for evaluation of specific model parameters. In the

development of new models particular attention will be given to the simulation of soil moisture and ground water conditions as well as stream flow. Existing data will be used in developing procedures and checking results.

Lytle, W. S. and Chu ,S. T.

"Hydrology of small drainage basins for developing hydrologic design", South Dakota State University, Water Resources Institute, Brookings, South Dakota.

OBJECTIVE: To investigate existing records of rainfall and runoff through the state. To determine the physical parameters above a particular gaging station with past flow records to see if they can be adequately measured. To correlate commercial records to those stations with complete records in order to determine which partial record stations can be used by knowing where good correlation exists.

APPROACH: An analysis will be made of stations with maximum and minimum flow by extreme value probability methods and by comparisons of physical parameters with stations of known extreme flow values. A process of synthesis will be used to determine duration of flow curves and extreme flow values in those ungaged watershed areas where physical parameters can be determined.

Chu, S. T. and Lytle, W. S.

"Investigation of time parameters of watersheds in South Dakota", South Dakota State University, School of Agriculture, Brookings, South Dakota.

OBJECTIVE: To determine the time base of the instantenous unit hydrographs for 35 watersheds in South Dakota of 1.5 square miles to 1500 square miles. To determine the correlation of the time parameter with measurable physical properties of the watershed area, length of channel and average flow. To determine the correlation of this time parameter to other time parameters of the hydrographs, such as time of concentration, time of lag, time of virtual equilibrium, and time to peak.

APPROACH: Correlations will be determined by standard procedures. If none of the correlations turn out to be highly significant then the time to base unit hydrograph cannot be considered a constant for a watershed and an attempt will be made to relate the time of base of the instantaneous unit hydrograph to measurable properties of the rainfall and runoff curves or watershed properties for each runoff event studied. The computation of this time parameter would allow the use of the unit hydrograph method for computating maximum runoff for design purposes on South Dakota streams.

Ligon, J. T. and Law, A. G.

"Hydrologic simulation parameters related to develop metal changes on the watershed", Clemson University, School of Agriculture, Clemson, South Carolina.

OBJECTIVE: To simulate the hydrologic regime of selected Peidmont watersheds using a version of the Standford Waterhsed Model.

APPROACH: Watersheds studied will be those which have been subjected to developmental changes including urbanization, agricultural land-use changes, and public law 566 project measures. For each watershed, time variants for which the watershed physical conditions can be identified as being relatively constant will be selected. Optimum model parameters will be determined for these periods, and changes in these parameters between periods will be related to the physical changes on the watershed.

Baird, R. W.

"Runoff and streamflow regimes of agricultural watersheds in the Western Gulf Region", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Riesel, Texas.

OBJECTIVE: Determine water yield and the rates and amounts of storm runoff from agricultural watersheds as affected by: climatic factors, watershed size, land use and treatment, cover conditions, and soils and geology. Develop methods of estimating water yield and storm runoff from ungaged areas, and routing these flows in larger watersheds.

APPROACH: In the Blacklands near Riesel, runoff is measured from 20 acres of sizes from 0.243 to 4.380 acres. These areas include the major land uses and treatments used in the Blacklands. Supplemental records of land uses, soil moisture and climatic factors will expand the area of application. In the Edwards Plateau near Sonora, runoff is measured at 5 flood detention reservoirs and one gaging station, with drainage areas of 686 to 30,720 acres. Supplemental information regarding cover, geology, soils and ground water conditions, also available, will improve the accuracy of prediction of storm runoff and water yield from ungaged areas.

Gardner, W. R.

"Watershed water budget", University of Wisconsin, Agricultural Experiment Station, Madison, Wisconsin.

OBJECTIVE: Objective develop relations between the surface and subsurface components based upon the processes involved.

APPROACH: The procedure will be to instrument a small agricultural watershed so that the rainfall, runoff, evapotranspiration, soil water content, and deep percolation can be monitored continuously. The field data will be supplmented by model studies of idealized watersheds and mathematical solutions of relevant water transport problems. Present mathematical theories will be tested and improved where possible.

Shanholtz, V. O.

"Simulation of hydrologic cycle on small watersheds by digital techniques", Virginia Polytechnic Institute, Agricultural Experiment Station, Blacksburg, Virginia.

OBJECTIVE: Test the Standard Watershed Model on small agricultural watersheds in Virginia. Modify the model as required to fit the flow regimes of these small agricultural watersheds.

APPROACH: The proposed work involves testing the Stanford Watershed Model on small agricultural watersheds in Virginia. The model will be modified when required to make the algorithm functional for studying flow regimes from these watersheds. The concept of excess precipitation followed by routing through a partial linear storage system to obtain long time will be used in lieu of the Stanford technique. Storage routing without coefficients will be used in lieu of the semi-graphical technique for reservoir routing.

Lillard, J. H. and Burford, J. B.

"Water yields from small watersheds", Virginia Polytechnic Institute, Agricultural Experiment Station, Blacksburg, Virginia.

OBJECTIVE: Correlate runoff yields and rates to watershed characteristics and climatic conditions; develop procedures for estimating surface and subsurface contributions to runoff from parameters of climate and watershed characteristics; develop procedures and formulas to reliably estimate seasonal and annual water yields.

APPROACH: Continuous rainfall and runoff records from 10 mixed cover and 4 small unit source watersheds will be measured. Each watershed will be carefully characterized through soil, geologic, topographic and land use surveys; and correlations established between the watersheds characteristics and runoff yields. Additional investigations of soil moisture properties, effects of watershed size, shape and topography, land use patterns, soil conservation practices and management will be undertaken; and high speed data processing techniques employed.

Burford, J. B.

"Runoff and Streamflow regimes of upstream agricultural watersheds", Virginia Polytechnic Institute, Agricultural Experiment Station, Blacksburg, Virginia.

OBJECTIVE: Correlate runoff yields and rates to watershed characteristics and climatic conditions. Determine ground water contribution to streamflow. Develop predictive methods for both runoff and ground water yields.

APPROACH: Establish instrumentation and obtain precipitation and streamflow records on representative upstream watersheds in selected Land Resource Areas. Seek correlations between storm runoff, base flow, geology, geomorphic parameters, soils, land use, soil moisture, precipitation and other factors influencing streamflow regimes.

Comer, G. H.

"Runoff and stream regimes of agricultural watersheds in New England", U.S. Dept. of Agriculture, Soil & Water Cons. Research Division, Danville, Vermont.

OBJECTIVE: Develop mathematical functions of observed hydrographs from experimental watersheds, and devise methods of predicting amounts and rates of streamflow for various time intervals.

APPROACH: A basic network of hydrologic instrumentation has been established on Sleepers River watershed, including precipitation gages, snow courses, meteorological stations, water wells, and streamflow measuring stations. Characterize soils, geology, and land forms relevant to basic hydrology. Analyze and interpret data to establish relations between precipitation and resulting streamflow.

Shanholtz, B. O.

"Simulation of the hydrologic cycle on small agricultural watersheds by digital techniques", Virginia Polytechnic Institute, School of Engineering, Blacksburg, Virginia.

OBJECTIVE: To test the Stanford Watershed Model on small agricultural watersheds in Virginia.

APPROACH: The Stanford Watershed Model will be modified when required to make the outflow rythym functional for studying flow regimes from agricultural watersheds. The concept of excess precipitation followed by routing through a partial linear storage system to obtain lag time will be used in lieu of the Stanford Technique. Storage routing without coefficients will be used in lieu of the semi-graphical technique for reservoir routing.

Amermann, C. R.

"Runoff and streamflow regimes of agricultural watersheds in Wisconsin", University of Wsiconsin, Agricultural Experiment Station, Madison, Wisconsin.

OBJECTIVE: Characterize floodflows and water yield in relation to climatic and watershed characteristics and develop procedures for predicting flows from ungaged watersheds.

APPROACH: Record precipitation and streamflow, soil moisture, frost and snow depths, land use, geology, and watershed and stream channel geometry on Fennimore Experimental Watershed and at other selected locations. Make water balance studies of the flow systems and their environments.

LAND AND VEGETATION TREATMENTS FOR IMPROVING WATERSHED VALUES

Jordan, G. L.

"Effective use of available moisture on the San Simon Watershed", University of Arizona, Agriculture Experiment Station, Tucson, Arizona.

OBJECTIVE: To increase surface water detention and moisture penetration through pitting and various seedbed preparations, to develop or modify the machinery for pit formation concurrent with seedbed preparation, to select and promote the development of species having high seedling and drought tolerance, and to continue studies on the physiological and cultural requirements for establishing various forage and browse species.

Jordan, G. L.

"Improvements of range watersheds and wildlife habitats of Northern Arizona", University of Arizona, Agriculture Experiment Station, Tucson, Arizona.

OBJECTIVE: To study the time of emergence of various species, stand counts, yields of forage per acre and persistance.

APPROACH: All studies will be enclosed under livestock and rabbit-proof fence. The data will be correlated with climatic variables. Temperature, relative humidity, wind, and precipitation will be monitored at each of the study sites. Further classification of each will consist of the vegetation survey and soil analysis.

Cornelius, D. R. and Hylton, L. O.

"Tryland experiment in range improvements for Panoche area", U. S. Department of Agriculture, Berkeley, California.

OBJECTIVE: To test various drought resistant species and ecotypes of grass, legume, and browse plants to determine their adaptation to climate (Mediterranean) and soils of the area.

APPROACH: Treatment will include various kinds of furrows and cages to conserve moisture, shade seedlings, and reduce depredation by wildlife that might otherwise preclude establishment of the particular plant desired. Various types of furrows will be plowed both inside and outside 5-acre exclosures. Various species of plants that come mainly from drier or desert portions of the Mediterranean type of climate of Israel, Egypt, Lebanon, Jordan, Australia, Chile, and the U.S. Tests for adaptation will include resistance to heat investigation and laboratory, greenhouse and field.

McClurkin, D. C.

"Reduction in storm runoff, erosion, and sedimentation by rehabilitation of badly eroded forest areas", Southern Forest Experiment Station, Oxford, Mississippi.

OBJECTIVE: Develop methods for establishing protective vegetation on eroded forest soils and for minimizing runoff and erosion on rehabilitated sites as a result of cultural treatments, harvesting, and cover regeneration.

APPROACH: Determining adaptability of plant species to deteriorated sites, assessing protective values of such plants, and evaluating means of ameliorating eroded sites to favor cover establishment and maintenance. Assessing for rehabilitated sites effects of runoff and erosion of thinning, harvest cuts, site preparation, logging methods, hardwood control, regeneration, and prescribed burning.

Hagan, R. M., and Davenport, D. C.

"Potential usefulness of antitranspirants for increasing water use efficiency of plants", Universitg of California, School of Agriculture, Davis, California.

OBJECTIVE: (1) Continue evaluation of new antitranspirant materials (e.g., semipermeable films, reflectants and metabolic inhibitors) for phytotoxicity and their effects on transpiration, relative turgidity, leaf temperature, net photosynthesis and growth. (2) Determine relative permeabilities of film antitranspirants to water vapor, carbon dioxide and oxygen. (3) Study plant and environmental factors which may influence the effects of antitranspirants on transpiration, relative turgidity, and plant growth processes. (4) Develop techniques for supplying antitranspirants and for evaluating the completeness of their coverage on plant leaves, their stability and specific effects on stomatal movement. Investigate the potential usefulness of various combinations of antitranspirant materials as a means of increasing the water-use efficiency of plants. (6) Study special uses of antitranspirants in agriculture, ornamental horticulture, and watershed management.

APPROACH: Full use will be made of basic biochemical research on stomatal regulators by Dr. I. Zelitch and associates at New Haven, Connecticut and on external films by Dr. J. Gale at Jerusalem, Israel. Water use will be assessed by meteorological instrumentation, soil moisture studies, and lysometric techniques. Other observations may include stomatal measurements, relative turgidity of leaves, cell sap concentration, and diurnal measurements of tree trunk radius as indications of internal water stress. Field experiments will be conducted to determine effects of antitranspirant materials on water use efficiency of crops and also on their growth, yield and quality.

Goodin, J. R.

"Increasing chaparral watershed yield through improved use of phenoxy-ty-pe herbicides", University of California, School of Agriculture, Riverside, California.

OBJECTIVE: To study the influence of environment on the translocation of herbicides in resprouting chaparral species.

APPROACH: Soil moisture, soil and ambient temperature, light, and humidity will be investigated in an attempt to find the correct combination of environmental factors which will lead to the greatest chance of success in causing a growth regulating chemical to be translocated into the crown region. Labeled and unlabeled phenoxy-type herbicides will be used to study the rate and degree of absorption and translocation as influenced by soil moisture stress. Other environmental factors such as air and soil temperature, relative humidity, and light will be investigated with respect to their influence on translocation of herbicides.

Goodin, J. R.

"Increasing chaparral watershed yield through improved use of Phenoxy-ty-pe herbicides", University of California, Agriculture Experiment Station, Riverside, California.

OBJECTIVE: Investigate physiological influences of environment on translocation of herbicides in resprouting chaparral species; subsequent kill of undesirable plants can aid dramatically in increasing watershed yield in dry, Mediterranean climates.

APPROACH: Three predominant souther California sprouting chaparral species: chamise (Adenostoma fasciculatum), Eastwood manzanita (Arctostaphylos glandulosa), scrub oak (Quercus dumosa will be grown under controlled temperature, humidity, light, fertilization, and soil type. Phenoxy-type herbicides (2,4,-D; 2,4,5-TP; picloram) will be applied and rate of absorption and translocation studies as a function of soil moisture stress. Unlabelled and labelled herbicides will be employed.

Nelson, R. E.

"Timber and watershed resources research in Hawaii", U. S. Department of Agriculture, Honolulu, Hawaii.

OBJECTIVE: Select most productive tree species and determine management for timber and other purposes; and develop watershed management methods.

APPROACH: Research on evaluation of tree species for adaptability; silviculture of Acacia and selected species; determine the growth of selected exotic and native species. Study evapotranspiration, soil erodibility, and rainfall-streamflow relations. Study mechanical and physical properties, durability, seasoning of wood, and wood quality.

Eckert, R. E.

"Mountain meadow restoration", University of Nevada, School of Agriculture, Reno, Nevada.

OBJECTIVE: (1) To impose various restoration practices on experimental meadows. (2) To measure effects of restoration practices on meadow condition and forage production. (3) To determine effects of restoration on wildlife and livestock. (4) To evaluate restoration practices in terms of water, soil and vegetation conservation and improvement and livestock and wildlife production. (5) To determine which restoration practices can be best recommended for similar meadows in similar condition.

APPROACH: (1) Construction of "gully plugs" to raise the water table and their effect on depth and fluctuation of the water table as it influences native vegetation. (2) Source of ground water and hydrostatic pressure of water table. (3) Siltation of reservoirs to determine quantity of sediment carried and life of the reservoir behind the "gully plug". (4) Measurement of streamflow. (5) Mapping of vegetative sites and evaluate improvement practices such as protection, fertilization, weed control, seeding improved species, and combinations of these practices. (6) Determination of soil characteristics and climatic factor will permit application of best practices to similar meadows.

Gould, W. L., Wilson, M. L., and Herbel, C. H.

"Chemical control of creosotebush and mesquite", New Mexico State University, Agriculture Experiment Station, Las Cruces, New Mexico. (University Park).

OBJECTIVE: To develop methods for rehabilitating creosotebush and mesquite-infested sites to maximize watershed, wildlife, and forage values.

APPROACH: Determine proper sequence of variable springs; proper herbicides, additives, and carious; Effect of brush control on vegetation response and soil stabilization in dune areas; most effective herbicidal treatment for brush control by spot treatment with granular herbicides; successful reseeding practices including optimum methods, rates, and dates for various sites, weedy vegetation reduction, insect and rodent control, managing seeded stands for maximum production, and adaptation of new grass introductions to arid and semi-desert conditions; and evaluation of vegetation types and sites as to suitability for various treatment.

Leonard, R. E.

"Effects of different forest types and conditions on stream regimen and water yields", State University of New York, Graduate School, Syracuse, New York.

OBJECTIVE: Determine the influence of climatic, edaphic, and other environmental factors on hydrologic processes in relation to forest types and conditions.

APPROACH: This cooperative project with the New York State University College of Forestry is determining the reflection of solar radiation by a conifer forest; conducting a study of snow interception by conferious tree crowns and its disposition under climatic conditions of Central New York; and the effect of land-use changes on streamflow in the Allegheny Plateau Region of New York State.

Gifford, G. F.

"Effects of sagebrush and pinyon juniper conversion on watershed values in Utah", Utah State University, Agriculture Experiment Station, Logan, Utah.

OBJECTIVE: Determine the water budget of natural stands of pinyon-juniper and adjacent areas which have been cleared and/or seeded. Determine the effects of vegetation conversion on soil physical properties and soil stability. Ecologically evaluate sites before and after as to phenology, composition, and production of vegetation. Evaluate the economics of conversion practices in terms of the watershed values and multiple use relations. Obtain data necessary for determination of hydrologic soil cover complexes on the study sites.

ECONOMICS OF WATER MANAGEMENT

Martin, W. E.

"Determining and sharing costs and benefits from development of the central Arizona watershed", University of Arizona, Department of Agricultural Economics, Agricultural Experiment Station, Tucson, Arizona.

OBJECTIVE: Develop recommendations and procedures that can be used by the Arizona Watershed Committee to determine the economic feasibility of any program of watershed management it may propose, and to suggest a feasible plan for financial sharing of costs and benefits among affected parties.

APPROACH: The Department of Agricultural Economics will work with the Department of Watershed Management and the U.S. Forest Service in developing recommendations for arrangements applicable in the Arizona watershed program.

Rosenberry, P. E.

"Technology and economics of conservation", Iowa State University, Agricultural Experiment Station, Water Resources Research, Ames, Iowa.

OBJECTIVE: Determine and evaluate the economic aspects of current and developing technology of water management. This will include evaluating the effectiveness of alternative terrace systems and other land treatment measures in managing the flow of surface water to more effectively utilize precipitation in crop production through control of runoff, reduce soil fertility losses from sheet erosion, control gully growth, and reduce downstream sediment and flood damages. Associated effects will be analyzed including the maintenance or improvement of soil productivity, pollution abatement, efficiency of machinery use, and the land area removed from production as a result of the water management measures adopted.

APPROACH: The first step will be a comparative cost study of alternative types of terraces as applied in the North Central Region. The analysis will consider slope, soils and methods of construction. The large, parallel, grassed-backslope terraces currently receiving widespread acceptance will receive particular attention. Additional studies will evaluate the effectiveness of representative terrace systems and other measures in producing various on-site benefits.

Douglas, J. L.

"The economic impact of flood control reservoirs", Water Resources Institute, University of Kentucky, Lexington, Kentucky.

OBJECTIVE: To examine the consequences of four flood control projects in Kentucky on a post-ordered basis in order to determine whether cost and benefits actually realized correspondeto those predicted during project planning.

APPROACH: Specific topics to be studied include: (1) Deviations between planning and historical costs. (2) Effect of project

construction on local employment, (3) historical operation and maintenance, (4) right-of-way costs and cost incidence, (5) project build-up,(6) project effect on local economic activity and local economic structure, (7) project effect on public facilities and community services, (8) local public attitude concerning project, (9) non-flood-control benefits, (10) project effect on local tax revenues.

Brewer, D. and West, J. G.

"Water resource developments", University of Missouri, Agricultural Economics Department, Agricultural Experiment Station, Columbia, Missouri.

OBJECTIVE: Investigate the patterns of adjustments resulting from water resource projects. Provide indications of the changes which are likely to occur as a result of efforts to develop the water resource. Identify factors important in the rate of adjustment and to suggest alternative approaches which may be used to facilitate adjustments.

Forste, R. H.

"An economic analysis of water supply and demand in the Biscataqua River Watershed", University of New Hampshire, Durham, New Hampshire.

OBJECTIVE: To determine the aggregate and specific supply and demand functions for water by users in the Biscataqua River Watershed of New Hampshire. A second objective of this study is to specify the characteristics of procurement and distribution that will minimize the cost of allocating the supply of water among the various specific uses that presently exist in watershed. The third objective is to project the future supply of and demand for water by uses in the watershed and provide management alternatives available to concerned policy formulators.

APPROACH: Projections will be made via the normally acceptable statistical techniques of regression analysis. Monetary values placed on each water use will be determined using both market and non-market pricing criteria where applicable.

Maki, T. E., Lammi, J. O., Hafley, W. L., and Steensen, V. J.

"Economic evaluation of changes in land use , the municipal watershed as a guide to decision-making", University of North Carolina, Graduate School, Raleigh, North Carolina.

OBJECTIVE: To determine what increases in streamflow might be affected through alternative treatments and what the net benefits from such treatments would be.

APPROACH: The proposed research involves two major phases, the first phase of which consists mainly of photogrammetric analyses of six sets of photos taken at varying intervals over a 30 year period, supplemented by field investigations, to delineate the nature and extent of changes in land use over the past 40 years on the 168-square mile Lake Michie Municipal Watershed near Durham, North Carolina. Concomitantly, the Lake Michie reservoir records would be examined and compiled to provide data on variation and yield, quality, and treatment costs of the water over the same 40 year period. The data on land use changes and on weather factors would comprise the variables against which the reservoir water records would be assessed and correlated by appropriate statistical techniques. The second major phase consists of an appraisal of research results that several hydrologic stations where vegetative cover manipulation has been studied in relation to streamflow. Relative treatments would be selected and applied hypothetically in kind and degree to cover types on the Lake Michie Watershed after a detailed field investigation of the composition and the condition of the existing vegetative cover of the watershed. Finally, an attempt will be made to develop guides that will be helpful to managers of municipal watersheds in decision-making.

PLANNING AND OPERATIONAL MODELS

Martin, W. E. and Crouse, R.
"Economics of multiple-use water in originating watersheds in Central Arizona", University of Arizona, Water Resources Research Center," Tucson, Arizona.

OBJECTIVE: To devise an operational model for the termination of the economic optimum of joint production of timber, grazing, recreation and outflowing water that might be produced from water supplies available on central Arizona watersheds.

APPROACH: The imperical adequacy of the model devised will be tested by applying it to a selected watershed for the economic relation between the products, timber, grass and outflowing water, will be investigated. The technological relations of the complementarity, nutrality, and competitiveness between these three water-use products will be synthesized from other research and from the experienced judgements of other scientific investigators. Demand functions for products will be estimated by drawing on other available data and investigations. Having formulated the production possibilities surface and the demand functions for the three products, derivation of the economic optima in the joint production of timber, grazing and outflowing water from the water supply available in the selected watershed becomes a straightforward mathematical(and/or graphic) procedure defined by economic theory.

Nobe, K. C., et al.
"The economics and administration of water resources", Colorado State University, Natural Resources Center, Fort Collins, Colorado.

OBJECTIVE: To estimate the economic value of the alternative, high altitude, watershed manipulation practices. To relate Colorado's system of legally defined water rights to engineering-hydrologic criteria for the improved specification of the rights. To specify how water management organization can best adapt to a changing pattern of public water management objectives in a historically developed water management system where existing supplies are fully appropriated. To specify the relationships between "base studies" of a regional economy and the economics of system design to meet specific demands. To estimate the value of water and wet lands in wildlife recreation using comparison with alternative uses.

James, L. D.
"Economic analysis of alternative flood-control measures", University of Kentucky, College of Engineering, Lexington, Kentucky.

OBJECTIVE: To develop a program for a digital computer which will determine the optimum flood-control plan for given input conditions. To test the sensitivity of the analysis to changes in interest rate, urban growth projections, flood frequency, etc.

APPROACH: The proposed analysis will make use of previous research on the economic advantages of various combinations of channel improvement, reservoir storage, flood proofing, and land use adjustment. The emphasis will be on small watersheds in areas of urban growth. An attempt will be made to link available computer programs for developing a continuous synthetic hydrograph and flood routing through complex channel-reservoir systems with the developed program for flood-control planning.

Timmons, J. F., Shrader, W. D.

"Physical and economic analysis of watersheds", Iowa State University, Agricultural Experiment Station, Ames, Iowa.

OBJECTIVE: Update and refine physical inputs which are needed for solution of various economic problems of soil, water, and land use on a watershed basis. Economics methodology studies include use of linear programming and computer techniques and various adaptions of cost-benefit analyses.

APPROACH: Physical studies in progress or planned include studies of the effect of plant cover and cultural practices on defined segments of the hydrologic cycle on watersheds which range in size from about 2 to 500 acres.

Holtan, H. N.

"Hydrologic systems analyses for synthesis of runoff and streamflow regimes", U. S. Department of Agriculture, Soil & Water Cons. Res. Division, Beltsville, Maryland.

OBJECTIVE: Develop concepts and computational procedures for optimizing watershed development programs for the best use of soil and water resources; develop techniques for the prediction of long-term water yields; and develop and test new concepts in hydrograph analysis

APPROACH: This project applies computational techniques and procedures toward synthesizing the hydrologic performance for comparison with records obtained on gaged watersheds. Such applications indicate deficiencies in existing techniques and delineate areas of needed basicc research. Long-term records solicited from ARS projects and other agencies are analyzed to derive prediction equations for water yields, for soil moisture accounting as affected by climate, soils, vegetation, and geology; and to explain discrepancies between probabilities of rainfall and probabilities of runoff. The investigations are interdisciplinary, involving all members of the Hydrograph Laboratory and extensive participation and cooperation of Division personnel at other locations. Contracts and cooperative agreements are entered into with Federal, State, and private agencies when desirable and feasible.

Cadman, T. W., and Munno, F. J.

"Simulation of water resource regimes", University of Maryland, School of Engineering, College Park, Maryland.

OBJECTIVE: To simulate water resource regimes for analysis with analog computers.

APPROACH: Typical of the regimes to be studied are those such as the surface flow in a watershed, and espuarine system, for ground water supply and waste disposal. Initially, emphasis will be on the training of faculty members in the analog simulation and application. Subsequently, faculty members will utilize this knowledge in broader water resources research problems.

Mallory, C. W., Boland, J. J., and Horn, D.

"System study, design, and evaluation of the local storage, treatment, and reuse of storm water--Department of Interior", Hittman Associates, Incorporated, Ellicott City-Columbia, Maryland.

OBJECTIVE: To determine the economic technical feasibility of using systems for the local storage, treatment, and re-use of storm water as a method for providing pollution control. To synthesize a hydrograph using mathematical expressions derived by regression analysis techniques to predict the runoff from ungaged watersheds following urban development.

APPROACH: In the determination of the economic and technical feasibility of using local storage, treatment and re-use of storm water as a method for providing pollution control, the benefits derived from the re-use of storm water are used to offset the cost of pollution control. A system analysis technique is used to evaluate the various combinations of systems components, possible plant locations, and quality and quantity of re-use. The systems were optimized by computer techniques based on a net system cost given local site conditions as constraints. The cost of pollution control by conventional means and the value of the re-used water were taken as benefits. Four systems are considered for application to the Wildelake Watershed in Columbia, Maryland. Three are based on the local storage concept and the fourth is a design for pollution control of the same area using conventional design approaches and methods.

Carlozzi, C. A., et al.

"Program selection of optimum uses of a small water resource subjected to complex simultaneous demand stresses", University of Massachusetts, School of Agriculture, Amherst, Massachusetts.

OBJECTIVE: To develop methods for relating the demand-supply information to determine present or anticipated stress of the water resource. To simulate alternative use schedules and management inputs and tests fo optimum economic choices under various erradical management and use schemes. To develop methods for the graphic interpretation on watershed maps of probable sequential changes in the supply-demand relationships among the major water users. To develop methods for expressing the graphic

information derived as a series of alternative for choice in integrated watershed planning. To develop a computer graphics program that has applicability to integrated watershed planning generally and that can present complex multi-variate economic and statistical data in form easily assimilable and meaningful to planners and decision-makers in public and private roles.

APPROACH: This integrated project will draw information on water use and management from several disciplines: forestry, fisheries, wildlife ecology, resource planning, economics, engineering, business management and recreation. This will lead to an improved method for attaining use of a small water resource by analyzing and synthesizing diverse data on water demand and related supplies through the tools of computer graphics and multi-variate systems simulation.

Wyckoff, J. B.

"Economic analysis of coordinated watershed planning", University of Massachusetts, Agricultural Experiment Station, Amherst, Massachusetts,

OBJECTIVE: Determine the private costs of meeting water quality standards in a selected watershed. Synthesize the cost of meeting water quality standards through coordinated planning of a watershed. Examine the institutional setting affecting coordinated watershed planning. Examine the social costs and benefits associated with alternative water quality levels.

APPROACH: A watershed within the state ordered to improve its water quality will be studied in detail. Each individual firm and community is essentially solving their own problem. The private costs involved will be determined. Public health records will be utilized to determine the quantity and quality of effulent discharge by each in the watershed and aggregated for the stream total. An optimum treatment system, planned on a coordinated watershed basis, will be programmed considering alternatives. The legal, political, social, and economic institutions affecting coordinated planning will be determined and evaluated. Implications of the existing institutions relative to the efficiency of coordinated planning will be studied. The social costs and benefits of water quality will be determined. The framework provided by welfare economics will be used to determine the net effects upon society.

Boyd, B. W., and Williams, T. T.

"Development of a state water planning model", Montana State University, School of Engineering, Bozeman, Montana.

OBJECTIVE: To develop a specially structured simulation model which will permit the rapid evaluation of a proposed river basin treatment and determination of the probability of achieving the desired goals.

APPROACH: The systems approach will be applied to the design of a state water planning model, by implementing orderly systems engineering methodology based on the thesis that the dominating factor in the complex system is a large quantity of information involved. The model will

incorporate such operation research techniques as simulation and input-output analysis. A sigma 7 digital computer will be utilized in the simulation of various management policies. Development of a single watershed model for the Yellowstone River Basin will proceed concurrently with the decomposition, analysis, and structuring of the state-wide system. The Yellowstone model will then be interacted with other aspects of the system, and will form a unit of the state water planning model.

Badger, D. D.

"Economics of developments in watersheds of Oklahoma", Oklahoma State University of Agr. & Sci., Agricultural Experiment Station, Stillwater, Oklahoma.

OBJECTIVE: Determine the actual and potential changes in use of flood plain land by farmers as a result of reduction in flooding. Develop alternative predictive models of flood plain land use change. Estimate the effect of watershed development upon farm real estate values. Determine the potential value of the water supply created by the floodwater retarding structures for irrigation purposes. Estimate the local secondary effects of the watershed development. Determine feasible institutional arrangements and probable costs of developing alternative recreational facilities. A survey of about 200 farm operators with flood plain land in the watersheds of the Washita River Basin will be made. Data from secondary sources will be used to identify major trends in the use of upland and bottomland in counties of the Washita Basin. Local and total multiplies effects of increases in agricultural revenue due to watershed development in the county will be estimated by mathematical techniques.

APPROACH: Write manuscripts. Continue study on legal aspects of recreational enterprises.

Poulton, C. E.

"Development of a model resource analysis for range watersheds", Oregon State University, Agricultural Experiment Station, Corvallis, Oregon.

OBJECTIVE: Develop and field test a practical method of resource analysis for use by B.L.M. personnel. Demonstrate how the information may be interpreted and used in management decisions. Coordinate field testing throughout the western region and revise the procedures as necessary to meet locally varying conditions. Provide specialized technical training of personnel as needed to insure successful application of the new method.

APPROACH: On sample areas selected to represent different kinds of range, apply knowledge from the tri-state contribution to W-25, "Ecology and Improvement of Brush-Infested Ranges," in an improved method of resource analysis. Refine aerial photo interpretation as a tool in analysis. Base field mapping on existing conditions,

not on interpretations. Map both vegetation and the physical environment. Mapping intensity will be such as to map pure, homogeneous types or no more than three different types within a single delineation. Where complexes are mapped, the percentage of each component will be estimated and they will be written up separately. Interpretations will be made on overlays or on photo mosaic copies. Detailed instructions will be prepared.

Bevan, D. V. and Paulik, G. J.

"Simulation of a water resource system", University of Washington, Seattle, Washington.

OBJECTIVE: To produce digital computer simulation models of a biological and hydrological sector of a water resource system.

APPROACH: The model will integrate biological and hydrological data, costs and benefits from conflicting and compatabile uses or development, and variable operating procedures. These simulation models will include stochastic components as well as structures that allow information feedback with both delays and amplifications. Particular emphasis will be placed on the development of sub-models to represent the population dynamics of cooplankpers such as various types of fresh water crustacea which feed upon phytoplanktom. Particular emphasis is being placed upon the representation of the effect of water flow and quality in the movement of anadromous fish in these models. The simulation model will apply the experimental approach of water resource systems. The model can be used to determine public policy decisions on the use of watersheds, and will be useful in the training of students of public administration.

HYDROLOGIC MODELS OF NON-CULTIVATED WATERSHEDS

Kisiel, C. C. and Duckstein, L.

"Efficiency of data collection systems in hydrology and water resources for prediction and control", University of Arizona, Graduate School, Tucson, Arizona.

OBJECTIVE: To contribute to the metodology for determining the worth of hydrologic and water resource data for prediction and control of water resource systems.

APPROACH: A hybrid computer will be employed to simulate a range of hydrologic situations in Central Arizona where data are available. The simulation model is to be formulated in the spirit of recent developments in stocastic and parametric hydrology and will employ operations research techniques as necessary. Data analysis requisite to such modeling include time series analysis and regional analyses.

Hickok, R. B. and Chery, D. L.

"Streamflow regimes of semi-arid rangeland watersheds in the southwest", U.S. Department of Agricultural, Soil and Water Conservation Research Division, Tucson, Arizona.

OBJECTIVE: Determine relations of streamflows to storm patterns, runoff source-area characteristics, and hydraulics of the stream channel system, and derive improved equations for predicting the flow regimes of complex watersheds.

APPROACH: Categorize storm patterns according to runoff-producing potentials and relate to frequencies of occurrence for particular localities, determine runoff response characteristic of varying land types and conditions as affected by topography, geology, soils, vegetation, and cultural practices, and determine runoff transmission characteristics on varying stream channel systems. Determine how runoff generation and down-slope runoff abstraction processes are affected by varying rainfall parameters, pending on land conditions, and the manner in which resulting runoff inputs to major channels are modified by hydraulics of the channel system to effect their outflow hydrographs.

Amorocho, J. and Brandstetter, A.

"Generalized analysis of small watershed responses", University of California, School of Engineering, Davis, California.

OBJECTIVE: To develop generalized procedures for the establishment of the relationships between inflow and outflow in natural watersheds, with full recognition of their non-linearity and parameter distribution characteristics. These relationships will be used in the reconstruction and prediction of hydrologic events.

Amorocho, J.
"Generalized analysis of small watershed responses", University of California, Agricultural Experiment Station, Davis, California.

OBJECTIVE: Expand theory of functional series representation to description of non-linear fiscal systems with particular emphasis on hydrologic system; investigate application of these non-linear methods of analysis to evaluation of responses of watersheds under action of rain.

APPROACH: Work will be conducted in theoretical area by development of necessary mathematical procedures of analysis; and in experimental field by laboratory experiments on small catchments and by analysis of small natural watersheds.

Anderson, H. W.
"Hydrologic analysis methods", U.S. Dept. of Agriculture, Pacific Southwest Forest & Range Experiment Station, Berkeley, California.

OBJECTIVE: Develop, test, and illustrate improved methods of analysis in forest hydrology.

APPROACH: Develop and evaluate variables that influence water yield, floods, and sedimentation. The variations in water yield are being related to rain and meteorological factors. Using past records of floods on many watersheds, land-use variables will be evaluated, after basic watershed characteristics and meteorological factors have been related to floods. Study the relationship between wildland watershed characteristics and suspended sediment discharge and disposition.

Linsley, R. K. and Crawford, N. H.
"A study of the hydrologic effects of rainfall augmentation", Stanford University, School of Engineering Palo Alto, Stanford, Calif.

OBJECTIVE: To use a watershed model, which effectively simulates the behavior of watersheds on a digital computer, as a basis for evaluating the probable hydrologic effects of rainfall augmentation for watersheds typical of several regions of the country.

APPROACH: Six watersheds will be selected as representative of typical climatological and hydrologic regimes of the United States. Each watershed will be modeled; that is, necessary parameters for hydrologic model will be determined by a study of actual records. Actual rainfall over a period of thirty years will be fed into the computer as input, with appropriate instructions to increase the observed amounts to simulate rainfall augmentation by 5, 10, and 15 per cent. The outputs in the form of evapotranspiration, soil moisture, stream flow, flood peak frequency, sediment yield, and other factors will then be computed for the thirty year period and compared with the actual occurrences to determine the possible effect of rainfall increase.

Holland, M. E.

"Multivariate analysis of small watershed rainfall-runoff relations". Colorado State University, School of Engineering, Fort Collins, Colorado.

OBJECTIVE: To select an effective set of variables for rainfall-runoff relations and with these variables to derive rainfall-runoff relations for small watersheds, to test their validity for various regions, especially arid and semi-arid.

APPROACH: An extensive research data assembly for small watershed floods will be divided into two data sets of approximately equal size. The first set of data will be used to derive relationships and the second will be used to evaluate them with independent information. Multivariate statistical analyses will be used to analyze the first data set. In particular, the principal component analysis will be the first step in determining the most appropriate groupings of the variable. These results will be studied to find physical justifications for factor groupings and the relationships may be modified by a factor analyses.

Yevjevich, V.

"Mathematical modeling of small watershed floods", Colorado State University, Agricultural Experiment Station, Fort Collins, Colorado.

OBJECTIVE: Characterize response of small watersheds to rainfall in terms of mathematical relations among physical parameters of the watershed. These relations will then be used to predict runoff hydrographs for floods from small watersheds.

APPROACH: Statistical correlation of watershed parameters will be made with runoff; investigate models developed from concepts of physical processes at work in runoff; coordinate with the related project involving a one-acre experimental facility for rainfall-runoff experiments. Data from actual flood events will be added to the existing small watershed data file.

Jones, E. B., Sopper, W. E. and Hiemstra, L. A.

"Hydrologic behavior of selected watersheds in the Northern Appalachian Region", U.S. Dept. of Interior, Bureau of Reclamation, Denver, Colorado.

OBJECTIVE: To develop a procedure for predicting hydrologic behavior of watersheds in the Northern Appalachian Region including the impact of the application of precipitation modification techniques.

APPROACH: Representative watershed will be selected and certain existing simulation techniques will be utilized, (be modified as necessary to better meet regional conditions). Once the simulation techniques have been finalized, the effect that weather modification might have on the stream flow will be studied for periods of overflow.

Fletcher, H. C., Hoover, M. D. and Leaf, C. F.

"Skywater-park range forest hydrology", U.S. Department of Interior, Bureau of Reclamation, Denver, Colorado.

OBJECTIVE: To study the effect of forest cover and land management so that the result of possible changes can be segregated from achievements of the weather modification program.

APPROACH: Available information is used to develop a conceptual non-linear model of snow melt runoff in which stream flow is the transformation of generated snow melt by a watershed system that delays, modulates, and attenuates input and compared to output.

Hamon, W. R. and Lipscomb, G. H.

"Reynolds Creek Experimental Study", U.S. Department of Agriculture, Northwest Hydrology Research Center, Boise, Idaho.

OBJECTIVE: To collect streamflow, surface runoff, precipitation, sediment, infiltration and similar hydrologic data and to select or develop an infiltration model for the prediction of surface runoff; establish values of the model parameters for selected soil-cover complexes; and where possible, relate the parameters to soils, cover, precipitation intensity, and landfall.

APPROACH: Using data obtained from natural and simulated events, sediment runoff relationships will be established for each selected soil-cover complex; and where possible, parameters will be related to quantitative measures of precipitation, soils, cover and landfall.

Delleur, J. W. and Blank, D.

"Assembly and analysis of hydrologic and geomorphologic data for small watersheds in Indiana", Purdue University, School of Engineering, Lafayette-West Lafayette, Indiana.

OBJECTIVE: The ultimate objective of the project is the development of prediction methods for streamflow forecast for ungaged basins in Indiana.

APPROACH: A computer-oriented assembly and a retrieval system will be developed for hydrologic and geomorphologic data for watersheds from 2 to 300 square miles in Indiana. This will include approximately 55 watersheds for which a large number of single peak hydrographs will be digitized at 15 or 30 minute intervals. A number of hydragraphs and storm characteristics will be evaluated. The geomorophologic characteristics will be obtained from drainage and topography maps. Upon completion of the data assembly, the hydrologic response of the watersheds will be evaluated under varying rainfall and climatic conditions.

Ragan, R. M.

"Partial area contribution to stream flow", University of Maryland, School of Engineering, College Park, Maryland.

OBJECTIVE: To develop a simulation model of a watershed that will be capable of isolating components of the runoff cycle of the watersheds for intensive investigation.

APPROACH: Numerical investigations of data already available from a pair of well-instrumented research watersheds will be made using the the IBM 7094 Digital Computer. This study proposed is a continuation of work initiated under project B-003MD in September, 1968.

Showalter, A. K.

"Two or more phases of the water cycle", U.S. Department of Commerce Hydrologic Research and Development Laboratory, Silver Springs, Maryland.

OBJECTIVE: To develop and test an improved conceptual hydrologic model for application to operational river forecasting. The model must produce a synthesis of the continuous stream flow hydrograph.

APPROACH: The Stanford watershed model is one model that is being tested. A modification of current operational API method was made to provide a continuous hydrograph for comparison with other models tested.

Cooper, C. F.

"Computer simulation of effects of land management and weather modification on watershed ecosystems", University of Michigan, Graduate School, Ann Arbor, Michigan.

OBJECTIVE: Develop improved computer simulation models for preliminary evaluation of the effects of land use and weather modification on watershed ecosystems and on the quantity, quality, and timing of water yields.

APPROACH: Review existing simulation models. Test multivariants statistical techniques for mathematical description of ecosystem structure. Develop preliminary simulation model of a small forested catchment. Test and refine preliminary model against observed data. Determine response of hypothetical ecosystem to changes in weather inputs. Define gaps in existing data programs and analytical procedures.

Larson, C. L. and Machmeier, R. E.

"Effects of areial and time distribution of runoff supply on watershed hydrographs", University of Minnesota, School of Agricultural, St. Paul, Minnesota.

OBJECTIVE: To modify a mathematical model watershed recently developed in which the physical characteristics of all channels of a fourth-order, 21.35 square mile, idealized but representated watershed are specified. In the model, runoff supply excess rainfall is routed through the channel system by means of the differential equations governing unsteady flow, infinite difference form for numerical solution.

APPROACH: The model will be modified to permit variations in aerial distribution of runoff supply over the watershed. Experiments will be made with spacially varied input to the model, and the results will be used to determine what degree of storm coverage causes maximum crude flow. The shape of the watershed will then be varied systematically to determine the effects of typical shape types and various length-width ratios on peak discharge.

Larson, C. L.
"Study of the factors affecting the channel phase of runoff from small watersheds by mathematical modeling", University of Minnesota, School of Agriculture, St. Paul, Minnesota.

OBJECTIVE: To develop a detailed mathematical model of a watershed channel system, including tributory channels.

APPROACH: The length, cross-section, slope and roughness of each segment of channel will be varied independently. The input to the system will be overland flow of various durations and rates. The flows will then be routed through the various channel segments by the use of the basic equations of fluid mechanics governing non-steady flow in open channels, using finite difference solutions and a CDC 1604 digital computer. The results will be used to develop, if possible, a general relationship between channel characteristics and the time parameter.

Larson, C. L.
"Hydrologic characterization of small watersheds", University of Minnestota, Agricultural Experiment Station, St. Paul, Minnesota.

OBJECTIVE: Investigate use of mathematical, electrical, and physical models to study hydrologic phenomenon of watersheds.

APPROACH: Develop a comprehensive mathematical watershed model suitable for use in areas having freezing climates, use this model as a research tool to study basic factors involved in surface runoff, and their relationships. This would be done by using model on gaged streams, printing of intermediate data, and making studies with these data. Develop a suitable technique for synthesizing peak runoff from rainfall data for ungaged small watersheds.

Dunn, D. E.
"Computer simulation of the hydrologic system of a mountain watershed", Montana State University Graduate School, Bozeman, Montana.

OBJECTIVE: To simulate the hydrologic system of a small mountain watershed using digital computer techniques.

APPROACH: Both surface and sub-surface portions of the system will be included in the synthesis. Parameters in the model will be related to physical characteristics of the system. Initial estimates of the parameters will be based on field observation, and then the parameter values will be improved by trial and error matching of computer and protype stream-flow rate outputs.

Dunn, D. E.

"Comparison of field measurements to computer model results for Montana watersheds", Montana State University, Graduate School, Bozeman, Montana.

OBJECTIVE: To test the accuracy and applicability of a digital computer watershed model which is kindly being developed.

APPROACH: The model is a finite difference approach to simulation which uses chronologic weather data for input.Output can be water storage and head in any or all parts of the system and rate of transport of water from any part of the system to an additional part. The model will use watershed parameters which are potentially measurable. The accuracy of the model will be checked by comparing computer output to actual hydrologic measurements. The applicability of the model will be tested by field experimentation to determine the ease and accuracy of watershed parameter measurement estimation by experimenting with the model to learn how much computer time and expense is required for accurate simulation.

Stidd, C. K. and Guppa, V. L.

"Precipitation and runoff distribution analysis", University of Nevada, Desert Research Institute, Reno, Nevada.

OBJECTIVE: To apply the concepts of "spectral" and "linear system" analysis to the development of mathematical expressions relating precipitation to streamflow.

APPROACH: The convolution (Duhamel) integral: y(t) equals the integral between the limits of zero and t of h(Tau) x (t-Tau) d Tau; describes the approach when x and y are input (precipitation) and output (streamflow), t and Tau are time and time-lag and h is the transfer function that describes the basin response.

Metholodogies to be explored in the evaluation of the transfer function, h, will be (i) Fourier or Laplace transforms, (ii) direct methods, (iii) Weiner-Hopf equations.

Transfer functions will be studied to relate their parameters to observed hydrologic behavior of drainage basins in order to simplify the problem of making hydrologic estimates in areas of insufficient data.

Krygier, J. T. and Klindeman, P. C.

"Hydrology of water yield prediction", Oregon State University, Water Resources Research Institute, Corvallis, Oregon.

OBJECTIVE: To predict water yields from meteorological parameters for watersheds composed of heterogeneous vegetation, and to measure changes in water yield caused by logging. The long-range goals of the project will be to estimate measured water budget on plots and watersheds for meteorological parameters.

APPROACH: Small watersheds will be utilized in the Coast Providence for prediction purposes and to observe the magnitude of change in water yield caused by clear-cut logging. Water budget measurements will be made weekly or bi-weekly throughout the year on plots of douglas-fir and oak near Corvallis.

(Continued) Freely fluctuating plots and two functioning as open-ended lysimeters will be utilized. The measurements will consist of gross rainfall, net rainfall, soil moisture change and measured unsaturated flow. The latter will be organized as a separate research project. Water budgets on the plots will be estimated from incoming solar radiation, net radiation and air temperature, as measured above the forest stands.

Sopper, W. E.

"Characteristics of streamflow of small watersheds in Pennsylvania and influencing factors", Pennsylvania State University, Institute for Research on Land and Water, University Park, Pennsylvania.

OBJECTIVE: To develop predictive equations for water yield values based on climatic, edaphic, topographic and land-use parameters.

APPROACH: Research data from the Leading Ridge experimental watersheds operated by the School of Forestry will be used to develop water yield models which will then be tested on other selected watersheds to devise regional coefficients and to relate coefficients to watershed physiographic features.

Lull, H. W.

"Watershed analysis by correlation and synthesis; techniques for prediction of watershed behavior",

OBJECTIVE: Assembly, correlate, and synthesis forest watershed information for the prediction of the effects of forest watershed management practices on stream flow by major physiographic regions of the Eastern United States; and through research on municipal watersheds and correlative information determine the practices that will meet municipal water-yield and water-quality management needs.

APPROACH: Using long-term stream flow records from northeastern watersheds, this program will determine the hydrologic functions of forest cover on yield and distribution of stream flow, the effects of historical changes on land use, and the effects of present-day land use. It will also evaluate the present systems of determining hydrologic condition of forest land for river basin planning and flood prevention programs. In municipal watershed research, the staff will determine the effects of forest land treatment on increasing water yields through the use of numerous cooperative watershed studies.

Spath, P. C.

"Upper Bear Creek Experimental Project", U.S. Tennessee Valley Authority, Knoxville, Tennessee.

OBJECTIVE: (1) The development of methods to predict stream flow information for small head water areas from physical watershed measures and hydrologic data and project this information downstream to larger drainage areas and then develop techniques for using these projections and predicting methods to simulate hydrologic information on other areas where data are scarce or missing.

APPROACH: The approach will involve the development of a general computer program to solve non-linear equations, the development of mathematical models with generating parametric measures of stream flow, the detailed study of these mathematical models to assure that consistent results are obtained, a factor analysis study of the physical measures of watershed characteristics and the development of a model to relate stream flow parameters to the physical watershed it measures.

Spath, P. C.

"Development of hydrologic analyses techniques", U.S. Tennessee Valley Authority, Knoxville, Tennessee.

OBJECTIVE: The development of specific mathematical models and special studies aimed at improving hydrologic knowledge using data obtained from various dba watershed projects.

APPROACH: The approach includes the derivation, development, and verification of equations designed to simulate various aspects of hydrology and hydrologic response as these are related to land cover, topography, and other watershed characteristics so that watershed hydrology can be incorporated in land-use improvement plans.

Riley, J. P., Chadwick, D. G. and Israelsen, E. K.

"Application of an electronic analog device to solution of hydrologic and river basin planning problems", Utah Center for Water Resources Research, Utah State University, Logan, Utah.

OBJECTIVE: (1) To develop, improve and evaluate basic hydrologic functional relationships for possible use in an electronic computer. (2) To make design improvement in the electronic analog by increasing its flexibility, reliability, and facility of use.

APPROACH: Information from well-instrumented experimental watersheds will be utilized to test the relationships and final computer design resulting from this work.

Downer, R. N.

"Parameterization of the observed hydrograph as a means of understanding runoff phenomenon from small watersheds," University of Vermont, School of Engineering, Burlington, Vermont.

OBJECTIVE: The primary objective of this investigation will be to develop an analytic method of fitting a mathematical model to the observed hydrograph and to express this model by parameters which can be related to measureable watershed characteristics.

APPROACH: The study will involve the fitting by means of the computer of a form of the incomplete gama function to the observed hydrographs from a small watershed. Incidental to this work will be the establishment of criteria for goodness of fit. Once fits have been made for many storms statistical procedures will be used to establish relationships between

the parameters of the hydrograph and the causative factors. Having developed adequate relationships between the parameters of he hydrograph and their caustive factors for a gaged watershed, an attempt will be made to extend methodology to ungaged watersheds typical of the northeast.

Gladwell, J. S.

"Runoff generation as a function of precipitation and watershed chacteristics", Washington State University, State Water Research Center, Pullman, Washington.

OBJECTIVE: To define quantitatively the effect of physical and climatological parameters of western Washington watersheds on the transformation of effective precipitation into runoff.

APPROACH: Through the use of parametric coefficients it is planned to study the possibility of generating synthetic hydrographs in areas with no runoff gages, and extensions of current gage histories through the use of precipitation information. It is hoped also to explain variations in probability distribution between watersheds relatively close together.

Campbell, D. H.

"The study of serial correlation in annual stream runoff", University of Washington, School of Engineering, Seattle, Washington.

OBJECTIVE: (1) To improve existing stochastic models of annual stream runoff by including the variability of the serial correlation coefficient, and to apply the resulting model to methods of studying the probability of periods of drought or of excessive runoff. (2) To relate the serial correlation coefficient to physical watershed parameters.

APPROACH: Streams with sufficiently long historic records will be analyzed for variability of the serial correlation coefficient, which reflects the carry-over effect from a relatively wet or dry year into the following year. Methods for determining this variability will be evaluated. Methods for studying periods of drought or of water excess will be involved.

Gessel, S. P. and Wooldridge, D. D.

"Methods of analysis and determination of effects of alternative uses of forested lands on stream flow", University of Washington, Graduate School, Seattle, Washington.

OBJECTIVE: To investigate: (1) The effects of forest management, harvesting regimes, and alternative uses of forest lands on hydrology of certain river basins in Washington. (2) The application of multivariate statistics for evaluation of alternate land uses and design of complex hydrologic models. (3) Development of analog computer models for solution of complex hydrologic problems involving alternative uses of forest lands.

APPROACH: Long-term U.S. Geological Survey stream flow records will be used with climatological records in multivariate analysis to develop regression equations for predicting daily stream flow. Major changes in vegetative cover which alter water yield should result in significantly different equations.

These equations will be used to develop analog models of the influences of various parameters and treatments on water yield of a river for a variety of physiography conditions.

Gessel, S. P. and Wooldridge, D. D.

"Effects of forest cover manipulation on water yield as studied by an electrical analog", University of Washington Graduate School, Seattle, Washington.

OBJECTIVE: (1) To establish electric analogy models for study of the impact of forest cover manipulation on water yield for certain soils, forest types and climatic zones in Washington State. (2) To use these models to evaluate the influences of combinations of precipitation and temperature extremes in addition to varying densities and ages of forest stands.

HYDROLOGIC MODELS OF URBAN WATERSHEDS

Hilpman, P. L., Steward, G. F., Dingman, R. J., et al.
"The effect of urbanization on small drainage basins", State Geological Survey of Kansas, University of Kansas, Lawrence, Kansas.

OBJECTIVE: To investigate the physical and biological changes in small drainage basins brought about by the transition from rural to urban land use.

APPROACH: The initial phase of the project will consist of a complete survey of the geological, zoological and botanical conditions of a small (4-square-mile) rural drainage basin adjacent to a rapidly expanding urban area. After completion of the survey the drainage basin will be re-evaluated on an annual basins over a 4- to 5-year period in an attempt to correlate changes noted with increasing urban influence. Meteorological and hydrological data will be recorded continually throughout the study period.

Delleur, J. W.
"The effect of urbanization on runoff in small watersheds - Phase B", School of Civil Engineering, Purdue University, Lafayette, Indiana.

OBJECTIVE: To study the effect of varying degrees of urbanization on the rainfall-runoff relationship and on runoff quality in pre-urban, sub-urban and urban watersheds principally in Indiana and to develop design criteria for urban drainage systems.

APPROACH: The following watersheds will be used: a) The Ross Ade Drain Upper and lower Watersheds having areas of 29 and 333 acres respectively, covering a fully developed suburban development and a portion of the Purdue Campus, respectively b) The Purdue Swine Form covering three watersheds totalling approximately 700 acres which are in the pre-urban stage and several stages of suburban development. In addition rainfall and runoff data, (but no water quality information) will be obtained for a downtown section of Indianapolis and Freeman Air Force Base and possibly other urban locations in Indiana. The data obtained will be analyzed by means of conceptual and/or mathematical models simulating watersheds with varying degrees of urbanization. As part of the water quality study, measurements will be made of total solids, suspended solids, dissolved oxygen, BOD, specific conductance, temperature, pH, chloride, amonia, nitrite, nitrate, phosphate, herbicide and pesticide. A Sociological study will also be made to evaluate man's attitude towards the temporary failure of an urban or suburban drainage system to evacuate complete and temporary failure of an urban or sub-urban drainage system to evacuate complete and immediately the surface runoff. It is expected that this evaluation will lead to the formulation of a decision making structure that will guide in the choice of design criteria.

Rao, A. R. and Delleur, J. W.
"Effect of urbanization on hydrology of watersheds", Purdue University, School of Engineering, Lafayette-West Lafayette, Indiana.

OBJECTIVE: To develop mathematical models which would characterize the effect of urbanization on runoff.

APPROACH: Data from watersheds of varying degrees of urbanization in West Lafayette, Indiana, as well as from other watersheds located in Indiana and elsewhere will be used. Data analysis will be carried out by means of conceptual and/or mathematical models simulating watersheds of varying degrees of urbanization. Both digital and analog simulations will be attempted. Linear and non-linear mathematical models will be used to investigate the effect of urbanization on runoff. For analog simulation a simulator which has the capacity to simualte up to five linear reservoirs in series has been built. This simulator will be developed further to simulate a series of non-linear reservoirs. After suitable models are selected, it is proposed to develop a design manual based on the results of the study for the use of practicing engineers.

Remson, I., and Fungaroli, A. A.
"Hydrologic models for predicting the effects of urbanization", Drexel Institute of Technology, School of Engineering, Philadelphia, Pennsylvania.

OBJECTIVE: (1) To complete an initial study on modeling for soil moisture and ground water movement by extending it to include overland flow, ground water discharge to streams, streamflow and other hydrologic phenomenon. (2) Testing of the validity of the model against a protype watershed.

APPROACH: Presently, it is planned to do this in conjunction with a study of urbanization and regional planning in the Brandywine watershed by personnel of the Institute for Environmental Studies at the University of Pennsylvania and the Regional Science Research Institute. Use of the model to determine hydrologic effects of different urbanization, growth patterns.

Jameson, D. L.
"A model relating waterquality, vegetational structure and urbanization in the San Gacinto River Basin", University of Houston, Graduate School, Houston, Texas.

OBJECTIVE: To analyze the correlation between vegetational structure, amount and kind of land utilization, urbanization and the chemical and biological measures of water quality in the San Gacinto River Basin.

APPROACH: The initial parameters will be obtained from government documents, reports already available are currently obtained (weather and hydrograph stations). Principal component analysis will be used for data reduction. Kanonical correlation analysis will be used to obtain a preliminary estimate of the significant parameters. Multiple

discriminate analysis will be used to identify the significant variables correlated with specific water quality stations. The data from these analysis will be used to construct a model which will characterize the present situation. The parameters of this model will then be manipulated with simulation programs in computers to attempt to predict the course and nature of water quality changes during the continued expansion of urbanization in the vicinity of Houston, Texas.

Riley, J. P., Chadwick, D. G., and Israelsen, E.K.
"Application of an electric analog computer to the evaluation of the effects of urbanization on the runoff characteristics on small watersheds", Utah Center for Water Resources Research, Utah State University, Logan, Utah.

OBJECTIVE: 1) Develop, improve, and evaluate fundamental mathematical relationships for describing the various processes which occur within an urban watershed, (2) Synthesize these relationships into a dynamic watershed model by means of an electronic analog computer.

APPROACH: The background of the experience already obtain in analog modeling will be applied to the development of a basic model of urbanized watersheds. The model will be verified by simulating both field and laboratory pro-type watersheds.

Riley, J. P., Chadwick, D. G., and Israelsen, E. K. and Narayana, P.B.
"Computer simulation of urban hydrologic systems", Utah State University, Utah Center for Water Resources Research, Logan, Utah.

OBJECTIVE: To classify an urban watershed into a number of homogeneous sub-units and to apply the equations of gradually varied, unsteady flow in open channels to describe the mechanics of runoff.

APPROACH: To extend the work performed under a previous project (The 016-Utah). Under the previous work, urbanization factors were expressed as parameters that define an equivalent rural watershed in a lumped system. In this study, the urbanization factors, were accounted for by analyzing each unit of the watershed. It is anticipated that the results of this study will be useful in the design of drainage structures on an urban micro-watershed basis.

FLOOD MODELLING

Gonzales, D. D.
"Flood frequency in Urban areas, Colorado", U.S. Department of Interior, Water Resources Division, Denver, Colorado.

OBJECTIVE: To collect data in type areas and develop rainfall runoff relations that can be extrapolated to all small watersheds in the metropolitan areas of the 6-county area surrounding Denver.

APPROACH: Rainfall and runoff data will be collected in at least four drainage basins in the 6-county area. The basins will be selected to sample the following ranges in basin parameters" (a) Size: 40 acres to 10 square miles; (b) Cover: Natural to completely impervious; (c) drainage appurtenances: Fully sewered to non-sewered: (d) Development: Natural to fully urbanized, the natural basins being subject to development in perhaps 15 years. Rainfall data will include continuous records of rainfall at one or more sites in each basin, supplemented by data from standard rain gages. The runoff data will include continuous records of outflow from each basin, supplemented where desirable by crest gages to record peak stages at other locations in the basin.

Yevdjebich, V. M., and Holland, M. E.
"Design floods for small watersheds in the area, semi-arid west", Colorado State University, Fort Collins, Colorado.

OBJECTIVE: To further pursue the effects of short duration storms with different intensities on the predictions of runoff in an effort to improve existing prediction methods.

APPROACH: The study will use processed data already available in the small watersheds file of Colorado State University. The optimum storm duration for different designed storms on small watersheds with different size ranges and in different hydrological conditions will be investigated. Results will be presented in a form which makes the selection of optimum storm duration possible for specific conditions. Existing methods of flood prediction will be modified to incorporate this refinement and this form of duration.

Yevdjebich, V. M., Smith, G. L., and Holland, M. E.
"Floods from small watersheds", Colorado State University, School of Engineering, Fort Collins, Colorado.

OBJECTIVE: To study the flood response of rural watersheds within the size range of 1-5th to 50 square miles distributed throughout the United States.

APPROACH: Systems investigations will be undertaken with theoretical conditions involving rainfall as input and runoff as output. Hydrodynamic prototypes will be investigated by applying artificial rain to a 1- to 2-acre outdoor facility. Provisional results from both of these will be checked against, and appraised in the light of, storm and flood events observed in the nature on many experimental and other watersheds. This latter data assembly, which is already underway, will

itself facilitate statistical and hydrological analyses of natural basin response.

Snyder, William M. and Jones, C. C.
"An urban hydrology study in East Point, Georgia", School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia.

OBJECTIVE: To statistically define the frequency and the extent of flooding of river areas.

APPROACH: Continuous rainfall and streamflow data will be obtained on three small urban watersheds within the city limits of East Point. Various subjects to flooding are determined. Impervious various buildings, pavements, are measured and located as sources of high intensity runoff. Flooding will be related to rainfall frequency, to drainage area, to surface features, and to other factors as necessary to establish working methods in urban drainage design.

Robertson, A. C., and Bloomsburg, G. L.
"Hydrology of frozen ground floods", University of Idaho, Water Resources Research Institute, Moscow, Idaho.

OBJECTIVE: To relate infiltration rates of frozen ground to parameters of moisture content of the soil, temperature of surface water, and time, to apply these relationships to hydrograph studies of surface runoff under frozen ground conditions.

APPROACH: Infiltration rates into frozen soil columns under various temperature and moisture conditions will be measured in the laboratory. Relationships developed from the data will be tested and hydrographs studies from a small watershed and in examination of past measured frozen ground floods in the region.

Harria, S. E.
"Flood analysis in Carbondale area, Illinois", Southern Illinois University, Carbondale, Illinois.

OBJECTIVE: To compute flood levels using standard hydrologic engineering methods.

APPROACH: Rainfall data, drainage area, runoff from the city have been analyzed and is being evaluated against the physical conditions of the low-land areas and their channels. The results will be compared with those obtained by past observations and the computations made by other agencies.

Ellis, D. W.
"Flood-frequency study, Illinois", U.S. Department of Interior, Water Resources Division, Champaign, Illinois.

OBJECTIVE: To develop a technique for estimating the magnitude and probable occurrence of floods at ungaged sites.

APPROACH: Data collected through the 1966 water year will be used as the base to identify and correlate the parameters.

EROSION AND SEDIMENTATION

Renard, K. G., and Libby, F. J.

"Sediment yield from rangeland watersheds in the Southwest", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Tucson, Arizona.

OBJECTIVE: Develop methods for predicting sediment amounts, types, and delivery characteristics from agricultural watersheds of varying sizes, physiography, land use and management.

APPROACH: Establish factors governing amounts and types of sediments produced and their transport. Determine sediment loads in streams and deposited in reservoirs, relating these to rainfall, runoff, topography, geology, soils, land use, and cultural practices. Identify and evaluate production of various types of sediment sources areas, and determine and characterize sediment delivery processes to derive improved equations for estimating sediment yields.

Ziemer, R. R.

"Flood and sediment reduction in the coniferous timber zone in California", U. S. Department of Agriculture, Pacific SW Forest & Range Experiment Station, Berkeley, California.

OBJECTIVE: Develop management methods that will minimize local floods, erosion and sedimentation, mainwater quality, and improve timing of streamflow; and to develop methods for predicting the effects of forest and land management practices upon sedimentation and streamflow.

APPROACH: Studies of gravitational mass movement will continue; resurveys of inclinometer holes will determine rate and location of surface and subsurface creep; and aerial photo comparisons will point out causes of landslides. Continue to study the effects of logging on streamflow, sedimentation, and fish habitat, and current studies will relate soil moisture to logging effects and to moisture storage opportunities for flood abatement.

Shen, H. W., and Simons, D. B.

"Sedimentation and contamination criteria for water resources planning and management", Colorado State University, Department of Civil Engineering, Agricultural Experiment Station, Fort Collins, Colorado.

OBJECTIVE: Study the effect of vegetation on flow rates, sediment yield and dispersion of contaminent (attached to soil), during surface runoff in watershed.

APPROACH: Cylinders and other flexible elements will be inserted in laboratory flume to simulate vegetation. Radioactive and fluroescent tracers will be used to study the movement of contaminant material and sediment yield. Analysis will be made from a combination of stochastic and analytical approaches.

Bwer, C. E., Shrader, W. B., Moldenhauer, W. C., Johnson, H. B., and Larson, W.E.
"Investigations of erosion control and water conservation", Iowa State University, Agricultural Experiment Station, Ames, Iowa.

OBJECTIVE: To study and quantitatively evaluate the factors associated with soil erosion.

APPROACH: Analysis to date have provided information for use and the design of more efficient methods of soil and water management. This has been accomplished through develop ment of factors used in the universal soil loss equation and a quantitative expression for prediction of gulley development. The procedures used in the research include data collection from instrumented watersheds in small plots. The watersheds vary in size from 7 to 14 square miles and are instrumented for precipitation measurement, amount and rate of runoff and sediment production and detailed changes in land cover and erosion development.

Megahan, W. F.
"Preventing or controlling accelerated erosion of unstable forest soils--Northern Rocky Mountains", U.S. Department of Agriculture, Intermountain Forest & Range Experiment Station, Boise, Idaho.

OBJECTIVE: Determine the effects of climate, vegetation, and land use on the unstable soils of the Idaho batholith, and develop practices to maintain or improve soil stability.

APPROACH: Research studies fall within four problem areas: watershed function under natural forest conditions of the Idaho batholith; instability caused by road constructions: measurement of erosion and effect of stabilizing vegetation on road fills; erosion induced by logging; and stabilizing slopes: testing adaptability of native and introduced plants, alone and in combination with mechanical and chemical treatments.

Kohnke, H.
"Relationship between the erodibility of soils and the sedimentation rate of reservoirs", Purdue University, School of Agriculture, Lafayette-West Lafayette, Indiana.

OBJECTIVE: To determine the soil properties that can be expected to contribute to sedimentability in watersheds that drain into reservoirs for which the sedimentation rates are known. An attempt will also be made to correlate measureable soil properties to the sedimentability of the soils studied.

APPROACH: THe study will attempt to relate the properties to the soils of the contributing watershed to the sedimentation rates. It will be assumed that these are related to the erodibility of the soils. However, the same amount of eroded soil material from two watersheds

will contribute different amounts to sediment to the reservoir, depending on the mechanical composition. Much of the sand is frequently deposited in the flood plains of other reservoirs while a big portion of the clay passes through the reservoir unless the electrolyte content of the water is quite high.

Wolman, M. G.

"Sources, movement, and distribution of sediment in a small watershed", Department of Interior, Water Resources Division, Baltimore, Maryland.

OBJECTIVE: To understand the system by which sediment is removed from the upland surfaces and makes it way downstream and thence out of the drainage basin.

APPROACH: Streamflow and sediment discharge are being measured at two locations, one located directly below a source area of 100 acres of agricultural cropland, the other downstream at one mile. Most of the intervening area is forested thus providing relatively little additional sediment inflow. Comparisons of particle size and sediment load by individual storms are being made. In addition, measurements of channel cross-section, particle movement, and slope processes are being made. Geomorphic studies including both stratigraphic observations and mapping are being undertaken to establish long-term trends and history in the drainage basin as a basis for evaluating and extrapolating relatively short-term measures.

Piest, R. F.

"Sediment yields from agricultural watersheds in the Corn Belt", Corn Belt Branch, U.S. Department of Agriculture, Soil & Water Conservation Research Division, Columbia, Missouri.

OBJECTIVE: Relate sediment yields in the Corn Belt to source areas of erosion and controlling factors; determine the nature of watershed delivery ratios in the Missouri Valley loessial region; determine the amount and cause of gully erosion; develop and evaluate criteria for gully stabilization.

APPROACH: Four gullied watersheds in the Missouri Valley loessial area were instrumented to furnish detailed field measures of most erosion-affecting hydrologic and sediment variables. Gully changes are being monitored and sediment yields are being determined. Study results will be extended by reconnaissance data that are to be collected at scattered locations throughout the region. The performance of level terrace systems will be evaluated. Special field tests will determine the stresses and the sequence of failure of gulley banks. Companion study involves a cataloging of gulley systems in several drainage basins for insight to the pattern of development of gullies and their age in historic and near-geologic times.

McDowell, L.L., Grissinger, E. H., and McHenry, J. R.
"Physical and chemical properties of sediments", U.S. Department of Agriculture, Sedimentation Laboratory, Oxford, Mississippi.

OBJECTIVE: Extend knowledge of the deleterious and beneficial physical and chemical attributes of sediments in runoff waters, in channel deposits, and in impoundments.

APPROACH: Obtain sediment samples for analysis and evaluation at selected sites in the Lower Mississippi River and some principal tributatries, in selected channels draining agricultural lands, and in selected reservoirs and impoundments. Factors involved include dispersion and flocculation tendencies, exposure to air and sunlight, water depths in reservoirs, age and depth of submerged sediments, and other environments.

Bowie, A. J., and Spraberry, J. A.
"Sediment yield in relation to watershed characteristics and hydrologic events", U.S. Department of Agriculture, Sedimentation Laboratory, Oxford, Mississippi.

OBJECTIVE: Determine watershed sediment yields and develop dependable, workable methods for estimating sediment yields from measurable watershed and hydrologic characteristics and conditions; develop pertinent instrumentation and techniques.

APPROACH: Utilize existing and newly develop instrumentation and techniques to acquire runoff, sediment yield, rainfall, and other hydrologic data on selected watersheds. Relate land use, cover, topography, soils, geology, conservation practices, and runoff qualities to watershed sediment yields.

Happ, S. C.
"Sedimentation on flood plains and in estuaries and harbors", U.S. Department of Agriculture, Sedimentation Laboratory, Oxford, Mississippi.

OBJECTIVE: Extend knowledge of: the amounts, rates and quality of valley sedimentation; the amounts, rates, and causes of channel deposition; the rates, amounts, causes, and location of deposits in valleys, harbors, and estuaries in relation to the flow regimen, basin geometrics, sediment characteristics and other things.

APPROACH: Determine the net effects over a period of 25-30 years of stream and valley sedimentation in selected valleys from a compilation of existing data, resurveys of established cross-sections, and supplemental measurements of selected alluvial fan deposits, streambank and gully erosion, and surveys of selected small reservoirs. Use C-14 dating techniques where appropriate.

Dendy, F. E., and McHenry, J. R.
"Reservoir sedimentation", U. S. Department of Agriculture, Sedimentation Laboratory, Oxford, Mississippi.

OBJECTIVE: Expand knowledge of sedimentation volumes and rates in various type reservoirs. Evaluate reservoir, watershed, and hydrologic factors affecting the deposition rate, density, and aread distribution of sediment and the trap efficiency of reservoirs. Develop instrumentation and techniques to measure significant variables.

APPROACH: Compile and analyze existing reservoir sedimentation data. Isolate and evaluate effects of significant parameters such as capacity-watershed ratio, capacity-inflow ratio, reservoir size and shape, spillway design and operating practices, and watershed and climatic characteristics on reservoir sedimentation. Use field and laboratory models. Study sediment bypass and discharge methods.

Morris, R. J.
"The study of the relationships between stream-water quality and watershed characteristics", University of Nevada, Desert Research Institute, Reno, Nevada.

OBJECTIVE: To test the feasibility of predicting certain stream-water quality parameters notabily, nitrogen, phosphorus, and sediment production.

APPROACH: To develop multiple regression prediction equations based on watershed characteristics, including information developed from and about soils, geology, physiography, vegetation, cultural practices, wild fires, and land use and development. The intent is to test this technique by attempting to develop meaningful prediction equations for several small watersheds covering a variety of vegetative and land-use conditions.

Anderson, B. W.
"Alluvial sedimentation in stony brook watershed", U.S. Department of Interior, Water Resources Division, Trenton, New Jersey.

OBJECTIVE: To develop improved technology for measurement of peak runoff from small areas.

APPROACH: Peak runoff rates from small watersheds are difficult and often impossible to measure by conventional methods. Use of a pond or small lake to capture and temporarily store most or all of such runoff from a given storm offers a direct volumetric solution. This solution requires that the capacity of a pond at different levels and the outflow, if any, be accurately known. It also requires that the change in level of the pond be observed or recorded frequently during the period of maximum runoff. The digital recording water

levels gage is being evaluated for this purpose. The research includes required frequency of data recording, required accuracy in the recording of water levels, the program for processing data through a digital computer and final presentation of results, and a study of the various sources and degrees of error.

Aldon, E. F.

"Watershed rehabilitation to control erosion and sedimentation in the Southwest", U.S. Department of Agriculture, Rocky Mountain Forest & Range Experiment Station, Albuquerque, New Mexico.

OBJECTIVE: Develop methods for restoring plant cover and controlling erosion on Southwestern watersheds.

APPROACH: The project staff is continuing to select and evaluate various plants for erosion control and to investigate sediment movement on Southwestern watersheds. They are initiating new studies on the hydrology of pinyon-juniper flood plains and factors affecting the stability and productivity of Cretaceous soils. They are developing prefabricated check dams for gully stabilization.

Clayton, L. and Tinker, J. R.

"Rainwash and soil creep in Western North Dakota", University of North Dakota, Graduate School, Grand Forks, North Dakota.

OBJECTIVE: To investigate slope processes and rates of slope erosion and drainage basin characteristics of two drainage areas in the Badlands of western North Dakota.

APPROACH: Field work will involve the study of types of slope processes, their intensity, their rates, and their relationship to climate and lithologic conditions. Direct observation and observation through time will be made to record changes in landscape features. Laboratory work involves a quantitative study of the "Form" factors of the drainage basin following Horton's and Strahler's work. Parameters to be considered are drainage density, stream frequency, hypsometric integral, Horton's number, basin shape, constant of channel maintenance, and ruggedness.

Cox, M. B.

"Water erosion control practices for the Central Rolling Red Prairies", U.S. Department of Agriculture, Wheat Land Conservation Station, Cherokee, Oklahoma.

OBJECTIVE: Increase knowledge of water erosion processes and define principles to provide a scientific basis for the development of control practices for any land surface such that the productive capacity of farm lands will not deteriorate.

APPROACH: Develop and test practices for the most effective use of plant cover, crop residues, and tillage techniques to reduce erosion through more rapid intake of water by the soil, less channelization of runoff, and reduced flow velocity. The studies involve terraces with soil and concrete channels and 24 small plots equipped with concrete gutters for collecting and sampling soil losses from various lengths of slope. Six small unit source watersheds for evaluating methods of residue management were used.

Allen, P. B.

"Sediment yield in relation to watershed features in the Southern Plains", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Chickasha, Oklahoma.

OBJECTIVE: Develop procedures for predicting the sources, amount, rate, and character of sediment yield and delivery from agricultural watersheds of varying sizes in the principal physiographic and climatic regions of the area; and determine the effects of upstream watershed protection programs on sedimentation along the main stem of river systems.

APPROACH: Before and after basin treatment collect and analyze sufficient floodwater samples to define continuous suspended sediment transport by size ranges at enough gaging sites to accomplish objectives. Compute unmeasured load with one or more of the applicable methods. Use available flow, land use, cover, and rainfall data to relate variables. Periodically survey reservoir ranges for sediment accumulation; determine inflow with continuous stage record; determine trap-efficiency with occasional outflow water samples.

Rothacher, J. S.

"Soil stabilization and runoff regulation in conifer watersheds of Western Washington and Oregon", Oregon State University, Agricultural Experiment Station, Corvallis, Oregon.

OBJECTIVE: To determine how logging methods, road construction, and forest management practices can be improved to curtail erosion, prevent channel impairment, maintain water quality, and regulate quantity and timing of runoff.

APPROACH: The project will study erosion production and mass soil movements resulting from logging and road building; quantity and timing of runoff; and water quality. Various cutting methods will be investigated to determine their comparative effect on streamflow, soil movement, sedimentation, and chemical quality of water. Forest management in the Douglas-fir region will be studied in relation to soil moisture and water yield.

Harris, D. D.
"Sedimentation in small forested drainage basins", U.S. Department of Interior, Water Resources Research Division, Portland, Oregon.

OBJECTIVE: To relate changes in sedimentation datas due to logging operations in a group of three watersheds in the Alsea River system.

APPROACH: A comparison of similar basins which are ultimately subjected to extensive logging operations will provide the basis for correlating runoff and sediment discharge as recorded from numerous measurements made at control weirs and backwater pools.

Williams, K. F.
"Relating sediment yields to watershed variables-Susquehanna River Basin", U.S. Geological Survey, Water Resources Division, Harrisburg, Pennsylvania.

OBJECTIVE: To relate average annual sediment yields of selected sub-basins to the hydrologic, physiographic, and land-use variables of the sub-basins.

APPROACH: Sediment yields from some basins ranging from 87 square miles to about 1,500 square miles have been computed from measurements of suspended sediment discharge that remain during direct runoff events. Watershed variables that significantly affect sedimentation rates in adjacent to the Susquehanna River Basin will be determined.

Younkin, L. M. and Gardner, R. A.
"Prediction of water quality change in a stream due to highway construction on the drainage basin", Buckmell University Graduate School, Lewisburg, Pennsylvania.

OBJECTIVE: To develop a method for predicting water quality changes in a stream due to highway constructon on the drainage basin.

APPROACH: Data to verify the method are being collected on a local basin through which construction of an interstate highway is now in progress. The affected basin has approximate area of 18 square miles and it is entirely wooded. The highway being constructed roughly parallels the stream and is about 10 miles long. Hydrologic observations include precipitation, stream discharge, sediment concentrations, and soil moisture. Data describing processes and phases of construction, exposed soil characteristics, and down-slope ground surface conditons are being collected.

Williams, K. F. and Reed, L. A.
"Effect of conservation practices on hydrology and sedimentation rates", U.S. Department of Interior, Geological Survey, Harrisburg, Pennsylvania.

OBJECTIVE: To evaluate the effects of changing land use and agronomic practices on hydrology and sedimentation rates of 2 small watersheds in Pennsylvania.

APPROACH: One watershed is undergoing land treatment at a moderate rate; therefore, a time control is being used. The other watershed is undergoing land treatment at an accelerated rate; therefore, an external control watershed is being used for comparison with the study area.

Kuhlman, A. R.

"Sediment yields from rangeland watersheds in the Northern Great Plains", U.S. Department of Agriculture, Soil & Water Conservation Research Division, Newell, South Dakota.

OBJECTIVE: Obtain measurements of sediment yield from rangeland watersheds in western South Dakota and to develop procedures for estimating sediment accumulation in stockponds in this area.

APPROACH: Periodic surveys are made of sediment accumulations in 74 stockponds in western South Dakota. Precipitation is measured at each pond with small orifice storage gages. All Watersheds have been surveyed for range site and conditions and will be resurveyed every three years. The data will be analyzed to determine mean sedimentation rates and to determine if differences in soils or vegetation results in significant differences in the mean annual rates.

Kunkle, S. H.

"Sediment yield from agricultural watersheds in New England", U. S. Department of Agriculture, Soil & Water Conservation Research Division, Danville, Vermont.

OBJECTIVE: Obtain, assemble, and report data on the rate, quality, sources, and types of sediment transported in steep mountainous streams; relate sediment yield to land use, sediment properties and hydraulic parameters.

APPROACH: Suspended sediment samples are taken at a number of gaging stations. Total load measurements will be made by measuring the accumulation of sediment in settling pools and measuring the suspended outflow from the pool. Movement of large particles is made by marking and accurately placing stones in channel reaches and periodically checking for movement.

Satterlund, D. R.

"Watershed disturbance by tractor skidding", Washington State University, Forestry & Range Management, School of Agriculture, Pullman, Washington.

OBJECTIVE: Compare surface soil disturbance resulting from skidding by crawler and wheel tractors, and relate disturbance to soil bulk density and macroporosity.

APPROACH: Conduct post-logging surveys on timber sale areas. Stratify areas by skidding method, soil type, slope, and if possible by volume removed. Transects will be established across each stratum to determine disturbance, and soil samples collected from each class of disturbance. Analyses will be by standard laboratory and statistical techniques.

Sartz, R. S.

"Reduction of flood runoff and sedimentation and streamflow improvement in unglaciated areas", U.S. Department of Agriculture, North Central Forest Experiment Station, LaCrosse, Wisconsin.

OBJECTIVE: Determine: (1) importance of forests in runoff and erosion control in the Driftless Area and adjoining lands of intermingled farm woods in the Upper Mississippi Valley; disposition of precipitation of forest, brush, and other steeply sloping lands under different treatments; and (3) the influence of plantations on erosion and on the components of the water cycle.

APPROACH: Measure flood flows from plots and experimental watersheds to determine source of flood runoff. Measure interception of overland flow from fields by forested slopes and attempt to increase effectiveness of the forest in dissipating flow. Continue to evaluate effect of forest plantations on snow buildup, soil freezing, and other soil properties and effect of natural forest cover on soil freezing.

Baird, R. W.

"Sediment yield in relation to climatic and watershed characteristics in the Edwards Plateau", Blackland Experiment Center, Temple, Texas.

OBJECTIVE: Determine the amounts and sources of sediment yields from small agricultural watersheds as affected by land use and treatment.

APPROACH: In the Edwards Plateau near Sonora sediment will be measured by surveys of five detention reservoirs with watershed areas of 686 to 10,787 acres. Resurveys will determine sediment deposited.

Baird, R. W.

"Sediment production, yield and delivery rate in relation to climatic and watershed characteristics", Blackland Experiment Center, Temple, Texas.

OBJECTIVE: Determine the amounts and sources of sediment yields from small agricultural watersheds as affected by land use and treatment.

APPROACH: In the Blacklands near Riesel, measured runoff will be sampled and sediment yields computed by storm periods from six watersheds with different treatments and sized from 16.3 to 4,380 acres. Two are paired watersheds with major differences in treatment.

Baird, R. W.

"Sediment yield in relation to watershed features in the Western Gulf Region, U.S. Department of Agriculture, Soil & Water Conservation Research Division, Riesel, Texas.

OBJECTIVE: Determine the amounts and sources of sediment yields from small agricultural watersheds as affected by land use and treatment.

APPROACH: In the Blacklands near Riesel, measured runoff is sampled and sediment yields computed by storm periods from six watersheds with different treatments and sizes from 16.3 to 4380 acres. Two are paired watersheds with major differences in treatment. In the Edwards Plateau near Sonora sediment is measured by surveys of five detention reservoirs with watersheds areas of 686 to 10,787 acres. Resurveys will determine sediment deposited.