Hydraulic Research in the United States 1966

United States Department of Commerce

National Bureau of Standards

Miscellaneous Publication 280
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*Located at Boulder, Colorado, 80301.
**Located at 5285 Port Royal Road, Springfield, Virginia, 22151.
Hydraulic Research in the United States 1966

(Including Contributions from Canadian Laboratories)

Edited by Helen K. Middleton and Gershon Kulin

National Bureau of Standards Miscellaneous Publication 280

Issued September 8, 1966
PREFACE

The information contained in this publication was compiled from reports by the various hydraulic and hydrologic laboratories in the United States and Canada. The cooperation of these agencies is greatly appreciated. The National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend upon reporting laboratories for the completeness of the coverage of their own programs, as well as upon new laboratories engaged in hydraulics to bring their activities to our attention.

Projects are numbered and the number once assigned is repeated for identification purposes until a project is completed. The numbers 5656 and above refer to projects reported for the first time. All projects are in active state, unless otherwise noted under (f).

The National Bureau of Standards does not maintain a file of reports or detailed information regarding the research projects reported by other organizations. Such information may be obtained from the correspondent listed under (c) or immediately following the title of the organization reporting the work. It is of course understood that any laboratory submitting reports on the work will be willing to supply information to properly qualified inquirers.

A similar bulletin, "Hydraulic Research", compiled and published biennially by the International Association for Hydraulic Research, contains information on hydraulic research being conducted in foreign countries. This bulletin is edited by IR H. J. Schoemaker, Director, Delft Hydraulics Laboratory, Delft, Netherlands, and Secretary of the International Association for Hydraulic Research. Copies are available to nonmembers of the International Association for Hydraulic Research from the Secretary at $7.50 each (postage included).

CONTENTS

Preface .................................................. iii
List of contributing laboratories ............................... v
Project reports ............................................. 1
Subject index .................................................. 231

Key to Projects

(a) Number and title of project
(b) Project conducted for
(c) Correspondent
(d) Nature of project
(e) Description
(f) Present status (see Foreword)
(f) Results
(h) Publications
<table>
<thead>
<tr>
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Laboratory investigation; design, development and operation.

The development of two-dimensional hydraulic models simulating common geological situations in consolidating porous media permits the construction of three-dimensional water flow models. The effects of grain size, various lithologies, boundary conditions, recharge and discharge will be investigated. The development of ground water movement will then be readily observable in the models.

The immediate objective of this project is to develop a three-dimensional transparent porous medium system. The system will consist of a colorless porous medium immersed in a colorless liquid with identical indices of refraction.

With the aid of such a system, it will be possible to (1) provide basic descriptions and explanations of three-dimensional laminar flow in unconsolidated porous media, and (2) demonstrate how grain size, lithologic fabric, structural features, hydraulic head and rock pressures are related to ground water movement.

Experiments have been conducted to determine the most suitable solid and liquid media having the same indices of refraction. The media are being combined in a wide range of case designs for testing transparency under several light conditions. Tracer dyes are being developed which will produce the most distinct flow bands in the transparent model.

A STUDY OF PARTIALLY SATURATED FLOW IN SAND-EPOXY RESIN COLUMNS.

(b) Departmental.
(c) Professor Richard L. Sloane; Department of Civil Engineering, Univ. of Arizona, Tucson, Arizona 85721.
(d) Laboratory investigation related to theory; doctoral thesis.
(e) The flow of water through soils often takes place under conditions of partially saturated flow. The prediction of fluid distribution and pressure under conditions of partially saturated flow will make use of vertical columns made of sand grains cemented together with epoxy resin. The use of this type of sand columns will result in a model for which properties such as void ratio and water flow rate will remain constant during a series of tests.

Radioisotopes AS A TRACER IN GROUND WATER PROBLEMS.

(b) Research Corporation and State of Arizona.
(c) Prof. Paul L. Damon, Geology Dept. and Geochronology Lab., University of Arizona, Tucson, Arizona 85721.
(d) Laboratory and field research; doctoral thesis.
(e) The radioisotope content of ground and surface waters is being used as a tracer to study surface and ground water movement. The data is now related to such ground water problems as the rate of laminar flow through aquifers, their permeability, the source, time and rate of recharge, radioactive contamination of water supplies and the waste disposal problem. The increase in the carbon-14 content of the atmosphere, biosphere and hydrosphere due to Nuclear Technology is also being monitored.

MODELS FOR STUDY OF GROUND WATER MOVEMENT.

(b) National Science Foundation.
(c) Dr. J. W. Harshbarger, Project Director,
correlate reasonably well with field observations.

(5531) HYDRAULICS OF SURFACE IRRIGATION.

(b) Agricultural Experiment Station, University of Arizona.

c) Mr. Charles D. Busch, Associate Agricultural Engineer, Dept. of Agricultural Engineering, Univ. of Arizona, Tucson, Ariz. 85721.

d) Field studies; applied research.

e) Previous research in surface irrigation hydraulics has developed a theoretical framework for the improvement of surface irrigation systems. This project will contribute through field research for the evaluation of mathematical models that were developed by earlier investigators. Field evaluation will consist of two phases. First, equipment will be perfected to measure and record electronically the advance and recession curves for border furrow irrigation. Second, the equipment will be used for field measurement and evaluation of a variety of surface irrigation systems. The signal of a float-actuated potentiometer, modulated for a milli-volt recorder, will provide the desired record of water depth. Preliminary data indicate that advance and recession curves will require separate treatment in analysis.

(5554) PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS.

(b) U. S. Dept. of Agriculture and State of Arizona.

c) Dr. D. D. Evans, Dept. of Agricultural Chemistry and Soils, Univ. of Arizona, Tucson, Arizona 85721.

d) Theoretical and experimental; basic research.

e) The flow of water and energy will be examined under conditions of simultaneous water potential and temperature gradients for the purpose of improving the prediction of flow to evaporative surfaces. Initially, flow will be restricted to one-dimensional steady-state flow to an evaporative soil surface when the water potential and temperature are held constant at the surface opposite the evaporative surface. Water potential and temperature gradients, quantity of flow and appropriate soil properties will be measured and the data used to evaluate different equations developed for predicting flow under those conditions.

(5669) ELECTRICAL ANALOGUE ANALYSIS OF THE TUCSON GROUNDWATER BASIN.

(b) University of Arizona.

c) Mr. Dennis E. Peterson, Instructor, Geology (Hydrology Dept.), Univ. of Arizona, Tucson, Arizona 85731.

d) Experimental and analytical.

e) A lumped parameter resistance-capacitance model is being constructed to simulate the Tucson groundwater basin. The model is based on the analogies between Darcy's law and Ohm's law and between the groundwater and electrical forms of the diffusion equation.

(f) When it is complete, the model will simulate the original steady-state groundwater conditions that existed until approximately 1930 and will duplicate the subsequent seasonal water level changes that have occurred due to pumping.

(g) The next step will be to examine the response of the system, in the next 20 years, due to several hypothetical inputs (e.g., pumping due to projected population changes, changes in pumping waters, artificial recharge).

(5870) FLUID DISPERSION IN FLOW THROUGH NON-UNIFORM POROUS MEDIA.

(b) University of Arizona.

c) Dr. R. E. Simpson, Dept. of Geology, Univ. of Arizona, Tucson, Arizona 85721.

d) Experimental; basic research.

e) Dispersion of a fluorescent dye, transverse to direction of flow, is measured by filter paper placed in flow field. After contact with dye, paper is removed and dried and concentration distribution of dye is measured in dye concentration. This series of experiments is planned to measure transverse dispersion of a dye stream moving across interfaces separating regions of differing permeability and at various angles to flow direction. Experimental data will be analyzed to better understand nature of dispersion in non-uniform media and to further develop theory.

(5871) UNSATURATED SOIL MOISTURE MOVEMENT IN PLANT ROOTS.

(b) Agricultural Research Service, Soil and Water Conservation Research Service.

c) Prof. O. C. Stanberry, Univ. of Arizona, Tucson, Arizona 85721.

d) Experimental; basic research.

e) An idea of Japanese workers is being utilized to study water movement in soils. Water is "tagged" with chlorine and measured with time as it changes the color of potassium dichromate from yellow to white. Moisture movement is being studied in pressure-membrane chambers developed at Tucson, Ariz. First the soil is saturated with moisture. Then it is forced out of the soil by a given pressure. Using a sensitive gauge, the pressure is reduced, permitting water with chlorine to move into the soil again. A specially made apparatus is necessary to permit this taking place. The water film thickness is being studied in relation to the movement of the unsaturated moisture.

UNIVERSITY OF ARKANSAS, Agricultural Experiment Station.

(2225) GROUND WATER, RESOURCES AND RECHARGE, IN THE RICE GROWING AREA OF ARKANSAS.

(b) Arkansas Agricultural Experiment Station cooperative with U. S. Geological Survey and U. S. Department of Agriculture.

c) Prof. Kyle Engler, Head of Agricultural Engineering Dept., University of Arkansas, Fayetteville, Arkansas.

d) Basic and applied research.

e) The straight 26-inch sand-packed recharge well has been tested for one year and results have not proved completely satisfactory. Main difficulties encountered arise in duplicating test condition under field situations. The sand packed well seemed to filter out plugging material but redevelopment proved more difficult than in the gravel packed well. Separation AP-30 was tried but proved unsatisfactory for conditions encountered in this test. A slow gravel filter was constructed and tested as a means of clarifying recharge water during the winter and spring of 1960-61. The slow gravel filter did not work under the conditions set up on this situation. Turbidity was slightly reduced but not enough to be practical and project was closed out.

(4066) HYDRAULICS OF PULVER IRIGATION.

(a) Arkansas Agricultural Experiment Station.

(b) Prof. Billy B. Bryan, Acting Head, Dept. of Agricultural Engineering, University of Arkansas, Fayetteville, Arkansas.

(c) Experimental, field investigations; basic research.

(d) Investigation of fundamental hydraulic criteria involved in flow of water in irrigated furrows (shallow in small, open channels). Object is to develop equations for determining (1) rate of stream advance and recession; (2) depression storage; (3) stream size-storage relationships.

(e) Suspended.

(4067) SURFACE DRAINAGE IN BOTTOM LANDS AND TOPOGRAPHY.

(a) Arkansas Agricultural Experiment Station.

(b) Asst. Prof. Warren Harris, Dept. Agric. Engr., Univ. of Arkansas, Fayetteville, Arkansas.

(c) Experimental and field investigations; applied research.

(d) The purpose of this study is to define the physical requirements for adequate drainage of individual crop rows and of field-sized areas in the bottom land soils and topography of the Miss. River Delta. Shallow surface ditches for field drainage are the largest drainage structures considered. Findings are based on the assumption that larger drainage structures must be of a size that will not restrict drainage for unduly long periods of time.

(e) Depressions and restricted outlets have been found to be the basic causes of inadequate drainage in both individual rows and in shallow surface ditch ditches. Shallow ditches can be designed and constructed so that with a nominal amount of maintenance, they will provide only minor obstructions to mechanized farming operations.

(h) "The Warped Surface Method of Land Grading," by Warren Harris, paper presented at Joint Southeast and Southwest Regional Meeting of ASAE, Dallas, Texas, February 1, 2, 3, 1965.


BATTLE NORTHWEST LABORATORIES, Chemistry Department.

(5699) MATHEMATICAL MODEL ANALYSIS OF FLOW THROUGH PARTIALLY SATURATED HETEROGENEOUS POROUS MEDIA.

(b) Atomic Energy Commission, Division of Biology and Medicine.

(c) Mr. William A. Haney, Manager, Geochemical and Geophysical Research, Battelle-Northwest, P.O. Box 998, Richland, Washington 99352.

(d) Experimental and field investigation; applied research.

(e) The development of mathematical formulations and digital computer programs for computing the movement of radioactive waste in this instance through the vadose zone. Interest is in three-dimensional analysis of liquid flow through partially saturated and unsaturated, heterogeneous soils for steady-state and transient conditions. Methods of measuring soil parameters, conductivity and moisture content, needed as input data to computer programs are being investigated.

(f) A computer program (STEADY) was developed to analyze steady-state flow conditions in saturated or unsaturated heterogeneous soils. The program, in Porten II, uses iteration techniques to solve one-, two- and three-dimensional or axisymmetrical cases for up to 8,000 grid points using input data from as many as 15 soil types in the unsaturated system. Inputs are in the form of equations describing relationships between conductivity and pressure and/or moisture content and hydraulic conductivity for each soil type. Work towards transient case solution methods was started recently. A new (low energy gamma ray) source technique is being used to measure moisture content, conductivity and pressure simultaneously. Nonnuclear applications of programs are in the analysis of seepage losses from irrigation canals, ditches, etc.


(g) MATHEMATICAL MODEL ANALYSIS OF LARGE COMPLEX GROUND WATER FLOW SYSTEMS.

(b) Atomic Energy Commission, Division of Biology and Medicine.

(c) Mr. William A. Haney, Manager, Geochemical & Geophysical Research, Battelle-Northwest, Richland, Washington 99352.

(d) Experimental and field investigation; applied research.

(e) Work is directed towards the development of mathematical models and associated digital computer programs for accurate analysis of large, complex (heterogeneous soils) groundwater flow systems in three dimensions. Immediate application is in the analysis of the movement of radioactive wastes which might enter the saturated zone. Also, means for evaluating the effects of boundary condition changes on flow systems are under investigation. Methods desired will provide data for available field input data: Ground-water potentials, boundary conditions in permeability, and flow system physical boundaries. Two digital-computer programs (GENORO and STREAM) were developed to permit accurate flow system analysis programs, which use ground water potentials in functional form rather than as tabular data, and provide determinations of permeabilities, travel paths and travel times using potentials and boundary conditions in permeability as input data. Optimum fitting functions for measured potentials and physical boundaries are being sought. A third program (W-STEADY) is under development for determination of altered potentials due to boundary condition changes. Program testing showed no significant errors in using finite difference approximations. Additional applications are in pollutant transport and petroleum reservoir analysis.


BOLT BERNANEK AND NEWMAN INC.

(S5190) SOUND RADIATED FROM A TURBULENT BOUNDARY LAYER.

(b) Bureau of Ships Fundamental Hydrodynamics Research Program Administered by the David Taylor Model Basin.
(c) Prof. Vito A. Vannoni, Calif. Inst. of Tech., Pasadena, California.
(d) Basic theoretical research.
(e) The research is aimed at clarifying the exact role of a solid surface in determining the mechanism by which sound generated in a turbulent boundary layer is radiated. It is known that if the surface is very large, it merely acts like a passive reflector, and if it is small, it constitutes an additional dipole field. The intermediate size situation remains obscure and it is on this problem that the work is concentrated.
(f) Completed.
(g) The role of a responsive homogeneous surface of infinite extent has been studied. The main result of the analysis is that no fundamentally more efficient source of sound is introduced to the surface motion. The radiation remains quadropole in character. The surface merely accounts for a reflection of the turbulence generated sound, with the reflection coefficient being identical to that for plane acoustic waves.

(S5191) INTERACTION OF DISTRIBUTED SURFACE VIBRATIONS WITH AN ADJACENT BOUNDARY LAYER FLOW.

(b) Bureau of Ships Fundamental Hydrodynamics Research Program Administered by the David Taylor Model Basin.
(c) Dr. Francis J. Jackson, Bolt Bernaneck and Newman Inc., 50 Moulton St., Cambridge, Mass. 02138.
(d) Basic theoretical and experimental.
(e) The program is aimed at studying the stability of a flow in contact with a non-rigid (responsive) wall. The effect of the wall response on the properties of the adjacent boundary layer flow are of special interest. Particular attention is being paid to the effects of actuating the wall motion by external means.
(f) Completed.
(g) An analysis of the Reynolds stress very close to the wall indicates that the direction of energy flux between the mean flow and the boundary layer disturbances (which may give rise to instability) depends upon the properties of the wall, and its response to the pressure fluctuations produced by the disturbance field. In addition analysis of the interaction between a fluid flow and an adjacent boundary which is excited so as to produce a transverse wave at the fluid-solid interface has been carried out. An idealized treatment permits some conclusions to be drawn as to the conditions under which amplification of the induced boundary layer disturbances occurs as they are transmitted through the steady flow boundary layer.

(S5228) KOOL TESTS OF NEW JERSEY DAM NUMBER 3.

(b) Hackensack Water Co.
(c) Dr. Chilton A. Wright, Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn, New York 11201.
(d) Model study of a particular dam design.

(p. 4) The dam is about 15 ft. high and will be built on a sand foundation. There is a movable gate on the crest. The model is constructed to a scale of 1 to 55 and is set in a wooden flume 20 inches wide with a sand bed downstream. The purpose of the project is to study scour and performance of the model under various flows.

(f) Completed.

(E5458) PROBLEMS IN HYDRODYNAMICS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. Milton S. Plesset, Calif. Inst. of Tech., Pasadena, California.
(d) Theoretical and experimental; basic research.
(e) Studies of cavitation and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical studies of cavitation damage.


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POLYTECHNIC INSTITUTE OF BROOKLYN.

(E5598) SOURCH TESTS OF NEW JERSEY DAM NUMBER 3.

(b) Dr. Chilton A. Wright, Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn, New York 11201.

(d) Model study of a particular dam design.

(E5551) DYNAMICS OF DENSITY-STRATIFIED RESERVOIRS.

(b) U. S. Public Health Service (research grant).
(c) Prof. Norman H. Elam, Calif. Inst. of Tech., Pasadena, Calif. 91109.
(d) Basic theoretical and experimental research.

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(e) (1) In reservoirs having density variation with depth, the pattern of flow toward an outlet may be quite different from the flow in a homogeneous reservoir. The withdrawal pattern has been studied experimentally in a laboratory tank of water having a linear density profile induced either by dissolved salt or heat. Application will ultimately be in management of waters supplies in rivers by selective withdrawal from reservoirs.

(2) Research is continuing on the problem of discharge into a stratified environment. When a buoyant jet (or plume) is generated from a point or line source in a stratified ambient fluid, it may rise only to some equilibrium level, then spread in a thin plume.

(g) (1) At very low Reynolds numbers there is a distinct "withdrawal layer" extending upward at the inlet of the basin. Fluids above and below this layer is withdrawn through the outlet. Research has been extended from line sinks to point sinks during the past year with good agreement between theory and experiment. The theoretical analysis based on the laminar boundary-layer equations and the diffusion equation for the substance causing density variation. An approximate integral theory, valid for somewhat larger flow rates, has also been developed for both the two-dimensional and axisymmetric cases.

(2) Integral type solutions for buoyant jets and plumes have been made following Morton's approach, with initial variations including mass flux, buoyancy flux, and the momentum flux vector.


(5013) DYNAMICS OF DENSITY-STRATIFIED GROUND-WATER FLOW.

(b) U. S. Public Health Service (research grant).

(c) Prof. Norman H. Brooks, Calif. Inst. of Tech., Pasadena, Calif. 91109.

(d) Basic theoretical and experimental research.

(2) Slight density variations often affect ground-water flow patterns. Water which is recharged artificially may not mix readily with native waters but develops density stratification in the aquifer. Studies include problems such as overturning of unstably layered systems, flow due to sources or sinks and effects of density difference on fluid dispersion in flow through porous media.

(g) (1) Theory and experiments have shown it possible to have a more or less dense liquid in a quasistable horizontal motion above a less dense liquid in a saturated porous medium.

(2) Lateral dispersion in saturated porous media has been shown experimentally to be dependent solely on the Feclet number provided the Reynolds number is low enough for laminar flow. High Reynolds numbers dispersion becomes independent of the Feclet number.


(5014) WAVE INDUCED OSCILLATIONS OF SMALL MOORED VESSELS.

(b) Dept. of the Army, Corps of Engineers.

(c) Prof. Fredric Raichlen and Prof. Vito A. Vanoni, Calif. Inst. of Tech., Pasadena, Calif. 91109.

(d) Experimental and theoretical research.

(e) Serious ship and dock damage can be caused by wave induced oscillations of moored vessels. The ship and its mooring system constitute a dynamic system capable of resonant oscillations. The objective of this research is to investigate the motion of small boats moored to fixed and floating platforms in a standing wave environment. The study is directed toward an understanding of the problems involved in small marinas and to providing information that will assist in planning and operation of marinas.

A wave basin with wave generator and measuring and recording equipment have been assembled and the research is proceeding actively. Some prototype measurements of the small natural period and damping characteristics of moored small craft have been made.


(5560) MECHANICS OF SLUG FLOW IN STEEP CHANNELS.

(b) Los Angeles County Flood Control District.

(c) Prof. Vito A. Vanoni and Prof. Richard Brook, Calif. Inst. of Tech., Pasadena, Calif. 91109.

(d) Experimental and theoretical research.

(e) Detailed laboratory observations are being made of slug flows (also called roll waves) with a view to checking the many theoretical studies of this problem and to evaluating problems arising from slug flows in the many high-velocity flood channels in Los Angeles County.

(5561) EXPERIMENTS ON TURBIDITY CURRENTS.

(b) Petroleum Research Fund.

(c) Dr. Gerard V. Middleton, McMaster Univ., Hamilton, Ontario, Canada.

(d) Experimental research.

(e) Comparative studies were made on the behavior of density underflows composed of salt solutions, clay suspensions and clay-salt suspensions. Particular attention was devoted to the movement of the head of the current, and to deposition of sediment from the current.

(f) The experiments have been completed and the report is being prepared.

(g) A report on the preliminary experiments is available on request.


(5773) LONGITUDINAL DISPERSION IN OPEN CHANNEL FLOW.

(b) U.S. Geological Survey and Laboratory Project.

(c) Prof. Norman H. Brooks, Calif. Inst. of Tech., Pasadena, Calif., 91109.

(d) Experimental and theoretical, laboratory and field; basic research for Ph.D. dissertation.

(e) Contaminants or tracers are dispersed longitudinally in flow in a channel by an interaction of the longitudinal medium flow velocity in the cross section and the transverse turbulent mixing. The purposes of this project are: first, to test the existing theory and determine whether or not it holds; second, to identify the dominant mechanisms responsible for dis-
The Experimental pp.

The method included participation in a field study being carried out by the U.S. Geological Survey in the Duwamish River and Estuary in the State of Washington. Large values of dispersion coefficients in rivers are due to effect of horizontal velocity profiles as well as vertical velocity profile.


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CALIFORNIA INSTITUTE OF TECHNOLOGY, Hydrodynamics Laboratory.

(3378) HYDRODYNAMICS OF TURBOMACHINES.

(b) Fluid Dynamics Branch, Office of Naval Research.

(c) A. J. Acosta, California Institute of Tech., Pasadena, Calif.

(d) Experimental and theoretical investigation, basic research.

(e) The effort of the past year on this investigation of the hydrodynamics of turbomachines has been mainly devoted to an intensive experimental study of the cavitation flow in a cascade arrangement. It has been found possible to simulate the cascade effect in the High Speed Water Tunnel of the Hydrodynamics Laboratory. Fully wetted flow, partially cavitated and supercavitating flows were investigated under these conditions, using one simple profile shape (a plano-convex hydrofoil) and a basic stager angle (45 degrees).

The fully wetted and fully cavitating flows were in reasonably good agreement with theoretical predictions. Under conditions of partial cavitation, strong flow oscillations take place similar to those on isolated hydrofoils.


(5770) EXPERIMENTAL STUDIES OF UNSTEADY CAVITY FLOW.

(b) Fluid Dynamics Branch, Office of Naval Research.

(c) A. J. Acosta, Calif. Inst. of Tech., Pasadena, Calif.

(d) Experimental and theoretical investigation.

(e) The concern of this research program has been the measurement of non-steady forces on simple hydrofoil shapes due to a steady imposed heaving oscillation. A method and equipment for force measurement have been developed, and experiments have been conducted on several hydrofoils of aspect ratio unity in the Free Surface Water Tunnel. These include: a flat, percent thick, flat plate hydrofoil with sharp leading edges, a wedge with included angle of 8 degrees, and a plano-convex hydrofoil of 8 percent thickness.

The fully wetted experiments are reasoning agreement with theoretical experiments. Base vented hydrofoils act essentially the same as fully wetted hydrofoils. The flat cavitating flow which might be used as a basis for hydrofoil design.

The following studies were made in collaboration with the U.S. Naval Ordnance Test Station, Pasadena, Calif.:

(1) A series of tests were made to determine the added mass of a 1-inch-diameter steel sphere impulsively accelerated vertically upward from rest along the axis of Locite cylinders with which mass added mass results correlated with ideal fluid theory. No free surface effects were involved. The sphere was impulsively accelerated electromagnetically and the acceleration recorded remotely briefly so that essentially potential frictionless flow obtained. Eight cylinders were used which varied from 1.11 to 4.45 inches. The agreement between experiment and theory was very good.

(2) Further tests were made to determine the effect of water surface proximity on the added mass of a 1-inch-diameter steel sphere accelerated vertically upward from rest in open water and the results correlated with ideal fluid theory. Again, essentially frictionless potential flow obtained during the acceleration regime. The agreement between experiment and theory was very good and the results indicate that surface proximity has practically no effect on the added mass until the sphere center is about two diameters from the surface. For large depths, the added mass decreases with depth.

(3) Several techniques for metric photography were developed and used in the studies above. In the first, a base position was obtained from measurement of photographs of the virtual image produced in a precision-ground sphere by a timed stroboscopic point-source lamp. In the second, a rotating circular film disk is covered with sector-shaped exposures using a timed stroboscopic lamp. In the third, the previously described techniques are combined to obtain data simultaneously.

(4) In addition to the above collaborative studies, an experimental and theoretical evaluation of the viscous drag forces acting on a sphere launched impulsively from rest along the axis of a cylinder in a viscous liquid was made at the California Institute of Technology.


(5053) FORCES ACTING ON A BODY DURING WATER EXIT.

(b) Bureau of Weapons, Dept. of the Navy.

(c) Prof. A. T. Ellis and Dr. J. G. Waugh, Calif. Institute of Technology, Pasadena, Calif.

(d) Experimental and theoretical investigation.

(e) To assess the validity of theories for determining added mass in the presence of a free surface and hydrodynamics of non-cavitating hydrofoils in the neighborhood of, or approaching a free surface. To provide experimental data on surface effects on missiles of simple mathematical configuration under conditions of
plate hydrofoils were also ventilated from the leading edge. The dynamic force coefficients were not in agreement with theories based on the assumption of a constant pressure difference across the cavity.


(571) RESEARCH ON CAVITATING RING WINGS.

(b) Bureau of Naval Weapons and Office of Naval Research, Department of the Navy.

(c) A. J. Acosta, Calif. Inst. of Tech., Pasadena, California.

(d) Experimental and theoretical investigation. Basic research.

(e) Research covers an investigation of cavitating and ventilated ring wings in the Hydrodynamics Laboratory, including model construction, testing and analysis of results. The immediate objective of this work was to explore the feasibility of using partial ventilation to control vehicles equipped with ring tails and to evaluate a suitable design theory. This required systematic investigation of the effect of alterations in chord diameter ratio, velocity, and cavitaiton number in both fully wetted and ventilated flows.


(5722) INVESTIGATIONS IN HYDRODYNAMICS OF UNDERWATER ORDINANCE.

(b) U. S. Naval Ordnance Test Station, Pasadena, California, (Bureau of Naval Weapons, Dept. of the Navy).

(c) A. J. Acosta, T. Y. Vu, T. Kicienuk.

(d) Experimental and theoretical investigation. Basic research.

(e) Fundamental and design investigations in the field of hydrodynamics of underwater ordnance. These have included studies of the forces acting on underwater bodies when fully wetted and when cavitating.

(f) Discontinuous data on cavitating and ventilated ring wings.


UNIVERSITY OF CALIFORNIA, College of Agriculture, Department of Water Resources Engineering.

(23) HYDROLOGY OF IRRIGATION SUPPLIES IN CALIFORNIA.

(b) University of California.

(c) Prof. R. H. Burgy and Mr. D. C. Lewis, Dept. of Water Resources Engineering, Univ. of California, Davis, California.

(d) Experimental and field investigations; applied research.

(e) Hydrologic investigations of mountain watersheds are being conducted on pilot watersheds in three areas of the state. Measurements are being made of rainfall, surface runoff, erosion, and groundwater storage and outflow. The hydrologic effect of vegetative cover on the watersheds is under long-range study. Various tracer techniques are used to study groundwater movement and sources of water for native vegetation water uptake. Moisture movement and storage above water tables in rainfall-runoff basins are measured with neutron scattering meters, combined with seismic and resistivity methods. Micrometeorological techniques and equipment are being tested to provide precipitation and evaporation data and radiation data for evapotranspiration from the study watersheds.


(1819) DRAINAGE IN RELATION TO IRRIGATION.

(b) University of California.

(c) Dr. J. N. Luthin and Mr. J. Woerner, Univ. of California, Davis, California.

(d) Basic and applied research.

(e) The developments of computer programs and solutions of problems involving surfaces of seepage, unsaturated flow above the water table and transient flow phenomena has continued with some success. The majority of problems have been solved including the steady-state rainfall equilibrium problems for sloping land.


(4066) MISCEILABLE AND IMMISCIBLE FLUID DISPLACEMENTS IN RELATION TO SOLUTE MOVEMENT IN SOIL AND OTHER POROUS MATERIAL.

(b) University of California.

(c) Drs. J. W. Biggar and D. R. Nielsen, Dept. of Water Science and Engineering, Univ. of California, Davis, California.

(d) Theoretical and experimental; basic and applied.

(e) The simultaneous transport of fluids and solutes through porous media is under investigation. The mixing and spreading of the fluids in the medium, the interaction of the fluids with each other and the medium have been studied. The extent of dispersion will help define the nature of the porous structure of materials, and the coupling between velocity and diffusion in the dispersion process. Leaching phenomena, disposition, industrial and radioactive wastes, and the movement of pesticides in soil water depend upon the dispersion process.

(g) Transient water and salt conditions in columns of soil are currently under study. These conditions involve, among other complex processes, the hysteretic moisture content-pressure relation and the rate dependence of this relation. The mixing processes in unsaturated medium which have not been understood are also involved. Field experiments demonstrating the importance of mixing in saturated and unsaturated soils have been completed. A computer program for predicting leaching of salts has been improved to include a variable K and mixing processes.


IRROTATIONAL FLOW OVER A VERTICAL, SHARP-CRESTED WEIR.
(b) University of California.
(c) Dr. Theodor S. Strelkoff, Dept. of Water Science and Engineering, Univ. of Calif., Davis, California.
(d) Theoretical, basic research.
(e) A digital computer is used to carry out the approximate numerical solution of an exact integral equation, derived by conformal mapping and singularity distribution, and describing the two-dimensional flow over a boundary. The effect of rotationality on an inviscid flow is studied by a relaxation solution of the Poisson equation in the complex plane.

(g) A velocity distribution imposed as a boundary condition far upstream from a free overfall results more closely in accord with experiment than results from potential theory.


(4857) USE OF WELLS IN AREA DEVELOPMENT.

(b) University of California.
(c) Dr. V. H. Scott, Department of Water Science and Engineering, Univ. of California, Davis, California.
(d) Theoretical and field research including doctoral thesis research.
(e) These studies are in progress: (1) Effect of well interference on discharge and drawdown of individual wells; (2) Evaluation of aquifer characteristics from transient well discharge tests; (3) Dimensional analysis approach to groundwater flow in confined and unconfined aquifers; (4) Optimum schedule for cyclic operation wells; (5) Hydrologic balance of a two-aquifer system under conjunctive use of imported surface and groundwaters; (6) Artificial recharge through injection wells into confined and unconfined aquifers; (7) The potential for groundwater recharge by deep wells; (8) Groundwater recharge through a multiple well system along a coastal aquifer.

(g) (1) A study on the combined effects of well interferences, location of aquifer boundaries and variations in discharge on the piezometer water table and well yields was made; (2) Simple graphical procedures were developed for evaluating the hydraulic characteristics in a confined aquifer pumped at a gradually or stepwise changing discharge rate; (3) The relationships between drawdown, discharge and aquifer characteristics in confined and unconfined aquifers was analyzed and presented in dimensionless form; (4) Guidelines for determining the ebb and/or flood duration schedule to obtain a constant residual drawdown after each completed cycle are under study; (5) A mathematical model of a confined aquifer overlain by an unconfined aquifer was analyzed and presented in dimensionless form; (6) Numerical solutions for recharge into confined or unconfined aquifers are being determined by computer techniques and will be presented in dimensionless form; (7) A study on the comparative capacity and cost of recharge wells versus shallow ditches was performed; (8) General series are being series for the optimization of recharge well location and recharge operations to prevent sea water intrusion in coastal regions.


(5142) VARIABLE FLOW UNDER A VERTICAL GATE.

(b) University of California.
(c) Dr. Theodor S. Strelkoff, Dept. of Water Science and Engineering, Univ. of Calif., Davis, California.
(d) Experimental, theoretical; basic research.
(e) Time-dependent flows under sluice gate moving vertically in its own plane are being studied in a laboratory flume. A numerical, quasi-steady, potential-flow analysis is being developed to complement the experimental investigation.

(g) The case of steady flow under a gate has been solved for a single opening: total-head ratios of 0.1, to 0.53.

(5143) PROFILE OF A WETTING FRONT ADVANCING AT An UNFATIGUED BOUNDARY.

(b) University of California.
(c) Dr. Theodor S. Strelkoff, Dept. of Water Science and Engineering, Univ. of Calif., Davis, California.
(d) Experimental, theoretical; applied research for Ph.D. dissertation.
(e) This is a steady case of surge on a dry bed. Vegetation is simulated in a laboratory flume by an array of uniformly distributed vertical rods set into the bottom. Flow is introduced at the head end and the passage of the wave through the rods is measured by electrical depth gauges. The unsteady flow is being analyzed by a numerical method related to the characteristic equations.

(5144) UNSTEADY FLOW IN OPEN CHANNELS.

(b) University of California.
(c) Dr. Theodor S. Strelkoff, Dept. of Water Science and Engineering, Univ. of California, Davis, California.
(d) Theoretical; basic research.
(e) A computer-implemented numerical solution is being developed for the one-dimensional continuity, momentum and energy equations of unsteady flow in canals of arbitrary cross-sectional form. A method is sought which will permit automatic tracking of spontaneously formed shock-discontinuities in the profile. Under investigation are various finite-difference and integral methods.

(g) An effective computer program has been developed for gradually variable flow with surface profile discontinuities only at checks, siphons and pumping plants. Arbitrary initial and boundary conditions for depth, velocity and discharge are easily introduced. Computations have shown satisfactory agreement with field tests conducted in the Delta-Nonda Canal System.


(5145) GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES.

(b) University of California.
(c) Professor J. Amorcho, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(d) Theoretical and experimental investigation; basic and applied research.
(e) (1) Studies on the mathematical theory of nonlinear systems with lumped and with distributed parameters. (2) Characterization of time- and space-variable rainfall dis-
tributions.  (3) Development of methods for the establishment of nonlinear inflow-outflow relationships for natural catchments. (4) Laboratory and field application of (3) above.

(g) A method has been developed for the characterization of gage level precipitation patterns, which expresses the input to a hydrologic system in terms of the coordinates of a point in the catchment and time. This method has been applied to California watersheds and has led to the preliminary establishment of criteria for the design of precipitation networks for hydraulic analysis. New equipment is now under test for the simulation of special distribution of rainfall over the catchment.


(5146) THE EFFICIENCY OF ENERGY DISSIPATORS.

(a) University of California, Davis.
(b) Dr. J. Amorocho, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Theoretical and experimental investigations; preliminary research; investigation.
(d) Development of analytical criteria for the efficiency of energy dissipating structures in terms of the characteristics of the flow stream delivered and the shear stress over the boundary of the receiving channel.
(e) Experimental evaluation of efficiencies from hydraulic model data; "energy efficiency" and "shear efficiency" criteria have been developed as means of evaluating: (1) The effectiveness of a structure in dissipating energy; and (2) the scouring potential of the outflowing water. Experiments with a vortex-type energy dissipator and with a classic open chute structure. The criteria based on hydraulic model investigations. The course of recent studies; a comprehensive investigation of velocity distributions in flow area where the boundary layer is not fully developed has been advanced.

(5861) THE MECHANICS OF OPEN CHANNEL FLOW SYSTEMS.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Prof. T. S. Strekoff, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Theoretical and experimental investigations.
(d) Comprehensive analytical and experimental study of phenomena encountered in the operation of complex open channel systems with multiple controls. Development of mathematical models of the systems for steady and unsteady state operation.
(e) Preliminary models for the study of hydraulic transients in gated channels have been developed.

(5862) BEHAVIOR OF LARGE PUMPING PLANT SYPHON-DISCHARGE LINES.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Mr. A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Hydraulic studies; investigation of energy losses due to air entrainment at the crests of large pumping plant discharge siphons due to the release of air in the water stream due to pressure reduction near siphon crests.

(5863) OVERFLOW AND UNDERFLOW DISCHARGE COEFFICIENTS FOR RADIAL GATES.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Mr. A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Experimental, applied research.
(d) Theoretical and experimental investigation of discharge coefficients of radial gates under steady and unsteady states for the cases of simultaneous gate overflow and underflow, and for situations of flow reversal. The purpose of the study is to establish the theory and to obtain experimental data applicable to the analysis of surge problems in gate-controlled open channel systems in which flow reversal can be expected.

Del Valle Dam Glory Hole Spillway.

(a) University of California, Davis.
(b) Prof. J. Amorocho and A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Model studies for design development.
(d) Study of glory hole spillway for a Calif. dam. Investigation of the effect of the asymmetrical flow field created by the topography of the reservoir in the immediate vicinity of the spillway on the over-flow capacity. Effects of discharges from the river outlet into the spillway tunnel on the performance of the structure.

MIXING CHAMBER FOR WATERS OF DIFFERENT QUALITIES.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Mr. A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Hydraulic model investigation for design development.
(d) Development of a mixing chamber for obtaining homogeneous quality in the mixture of two dissimilar water supplies. The optimization of this device is sought in terms of mixing qualities and minimum energy losses.

FLOW CONVEYANCE EFFICIENCY OF TRANSITIONS AND CHECK STRUCTURES IN A TRAPEZOIDAL CHANNEL.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Mr. A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Investigation of the flow conveyance efficiency of transitions and check structures in the California Aqueduct. A detailed study of energy conversion performed on a 1:16 scale model of structures with various inlet and outlet transition configurations. Completed.
(d) The design of the check structures was optimized; substantially smaller losses than those predicted by conventional design analysis were obtained. Data for detailed analysis of the flow field in the zones of separation were obtained.

EFFECTS OF PONDS CONFIGURATIONS ON THE FORMATION OF VORTICES NEAR PENTOSTOCK ENTRANCES.

(a) University of California, Davis.
(b) Prof. J. Amorocho and Mr. A. Bab, Dept. of Water Science and Engineering, Univ. of Calif., Davis, Calif.
(c) Model studies for design development.
(d) Study of flow and parameters affecting the formation of vortices near power plant pentostock inlets. Completed.
(g) A new design involving the construction of a skirt wall overhanging the penstock inlets, together with improvements in the inlet and approach channel configurations proved to be very effective in the total elimination of vortices created by unfavorable approach conditions.


(5069) DEL VALLE DAM AND SPILLWAY.

(b) University of California, Davis.

(c) Prof. J. Amrocho and A. F. Babb, Dept. of Water Science and Engineering, Univ. of California, Davis, California.

(d) Model studies for design development.

(e) The study of a non-gated ogee-created chute spillway including the effect of upstream geometry upon the flow configurations within the chute. Shock wave patterns in the spillway were studied in some detail. This configuration includes an auxiliary flood control outlet tunnel discharging through a large opening in the spillway floor which was tested for various combinations of flood control and spillway discharges.

(f) Completed.

(g) Shock wave patterns occurring in the open chute were compared with predicted patterns computed on the basis of conventional theory. Shock wave nodes were partially eliminated by modifications in the configuration of the chute. 

UNIVERSITY OF CALIFORNIA, BERKELEY, Dept. of Civil Engineering, Fluid Mechanics Laboratory.

(1554) SEA WATER CONVERSION RESEARCH.

(b) State of California.

(c) Prof. Everett D. Howe, Coordinator, Saline Water Conversion Research, University of Calif., 1501 South 46th Street, Richmond, California.

(d) The purpose of this project is to discover whether there is available any method for the large-scale, low-cost demineralization of sea water. The project includes a number of investigations, of which the following have been active during 1964-65: (1) Multiple effect rotating evaporator; (2) evaporation by immiscible fluid heat transfer; (3) vacuum flash distillation (4) temperature difference method; (4) solar distillation; (5) electrolysers tests; (6) freeze-separation; (7) ion exchange; (8) biological studies; (9) capillary control of vapor transfer gaps; (10) reverse osmosis pilot plant; (11) thermodynamic and economic analysis; (12) experimental heat transfer studies; (13) transport phenomena near a liquid-vapor interface; and (14) fundamental studies of corrosion processes. Investigations are being carried out at Berkeley, Los Angeles and San Diego Campuses.

(e) Detailed results may be obtained from the progress reports and publications listed under (h) below. This project has been active since 1951-52 and previous summaries have listed all reports prior to July 1964.

(2265) FORCES ON ACCELERATED CYLINDERS.
(b) Laboratory project.
(c) Prof. A. D. K. Laird, 109 Mechanics Bldg.,
Univ. of California, Berkeley, Calif. 94720.
(d) Experimental and theoretical, basic research.
(e) Measurements and prediction of drag coefficients and flow configurations about cylinders during accelerated motion in fluids as related to wave forces as cylinders including effects of support flexibility. "Hydroelastic Vibrations of Circular Cylinders," by G. L. Fritzler and A. D. K. Laird.
Univ. of California IES Rept. HFS-64-2, August 1964.
(f) Concluded.
(g) It was found empirically that it is practically impossible to create the characteristic alternate bars based on reversing secondary currents in laboratory flumes with smooth vertical banks. Under the same average flow and sediment conditions in the same flumes the alternate bars appear if rough sloping banks are substituted. The bank friction is used to explain the creation of the bars.

(3675) CLAY TRANSPORT.
(b) National Science Foundation and California State Water Resources Center.
(c) Prof. H. A. Einstein, Dept. of Civil Engineering, Univ. of California, Berkeley, Calif. 94720.
(d) Experimental, basic research.
(e) Determination of the friction factor of flocculated clay deposits used in mud from San Francisco Bay.
(f) Terminated.
(g) The 1000-ft channel is used to measure the friction characteristics of mud deposited in flowing salt water. The mud surface is hydraulically smooth except in periods of active scour or deposition when the irregularities increase the friction up to twice the value of the smooth surface. No extraneous materials such as vegetation were considered on the bed.

(3677) ANNULAR NOZZLE GROUND EFFECT MACHINE.
(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. R. L. Wiegel, Dept. of Civil Eng., University of Calif., Berkeley, California 94720.
(d) Experimental and theoretical; applied research.
(e) Study of the physical conditions within a basin so that ground water levels at any point can be predicted for any future time for given recharge and discharge conditions. Subsequently, study of alternate methods for operating the basin to obtain an economically optimal system.

(3679) OCEAN SEWER OUTFALLS.
(b) U. S. Public Health Service.
(c) Basic research.
(d) This study is concerned with the various phenomena involved in the diffusion of sewage at the discharge end of an ocean sewer outfall.
(e) Completed.
(f) Recent work has been done on the mixing of warm water jets being discharged horizontally at the surface of a body of water.

ANALYSIS OF NONLINEAR SYSTEMS.
(b) Laboratory project.
(c) Prof. J. A. Harder, Hesse Hall, Univ. of California, Berkeley, Calif. 94720.
(d) Theoretical; basic research.
(e) Given a sufficiently long record of the input and output of a stationary system that may include nonlinearities, the purpose is to develop a predictor for arbitrary inputs. Computer program is written that has enabled close prediction of the output of an experimental nonlinear system to a sine wave having an amplitude and frequency well within the limits of the random input used to develop the predictor.

MATHMATICLAL MODELS FOR FLOOD ROUTING.
(b) U. S. Corps of Engineers, Omaha District Engineer Office.
(c) Prof. J. A. Harder, Hesse Hall, Univ. of California, Berkeley, Calif. 94720.
(d) Theoretical; basic research.
(e) Various models are being fitted to experimental floods induced by spillway releases from reservoirs on the Missouri River.
(f) Principal limitation has been found to be accuracy of channel data.

COASTAL SAND MOVEMENT.
(b) Corps of Engineers, U. S. Army, Coastal Engineering Research Center.
(c) Experimental; laboratory and field.
(d) This investigation is concerned with the transportation of sand by both wind and waves.

GROUND WATER BASIN MANAGEMENT.
(b) Laboratory project.
(c) Experimental and theoretical; applied research.
(d) Study of the physical conditions within a basin so that ground water levels at any point can be predicted for any future time for given recharge and discharge conditions. Subsequently, study of alternate methods for operating the basin to obtain an economically optimal system.

HYDRAULIC SYSTEMS ANALYSIS.
(b) California Department of Water Resources.
(c) Prof. J. A. Harder, Resse Hall, Univ. of California, Berkeley, Calif. 94720.
(d) Experimental; field research.
(e) A circular flume has been constructed in which various flows are established and cross sections established. The cross sections are statistically described by a minimum of parameters and the change of these parameters established in terms of the flow and sediment parameters. River sections are equally analyzed.

(4534) WAVE DIFFRACTION AND REFRACTION.

(b) Corps of Engineers, U. S. Army, Coastal Engineering Research Center, Washington, D. C.
(c) Prof. R. L. Wiegler, Univ. of California, Berkeley, Calif. 94720.
(d) Experimental; basic research.
(e) Determination by model tests the diffraction and refraction characteristics of wind waves. Also, model studies of the "Mach-step" equivalent of water waves.

(5415) GROUND WATER FLOW IN THE CAPILLARY ZONE.

(b) Water Resources Center.
(c) D. K. Todd.
(d) Experimental; basic research.
(e) A sand model with steady ground water flow is employed to study flow in the capillary zone, its relative magnitude, and its importance in relation to flow in the saturated zone.

(5817) SHIP WAVES IN NAVIGATION CHANNELS.

(b) Laboratory project.
(c) Prof. J. W. Johnson, Univ. of Calif., Berkeley, Calif.
(d) Experimental; basic research.
(e) The transmission of wave energy through three scale models of rubble structures was conducted with rubble size and wave characteristics as the principal variables.

(5820) TRANSPORT OF SILT THROUGH POROUS MEDIA.

(b) National Science Foundation.
(c) Prof. H. A. Einstein, Dept. of Civil Engineering, Univ. of California, Berkeley, Calif.
(d) Experimental and theoretical basic research.
(e) Silt-carrying water is flowing at various directions through porous media. The deposition, transport and erosion of the silt are studied as a function of silt size,
concentration and density, and of the flow velocity.

(f) Literature survey shows very little information.

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UNIVERSITY OF CALIFORNIA, Institute of Industrial Cooperation, Department of Engineering.

(5872) STUDY OF THE OPERATION OF FLOAT CONTROLLED VALVES FOR IRRIGATION DISTRIBUTION SYSTEMS.

(b) Laboratory project supported by the University of California's Water Resources Center.

(c) Prof. E. H. Taylor, Univ. of California, Dept. of Engr., Los Angeles, Calif. 90024.

(d) The project was primarily experimental in that empirically determined characteristics were employed in the attempts at analyses. Project was the basis of a Ph.D. dissertation.

(e) The work is being done for the purpose of arriving at design criteria for float operated valves. An existing valve and float were tested for head loss characteristics by using repeated experiments and transient response properties. A theory of operation was developed and compared with observation.

(f) A first phase of the project is complete.

(g) It has been possible to arrive at equations amenable to solution by digital computer to predict the behavior of a particular valve and float combination. The techniques are being refined in an effort to determine the necessary coordinate and mechanical characteristics which will result in the design of a valve which will operate in a pre-determined manner.

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UNIVERSITY OF CALIFORNIA, BERKELEY, Dept. of Naval Architecture.

(4083) DYNAMIC INTERACTION BETWEEN SHIPS.

(b) Office of Naval Research, Dept. of the Navy.

(c) Prof. J. R. Paulling, Dept. of Naval Architecture, College of Engineering, University of California, Berkeley, California 94720.

(d) Theoretical and experimental.

(e) The linearized equations of motion for two ships operating on parallel courses are formulated. Coefficients appearing in these equations are being evaluated by captive model tests and digital means of solving the equations are being studied.

(f) Rudder forces and moments, interaction forces and moments, and velocity and acceleration derivatives have been found experimentally for two models operating on parallel courses.

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UNIVERSITY OF CALIFORNIA, BERKELEY, Dept. of Naval Architecture.

(4084) SHIPS OF MINIMUM RESISTANCE.

(b) Office of Naval Research, Dept. of the Navy.

(c) Prof. J. V. Wehausen, Dept. of Naval Architecture, College of Engineering, University of California, Berkeley, California 94720.

(d) Theoretical applied research.

(e) The general aim of this work is to find computer designed ships of minimum "total" resistance, to variously restraining conditions. Here "total" resistance means the Michell wave resistance plus the equivalent of the added frictions resistances.

(f) Computations reported earlier produced ships with rather wavy lines. Increasing the number of terms in the Fourier series describing the ship has produced smoother lines, which do not, however, 'smooth' the earlier ones. A model has been made and tested corresponding to Froude number 0.29.

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PRESSURE DISTRIBUTION ON SEMI-SUBMERGED OSCILLATING BODIES.

(b) David Taylor Model Basin, Department of the Navy, continued under ONR.

(c) Prof. J. R. Paulling, Dept. of Naval Architecture, College of Engineering, University of California, Berkeley, California 94720.

(d) Experimental and theoretical.

(e) To determine the resistance and motions of a floating body in a seaway, it is necessary to know the magnitudes and phases of hydrodynamic forces and moments acting on this body. In the paper, an analysis of the total pressure at any point takes the form of two terms: (a) exciting pressure dependent upon the waves only; (b) pressure dependent upon the geometry and motion of the body and independent of the waves. These two terms are being measured on: (1) A prolate spheroid; (2) A ship-like form.

First the models are attached rigidly to the dynamometers, towed in waves and the pressure distribution, total forces and moments measured. Then the models are oscillated sinusoidally in still water and again the pressure distribution, total force and moment measured. The results will be compared with theoretical calculations.

(g) Both the models have been tested in still water as well as in waves. The results indicate that the wave forces and moments are of the same order of magnitude as those predicted by Krylov's theory.

(h) "Measurements of Heave and Pitch Moments Acting on a Restricted Shiplike Model in Regular Waves," by Hou-Wei Huang, Univ. of Calif., IER Report No. NA-64-11, December 1964.

"Measurements of Pressures and Hydrodynamic Forces on a Shiplike Model Oscillating in a Free Surface," by Hou-Wei Huang, Univ. of Calif., IER Report No. NA-64-1, January 1965.

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SHIP RESISTANCE IN IRREGULAR WAVES.

(b) David Taylor Model Basin, Dept. of the Navy.

(c) Mr. O. J. Sihul, Dept. of Naval Architecture, College of Engineering, University of Calif., Berkeley, California 94720.

(d) Experimental; applied research.

(e) The previous resistance measurements of ship models in uniform waves will be used to predict the total added resistance in irregular waves of known spectral content. The predictions will be compared with experiments in irregular waves of various spectral contents and severity, combined with a number of model speeds.

(g) To test the validity of the linear theory for the prediction of resistance of ships in irregular seas, a wave, containing only two components of the uniform waves, was used. In the first set of experiments individual wave steepnesses were approximately 1:70. The resultant combined wave was rather severe and green water was washed over the deck. The measured resistances in the combined waves were higher than the addition of the measured resistances in the component waves predicted. On the second set of experiments the steepnesses of the individual waves were reduced to approximately 1:160. The measured resistances in the combined waves agreed well for the intermediate speeds, but were somewhat higher than predictions for low and high speeds.

(h) In preparation.

SHIP SLAMMING.

(b) U. S. Dept. of Commerce, Maritime Administration.

(c) Prof. H. A. Schade, Dept. of Naval Architecture, Univ. of Calif., Berkeley, Calif. 94720.

(d) Experimental and theoretical; applied re-
search.

The purpose of the project is to investigate the impact loads (pressures) caused by slamming and the response of the ship structure to these loads. The capacity of the testing equipment is as follows: (a) 1/4 scale models, (b) total model weights up to 40,000 lbs, (c) drop height up to 10 ft., above the still water surface.

(g) Preliminary results for one extra stiff flat model indicate that: (a) For lower drop heights the peak pressure varies nearly as the square of the impact velocity; (b) the pressure is proportional to the deceleration (for the range 10 to 30 g). More experiments in preparation.

(h) Report in preparation.

(5774) HYDRODYNAMICS OF SHIP SLAMMING.

(b) University of California-Berkeley and David Taylor Model Basin.

(c) Prof. J. V. Vehausen, Dept. of Naval Architecture, College of Engrg., Univ. of Calif., Berkeley, California 94720.

(d) Theoretical and experimental.

(e) Some experimental results suggest that air trapped under the flat bottom of the falling model is cushioning the impact and reducing the peak pressures for slamming. A preliminary theory has been developed to take into consideration the entrapped air.

(g) Preliminary results indicate that the theory (under e) gives pressure-time curves that agree reasonably well with the experimental results. More detailed experiments are in preparation.


THE CATHOLIC UNIVERSITY OF AMERICA, Department of Civil Engineering.

(3030) TRANSIENT FLOW THROUGH FORCING INCOMPRESSIBLE MEDIA WITH VARIOUS BOUNDARY CONDITIONS.

(b) Experimental part was supported by the National Research Council of Canada.

(c) Dr. B. S. Brown, Professor of Civil Engrg., The Catholic University of America, Wash., D. C. 20017.

(d) Experimental and theoretical; basic research.

(e) The unsteady laminar flow was reproduced by a highly viscous liquid flowing between closely spaced translucid plates on a number of models with geometric boundaries representing various types of earth dams on impervious foundations and earth masses crossed by open channels. Experimental part concerning earth dams and earth masses on impervious foundations completed. The theoretical part of the research completed for the case of rapid drawdown in homogeneous dams. The theoretical research of cases of gradual drawdown, of non-homogeneous dams, of tailwater condition, and the drawdown in canals was continued for the reported period. It is intended to continue to fit farther for the coming year.

(g) An approximate function, relating by dimensionless parameters, the shape and the position of free surface of flow through the earth dam, following rapid reservoir drawdown, to the geometry of the dam, was obtained theoretically and confirmed by experiments.


(3031) THE VARIATION OF HYDROLOGIC FACTORS AND THEIR INFLUENCE ON RIVER REGIMES IN THE GREAT LAKES-ST. LAWRENCE DRAINAGE AREA.

(b) Laboratory project.

(c) Dr. B. S. Brown, Professor of Civil Engineering, The Catholic University of America, Wash., D. C. 20017.

(d) Theoretical.

(e) Mathematical solution from recent foreign literature is collected, summarized and presented primarily for dam designers. Use of generally available tables of special functions is proposed to facilitate designers to apply in practice these highly efficient new methods.

(f) Completed.


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COLORADO STATE UNIVERSITY, Civil Engineering Section.

(55) SNOW COURSE MEASUREMENTS AND FORECAST ANALYSIS.

(b) Soil Conservation Service, Colorado Agric. Experiment Station.

(c) Mr. Jack N. Washichek, Snow Survey Supervisor, Agricultural Engineering Section.

(d) Field investigations; applied research.

(e) Systematic measurement of water content of snow are being made at high elevations in Colorado and New Mexico mountain areas for the purpose of forecasting the runoff of the principal rivers in the interest of irrigation, power, domestic supplies, and other uses. Investigation of the area at headwaters of the Flaming Gorge Reservoir will be made to determine the need for additional snow courses. Additional installations may be necessary to get stream flow for the project.

(g) Forecasts are now being issued at forty-four gaging stations in Colorado and New Mexico. As forecast procedures improve, additional stream will be forecasted and other areas of potential power and irrigation development will be investigated on the Colorado,
(h) Colorado Agricultural Experiment Station General Summary Papers Series 617, 618, 619, and 820 covering monthly snow reports for all of Colorado and New Mexico. Nine small basin reports have been prepared covering the South Platte River watershed; Arkansas River watershed; Rio Grande watershed in Colorado; Rio Grande watershed in New Mexico; Colorado River watershed; San Juan and Animas River watershed; Gunnison River watershed; Colorado River watershed; Yampa, White, and North Platte River watershed; Lower Colorado River basin. Supplemental reports are issued January 1, May 15, and June 1. "Progress Report of Steamboat Project." Second Progress Report of Steamboat Project.

(2902) DEVELOPMENT IMPROVEMENT OF WATER MEASURING DEVICES.

(b) Northern Plains Branch, Soil and Water Conservation Research Division, ANS, USDA.

(c) E. Gordon Kruse, Agricultural Engineer.

(d) Experimental, laboratory investigation; applied research, operation and development.

(e) New and improved devices and techniques for measurement of irrigation water are being developed. Specific objectives are (1) Design, evaluation and calibration of trapezoidal measuring flumes, (2) Design and evaluation devices for orifice irrigation measurement and control, and (3) Development of a probe using the drag on a suspended wire to indicate total flows, velocity distributions and forces on sediment particles. Completed.

(3398) TURBULENT DIFFUSION IN SHEAR FLOW.


(c) Dr. J. E. Cermak.

(d) Experimental research; basic research, doctoral thesis.

(e) The objective of this project is to determine the influence of geometrical factors (land surface roughness and topography), similarity coefficients, and thermal and aerodynamical factors (turbulence intensity and scale) on atmospheric diffusion of heat and mass. "Laws of model or 'similar' scale parameters" are sought by obtaining detailed data under various conditions in the wind tunnel and by comparing them with similar data now existing for the atmosphere prototype. Application of a hypothesis of Lagrangian similarity to particle motions in a turbulent shear flow near a solid boundary has yielded similarity parameters and relationships between them which correlate the wind tunnel diffusion data and available diffusion data obtained in the atmosphere surface layer.

(3400) HYDRAULICS OF SUB-CRITICAL FLOW IN SMALL, NOUGH CHANNELS.

(b) Colorado Agricultural Experiment Station and Agricultural Research Service, U. S. Department of Agriculture.

(c) Dr. Norman A. Evans, Head, Dept. of Agricultural Engineering.

(d) Theoretical, laboratory experiment.

(e) Both laboratory and field studies have been conducted. A tilting flume was used in the laboratory, and a portable truss to carry a measuring carriage was used in the field. The purpose is to relate roughness in small channels to flow resistance.

(g) Resistance to flow in small channels does not follow the relationship established for large channels. The standard deviation of peak to valley heights was found to be a significant parameter, and a spectral density description of roughness is being tested.

(3704) DEVELOPMENT AND USE OF COLORADO BENTONITE IN IRRIGATION CANALS AND RESERVOIRS.

(b) State of Colorado.

(c) R. D. Dimeyer, Jr., Project Leader.

(d) Field investigation; applied research and development.

(e) The work consists of three stages: (1) Inventory of clay deposits in Colorado with
emphasize on those potentially usable in sealing canals and reservoirs. (2) Laboratory evaluation of clays from (1) above. (3) Field trials in canals and reservoirs with best clays found in (1) and (2) and evaluation of sealing results (initial and with time). Completed.

Inventory and Testing -- A total of 321 samples of Colorado clays were collected and tested in the laboratory. Developments of Deposits and Field Trials -- Eight deposits have been developed commercially. Clays from these deposits were used in 152 trials in canals and ponds during the three year project.

WAKE CHARACTERISTICS FOR BODIES OF REVOLUTION WITH MOMENTUM ADDITION.

David Taylor Model Basin.

Dr. L. V. Baldwin, Acting Dean of Engineering.

Experimental, theoretical; basic research.

Turbulent and mean flow characteristics of wakes formed behind axisymmetric and elliptical bodies have been studied experimentally in a wind tunnel using hot-wire anemometers. Theoretical studies have lead to explanations of all observed phenomena. Completed.


INVESTIGATION OF RAINFALL AND RUNOFF SEQUENCES.

National Science Foundation.

Dr. V. M. Yevdjevich, Professor of Civil Engineering.

Theoretical; basic research.

The time study of river flow and precipitation has been continued.

The time dependence of annual values and monthly values have been determined for samples of several hundreds of river flow and precipitation stations.


UNSTEADY FREE SURFACE FLOW IN A LARGE STORM DRAIN.

U. S. Bureau of Public Roads and U. S.

Public Health Service.

Dr. V. M. Yevdjevich, Professor of Civil Engineering, A. H. Barnes, Assoc. Prof. of Civil Engineering and G. L. Smith, Asst. Prof. of Civil Engineering.

Experimental and theoretical; basic research.

A 626-ft long, 36-in. diameter conduit, movable on 43 supports on a hillside, is used as the main experimental facility to simulate and record free surface waves in pipes. The experimental data are computed by using a digital computer and then a comparison is made. The ultimate purpose is a development of a set of routing methods to suit the desired accuracy and the quality of the initial and boundary data. The experimental part of the hydraulic study has progressed sufficiently during 1964 so that the analysis of data is underway. The analytical study for directing the research is being completed.


GROUND-WATER RESERVOIR MANAGEMENT.

Colorado Agricultural Experiment Station.

Mr. R. A. Longenbaugh, Junior Civil Engineer and M. W. Bittinger, Associate Civil Engineer.

Theoretical and field investigation; applied research.

It is the purpose to study the operating characteristics of ground water reservoirs in Colorado. Specific studies include (1) natural recharge from ephemeral streams, (2) electric analog study of High Plains aquifer, (3) evaluation of natural recharge to High Plains aquifer, and (4) development of a general mathematical model, for solution on a digital computer, that can be adopted to particular ground water aquifers to relate the effect of the various parameters on the aquifer. (1) Kiowa Creek data analysis reveals influence of ephemeral stream flow on irrigation wells. (2) Electric analog model has provided preliminary estimates on the quantity of water that can be pumped from the High Plains Aquifer. (3) Mathematical models have shown importance of priority of rights, aquifer characteristics, ground water pumping and consumptive demand on management of an integrated surface-ground water system.


WATERSHED HYDROLOGY.

Colorado Agricultural Experiment Station.

Dr. V. M. Yevdjevich, Prof. of Civil Engineering, and Dr. Brian M. Reich, Asst. Professor.

Theoretical and experimental; basic research.

The research is concerned with floods from small watersheds. It is being pursued in three phases: (1) Assembly of research data from actual floods on small watersheds, (2) physical experimental studies on a large rainfall-runoff simulator-drum, (3) theoretical studies of the relation between flood hydrographs and the rainfall and catchment factors that affect them. Phase one is complete, data have been assembled, progressing well; Phase Two is active in the planning stages, and Phase Three is active in the initial stage. The leads to stem flumes and rainfall data, that have been established, will be carried to the conclusion of punching all the information onto cards. The programs developed thus far will be improved so that the observed and theoretical hydrographs can be
obtained at maximum speed from an x-y-plottter. Additional multi-variate analyses on such items as total runoff volumes, peak rates of runoff will be completed. Theoretical considerations of runoff, and probability analyses will be made.


4.110 TURBULENT AIR MOTION IN THE HIGH ROCKIES IN RELATION TO THE WATER YIELD OF UPPER WATERSHEDS.

(b) Colorado Agricultural Experiment Station.
(c) Dr. Herbert Riehl, Professor of Atmospheric Science.
(d) Field, basic and applied.
(e) The structure of the turbulent wind eddies, which propagates an exchange of energy between atmosphere and ground in the high mountains, is unknown. Yet these have sufficient force for the most part to blow the snow away from the mountain slopes above timberline. This snow in part drifts into high-altitude basins where it accumulates in depth augmenting the summer water supply; in part it drifts on slopes where it readily evaporates. Much interest has been shown in the possibility of channeling the drift so that it can be carried by an engineering structure that will discharge it to a basin. This possibility is feasible. But any construction is dependent on knowledge of the turbulence spectrum, especially on the first day following snowfall. In order to determine this spectrum, a first installation containing electronic wind and temperature measuring instruments has been established above timberline in the Central Colorado Rockies.

4.112 THE DISCHARGE OF MAJOR WESTERN RIVERS IN RELATION TO THE GENERAL CIRCULATION OF THE ATMOSPHERE.

(b) Office of Naval Research, Department of the Navy.
(c) Dr. Herbert Riehl, Professor of Atmospheric Science.
(d) Basic research.
(e) The discharge of major western rivers (Colorado, Columbia, Sacramento, Rio Grande) has fluctuations with the order of magnitude of the mean values discharged annually. These fluctuations are brought about mainly by variations in precipitation yield and by variable evaporation. Heavy precipitation may result in conditions favorable for the recurrence of cyclones over headwater areas. High evaporation, requiring weeks of abnormally dry and warm conditions, may result in the general circulation anomalies of longer duration. The objective of the study is (1) to separate the "systematic" and "random" components of the precipitation, and (2) to determine the controls for the systematic anomalies of precipitation and evaporation.

(f) Completed.

4.608 STRUCTURE OF TURBULENCE IN TURBULENT SHEAR FLOW.

(b) Department of the Army.
(c) Dr. J. E. Cermak, Prof. of Engineering Mechanics and Civil Engineering; Dr. E. J. Plate, Assoc. Professor, and Dr. V. A. Sandborn, Associate Professor; Dr. H. Chuang, Asst. Prof.; Dr. G. J. Binder, Assoc. Professor; and Dr. M. E. Mckinstry, Asst. Prof., Engineering Department, CSU.
(d) Experimental research; basic research, doctoral theses.
(e) The effect of surface roughness and surface heating or cooling upon the structure of turbulence in boundary layer flow will be determined. The flows investigated will be those on the heated or cooled floor of a wind-tunnel test section 6 x 6 ft in cross section and 60 ft long. Space-time correlations, joint probability densities, spectra and intensities of the turbulent velocities and temperatures will be obtained by hot-wire and anemometer analog computers employing magnetic tape input.

Efforts are being made to determine the diffusion characteristics for instantaneous point and line sources of heat and mass located within the turbulent boundary layer. This work is another way in which the effect of vertical temperature gradients and the turbulent boundary layer effect the turbulence structure.


4.612 TRANSPORT OF PARTICLES THROUGH UNSATURATED SOILS.

(b) Department of the Army and National Center for Atmospheric Research.
(c) V. A. Sandborn, Associate Professor.
(d) Laboratory development.
(e) The system employing magnetic tape input is designed to yield the following information:
   (1) spectra (10^7 to 10^12 cycles/second), (2) joint probability densities, (3) root-mean-squares, and (4) space-time correlation.

(f) Active, continuing.
(g) A considerable amount of data has been
accumulated which show that soils (and even sand) have a considerable capacity to adsorb virus-like particles. If, however, a continuous supply of these particles are supplied over a period of time, sand will eventually lose its capacity to retain additional particles. Under the latter conditions virus-like particles may be transported for considerable distances through sands (even fine sands). Soils having even a small amount of clay can retain a vastly greater quantity of virus particles than clean sands. The mechanism is apparently physical adsorption rather than entrapment.

(4617) MECHANICS OF LOCAL SCON.

(b) Department of Commerce, Bureau of Public Roads, Hydraulic Research Division.

c) Mr. S. S. Karaki, Associate Professor and Dr. H. W. Shen, Assoc. Professor.

d) Theoretical and experimental; basic research.

e) A theoretical study of the mechanics of local scour is under way to develop basic equations for determining local scour. Basic experiments will be undertaken simultaneously to assist theoretical development.


(5165) HYdraulics.

(b) Colorado Agricultural Experiment Station and Civil Engineering Section.

c) Dr. D. B. Simons, Associate Dean for Research, Colorado State Univ., Fort Collins, Colorado.

d) Basic hydraulic research.

e) This research is in hydraulics oriented toward agriculture and irrigation. The principal areas under study include: flow velocity, sediment transport, resistance to flow in alluvial channels with limited research on rigid boundary hydraulics including loss in bends and the mechanics of flow in alluvial channels.

(g) A study has been completed on the fall velocity of gravel size particles. Reports are in preparation on resistance to flow in open channels, bed material transport in open channels, and design of stable channels.


(5161) CHANGE IN QUALITY OF DRAINAGE EFFLUENT FROM IRRIGATION PROJECTS USING A VISCOS FLOW ANALOGY MODEL.

(b) U. S. Bureau of Reclamation.

c) Mr. M. W. Bittinger, Assoc. Civil Engineer, Colo. State Univ., Fort Collins, Colo.

d) Experimental.

e) The study is designed to determine quality change (with time) of tile drainage effluent under various aquifer and geometry conditions.

(g) Results - Dimensionless curves have been prepared relating quality of effluent to time, permeability, porosity, tile spacing, and distance above impermeable layer, and recharge rate for uniform aquifers. Additional studies are being conducted on layered aquifers.

(5164) FLOW MEASUREMENT.

(b) Colorado Agricultural Experiment Station, Civil Engineering Section and Northern Plains Soil and Water Conservation Research Division, ARS, USDA.

c) Dr. H. J. Koloseus, Assoc. Prof. of Civil Engineering, Colorado State Univ., Fort Collins, Colorado.

d) Experimental laboratory and basic research which involves staff and graduate student participation leading to M.S. and Ph.D. degrees.

e) This project has the general objective of developing and improving devices and techniques for the measurement of irrigation water. The specific research activities include:

(1) The further development of the semi-conductor strain gage method of measuring velocity in pipes and open channels and its utilization to measure the velocity distribution above and very close to both smooth and rough boundaries in open channels, and (2) Continued studies of the trapezoidal measuring flume, control structures for alluvial channels and other metering devices.

(g) A suspension wire probe involving use of semiconductor strain gage has been developed to measure average velocity in pipes and essentially point velocities in open channels. The probe is being further modified to measure velocity very close to boundaries. Also, a pipe insert flow meter is being developed.

(5393) MANAGEMENT OF GROUND WATER RESERVOIRS - SURFACE WATER SUPPLIES.

(b) Colorado Water Conservation Board.

c) M. W. Bittinger, Associate Professor.

d) Theoretical and experimental; applied research.

e) A study of operation and management of ground water reservoirs which are in hydraulic connection with appropriated stream flow. It is the purpose of this study to develop practical conjunctive-use plans so as to alleviate water right conflicts, increase beneficial use and stabilize water supplies for junior appropriators.

(f) Completed.

g) Systems analysis studies have been completed on simple hypothetical stream-aquifer systems.

(5394) ECONOMICS OF WATER TRANSFER: AN INSTITUTIONAL APPRAISAL.

(b) State of Colorado Experiment Station - Western Regional Project W-01.

c) L. M. Hartman, D. A. Seastone and R. L. Anderson.

d) Theoretical, field investigation, basic research and applied research.

e) The study was set up to investigate and compare various organizations and procedures, which control the use of water in terms of their respective achievement of allocative efficiency. Also, to investigate and estimate demand functions for water in various uses and investigate complimentary and competitive relationships between uses, with emphasis on the implications of these relationships for organizational arrangements. The project has just been initiated and present accomplishments include a rather comprehensive study of the organization of the Northern Colorado Conservancy District.

(5395) WATERSHED MANAGEMENT PRACTICES AFFECTING WATER SUPPLIES ON IRRIGATION PROJECTS.

(b) U. S. Bureau of Reclamation.

c) R. E. Dilts and J. H. Weiman.

d) Field investigation; applied research.
(e) The objectives of this study are: (1) to evaluate the use of dye solutions as a method of determining yields from watershed subdivisions, (2) to test snow surface additives for the suppression of evaporation and control of snow melt, and (3) to study such additional watershed management measures as are suggested by the work and which offer promise of successful application to Bureau projects.

5396 EXPERIMENTAL ARTIFICIAL RECHARGE STUDY-AIRICKAREE RIVER.

(b) Colorado Ground Water Commission.

(c) Mr. Robert A. Longenbaugh, Assistant Research Engineer, CSU.

(d) Experimental; applied research, design and operation.

(e) The purpose of this study is to determine the feasibility and practicality of artificial ground water recharge with Eastern Colorado ephemeral-stream flood flows using temporary low-cost structures. The project will include the design and evaluation of several different types of recharge structures.

(g) Structures were designed and constructed on two artificial recharge sites. Data were collected for two floods in June prior to the destruction of the project by the July 24 flood. Analyses of data and consideration on reconstruction of the project are underway.


5397 PUMPING PLANT EFFICIENCY STUDIES.

(b) KO, Highline and YW Rural Electric Associations, Kansas-Nebraska and Plateau Natural Gas Companies, and Colorado Farm Power Council.

(c) Mr. R. A. Longenbaugh, Assistant Research Engineer, Colorado State University, Fort Collins, Colorado.

(d) Field investigation and operation.

(e) This is a part of an interdepartmental study that is being conducted to determine the pumping costs for the deep well turbine irrigation pumps in Eastern Colorado. Both Natural Gas and Electric pumping plants will be evaluated. Efficiency data will also be used to calculate the total quantity of water pumped from various sources in Eastern Colorado using electricity, natural gas, and liquid petroleum gas for power.

(h) Final report on observed efficiencies of the 303 wells and a discussion of the causes of low-efficiencies will be published by January 1, 1966.

5398 ELECTROKINETIC-POTENTIAL-FLUCTUATION METHOD FOR INVESTIGATION OF TURBULENT FLOW.

(b) National Science Foundation.

(c) J. E. Cermak, Professor of Engineering Mechanics in charge of Fluid Mechanics Program, Civil Engineering Section, Foothills Campus, CSU.

(d) Experimental and basic research.

(e) A systematic study is being made of the response of electrodes to electrokinetic fluctuations produced by turbulence in flowing water. An effort is being made to determine functional sensitivity of the probes and to optimize their design for use in measuring turbulence characteristics in water. Work in the effect of dissolved salts and different electrode materials on response of the probes is underway.


5400 CHEMICAL SEALING OF WATER CONVEYANCES.

(b) State of Colorado.

(c) Mr. R. D. Dirmeyer, Jr.

(d) Experimental and field investigation; applied research and development.

(e) The purpose of this project is to develop practical, fast and low-cost design procedures for utilizing chemicals, such as NaCl and NaCO3, for pond sealing purposes. The work is included in laboratory evaluations and field trials.

(g) Three field trials have been installed and are being evaluated.

5401 DIFFUSION IN SHEAR FLOWS.

(b) Health, Education and Welfare, State Services.

(c) Dr. J. E. Cermak, Professor of Engineering Mechanics in charge of Fluid Mechanics Program, Dr. L. V. Baldwin, Acting Dean, College of Engineering.

(d) Experimental; basic research.

(e) A study of turbulent diffusion in turbulent boundary layers with varying degrees of thermal stability is being conducted in the meteorological wind tunnel. One specific goal is to determine the effect of molecular diffusivity of a diffusing gas upon the overall diffusion rate.

5402 RESEARCH INITIATION - MEANDERING IN STRAIGHT ALLUVIAL CHANNELS.

(b) National Science Foundation.

(c) H. W. Shen, Associate Professor.

(d) Experimental and theoretical; basic research.

(e) This is to study the generation of secondary currents between the smooth and rough boundaries in an open channel. The development of secondary currents in the flow is the cause of forming alternating scour holes (commonly known as meander pattern) on the alluvial channel bed.

(f) Temporarily discontinued.

(g) The generation of secondary currents in open channel was found to be associated closely with both the presence of rough boundaries and the unsteadiness of the main flow.

(h) Under preparation.

5403 SLICE JET INVESTIGATION.

(b) Kalium Chemical Limited.

(c) V. M. Yevdjevich, Professor.

(d) Experimental; basic research.

19
The diffusion of submerged circular and two-dimensional jets have been well studied. This investigation refers to slot jet deflection, with varying width-length ratio of slots. The time-average velocity distributions, as well as flow rate, momentum and energy changes with distance from the orifice are investigated.

The distribution of velocities as function of length-width ratio of slot jets have been determined. As a result of the research on the project, Slot Jet Investigation, the following paper was published: "Diffusion of Slot Jets with Finite Orifice Length-Width Ratios," by V. M. Yevdyjevich, Dec. 1965, CSU, Hydraulics Paper No. 2.

REMOTE SNOW MEASURING DEVICE.


Jack N. Washichek, Supervisor, USDA and SCS.

Field Investigation; operation and development.

This device is a 12-foot diameter pillow filled with anti-freeze which indicates water content of the snow at the site. This is achieved by the use of a pressure indicating pressure on the pillow. This data can be recorded on standard A-55 or F Recorder or telemetered to any area for reception. Purpose is to develop some instrument to gather continuous data relating to snow pack in the mountainous areas. It will also indicate duration, and intensity of each snow event, this equipment could be installed in unaccessible areas. Six more remote sentinels will be installed in the Steamboat Springs area. These will be capable of telemetering the information to Steamboat Springs.

The remote snow measuring device installed at Berthoud Pass last year accurately measured the water content of the snow at the site. Some problems encountered, generally were attributed to the expansion of the methanol. This year a closed system will be used to eliminate the diurnal change.


GROUND WATER IN HIGH PLAINS OF COLORADO.

Plateau Natural Gas Company

M. W. Bittinger, Associate Professor, Civil Engineering Section.

Thesis.

A study of ground water management problems and needs in the High Plains of Colorado.

Completed.

Natural ground water recharge is negligible to potential development and sound management is needed, based on physical, legal and economic considerations.

EVALUATING STREAM POLLUTION IN THE SOUTH FLATTE RIVER NEAR DENVER, COLORADO USING AERIAL PHOTOGRAPHY.

Civil Engineering Section, Engineering Research Center, Colorado State University, Ft. Collins, Colorado.

M. M. Skinner.

Field investigation and applied research.

Four film types (black and white, black and white infra-red, color and color infra-red) have been used to photograph a stretch of the South Platte River in the vicinity of Denver, Colorado. The purpose of the study is to (1) detect the location of outfalls; (2) observe the photographic impression of pollution in the stream; (3) determine film types most suitable for detecting stream pollution; and (4) develop photo interpretive techniques applicable to stream pollution studies in general.

Completed.
HYDRAULIC OPERATING CHARACTERISTICS OF LOW GRADIENT BORDER CHECKS IN THE MANAGEMENT OF IRRIGATION WATER.

(b) Colorado Agricultural Experiment Station and Office of Water Resources Research; Agricultural Research Service (Cooperator)
(c) Dr. Norman A. Evans, Head, Agricultural Engineering Dept.
(d) Field investigation and applied research.
(e) Determine water application efficiencies for low gradient border checks. Determine the limitations of border checks under different cropping practices. Determine effectiveness of automation on low gradient border checks. Develop design criteria for low gradient border checks.
(g) The project began on July 1, 1965 and as yet no significant results have been obtained.

(5876)

FLOW OF SUBSOIL WATER IN PROXIMITY OF DRAINAGE FACILITIES.

(b) Colorado Agricultural Experiment Station.
(c) Dr. Norman A. Evans, Head, Agricultural Engineering Department.
(d) Experimental, theoretical, basic research, and applied research.
(e) To develop methods for the construction and operation of laboratory models of systems involving flow from soils into drains.
(g) Criteria of similitude for flow in partially saturated soils have been developed theoretically and tested experimentally. The tests have shown these criteria of similitude to be valid.
(h) CSU Hydrology Paper No. 9.

(5877)

DEVELOPMENT OF MATHEMATICAL METHODS OF EVALUATION OF RESULTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS.

(b) U. S. Bureau of Reclamation, U. S. D. I.
(c) Dr. V. M. Yevjevich.
(d) Theoretical and applied research.
(e) The objectives of this research are: (1) to develop criteria for selecting mountainous drainage basins for general and experimental weather modification procedures; (2) to evaluate the hydrologic characteristics of river flows from basins selected for experimental weather modification purposes; and (3) to develop mathematical and statistical techniques for evaluating the achievements of experimental weather modification programs.
(g) Research still in progress.

(5879)

WATER STORAGE MANAGEMENT.

(b) Office of Water Resources Research, U. S. D. I.
(c) Dr. V. M. Yevjevich.
(d) Theoretical and basic research.
(e) The objective of this research is to determine the optimum method of water storage for any selected watershed or region on the basis of climatic, geomorphic, ecological and other characteristics.
(g) Project replaced by Project 5881, on which research is still in progress.

(5879)

IMPACT OF LAND USE ON WATER QUALITY WITHIN A FORESTED MOUNTAIN WATERSHED.

(b) Experiment Station, McIntyre-Stennis.
(c) James R. Heiman.
(d) Field investigation; basic research.
(e) The objectives of this study are to assess present water quality characteristics within a forested mountain watershed at varying natural flow regimes under land use conditions of limited development to non-use, and to measure the effects of multiple land use management—including road construction, logging, recreational developments, and grazing—on water quality.

(5876)
(5886) STUDY OF CHANGES IN WATER QUALITY IN A GROUND WATER RESERVOIR.

(b) Office of Water Resources Research.
(c) Robert A. Longenbaugh, Asst. Research Engineer, CSU.
(d) Theoretical investigation and applied research.
(e) A field study was conducted near Severance, Colorado, to determine the extent and cause of their ground water quality problems. Development of research techniques and experience in ground water quality investigations was one of principal goals.
(f) Ground water quality in the Severance area of Colorado is influenced by geology, fertilizer practices, feedlot contamination, oil field brine disposal and individual influences can not be differentiated.

(5881) WATER STORAGE MANAGEMENT.

(b) Office of Water Resources Research, U.S.D.I.
(c) Dr. V. M. Yevdeovich.
(d) Theoretical and basic research.
(e) The objective of this research is to determine the optimum method of water storage for any selected watershed or region on the basis of climatic, geomorphic, ecological and other characteristics.
(f) The term storage is here taken to mean the beneficial retention of water by impounding reservoirs, groundwater recharge, snow accumulation, and/or watershed management practices.
(g) The optimal method of storage is that which achieves the most economic balance between the value of water lost from beneficial use by evaporation or other causes and the cost of storage utilization.
(h) Research still in progress (continuation of Project 5875).

(5882) EVALUATION OF THE TOTAL WATER RESOURCES OF THE KIOWA-BIJOU BASINS OF COLORADO.

(b) Colorado Water Conservation Board.
(c) Robert A. Longenbaugh and Harold R. Duke, Research Engineers, CSU.
(d) Field investigation and applied research.
(e) All available data will be analyzed to evaluate the total ground water and surface water resources of the Kiowa-Bijou watersheds. Analyses will be made on the required accuracy of the data and suggestions made for the collection of the required data for management of the water resources.
(f) Quantities of water in storage, present pumping rates, annual natural recharge and projected pump withdrawals have been computed for the Kiowa-Bijou Basin.

(5883) USE OF RADIOISOTOPES IN MAKING ACCURATE DISCHARGE MEASUREMENTS IN PIPELINES.

(b) U. S. Bureau of Reclamation.
(c) Robert W. Filmer and Jack C. Schuster.
(d) Experimental, theoretical and applied research.
(e) To study the turbulent diffusion of a solute injected into a pipeline so that the accuracy of indirect flow measurements can be predicted.

(5884) DESIGN FLOODS FOR SMALL WATERSHEDS IN ARID AND SEMI-ARID WEST.

(b) Bureau of Land Management, Dept. of the Interior.
(c) Dr. Brian M. Reich.
(d) Theoretical and applied research.
(e) Knowledge is sought of floods in arid and semi-arid regions, their probability, hydrographs and relation to rainfall and basin parameters.

(5885) HYDRAULIC INVESTIGATION OF FLEXIBLE TUBES.

(b) Kallium Chemicals Limited.
(c) Mr. B. P. Edmonds, Kallium and Dr. A. H. Barnes, CSU.
(d) Experimental, development and applied research.
(e) The purpose of this study is to develop a nozzle of such a geometry that the hydrodynamic forces produced thereby will deploy a flexible hose under a free water-surface. The study is (1) to determine the hydrodynamic pressures of various nozzle geometries; and (2) to determine the hose diameter-discharge relationships for a stable hose position.
(f) Nozzle geometries have been determined to produce predictable forces on the end of a hose. Additional field tests are proposed to be made.

(5886) DEVELOPMENT OF TELESCOPING TUBES FOR USE IN SOLUTION MINING.

(b) Kallium Chemicals Limited.
(c) George L. Smith (CSU); B. P. Edmonds, Mining Manager (Kallium Chemical Limited).
(d) Experimental research; design; development.
(e) The purpose of this study is to design, construct and test a telescoping tube with a reactive head at the discharge outlet. The telescoping tube to have an O.D. range from 3-1/4 to 1 in., and to be tested under various conditions of discharge and buoyancy.
(f) Development of telescopic tubes and theoretical curves for determining maximum length of the nested tubes for given t/D = thickness/diameter and influence conditions of fluids of different specific gravities. Maximum deflection of the pipes for given lengths and fluid characteristics has been determined also.
(g) Preliminary report in preparation.

(5887) STUDY OF THE HYDRAULICS OF FLOW THROUGH SOLUTION CAVITIES.

(b) Kallium Chemicals Limited.
(c) Dr. E. F. Holingviant, Kallium and Dr. A. H. Barnes, CSU.
(d) Experimental and basic research.
(e) This is a basic observational study to (1) determine the characteristics of the fluid motion within a solution cavity; and (2) to identify those parameters relating geometry, discharge rate and specific gravity of the effluent brine from a solution cavity. Two experimental facilities have been constructed to observe the phenomena. Each represents an 18" cylindrical sector of an assumed solution cavity. One approximately 6 inches high by 24 inches long and the larger 5 feet high by approximately 15 feet long. The ultimate purpose will be to better understand the physical process of solution mining as it applies to water-soluble salts.
(f) Preliminary quantitative studies have indicated the general pattern of circulation as predicted. Certain anomalies are attributed to the character of the salt blocks (livestock) used. Natural rock salt blocks will be used to observe whether or not the same phenomena exists.

(5888) STUDY OF NIPPLES AND RIPPLE BED STRATIFICATION WITHOUT AND WITH SUPERPOSED WIND-GENERATED WAVES.

(b) Marathon Oil Company, Littleton, Colorado.
(c) Dr. D. B. Simons, Associate Dean for Research, Colorado State University, Fort Collins, Colorado.
(d) Experimental and basic research.
(e) A study of the characteristic stratifications of ripples generated at the sand-water interface in alluvial channels with and without wind generated waves at the air-water interface.

(5889) STABLE ALLUVIAL CHANNELS.

(b) National Science Foundation.
(c) H. W. Shen, Associate Prof. and D. B. Simon,
Professor.

(d) Experimental, basic research.
(e) The objectives of this project are to study:
1. The shear distribution on the rigid boundary of channels with different cross section shapes of treatment load; seepage force, flood plain material and hydraulic conditions on the ultimate stable channel cross section based on the variation of shear distributions along the boundary.

(5890) CHANGES IN THE PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF GROUND WATER RESERVOIRS AND ADJACENT SURFACE WATERS.

(b) The Office of Water Resources Research, Dept. of the Interior.
(c) S. M. Morrison, Prof. of Microbiology, Colorado State University.
(d) Experimental, basic research.
(e) The objectives of the research are (1) to determine the chemical and biological relationships between ground water and adjacent surface flows under laboratory conditions and (2) to determine the changes in physical and biological characteristics of ground water reservoirs as a result of man's activities in a specified natural location.

Laboratory studies will be done in models of a ground-water-surface flow system with known chemical agents and bacteria used as markers to study flow, movement and adsorption. The field studies will be at selected sites adjacent to a stream to study ground water movement and quality as related to the geology and man made structures.

(5891) DIFFUSION OF ENTRAPPED GASES IN RESPONSE TO INTERFACIAL ENERGY.

(b) National Science Foundation.
(c) A. T. Corey, Dept. of Agric. Eng., Colorado State University, Fort Collins, Colorado.
(d) Experimental, theoretical, and basic research.
(e) A study of the process whereby a gas and isolated pockets (surrounded by liquid) diffuse from porous media under the influence of interfacial energy. The object is to develop and test equations describing the rate of diffusion of entrapped gas from porous media.

(5892) FLOW INTO SUB-SOIL DRAINS.

(b) CSU Agricultural Experiment Station.
(c) A. T. Corey, Dept. of Agricultural Engrg., Colorado State University, Fort Collins, Colorado.
(d) Experimental, theoretical, applied research and development.
(e) Development of techniques for modeling systems involving drainage from soils.
(f) A theory of similarity for flow in partially saturated porous media (and applicable to drainage from soils) was developed. The criteria of similarity resulting from this theory were tested experimentally and found to be valid.

(g) CSU Hydrology Paper Number 9.

(5701) STUDIES OF BRANCHED OPEN-CHANNEL FLOW.

(b) Laboratory project.
(c) W. M. Flapay, Department of Civil Engrg., University of Colorado, Boulder, Colo. 80304.
(d) Laboratory investigation; applied research.
(e) Study of the division of flow in an open channel as influenced by the presence of a branch, the Froude number upstream, the ratio of the width of the branch to the width of the main channel for sub-critical flow.
(f) Master's thesis will be completed early in 1966 and will be available on loan from University of Colorado library. "Studies of Branched Open-Channel Flow," by Barada Sama.

(5702) REGIONAL ENVIRONMENTS ON THE EAST SLOPE OF THE COLORADO FRONT RANGE.

(b) Army Research Office.
(c) Dr. John W. Marr, Director of Arctic and Alpine Research, Univ. of Colorado, Boulder, Colorado 80304.
(d) Field investigation; applied research.
(e) A continuing project started in 1951 with measurements of air and soil temperature, relative humidity, precipitation, wind, snow depth and soil moisture at four stations ranging from 7,000 to 12,300 feet elevation. Solar radiation measurements started in 1964.
(f) A master's thesis on the relationship of geographic parameters and storm movement to precipitation is now being completed by Civil Engineering graduate student.

(h) The thesis by Donald Richard Minges will be available in 1966 on loan from University of Colorado library.

(5703) ENGINEERING-HYDROLOGIC ANALYSIS OF WATER RIGHTS.

(b) Office of Water Resources Research, Dept. of the Interior.
(c) Dr. J. Ernest Flack, Dept. of Civil Engrg., University of Colorado, Boulder, Colo. 80304.
(d) Field investigations; applied research.
(e) A case stream is being studied in detail to identify the potential quantities of water described in the legal water rights as to priority, yield and timing of the diversions. These are being correlated with stream flow to determine the inter-relationship of legal and hydrologic definitions of the rights.

(g) Preliminary results include evaluation of the effect of urbanization on downstream irrigation withdrawals. Low flow analysis of the case stream at various locations and with different end-of-season dates have been made.

(5704) ANALYSIS OF TOTAL WATER USE.

(b) Office of Water Resources Research, Dept. of the Interior.
(c) Dr. J. Ernest Flack, Dept. of Civil Engrg., University of Colorado, Boulder, Colo. 80304.
(d) Field investigation.
(e) The goal of this study is the determination of total water use of selected municipalities and industries. Total water use includes withdrawals, consumptive use and return flow. The effects of price and climate on water consumption will be considered.

(g) Water consumption by categories of users--residential, industrial and commercial--have been determined for Boulder, Denver and Colorado Springs, Colorado and Monterrey, Mexico. The effects of water and climatic factors on water use have been investigated. Changes in water use and revenue from water sales overtime have been investigated and some conclusions regarding projections have been made.

(h) "Analysis of Total Water Use by Selected Cities and Industries," by Fortunato Martinez. M.S. thesis published through cooperation of the Natural Resources Center, Colorado State University.

(5705) STABILITY OF STONES IN OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Dr. J. Ernest Flack, Dept. of Civil Engrg., University of Colorado, Boulder, Colo. 80304.
(d) Experimental, basic research, for master's thesis.
(e) This study is an experimental investigation of the scour of stones subjected to high velocity flow in an open channel. The loss
of material from the test section is being correlated with parameters such as the mean velocity of flow, the bed velocity, the rate of flow, depth of flow, slope of channel, and diameter and weight of the stones.

(f) Suspended.

(g) Empirical relationships have been developed correlating the scour of the stones with various flow and geometry characteristics.

(h) "Stability of Stones Under Flowing Water," by Nazir Jomejo. W. H. Posey, this, in preparation, will be available on loan from the University of Colorado library, Boulder, Colorado.

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UNIVERSITY OF CONNECTICUT, School of Engineering.

(5469) BOUND-ROCK EROSION PROTECTION FOR HIGHWAY DRAINAGE DITCHES.

(b) Connecticut State Highway Department and Institute of Water Resources.

(c) Prof. C. J. Posey, Box U - 37, Univ. of Conn., Storrs, Conn. 06268.

(d) Experimental, applied.

(e) Development of a scientific erosion-protection method to highway ditches. Experiments will provide necessary design data and develop construction methods for low-cost installations.

(5450) RECOVERY OF DEPTH OF SCOUR FLOATS RELEASED DURING FLOODS.

(b) Department of Civil Engineering.

(c) Prof. C. J. Posey, Hydraulics Research Laboratory, Box U - 37, Univ. of Conn., Storrs, Conn. 06268.

(d) Field investigation; for master's thesis.

(e) Flots devised by W. B. Moeller were released in Connecticut and Willimantic Rivers during spring 1964 peak flows. Flots were brightly marked and had instructions and a return postcard visible from the outside. A float capable of reporting by radio is now being designed.

(f) Design of reporting floats temporarily suspended; probable subject of doctoral thesis.

(g) M. S. Thesis available on loan from Wilbur Cross Library, University of Connecticut, Storrs, Connecticut 06268. "Depth of Scour by Detection of Release of Buried Floats" by W. G. Moeller, 1965. See also Rocky Mountain Hydraulics Laboratory item 5468.

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CORNELL AERONAUTICAL LABORATORY, INC.

(5493) THEORETICAL STUDY OF HYDROFOIL FLUTTER CHARACTERISTICS.

(b) David Taylor Model Basin, Office of Naval Research, Dept. of the Navy.

(c) Dr. Irving C. Stalder, Head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Inc., P. O. Box 525, Buffalo, New York 14221.

(d) Applied research (theoretical).

(e) The purpose of this investigation was to formulate the two-degree-of-freedom flutter determinant of a two-dimensional hydrofoil near the free surface and, then, to compute flutter boundaries for various values of system parameters.

(f) In progress.

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(5737) REDUCTION OF RIVER HEAT POLLUTION BY TURBULENCE STIMULATION.

(b) Institute of Water Resources.

(c) Prof. V. E. Scotttron, Civil Engineering Dept., Box U-37, Univ. of Conn., Storrs, Conn. 06268.

(d) Experimental and theoretical; basic research for both master's and doctoral theses.

(e) The objective of this work is to break up stratification of heated river flows by generation of three-dimensional turbulence. The laboratory program will investigate a variety of turbulence generating devices, including systematic roughness, in low-speed air flows.

(5756) STUDY OF DISTURBANCE ON THE FREE SURFACE OF ROTATING FLUIDS.

(b) Laboratory project.

(c) Dr. J. D. Lin, Civil Engrg. Dept., Box U-37, Univ. of Conn., Storrs, Conn. 06268.

(d) Experimental and theoretical; basic research for both master's and doctoral theses.

(e) A theoretical and experimental study of the scattering of the disturbance generated on the free surface of rotating fluids. A rotating tank of 5' in diameter and 3' in depth is used for the experiments.

(5759) A STUDY OF VISCOUS FLOW PAST A SHIP.

(b) David Taylor Model Basin, Navy Department.

(c) Dr. J. D. Lin, Dept. of Civil Engineering, Box U-37, University of Conn., Storrs, Conn. 06268.

(d) Theoretical, basic and doctoral thesis.

(e) Calculation of Potential Flow over the hull of a ship generated by singularity distribution. Calculation of the boundary layer along the streamlines on the hull. Investigation of the wake and wave resistance of the hull form.

(f) Quarterly progress reports since January 1965.

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(5769) FILTER EROSION PROTECTION.

(b) Water Resources Institute.

(c) Prof. C. J. Posey, Box U-37, Univ. of Conn., Storrs, Conn. 06268.

(d) Basic research, experimental.

(e) To determine whether finest-grained non-cohesive and cohesive materials can be protected by Terzaghi-Vickburg inverted filter.

(f) In progress.

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(5491) FLOW IN A WIDE FLAT TRIANGULAR CHANNEL.

(b) Laboratory project.

(c) Prof. C. J. Posey, Box U - 37, Univ. of Conn., Storrs, Conn. 06268.

(d) Experimental, basis.

(e) Measurement of water-surface configuration approaching drop-off at the end of a smooth channel with horizontal grade line.

(f) Suspended.

(g) Important of lateral components is evident but unaccounted for in presently available theories. Turbulence intensity seems uniform over entire width.

(5492) DISCHARGE FROM CIRCUMFERENTIAL WEIRS.

(b) Department of Civil Engineering.

(c) Prof. C. J. Posey, Box U - 37, Univ. of Conn., Storrs, Conn. 06268.

(d) Experimental; master's thesis.

(e) Head measurements and naspue measurements for water flowing out of vertical pipes and spilling over their horizontal peripheries.

(f) Completed.

THEORETICAL INVESTIGATION OF FORCES AND MOMENTS ON AN OSCILLATING HYDROFOIL WITH AN OSCILLATING FLAP.

(b) Bureau of Ships, Dept. of the Navy.
(c) Dr. Irving C. Statler, Head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Inc., F. O. Box 235, Buffalo, New York 14221.
(d) Applied research (theoretical).
(e) The objective of this study is to compute the lift, total moment and hinge moment for a fully-wetted oscillating hydrofoil with an oscillating flap from the exact, linearized, two-dimensional potential solution. The solution to be used takes full account of the forcing waves caused by the hydrofoil. Completed.

(5633) UNSTEADY FORCES AND MOMENTS ON A TWO-DIMENSIONAL FULLY CAVITATED HYDROFOIL.

(b) Bureau of Ships, Dept. of the Navy.
(c) Dr. Irving C. Statler, Head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Inc., F. O. Box 235, Buffalo, New York 14221.
(d) Applied research (theoretical).
(e) The purpose of the project is to determine the steady and unsteady forces and moments on a fully cavitated hydrofoil operating near a free surface. The approach being taken to this general problem is to use linearized flow theory to examine the forces and moments on a fully cavitated flat plate executing either steady or harmonic motion near a free surface. Full account is taken of the gravity waves generated by the motion of the foil-cavity system and cavitation numbers greater than or equal to zero are considered.

(5654) AN EXPERIMENTAL AND THEORETICAL STUDY OF SCATTERING FROM WATER WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. James A. W. Head, Applied Physics Dept., Cornell Aeronautical Laboratory, Inc., F. O. Box 235, Buffalo, N. Y. 14221.
(d) Applied research (experimental).
(e) The purpose of this research is to investigate certain aspects of microwave scattering from water waves. In particular, relationships were sought between characteristics of the waves and their Doppler spectra for back-scattering. The program included experimental and analytical work. In the experiments a forty-foot wave tank was used for producing gravity and capillary waves with a wide range of characteristics, and a small X-band CW Doppler radar provided the radar measurement. The report included a study of wave kinematics and the analysis of several possible mechanisms of scattering by water surfaces.
(f) Completed.
(g) A formulation of the physical optics theory applicable to microwave scattering from water surfaces has been developed. The special case of back-scattering from small gravity waves has been investigated, and expressions obtained for the scattering amplitudes from both smooth waves and rough waves. A simple model based on the assumptions that individual area elements of the water surface scatter independently with a Lambert's law distribution, and that the power scattered from an element is Doppler shifted in accord with the fluid velocity at the element has been considered in detail. Applications of this model to trochoidal waves have been made using expressions for particle trajectories and velocities derived from the theory of hydrodynamics.

(5776) THEORETICAL STUDY OF FREE-SURFACE EFFECTS ON APPARENT-MASS, QUASI-STeadY, AND WAKE CONTRIBUTIONS TO HYDROFOIL LOADS.

(b) David Taylor Model Basin, Office of Naval Research, Department of the Navy.
(c) Dr. Irving C. Statler, Head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Inc., F. O. Box 235, Buffalo, New York 14221.
(d) Applied Research (Theoretical).
(e) The purpose of this study was to evaluate the relative contributions to the lift and moment of apparent-mass, quasi-steady, and wake-induced loads for a hydrofoil oscillating near a free surface, using the exact linearized potential solution for determining the flow.
(f) Completed.

(5778) THEORETICAL INVESTIGATION OF HYDROFOILS RUNNING UNDER SINUSOIDAL SURFACE WAVES.

(b) David Taylor Model Basin, Office of Naval Research, Department of the Navy.
(c) Dr. Irving C. Statler, Head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Inc., F. O. Box 235, Buffalo, New York 14221.
(d) Applied Research (Theoretical).
(e) This study is directed to computing the oscillatory lift and moment experienced by a two-dimensional hydrofoil running under sinusoidal surface waves, using the exact linearized potential solution for the flow.

CORNELL UNIVERSITY, School of Civil Engineering.

(4531) SECONDARY CURRENTS IN NON-CIRCULAR CONDUITS.

(b) National Science Foundation.
(c) Dr. J. A. Liggett, Hollister Hall, Cornell Univ., Ithaca, New York.
(d) Theoretical and experimental.
(e) Those secondary currents caused by Reynolds stresses in straight, non-circular conduits are being studied. A triangular open channel is being used. Measurements are to be taken by hot-film anemometers.
(g) A quantitative theory has been developed and is being tested.

(5039) PRESSURES DUE TO SUDDEN DRAWDOWN IN EARTH EMBANKMENTS.

(b) Laboratory project.
(c) Dr. J. A. Liggett, Hollister Hall, Cornell Univ., Ithaca, N. Y.
(d) Theoretical and experimental; basic and applied research.
(e) The equations for unsteady flow in porous media are being solved to find the pressures and free surface shape resulting from sudden drawdown in a porous medium. Both analytical and numerical techniques are being used. Experimental work is conducted on a Hele-Shaw model.
(f) Completed.
(h) "Initial Motion Problem in Porous Media," by
(S040) FRICATIONAL EFFECTS IN RIVERS AND WATERWAYS.

(b) Laboratory project.
(c) Dr. W. H. Graf, Hollister Hall, Cornell Univ., Ithaca, N. Y.
(d) Applied research.
(e) Under study are different American, English, Indian, Swiss and Austrian rivers and waterways. The data investigated are furnished by the different governmental offices.
(f) A theory has been put forward to calculate the frictional effect (Manning's n).
(g) "Gesetze der turbulenten Geschwindigkeitsverteilung in geschlossen Rohren und offenen Gerinnen," by Schweizer Bauzeitung, 82. Jg., No. 53 (1964).

(5305) THE PHYSICAL PHENOMENA INVOLVED IN PAN EVAPORATION.

(b) Laboratory project.
(c) Dr. W. H. Brutsaert, Hollister Hall, Cornell Univ., Ithaca, N. Y. 14850
(d) Theoretical and experimental.
(e) Evaporation is being measured from a number of insulated shallow pans of different sizes and colors. These experimental results and simultaneous climatological data will be used to check and extend some theoretical models of the hydrodynamics and also of the energy budget aspects of pan evaporation and evaporation in general.

(5306) THE HYDRAULICS OF POROUS MEDIA.

(b) Laboratory project.
(c) Dr. W. H. Brutsaert, Hollister Hall, Cornell University, Ithaca, N. Y. 14850
(d) Theoretical and experimental.
(e) An analysis is being made of moisture characteristic curves of porous media to describe the pore size distribution by mathematical equations. These distributions are used to calculate hydraulic properties of the media.

(5307) MECHANICS OF INFILTRATION.

(b) Laboratory project.
(c) Dr. W. H. Brutsaert, Hollister Hall, Cornell Univ., Ithaca, N. Y. 14850
(d) Theoretical.
(e) The micro hydrological equations of unsaturated flow in porous media are being investigated and solved for different boundary conditions. The results of the mathematical analysis are extended to develop infiltration equations for larger areas or for an entire watershed.

(5308) END-DEPTH STUDIES IN CHANNELS WITH MILD SLOPE.

(b) Laboratory project.
(c) Dr. W. H. Graf, Hollister Hall, Cornell Univ., Ithaca, N. Y. 14850
(d) Applied research.
(e) The ultimate scope is to find end-depth relationship for channels with different geometries.
(f) M. S. Thesis is being written at the moment.

(5873) STEADY AND TRANSIENT FLOWS IN RIVERS CONNECTING TWO RESERVOIRS.

(b) U. S. Dept. of the Interior.
(c) Dr. W. H. Graf or J. A. Liggett, Hollister Hall, Cornell University, Ithaca, New York.
(d) Theoretical and field investigation.
(e) The effects of friction, reservoir level, and transients on the flow profile, velocities and discharge.

(5874) MATHEMATICAL FLOW ANALYSIS.

(b) U. S. Dept. of the Interior.
(c) Dr. J. A. Liggett, Hollister Hall, Cornell University, Ithaca, New York.
(d) Theoretical.
(e) The equations of continuity and momentum are being solved on a digital computer in order to analyze unsteady flow over surfaces and in channels.

(5875) REGIONAL VARIATION OF STATISTICAL PARAMETERS OF STREAM FLOW.

(b) Laboratory project.
(c) Dr. D. A. Woolhiser, Hollister Hall, Cornell University, Ithaca, New York 14850
(d) Theoretical, master's thesis.
(e) Stream flow records have been selected from
what would, a priori, appear to be a relatively homogeneous region with respect to the infil-
tration characteristics of the soils. This region also has a very low groundwater storage
capacity. Log-10 serial correlation coefficients for monthly, seasonal, and annual periods
have been calculated. Regression techniques are being used to relate these coefficients to
measurable physical properties of the basins, or to climatic variations.

-university of delaware, fluid mechanics laboratory section, dept. of civil engineering.

1423) STUDIES ON MECHANICS OF FLUID FLOW.

(a) Laboratory and U. S. Army's Harry Diamond Laboratory Projects.

(b) Laboratory.

(c) Dr. K. P. F. Frey, Prof. of Engrg. Mech., Dept. of Civil Engng., University of Delaware, Newark, Delaware 1971.

(d) Experimental, applied research.

(e) Verification of theoretical concepts of cusp devices and other abrupt enlargements

(f) Completed at project scope.

(g) The potential vortex motion theory is some-

(h) "Flow Stability for Two-Dimensional Cusp Devices," by K.P. Frey and N.C. Vasuki

(i) New Comprehensive Studies on Sudden Enlarge-

(j) Published in print.

(k) Publication in press.

(l) Laboratory project.

(m) Field investigation; applied research.

(n) Study of the stability of coastal inlets.

1427) FLUORESCENT TRACING OF SEDIMENT IN COASTAL AREAS.

(b) National Institute of Health, Department of Health, Education, and Welfare.

(c) Field investigation; basic and applied re-

(d) Tracing of sediment drift on beach and off-

(e) Statistical sampling methods, rapid measure-

(f) FLUX OF WAVE ENERGY PERPENDICULAR TO THE

(g) 


1429) INFLUENCE OF SEA LEVEL RISE ON EROSION.

(b) Laboratory project.

(c) Basic research.

(d) To determine the influence of short-term as well as long-term fluctuation of sea level on

(e) Tracer experiments being undertaken on trans-

(f) TRAVERSE DRIFT IN CONNECTION WITH OTHER

(g) FLUID ENGINEERING STUDY AT SOUTH LAKE WORTH

(h) COASTAL ENGINEERING STUDY AT HILLSBORO INLET,

(i) South Lake Worth Inlet District Commission.

(j) South Lake Worth Inlet District Commission, c/o K. C. Mook and Associates, 2300 Okeechobee

(k) Experimental field and applied research.

(l) To study distribution of Inlet currents, im-

(m) Report submitted to sponsor.

(n) Report submitted to sponsor.

(o) Publication in press.

1470) COASTAL ENGINEERING STUDY AT HILLSBORO INLET, FLORIDA.

(b) Hillsboro Inlet Improvement and Maintenance District, City of Pompano Beach and Trustees of the Internal Improvement Fund.

(c) Director, Trustees, Internal Improvement Fund, Capitol Blvd., Tallahassee, Florida.

(d) Experimental, field and applied research.

(e) To study methods for inlet stabilization, naviga-

(f) Completed.

(g) Completed.

(h) Review of beach erosion and coastal protection in Florida.

(i) Engineering and Industrial Experiment Sta.,
University of Florida.

(d) Field investigation; applied research.
(e) Review of the erosion and protection situation in Florida.

(f) Research continued.


(4482) EXPERIMENTAL STUDY OF MECHANICS OF DUNE BUILDING AT CAPE HATTERAS NATIONAL SEASHORE AREA.

(b) Cape Hatteras National Seashore, National Park Service, Manteo, North Carolina.

(c) Cape Hatteras National Seashore, National Parks Service, Manteo, North Carolina.

(d) Experimental and field research.

(e) Study of mechanics of dune building by various types of sand fences and other sand catchment devices under controlled conditions is underway in a laboratory wind tunnel to be later correlated with field tests.

(4895) SAND TRANSPORT BY WIND & MECHANICS OF DUNE BUILDING.

(b) National Science Foundation, Washington, D. C.

(d) Experimental and theoretical; basic research.

(e) To study the basic mechanics of sand transport by wind under dry and humid conditions, with and without vegetation, uniform and gusty winds and with and without solid and permeable vertical fences.

(4896) HYDRAULIC MODEL TESTS FOR SUCTION WELl DESIGN FOR MIAMI RIVER WELL TREATMENT PLANT, DAYTON, OHIO.

(b) F.M.C. Corporation, Hydrodynamic Division, Peerless Pump, Indianapolis, Indiana.

(d) Experimental & applied research.

(e) To determine the most optimum compatible location and design of suction well baffling for the field treatment plant.

(f) Completed.

(h) Report submitted to sponsor.

(4897) COASTAL ENGINEERING STUDY OF SEBASTIAN INLET, FLORIDA.

(b) Sebastian Inlet, District, Melbourne, Florida.

(d) Experimental and applied research.

(e) To conduct field survey and model study of the inlet for least shore erosion and best navigable inlet conditions.

(f) Completed.

(g) Report submitted to sponsor.

(4898) BASIC RESEARCH ON LITTORAL DRIFT BY WAVE AND CURRENT ACTION.

(b) National Science Foundation, Wash., D. C.

(d) Experimental and basic research.

(e) A laboratory basic research project on friction coefficients and sediment transport by currents and waves running with or against each other and running perpendicular to each other.

(4899) HYDRAULIC MODEL STUDY OF BURNS WATERWAY HARBOR, INDIANA.

(b) Indiana Fort Commission, State of Indiana.

(d) Indianapolis, Indiana.

(e) Experimental and applied research.

(f) Laboratory model study of the effects of diffraction, siltation, and harbor surging on the proposed harbor.

(g) Completed.

(h) Report submitted to sponsor.

(5281) TRACING OF LITTORAL DRIFT AT CAPE KENNEDY.

(b) Field project.

(c) Atomic Energy Commission.

(d) Basic applied research.

(e) Special tracer project on transversal drift in bottom and beach profile.

(f) Completed.

(h) Report submitted to sponsor.

(5282) PROTECTION FOR DREDGE OPERATION IN NEW YORK BAY.

(b) Laboratory project.

(c) Gehagan Dredging Co., Pacific, Atlantic, and Gulf Dredging Co.

(d) Applied.

(e) To arrange proper protection for dredging operation at Staten Island, N. Y.

(f) Completed.

(h) Report submitted to sponsor.

(5283) SCRAPER OPERATION, JUPITER ISLAND.

(b) Laboratory project.

(c) Coastal Engineering Research Center and Coastal Engineering Laboratory Cooperative project.

(d) Applied and basic.

(e) To check on operation of offshore scraper dragging sand in from 800 ft. from shore at 12-15 ft. depth.

(5284) SAND FENCES.

(b) Laboratory project.

(c) Coastal Engineering Research Center, Wash., D. C.

(d) Applied.

(e) To test various sand fences.

(5285) SIMILARITY OF BED LOAD TRANSPORT BY CURRENTS.

(b) National Science Foundation, Washington, D. C.

(c) Mr. J. A. Battjes, Dept. of Coastal Engrg., Univ. of Florida, Gainesville, Florida.

(d) Theoretical and experimental development research.

(e) A study of the feasibility of applying specially developed artificial roughness elements in movable bed models.

(5286) STUDY OF LONG WAVE PENETRATION IN DEEP NARROW FIOARDS (ICELAND).

(b) Office of Naval Research, Washington, D. C.

(c) Office of Naval Research, Washington, D. C.

(d) Basic research.

(e) Research on low frequency ocean waves and their penetration in narrow fjords.

(5287) COASTAL ENGINEERING STUDY OF MACQUARIE HARBOUR INLET (TASMANIA).

(b) Pickands Mather & Co., Cleveland, Ohio.

(c) Pickands Mather & Co., Cleveland, Ohio.

(d) Experimental, theoretical and field investigation, applied research.

(e) Stability computations for the proposed navigation channel study methods to arrive at a minimum of maintenance dredging.

(f) GRUMMAN AIRCRAFT ENGINEERING CORP.

(5195) THE EFFECTS OF GAS Bubbles IN LIQUID SHEAR FLOWS.

(b) Laboratory project.

(c) Dr. Richard A. Oman, Head of Gas Dynamics Group, N. Research Dept., Plt. 25, Bethpage, New York 11714.

(d) Experimental and theoretical; basic research.
(5894) HILO HARBOR, HAWAII SEICHING STUDY.

(b) Laboratory project, in conjunction with Hawaii Institute of Geophysics.

(c) Jan M. Jordaan, Jr., Assoc. Prof. of Civil Engrg., Univ. of Hawaii, Honolulu, Hawaii.

(d) Experimental, model and field data.


(5895) HILO HARBOR, HAWAII, BEACH EROSION AND RESTORATION STUDY.

(b) Laboratory project, in conjunction with Hawaii Institute of Geophysics.

(c) Jan M. Jordaan, Jr., Assoc. Prof. of Civil Engrg., Univ. of Hawaii, Honolulu, Hawaii.

(d) Experimental, model and field data.

(e) Determination of wave amplification and run-up potential, of tsunamis arriving from various directions at points around the principal islands of the Hawaiian chain, starting with a model of Oahu, on a 1:250,000 scale.

(5896) RUN-UP AROUND COASTLINE OF OAHU, HAWAII.

(b) Laboratory project, in conjunction with Hawaii Institute of Geophysics.

(c) Jan M. Jordaan, Jr., Assoc. Prof. of Civil Engrg., Univ. of Hawaii, Honolulu, Hawaii.

(d) Experimental, model and field data.

(e) Determination of wave amplification and run-up potential, of tsunamis arriving from various directions at points around the principal islands of the Hawaiian chain, starting with a model of Oahu, on a 1:250,000 scale.

(5903) LABORATORY STUDY OF LONG WAVE AMPLIFICATION AT SMALL CIRCULAR ISLANDS.

(b) Conducted as a part of the Hawaii Institute of Geophysics Tsunami Research Program, Dr. W. K. Adams; Principal Investigator.

(c) Dr. John A. Williams, Center for Engineering Research, College of Engineering, University of Hawaii.

(d) The project is experimental and of an applied research nature.

(e) The project is a model study to determine the amplification of long waves on cylindrical islands which have circular "sea mounts" as bases, i.e.,

\[ h = h_0 \left( \frac{r}{a} \right)^q \]

where \( h_0 \) is the water depth for all \( r > b \)
\( h \) is the water depth for \( a < r < b \)
\( a \) is the radius of cylindrical island, and \( q \) is an exponent which may vary over the range 0 < q < 2. Wave heights at \( r = a \) are observed and compared with predicted values based on linear, long wave theory.

(f) The experiments are being conducted at present with completion of the laboratory work expected by March 31, 1956, and a report completed by June 30, 1956.

(g) The results are to be published in a special report but only the results are to be published otherwise.

(h) Both essentially deep water waves, i.e., \( \lambda / D > 2.5 \) and long waves, i.e., \( \lambda / D > 2.2 \), were used in these runs with the amplification of the waves being determined by the amplifier showing reasonably good agreement with the theoretical predictions. The straight cylindrical island tests, conducted mainly as pilot runs to check out the experimental setup, are currently being followed by runs on islands with a's of .5, 1.0, and 1.3. where \( 0 < q < 1.357 \) for \( q \).

(i) The particular theoretical results with which this model study is concerned are those of Mrs. David Webster and Byrne Perry (as yet unpublished), who carried out their work in support of the H.I.G. Tsunami program.

(5907) CONSERVATION OF WATER FOR RANGE STOCK.

(b) Laboratory project; in cooperation with Bureau of Land Management and ranchers.

(c) Prof. G. C. Warnick, College of Engineering, Univ. of Idaho, Moscow, Idaho 83843.

(d) Field investigation; applied operational research.

(e) Field investigation; applied operational research. Field investigation to study hydrology of small desert watersheds and evaporation under field conditions and occurrence of impermeable earth materials has been made. Several small ponds have been constructed using various manufactured lining materials and the effectiveness of evaporation retarding materials under evaporation conditions has been investigated.
is proposed to construct several small ponds in naturally impermeable sites or lined with local impermeable earth materials in 1966.

(g) Performance of various manufactured lining materials and effectiveness of evaporation retarding chemicals under field conditions has been evaluated. Some criteria for estimate of evaporation losses over range areas have been developed. Studies of the occurrence of impermeable sites and earth materials and the correlation of the occurrence of such material with geomorphology, vegetation and air-photo appearance have been undertaken.

(h) A progress report discussing asphalt and glass fibre paving was made in 1966. A general report summarizing all aspects of the project will be presented in 1966.

(5167) TOTAL HYDROELECTRIC RESOURCES IN IDAHO AND DEVELOPMENT PROBLEMS ON IDAHO STREAMS.

(b) Laboratory project.
(c) Prof. Paul Mann, Elec. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental, applied research for master's thesis.
(e) A study of streamflow data is being made to determine water resource capability. The study is designed to develop estimating constants which may give a 90 percent accuracy. New ideas for stream-to-stream diversion will be investigated.

(5170) CORRELATION FOR THE DISPERSION OF LIQUIDS FLOWING THROUGH PACKED BEDS USING MODIFIED RANDOM WALK MODELS.

(b) Laboratory project.
(c) Dr. R. R. Purgason, Chem. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Theoretical and experimental, basic research for master's thesis.
(e) The random walk equations were used as a model for the horizontal liquid distribution in a packed bed. A study was made of the effect of the liquid properties (surface tension and viscosity) on the horizontal dispersion of the liquid and the horizontal step sizes. A proposed mechanism for liquid flow through packed beds, consisting of a series of pools and vertical steps was evaluated by comparing the residence time for a tracer in the liquid with the apparent residence time for the liquid itself.
(f) Completed.
(g) The dispersion of a liquid in a packed bed was found to be affected by both surface tension and viscosity. A decrease in surface tension caused an appreciable decrease in the horizontal dispersion coefficient while an increase in viscosity caused a lesser decrease for any given size of packing.
(h) A Ph.D. thesis will be completed in 1966.

(5368) GROUND WATER MOVEMENT IN HIGHWAY LANDSLIDES.

(b) Laboratory project; cooperative with Idaho Dept. of Highways and Idaho Bureau of Mines and Geology.
(c) Prof. J. J. Peebles, College of Engineering, Univ. of Idaho, Moscow, Idaho 83845.
(d) Experimental and field investigation; applied research and development with master's thesis.
(e) To study the flow characteristics of ground water movement in landslides and to ascertain sources of the water. Testing techniques are being studied using dyes and isotopes as well as other pressure measuring devices. This is an attempt to predict and identify slide behavior in places where slides are apt to occur.
(f) Various dyes have been experimented with in several locations in Northern Idaho.
(g) Master's thesis will be completed in early 1966.

(5897) FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES.

(b) Western Regional Research Project.
(c) Dr. G. L. Corey, Dept. of Ag. Engr., Univ. of Idaho 83843.
(d) Experimental basic.
(e) To develop a dimensionless nomograph for vertical free drainage from various soils.

(5898) TWO AND THREE-DIMENSIONAL DIFFUSION ANALYSIS OF UNSTABLE FLOW INTO POROUS MEDIA.

(b) Laboratory project.
(c) Dr. G. L. Corey, Ag. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental basic.
(e) To determine quantity and rates of advance of flow into porous materials with various initial capillary properties will be investigated.

(5899) PHYSICAL STATE PROPERTIES OF PRECIPITATION.

(b) Office of Water Resources Research.
(c) Prof. G. A. McKeen, Electrical Engr., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental and field investigation, basic research for master's thesis.
(e) Precipitation state (i.e. rain or snow) is a useful parameter for application in watershed management and flood control. The objective of this project is to ascertain precipitation state properties which would permit actual determination of the state. Various properties of rain and snow such as optical reflectance, acoustic, energy and momentum and electrostatic properties will be investigated.

(5900) MOVEMENT OF WATER FROM CANALS TO A GROUND WATER TABLE.

(b) Office of Water Resources Research.
(c) Dr. G. L. Bloomsburg, Ag. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental and field investigation, applied research for master's thesis.
(e) The movement of water from canals will be studied and new experimental tools such as a nullisometer for field conditions will be developed. An attempt to develop a procedure for determining permeability capillary pressure relationships in the field will also be made.

(5901) HYDROLOGY OF FROZEN GROUND FLOOIDS.

(b) Office of Water Resources Research.
(c) Prof. A. C. Robertson, Ag. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental and field investigation, basic research for master's thesis.
(e) Relationships between soil moisture, frozen ground temperatures, runoff water temperatures and infiltration rates will be investigated to develop procedures for use in estimating design discharges to expect from frozen ground floods.

(5902) TRANSITION BETWEEN LAMINAR AND TURBULENT FLOW IN POROUS MEDIA.

(b) National Science Foundation.
(c) Dr. G. L. Bloomsburg, Ag. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Theoretical and experimental basic research for master's thesis.
(e) A theoretical and experimental investigation will be conducted to develop an index of laminar or turbulent flow. This will be a modified Reynolds number which will better reflect the effect of pore size and tortuosity on the type of flow than the Reynolds numbers that have been used in the past.

(5903) EFFECT OF EXTERNAL AIR PRESSURE ON LIQUID FLOW THROUGH POROUS MEDIA.

(b) Laboratory project.
(c) Dr. G. L. Bloomsburg, Ag. Engr. Dept., Univ. of Idaho, Moscow, Idaho 83843.
(d) Experimental and theoretical, basic research.
(e) The effect of changes in external air pressure on flow of a liquid through a porous
media containing trapped air will be investigated in laboratory columns.

IIT RESEARCH INSTITUTE.

(5196) TURBULENT FLOW TRANSITION NEAR SOLID AND FLEXIBLE BOUNDARIES.

(a) BuShips Fundamental Hydromechanics Research Program administered by David Taylor Model Basin.
(b) Mr. Henry B. Karpus, Research Physicist, 10 West 35th St., Chicago 11, Ill.
(c) Experimental basic research.
(d) Transition to turbulence is investigated in a water channel having walls with adjustable rigidity. It is intended to obtain a better understanding of the effect of resilience and damping of the walls on the build up of turbulence in boundary layers. The ultimate objective is the reduction of drag of vessels and the reduction of boundary layer noise in hydrophone domes.
(e) Transition to turbulence is affected by wall resilience. Flexible walls may delay turbulence onset over limited flow rate regions.

(5538) STUDY OF VIBRATIONS INDUCED IN THIN-WALLED Pipes BY FLOW.

(b) Mr. J. M. Clinch, IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616.
(c) This work involved an experimental and theoretical investigation of the vibrational response of thin-walled pipe sections to the wall pressure field applied by fully developed turbulent water flow within them.
(d) Experimental measurements were made of the turbulent wall pressure field in a 20' long 6" diameter pipe section, and of the vibrational response which it induced. Results are presented for a Reynolds number range from $5 \times 10^4$ to $2 \times 10^5$. The measured pipe response is found to be in good agreement with that predicted theoretically using random vibration analysis.
(e) This work is to be extended to consider the effects of bends and elbows in the fluid line.
(f) See (e) above.

(5904) OPTICAL MEASUREMENTS WITH HIGH TEMPORAL AND SPATIAL RESOLUTION.

(b) Mr. H. J. Fisher, IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616.
(c) The aim of this project is the development of a technique for measuring the local turbulent properties of shear layers while avoiding the insertion of probes into the flow.
(d) An experimental technique is being developed with the aid of which estimates of local turbulent properties of shear layers may be obtained without the necessity of inserting probes into the flow field. The probe is replaced by two beams of radiation, which pass through the flow field in two mutually perpendicular directions. It has been shown, although each beam independently measures only one element of the flow parameters, that the entire light path between the source and detector, the covariance of the two detected signals does yield local turbulent information.
(e) Although the technique is primarily aimed at supersonic or hot turbulent flows a verification study has been performed using a subsonic jet. Good agreement with published hot wire data has been obtained.

(5912) STUDIES ON TWO-DIMENSIONAL TURBULENT JETS (THE RECEIVER NOISE PROBLEM).

(a) Sponsored by the Harry Diamond Laboratories of the U.S. Army Material Command, Conn. and Van Ness Sts., Washington, D. C.
(b) Mr. Dennis W. Prosser, Research Engineer, IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616.
(c) Experimental and theoretical; basic research.
(d) The object of this program was to study the "noise" problem associated with the operation of single-stage proportional fluid amplifiers. The word "noise" refers to the undesirable momentum fluctuations which turbulence superimposes on the mean "signal" measured at the entrance of a receiver placed in the fluid jet.
(e) Main results were: (1) With a receiver held stationary in the power jet the noise to signal ratio was limited by keeping the center of the receiver on the center line of the power jet. (2) When the receiver moves relative to the power jet the ratio of noise to change in genuine signal is limited by keeping the receiver away from the center line of the power jet.

(5913) NOISE TRANSMISSION IN FLUID AMPLIFIERS.

(a) Sponsored by the Harry Diamond Labs. of the U. S. Army Material Command, Conn. and Van Ness Streets, Washington, D. C.
(b) Mr. Dennis W. Prosser, Research Engineer, IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616.
(c) Experimental and theoretical.
(d) The objective of this program is to determine the relative importance of stage-produced noise and transmitted noise in two-stage proportional fluid amplifiers, and subsequently to investigate the basic geometric and flow parameters associated with the larger of these two contributors to noise.
(e) Started January 1966.

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ILLINOIS STATE WATER SURVEY DIVISION.

A list of publications is available upon request; write to Illinois State Water Survey, Box 226, Urbana, Illinois 61802.

(1865) HYDRAULIC DESIGN OF DROP-INLET SPILLWAY STRUCTURES FOR SMALL RESERVOIRS.

(a) Laboratory project, in cooperation with Agricultural Conservation Service, and Illinois Agricultural Experiment Station.
(b) Mr. H. W. Humphreys, Illinois State Water Survey, Box 226, Urbana, Ill. 61802.
(c) Experimental; generalized applied research for development and design.
(d) To determine the most desirable proportions and shapes of drop-inlet spillway structures that have unique flow characteristics and to develop anti-vortex devices. To provide
the necessary information on flow relations and discharge coefficients so that those structures may be economically designed. Experimental apparatus and tests conducted on the complete spillway. Information is being obtained on discharges, vortex effect on discharge, pressure, head loss coefficients, a flat plate anti-vortex device, and flow conditions.

(g) Model tests were performed on a drop-inlet spillway to determine whether or not a metal grating deck placed above the inlet can control vortices. The results of the tests show that gratings do not prevent or control strong vortices.

(h) Report of Investigation in preparation covering circulation effects, flat plate anti-vortex device effect, and vortex effect on model spillway performance.

(2535) FILTERING THROUGH COARSE MATERIALS.

(b) Laboratory project.

(b) Mr. Ralph L. Evans, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.

(d) Experimental; basic research.

(e) Small, coarse media [1/4 - to 3/4-inch] filters are operated at rates comparable to those achieved in field practice. Purpose is to study the effects of coarse media on physical, chemical, and bacteriological properties of recharged water thus to evaluate the function of coarse media in protecting aquifer materials.

(g) Results of former field tests of various sizes of materials are reported in State Water Survey Bulletin 48. Program of specially controlled laboratory test runs initiated in 1962 under grant from U. S. Public Health Service.

(4135) CORROSION PREVENTION BY CAOOC.

(b) Laboratory project.

(c) Dr. T. E. Larson or H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Ill.

(d) Experimental.

(e) To determine chemical requirements and velocity requirements to provide protective coating in water pipes.

(I) UNIVERSITY OF ILLINOIS, Soil and Water Conservation Engineering Lab., Department of Agricultural Engrg.

Inquiries concerning the following projects should be addressed to Prof. E. A. Jones, 100 Agricultural Engineering, University of Illinois, Urbana, Ill.

(2516) RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(b) Laboratory project cooperative with ANS, U. S. Department of Agriculture.

(d) Experimental and field investigation; basic research.

(e) To determine frequencies of peak rates and total amounts of runoff from agricultural watersheds of 25 to 1,500 acres; to determine maximum rates of runoff from agricultural watersheds in different soil association areas in Illinois; to compare runoff from agricultural watersheds under accepted soil conservation practices with watersheds cultivated without soil conservation practices. Watersheds of 45.5, 63, 82, and 390 acres near Monticello, Illinois are covered with a rain gage network, and runoff is measured at weirs and spillway structures by water level recorders. Maximum stage recorders are installed at field structures in 6 watersheds in Champaign, Platt, Vermillion, and Ford Counties on watersheds ranging in size from 45 to 1,400 acres. Model studies and field calibrations are made on the field structures.

(g) A computer program for the IBM 7094 has been developed to analyze and summarize rainfall data. Precipitation amounts are summarized for each storm, month, and year, and maximum intensities are tabulated for eleven duration ranges.

(h) Portran II Program for Precipitation Data Analysis. J. Kent Mitchell, Agricultural Engineering Research Report, Illinois Agricultural Experiment Station, University of Illinois Urbana.

(5549) ILLINOIS RIVER.

(b) State of Illinois.

(c) Mr. John C. Guillou, Chief Waterway Engr., Div. of Waterways, Dept. of Public Works and Buildings, 201 West Monroe Street, Springfield, Illinois 62706.

(d) Experimental; applied research.

(e) A hydraulic model study is being conducted to determine the effects, on the Upper Illinois River, of various flood relief measures proposed for the Illinois Waterway and Chicago Sanitary and Ship Canal.

(5656) KINSAID CREEK DAM.

(b) State of Illinois.

(c) Mr. John C. Guillou, Chief Waterway Engineer, Division of Waterways, 201 West Monroe St., Springfield, Illinois 62706.

(d) Experimental; applied research.

(e) A hydraulic model study is being conducted to assist in the design of the spillway and stilling basin for a proposed small dam to be constructed in Jackson County, Ill.

(2789) LABORATORY MODEL STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES.

(b) Laboratory project.

(d) Experimental investigation in the laboratory; applied and basic research.

(e) To investigate the performance of soil and water conservation structures by means of hydraulic model studies, to study water flow patterns in experimental drains and to determine the cause of failures and remedial measures of certain conservation structures under flood conditions.
(g) A model study of channel scour immediately upstream from a drop spillway is nearing completion. Preliminary analysis of scour location, rate, depth and volume data indicates that scour can be controlled by designing the weir and channel wide enough to maintain the depth and velocity of flow below scour threshold values.

A STUDY OF RAINFALL ENERGY AND SOIL EROSION.
(b) Laboratory project cooperative with ARS, U. S. Dept. of Agriculture.
(e) Experimental; basic research.
(e) Natural rainstorms are photographed with a raindrop camera to determine the number of raindrops, their size and size distribution, and the kinetic energy of a rainstorm may be calculated. Physical measurements will be made of the soil to determine the effect of the kinetic energy of the rainstorm on soil loss. The nature and properties of rainstorms that occur in this area of Illinois will also be studied.
(f) To be completed by June 30, 1966.

WATER INFILTRATION RATE METHODS AND DETERMINATIONS ON SOILS.
(b) Laboratory project.
(d) Field investigation, basic research.
(e) To field test practical methods for determining and predicting relative infiltration rates of soils during irrigation and during rain.
(g) To be reported by North Central Region, Agricultural Experiment Station Bulletin.
(h) "Artificial Rainfall Used to Measure Infiltration Rates on Illinois Soils," by G. D. Butzerker and R. A. Jones, Jr., Ill. Res. 6-1. In press (copies may be obtained from the authors).

THE EFFECT OF GYPSUM AND DRAINAGE ON SOIL AND SOILS (SLICK-SPOTS) IN ILLINOIS.
(b) Laboratory project in cooperation with Dept. of Agronomy.
(d) Experimental field investigation.
(e) To test the feasibility of replacing and removing excess sodium from solonetzic soils under field conditions with (a) different methods and rates of applying gypsum (calcium sulphate), (b) different degrees of disturbing the soil, and (c) different spacings of tile drains. Twenty plots were established in a random pattern to compare 3 positions for the application of gypsum and 3 spacings or tile drains with check plots. The tile effluent is measured by recording equipment to determine the rate and volume of flow. Also samples will be taken to determine the amount of sodium in the leachate.

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS.
(b) A laboratory project.
(d) Experimental and theoretical; basic research.
(e) The objective is to select a method for integrating the partial differential equations which will form a part of the mathematical model for watersheds.
(g) The computer programs developed in 1964 were used with new input data to analyze channel conditions leading to both sub-critical and super-critical flow up to 1200' from a free overfall. The non-converging solutions previously reported for the sub-critical case did not appear to be supercritical, apparently because there was no longer a discontinuity in the depth and velocity derivative at the overfall.
(h) Discussion of Computer Analyses of Overland Flow," by R. N. Fenzl, Proceedings ASCE.

SURFACE DRAINAGE OF SLOWLY PERMEABLE SOILS OF SOUTHERN ILLINOIS.
(b) Laboratory project in cooperation with Dept. of Agronomy; SCS, U. S. Dept. of Agriculture; and M and W Gear Company.
(c) Same as listed earlier.
(d) Experimental field investigation.
(e) To determine a recommended spacing for a uniform system of surface drainage channels on slowly permeable soils of southern Illinois. A field experiment will be conducted with four treatments replicated a minimum of three times. The treatments will be no drainage and parallel surface channels spaced 660, 990 and 1320 feet apart. Each treatment channel will drain approximately 1320 feet to a collection ditch. The no drainage area will be smoothed and the area between channels will be crowned to provide a uniform slope to all the channels. Likewise all channel grades to the collection ditches will be uniform. The effectiveness of each treatment will be determined by sampling crop yield on grid line perpendicular to the channels and the collection ditches.

DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS.
(b) Laboratory project in cooperation with the Dept. of Agronomy and Dept. of Agricultural Economics.
(c) Theoretical and field investigation.
(e) To formulate an assessment procedure based upon measurable physical features of the land in Illinois. The first phase will be to determine the over-all benefits that accrue to the land as a result of drainage. This will be based primarily upon the increase in land value or increase in return. The second phase will be to develop an empirical equation giving consideration to the influence of selected physical features on benefits accruing to drainage. The equation will be tested on existing drainage districts which have assessment roles accepted by the land owners and approved by the courts.

UNIVERSITY OF ILLINOIS, Hydraulics and Water Resources Laboratory, Department of Civil Engrg.

Inquiries concerning all projects should be addressed to Dr. V. T. Chow, Prof. of Hydraulic Engineering, University of Illinois, Urbana, Ill., 61803, unless otherwise indicated.

WATER DISTRIBUTION SYSTEMS-ANALYSIS CRITERIA.
(b) N. I. H. Research Grant.
(c) Prof. M. B. McPherson, Dept. of Civl Engrg., Univ. of Ill., Urbana, Illinois.
(d) Numerical; development.
(e) Exploitation of previous research on water supply systems; for optimization of a composite system design.
(g) The feasibility and comparative cost of various operating options have been determined. Using a computer, system parameter combinations for given demand schedules have been studied and results have been succinctly defined in simple representations. Simple analogous demand schedules, such as sine distributions, are being studied so that results can be generalized. More complex hydraulic cases will also be
investigated. Mathematical proofs and
practical applications of basic network and
system parameters are being developed.
Using statistical techniques, the possibility of
simulating future demand schedules for
general use in analysis, design, and operation
will be studied.

(h) "A Study of Distribution System Equalizing
Storage Hydraulics," by M. B. McPherson and
R. Fasrad, Univ. of I.I. Civil Engrr. Studies Series No. 6, March 1965.
"A Study of the Applicability of Generalized
Distribution Network Head Loss Characteris-
tics," by R. A. Wiseman and M. B. McPherson,
"A Study of Power Consumption for Equalizing
Storage Operating Options," by M. B. McPherson and
R. Fasrad, Univ. of I.I. Civil Engrg. Studies Series No. 8, June 1965.
"An Analysis of Demand Variations," by Gordon Gracile, Univ. of I.I.
Engrg. Studies Series No. 9, June 1965.

(4905) VARIATION OF TRACTIVE FORCE IN SEWERS AND
DRAINS.

(b) Laboratory project.
(d) Experimental and theoretical.
(e) To study the distribution of boundary shearing
stress, or tractive force in a circular
conduit flow, partially full, and to de-
termine the relationship between the shearing-
stress distribution and the velocity distri-
bution.

(g) The solution of the problem is based on
the assumption that a turbulent flow in the
channel has a uniform velocity distribution
modified by boundary effects and turbulent
mixing. The boundary effects are further
considered to consist of two additive compo-
nents, namely, viscous effects and the secondary
effects caused by the restraint of the tur-
bulent fluctuations at the walls and the
surface. The velocity of flow normal to the
channel cross section is therefore expressed as
the weighted sum of the functions of the
Poisson equation type. The relative influence
of the two functions of the total flow is de-
finite experimentally for the relationship of the
weighted coefficient to channel geometry
and roughness.
The experimental determination of the co-
efficient is accomplished by using a smooth
copper pipe and a rough steel pipe. The
tractive force distribution is determined by a
"law-of-the-wall" method and with the Preston
technique using piloted tubes calibrated in
placing. The equations are solved by the finite-
differences method using the digital computer to
evaluate the weight coefficient in the Poisson
equations for both smooth and rough pipes.
The relations developed from this investiga-
tion compare favorably with some published
velocity distributions including those ob-
tained by Basin.

(h) "Tractive Force Distribution in Open Channels," by John A. Replogle and Ven Te Chow, Proceed-

(4905) WATER RESOURCES SYSTEM ANALYSIS

(b) Laboratory project for R. W. Drucker's
special problem.
(d) Theoretical; basic research
(e) Operations research techniques are used to
optimize water resources systems for the plan-
ning and development of water projects. Con-
venient use is made of mathematical models and
simulation. Optimization is made by deter-
ministic and stochastic linear programming and
dynamic programming considering various types of
constraints including economic efficiency and
budgetal limitations. For mathematical simula-
tion, both random sampling and systematic
sampling are considered, and additional hydro-
logic data are generated sequentially by means of Monte Carlo methods and Markov-chain models.

Study of the reservoir design is made by us-
ing queueing theory through the sequentially generated stochastic input flow information.
Additional research during the year was made to investi-gate the similarity between the transport system and water resources system. Beginning with the nature of inputs and the physical formation of the systems, the com-
parable structures in both systems were studied.
To each system, basic components, such as the dams and reservoirs in the water re-
sources system and the points in the fluid
system, were identified and their uses were
compared. The nature of flow in the systems,
particularly the different types of flow, was also investigated. Finally, certain assumptions were discussed in order to equate
the two systems for purposes of comparative
analysis.

(4906) BASIC INVESTIGATION ON WATERSHED HYDRAULICS.

(b) National Science Foundation research project.
(d) Experimental and theoretical; basic research.
(e) To investigate the basic laws governing the
flow of surface water over drainage basins
by controlled experiments on geometric ba-
sins. By controlling the various factors in-
volved in the mechanics of flow, the experi-
mental data obtained can be more amenable
to theoretical analyses for the determination of
the basic laws. In addition to the shape of
the geometric basin, other factors such as
sprinkling systems composed of a large num-
ber of modules so that different patterns of
rainfall supply and even the effect of the
movement of rain-making clouds can be pro-
duced artificially. The output discharge
from the basin is to be measured by electronic
sensing devices which can automatically be
digitized for the computer to construct the
hydrographs of outflow.

(g) During the year, the hydraulic system as well as the electronic system were de-

(4906) THE FORCES CAUSED BY WAVES BREAKING AGAINST
VERTICAL IMPERVIOUS RIGID WALLS.

(b) Laboratory project for a doctoral thesis by
W. J. Garcia, Jr., under the direction of
Prof. V. T. Chow cooperative with U. S.
Civil Engineering Waterways Experimentation
Station.
(d) Experimental and analytical; basic research.
(e) To formulate relations which will enable one
to determine pressures on impervious rigid
walls due to breaking waves with sufficient
accuracy to afford an economical and safe design for sea walls and breakwaters; also to investigate the variation of pressure on the wall with respect to time and special distribution.

During the year the experimental data were analyzed and a final report is in preparation.

(4909) A STUDY OF THE EFFECT OF BASIN STORAGE ON SURFACE RUNOFF HYDROGRAPHS.

(b) Laboratory project.

d) Theoretical; basic research.
(e) To study the drainage basin taken as a lumped hydrologic system.

(5567) HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS.

(b) Laboratory project.

(d) The direct and indirect analog computers are used for the analysis of hydrologic problems on surface and ground water. In the analysis of surface water problems, the EAI FACE computer of the Analog Computer Lab at the Naval Ocean Laboratory is used to route floods through linear as well as non-linear reservoirs. For the analysis of ground water, the resistance networks were designed and analyzed for a number of ground water regions. The results will be recommended for use in the design and planning of water resources systems.

(5568) NONLINEAR SYSTEM PARAMETERS OF SURFACE RUNOFF HYDROGRAPHS.

(b) Laboratory project for Ph.D. thesis by R. Prasad directed by Prof. M. B. McPherson.

(d) The determination and correlation of generalized parameters defining the hydrograph of surface runoff for natural drainage basins in central Illinois using a lumped nonlinear system approach which being used. Involved are hypotheses relating to rainfall-runoff relations and to a simulated basin reservoir routing. An attempt will be made to delineate the contribution of various nonlinearities. The bulk of the computations will be performed on a digital computer, complemented with work on an electronic analog computer.

(5569) FLOW IN A TWO-DIMENSIONAL 90° CLOSED BEND.

(b) Laboratory project for Ph.D. thesis by W. H. Huang directed by Profs. J. M. Robertson and M. B. McPherson.

(d) To approximate the turbulent flow in two-dimensional closed bends for various bend-radii to approach-width ratios at different Reynolds numbers, using frozen vorticity fluid flow analysis.

(e) As a preliminary to the turbulent case, numerical and analytic solutions for potential flow were achieved, together with exploratory numerical solutions for simulated wholly viscous conditions using the frozen vorticity concept. Velocity and pressure fields generated from the turbulent flow of a system analyzed will be used in an attempt to explain general flow phenomena.

(5660) MICROSCOPIC DETERMINATION OF TRACTIVE FORCE DISTRIBUTION IN FREE-SURFACE WATER CONVEYANCES.

(b) Office of Water Resources Research Grant.

(c) Prof. V. T. Chow and H. G. Wenzel, Jr., Dept. of Civil Engrg., Univ. of Illinois, Urbana, Illinois.

(d) Experimental and basic research.

(e) Tractive forces of flow in conveyances tremendously affect the economy of water supply systems in water resources planning and development. The present knowledge of tractive force in flow lacks precision because it is based largely on a few empirical formulas using simplified analytical solutions. As a
result, water projects can be easily over-
designed or underdesigned. The present
research is to investigate the tractive force
distribution in water supply conveyances of
various cross-sectional shapes carrying tur-
bulent free-surface flow. Once the distr-
bution is determined, it will be possible to
apply this knowledge to channel proportion-
ing and design.

(g) Investigation will involve the use of a newly
invented high-power microscope equipped with
light condensers to examine the velocity in
the conveyance. By focusing the microscope
onto the very proximity of the boundary, pho-
tographs can be taken by a high-speed motion
camera. From these microscopic velocity
measurements within the laminar boundary sub-
layer, it is planned to establish the velocity gradient and thus to determine the
tractive force developed on the boundary. The
basic knowledge gained can be profitably in-
corporated in engineering design procedures.

(5661) INFLUENCE OF TURBULENCE ON SURFACE REAERATION.

(b) Laboratory project.
(c) Basic research.
(d) Data being obtained from a channel artifi-
cially roughened.
(e) Investigation reactivated, additional data
being taken with new improved instruments,
one of which is a hot wire probe.

(2536) STUDY OF HOMOLOGOUS TURBULENCE.

(b) Laboratory project, formerly National
Science Foundation.
(c) Basic research.
(d) The nature of turbulence (its production and
dissipation) is being studied in the sim-
plest possible shear flow-plane Couette flow
where the shear is constant and the turbu-
ulence homogeneous but not isotropic. Mean-
flow studies essentially complete.

(c) Reactivated.

(3427) STRUCTURE OF TURBULENCE NEAR ROUGH SURFACES.

(b) Bureau of Ships Fundamental Hydromechanics
Research Program.
(c) Basic research, experimental.
(d) Information on mean-flow and turbulence
structure of roughnesses being studied in an
8-inch "natural roughness" pipe and a
3-inch sand-roughened pipe.
(e) Completed.
(f) Temporal-mean velocity and frictional re-
sults agree with Nikuradse for sand and
Cobbleck for natural roughness. Pipe fac-
tor correlation on same basis establishes
another Nikuradse "shift." Turbulence in-
tensity in terms of shear velocity is found
to be similar to that in smooth pipe and to
be nearly constant with Reynolds number.
Spectral energy measurements evidence an
inertial subrange at high enough turbulence
Reynolds number when taken not too near con-
duit wall.

(h) "A Study of Turbulent Flow in Rough Pipes," by J. M. Robertson, T. H. Burkhard and J. D.

(4142) TURBULENT BOUNDARY-LAYER FLOW TOWARDS A NORMAL STEP.

(b) Laboratory project.
(c) Basic research.
(d) An analytical and experimental study is being
made of uniform separation i.e., the real fluid behavior (separation, mixing, resta-
achment) in front of a normal step projec-
ting inward from a plate along which fluid is
flowing and being separated. The energy
layer is fluid medium being used.

(e) Investigation in process.
(f) First phase of study completed; in one case
rather good agreement was found between
theoretical solution and experimental
observation of separation streamline.

(4143) HYDRODYNAMICS SIMILITUDE STUDY OF AN ARTERIAL
DISTRIBUTION SYSTEM.

(b) Public Health Service, National Institutes
of Health, Research Grant No. HE08330-02.
(c) Prof. M. E. Clark, 123 Talbot Laboratory,
University of Illinois, Urbana, Illinois.
(d) Basic research, experimental.
(e) The flow of blood in the Circle of Willis—
the arterial distribution system for the
brain—is to be studied utilizing large-
sized models with the prototype and model
numbers.
(f) Investigation in process.
(g) Fabrication of the model with prototype verification of
first-stage model essentially complete.

Studies being initiated in the pulsatile
flow aspects of flow in flexible conduits;
in particular, the wave reflections at bifurcations, the impedance characteristics of fluid Helmholtz resonators, and the velocity distribution in pulsatile flow as depicted by hydrogen bubble techniques.


(5559) EFFECT OF TURBULENT NORMAL STRESS ON DRAG EVALUATION BY WAKE MOMENTUM METHOD.

(b) Laboratory project.
(c) Basic research.
(d) Conventionally the evaluation of the drag of bodies from wake transverse ignores normal stresses in wake. Experimental measurements one half a chord length behind a fineness-ratio 3.5 strut indicates a contribution of some 2 percent. Further studies including finer bodies are planned.

(f) Suspended.

(5559) FLOW STABILITY AND HEAD LOSS IN BRANCHED TUBES.

(b) Public Health Service, National Institute of Health, Research Grant No. HG03530-02.
(c) Prof. M. E. Clark, 125 Talbot Laboratory, Univ. of Illinois, Urbana, Illinois.
(d) Basic research.
(e) In conjunction with a model study of the Circle of Willis-the arterial distribution system for the brain-a need was felt for a better understanding of the stability of viscous flows through certain types of junctions as well as the amount of head loss which occurs. A series of bifurcations and junctions of rigid, circular tubes are being studied to gain this understanding.
(f) Investigation in process.

(5777) THREE DIMENSIONAL EFFECTS IN TURBOMACHINERY.

(b) Caterpillar Tractor Co.
(c) Basic research, experimental and analytical, for Ph.D. thesis.
(d) Radial outward and inward flow systems are being studied in terms of base flow, boundary layer and secondary flow occurrences.
(e) Study initiated.

(5708) BODY DRAG AT LOW REYNOLDS NUMBERS.

(b) Laboratory project.
(c) Basic analytical and experimental research.
(d) Except for flat plate, analytical drag relations are available only in the creeping motion and boundary layer regime. Experimental data is available only for a few other bodies in the intermediate (Navier-Stokes) range. Objective of study is to help fill this gap.

(5776) UNIQUE ASYMPTOTIC EXPANSIONS IN THE THEORY OF HYDRODYNAMIC STABILITY.

(b) National Science Foundation.
(c) Leland K. Shires, 121 Talbot Laboratory, University of Illinois, Urbana, Illinois 61803.
(d) Theoretical, basic research.
(e) Asymptotic expansions of certain functions which occur in hydrodynamic stability theory are being studied with reference to their uniqueness; error bounds for such approximations are studied also.
(f) Have obtained explicit representations for functions which satisfy the differential equations pertinent to the stability theory and which have asymptotic approximation in-dextially equal to zero.

IOWA INSTITUTE OF HYDRAULIC RESEARCH, University of Iowa.

(66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

(b) Cooperative with the Agricultural Research Service and the U.S. Geological Survey.
(c) Prof. J. W. Hubbard, Dept. of Geology and Geophysics, University of Iowa, Iowa City, Iowa.
(d) Field investigation; applied research, and M. S. thesis.
(e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 23-square-mile area measured by U. S. G. S.; rainfall records at five automatic recording stations collected by Agricultural Research Service. Continuous records since 1924 of precipitation, runoff, groundwater levels, and vegetal cover.
(f) Yearly records available for examination at Iowa Institute of Hydraulic Research.
(h) Reports prepared annually since 1924 available in files at the Iowa Institute of Hydraulic Research. Summary of 33-year record published as Bulletin 16 of the Iowa Highway Research Board in 1961; available upon request from Iowa Highway Commission, Ames, Iowa.

(67) COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA.

(b) Cooperative with U. S. Geological Survey.
(c) District Engineer, U. S. Geological Survey, Iowa City, Iowa.
(d) Field investigation; collection of basic stream-flow data.
(e) Stream-flow and sediment measuring stations maintained throughout the State of Iowa cooperatively on a continuous basis. Records collected by standard methods of U. S. G. S.
(f) Records of stream-flow and sediment discharge computed yearly.
(g) Records contained in Water-Supply Papers available through offices of the Geological Survey.

(68) HYDROLOGIC STUDIES, RAPID CREEK WATERSHED.

(b) Cooperative with U. S. Geological Survey.
(c) District Engineer, U. S. Geological Survey, Iowa City, Iowa.
(d) Field investigation; applied research.
(e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 23-square-mile area measured and flood runoff on main subbasins determined by U. S. Geological Survey; rainfall records at four automatic recording stations collected by U. S. Weather Bureau. Continuous records since 1941 of precipitation, runoff, and ground-water levels.
(f) Rainfall records published in Weather Bureau Climatological Bulletins and surface runoff and ground-water levels published in Geological Survey Water-Supply Papers.

(75) MEASUREMENT OF TURBULENCE IN FLOWING WATER.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical. Basic and applied research.
(e) Instruments, primarily electrical in operation are being developed to measure the characteristics of turbulent flow in the range of laboratory and field conditions. Both sensing and computing elements are involved.
(f) Additional studies on the stability of heat transfer over surfaces, devices have shown that there is an "aging" effect. After a period of several hours of operation, the heat transfer is much more nearly constant.
(g) CAVITATION.
(b) Cooperative with Office of Naval Research, Department of the Navy.

(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.

(d) Experimental and theoretical; basic research and graduate theses.

(e) Basic information is sought on cavitation for systematically varied boundary conditions. Studies of cavitation in abrupt conduit expansions are now being pursued.


(1875) CHARACTERISTICS OF STABLE EDDIES.

(b) Laboratory project, partially supported by Office of Naval Research, Department of the Navy and U. S. Army Research Office (Durham).

(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.

(d) Experimental and analytical; basic research.

(e) Distributions of velocity, pressure, and turbulence have been investigated throughout the vicinity of separation zones produced by abrupt changes in flow section, to the end of establishing the primary eddy characteristics as functions of the boundary geometry.

(g) Analytical evaluations are now being carried out for a two-dimensional and an axisymmetric boundary expansion.

(h) "Characteristics of Separation at Conical Afterbodies," S. Narasimhan, Ph.D. Dissertation, Univ. of Iowa, June 1965, (available on loan).

(2031) RESEARCH ON SHIP THEORY.

(b) Cooperative with Office of Naval Research and David Taylor Model Basin, Department of the Navy.

(c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.

(d) Experimental and theoretical; basic research.

(e) To determine the laws governing the forces, moments, and motions of ships. Work is under way on the following problems:


"Induced Drag Due to Bilge Reels," Gabriel Echavez, M.S. Thesis, Univ. of Iowa, Feb. 1965, (available on loan).


(2328) INVESTIGATION OF SURFACE ROUGHNESS.

(b) Cooperative with University of Missouri, Geological Survey, and Watersway Experiment Station.

(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa.

(d) Experimental; basic research.

(e) Apparatus for measuring drag on individual roughness elements and element groups is now in use.


(2541) DEVELOPMENT OF INSTRUMENTS FOR USE IN ANALYZING APERIODIC SIGNALS.

(b) Cooperative with Office of Naval Research, Department of the Navy.

(c) Dr. John R. Glover, Iowa Institute of Hydraulic Research, Iowa City, Iowa.

(d) Experimental; applied research.

(e) The purpose is to improve the analysis of turbulent velocity as has been investigated from the point of view of real-time analysis. The utilization of matched silicon semiconductors for linearization of nonlinear flow variable-voltage relations has been investigated and found to be most successful.


(3074) WAKE OF ZERO MOMENTUM FLUX.

(b) Cooperative with Office of Naval Research, Department of the Navy.

(c) Dr. Eduard Nauwasser, Iowa Institute of Hydraulic Research, Iowa City, Iowa.

(d) Experimental; basic research.

(e) Mean flow and turbulence characteristics are being measured and the energy transformation is being analyzed in the field of flow past a bluff, axisymmetric body with a centrally located jet for the particular condition of zero momentum flux.

(f) Completed.


(3428) MECHANICS OF BANK SEEPAGE IN NATURAL STREAMS DURING FLOOD FLOWS.

(b) Laboratory project in cooperation with U. S. Geological Survey.

(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, University of Iowa, Iowa City, Iowa.

(d) Field investigation; basic research for Ph. D. thesis.

(e) Observations taken on transverse profile of ground-water levels during rise and recession of hydrographs. Sections on Missouri, Des Moines, and English Rivers, Clear Creek and Rapid Creek. Permeability tests made by pumping wells.

(f) Continuing.

(g) Early results indicate substantial flow into
banks during period of rise, thus showing a negative groundwater contribution to the flow in this period.

EDUCATIONAL FILMS ON THE MECHANICS OF FLUIDS.

National Science Foundation.
Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Six 20-minute sound films in color are planned to be shown as follow:\n(1) An introduction to the subject, stressing its great breadth of coverage, the necessarily close tie between theory and experiment, the role of the scale model in engineering analysis and design, and methods of flow measurement in laboratory and field. (2) The sources and significance of the fundamental principles of buoyancy, momentum, and energy, and their application to typical problems in many professional fields. (3) Gravitational phenomena, including jets, ripples, channel transitions, waves, surges, and effects of density stratification. (4) Effects of viscosity, examples of laminar flow, characteristics of fluid turbulence, and problems of surface resistance. (5) Farmer and lift, and their application to propulsion and fluid machinery. (6) Compressibility effects - water hammer, subma-
 Says: Marine signaling, gravity-wave and sound phenomena, and supersonic drag.

HYDRODYNAMICS OF FLUIDS UNDER CONDITIONS OF RAPID ACCELERATION.

Rock Island Arsenal, U. S. Army.
Dr. Enzo G. Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Theoretical and experimental; basic research.
Analytical techniques which are applicable to systems involving rapid acceleration of fluid or of solids through fluids. Results will be expressed as lumped-constant parameters similar to those used for steady-flow phenomena. Field tests have shown that losses are reduced by an order of magnitude if the volume changes due to compressibility are considered as shown by analysis of simplified models. However, pressure may also require consideration in the presence of extremely short impulses.


INTERFACIAL EFFECTS IN FLUID FLOW WITH DENSITY STRATIFICATION.

Cooperative with U. S. Army Research Office (Durham).
Dr. Enzo G. Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Theoretical; basic research and graduate theses.
Instability and mixing of two fluid layers of different densities flowing in the same direction. Effect of stratification on turbulent mixing of two fluid layers.

Completad.
Experiments on disturbances in the zone of establishment of a two-layer stratified flow have been compared with results obtained with a discretized computational model of the Navier-Stokes equations. The experimentally observed disturbances were successfully simulated for moderately long periods of time. "The Stability of a Stratified Flow in the Region of Flow Establishment," J. B. Hinwood, Ph.D. Dissertation, Univ. of Iowa, Feb. 1966, (available on loan).

MEAN-FLOW AND TURBULENCE CHARACTERISTICS OF RIVER BENDS.

Supported by the National Science Foundation.
Dr. E. M. O'Loughlin, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Experimental; basic research for Ph.D. dissertation and M.S. thesis.
To determine the mean-flow and turbulence characteristics of flow in a model river bend.

Phase I: Through an approximate theoretical solution and experiments in a meandering fixed-bed channel of trapezoidal cross section, the influence of the Froude number and the width-depth ratio of subcritical flow have been determined.
Phase II: Stable channels have been established in cohesionless material with fixed boundaries for three width-depth ratios and three Froude numbers. Measurements of longitudinal and transverse velocity, bed shear, turbulence intensity, and surface elevation have been made for one configuration of the stabilized channel.

DRAG OF SUPERCAVITATING BODIES OF REVOLUTION.

Bureau of Ships, Office of Naval Research.
Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Theoretical; applied research.
An approximate method of computing pressure distributions on supercavitating bodies of revolution has been developed. Equipment for measuring drag of nose forms with air-simulated supercavitating flow in a towing tank has been constructed and experiments are under way.


TURBULENCE CHARACTERISTICS OF THE WAKE OF A BODY OF REVOLUTION.

Cooperative with David Taylor Model Basin, Dept. of the Navy.
Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Experimental basic research.
Measurements are being made of the turbulence near the stern of an ellipsoid mounted in an air tunnel. Simultaneously designed instruments are used to respond correctly to the low-frequency, high-intensity components. Data on the pressure, velocity, turbulence, and turbulent shear are at hand for a zero angle of attack.

EFFECT OF LIFTING BEAMS ON GATE VIBRATION.

Cooperative with Tennessee Valley Authority.
Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Experimental; applied research.
The effect of the lifting-beam geometry upon the fluctuating hydrodynamic force acting on a multiple-leaf gate during over- and underflow is being investigated.

Due to interference of the wakes behind lift-

E. N. O'Loughlin, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
Experimental; basic research for Ph.D. dissertation and M.S. thesis.
To determine the mean-flow and turbulence characteristics of flow in a model river bend.

Phase I: Through an approximate theoretical solution and experiments in a meandering fixed-bed channel of trapezoidal cross section, the influence of the Froude number and the width-depth ratio of subcritical flow have been determined.
Phase II: Stable channels have been established in cohesionless material with fixed boundaries for three width-depth ratios and three Froude numbers. Measurements of longitudinal and transverse velocity, bed shear, turbulence intensity, and surface elevation have been made for one configuration of the stabilized channel.
(5320) DISCHARGE COEFFICIENTS OF SKEWED PIPE ORifices.
(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, Univ. of Iowa, Iowa City, Iowa.
(d) Experimental; for M.S. Thesis.
(e) Effect of inclination of orifice plate to pipe centerline for orifices of the same projected diameter.
(f) Completed.
(g) Discharge coefficients proved proportional to the ratio of the actual to the projected area of the orifice, indicating that flow is normal to the orifice plate even though the ratio of orifice diameter to pipe diameter is large.

(5321) PRESSURE FLUCTUATIONS AT GATED OUTLET WORKS.
(b) Cooperative with U. S. Army Corps of Engrs.
(c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research.
(e) Effects of shear-layer instability on the spectral distribution and the intensity of pressure fluctuations that may induce gate vibrations are being investigated for various gate and conduit geometries, including effects of cavitation and hydrostatic control.

(5905) RESISTANCE TO FLOW OVER RIPPLED SAND BOUNDARIES.
(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics & Hydraulics, Univ. of Iowa, Iowa City, Iowa.
(d) Analytical.
(e) To evaluate the roughness of rippled sand boundaries as a function of the ripple geometry and the flow parameters.

(5906) SCALE EFFECTS IN MODEL TESTS OF ROCK-PROTECTED STRUCTURES.
(b) Iowa Highway Research Board.
(c) Dr. E. N. O'Loughlin, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; applied research.
(e) To define quantitatively the influence of the viscous forces which result in imperfect similarity between the behavior in the model and in the prototype of rock protection around structures.

(5907) SELF-PRESERVATION TENDENCY IN TURBULENT SHEAR FLOWS.
(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Analytical; basic research.
(e) Shear flows not exhibiting self-preservation in the conventional sense are analyzed on the basis of a new self-preservation concept.

(5908) EFFECTS OF TURBULENCE AND CURVILINEARITY ON STRATIFIED FLOW.
(b) Supported by the National Science Foundation.
(c) Dr. Enzo O. Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research and graduate theses.
(e) The effects of introducing turbulent disturbances and of curving an otherwise stable density-stratified flow are being investigated experimentally on layers of fresh water and a layer of salt water are used in the first case, and a continuous stratification in the second. Work is also being done on improving an electrical probe to detect density variations.
(f) Preliminary results have been obtained for the effects of turbulence and curvilinearity on stratified flow.

(5909) ENERGY TRANSPORT AND DISSIPATION IN VISCOUS FLOW.
(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics & Hydraulics, Univ. of Iowa, Iowa City, Iowa.
(d) Analytical; basic research and graduate theses.
(e) Analysis of laminar steady and unsteady flows from the viewpoint of the energy transport and dissipation.
(f) Analysis of basic equations of viscous fluid flow in vectorial form has shown the advantage of introducing a Bernoulli vector associated with the Bernoulli sum, and a Navier vector associated with the viscous-stress tensor. A number of classical cases of viscous flow have already been studied to determine their transport and energy-dissipation functions.

(5910) STUDY OF DYNAMIC FORCES ON FLASHBOARDS.
(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics & Hydraulics, Univ. of Iowa, Iowa City, Iowa.
(d) Analytical.
(e) Analysis of results of various previous investigations.

(5911) EFFECT OF TURBULENCE CHARACTERISTICS UPON REGISTRATION OF THE PRICE CURRENT METER.
(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics & Hydraulics, Univ. of Iowa, Iowa City, Iowa.
(d) Experimental.
(e) Correlation of turbulence characteristics with variation of current meter registration.

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IOWA STATE UNIVERSITY, Department of Agricultural Engineering.

Inquiries concerning projects 2330, 2331 and 2334 should be addressed to Dr. R. T. Johnson, Dept. of Agricultural Engineering, Iowa State University, Ames, Iowa. Projects 4913, 5707 and 5708 should be addressed to Dr. C. E. Beer, Dept. of Agricultural Engineering, Iowa State University, Ames, Iowa 50010.

(2530) DEPTH, SPACING AND HYDRAULICS OF TILE DRAINS.
(b) Laboratory project.
(d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
(e) Analytical and experimental approach is being studied to determine depth and spacing of tiled drains by analyzing soil characteristics and geometry of systems. Work is cooperative with Dr. Kirkham, Soil Physics Department of Agronomy. Studies of the relationship of hydrologic and applied hydraulic problems of field tile systems being made.
(f) Field studies of flow through the spacing between individual tile for saturated conditions have been completed. A study of the effect of the geometry at the junction of individual drain tile is being made. A study of the probability of the water level being greater than a given elevation for a given time has been completed. The study was based on point rainfall records, climatological records, soil characteristics and tile depth and spacing.
(h) "Flow Into Tile at Joints," by D. W. DeBoer and
(2331) SURFACE RUNOFF FROM AGRICULTURAL WATERSHEDS.

(b) Laboratory project.
(d) Theoretical; applied research; M. S. and Doctoral thesis.
(e) A study comparing predicted volumes of storm runoff to measured runoff for small agricultural watersheds is being made. A survey is being conducted in which the relationship of surface storage in relatively level, recently glaciated watersheds on the storm discharge is being evaluated. A study has been completed in which runoff records from 11 Iowa watersheds under 50 sq. mi. in area were analyzed. The yearly yields were related to climatic, hydrologic and agronomic factors by multiple regression.


(4592) MOVEMENT OF WATER FROM WASTE RECHARGE INSTALLATIONS.

(c) Dr. Don Kirkham, Department of Agronomy, Iowa State Univ., Ames, Iowa 50010.
(d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
(e) The purpose of this project is to discover laws which predict, from the geometry of the waste recharge installation, and from the physical properties of the soil about it, how fast, and how far at certain times, water will move from the installation. This will be accomplished by (1) obtaining empirical laws governing seepage of water from an idealized scaled model (2) testing by full-scale field experiments to see if the empirical laws found in (1) above need to be modified when applied to field conditions, and (3) formulating rational relations between the water movement, the geometry of the system and the soil conditions, by setting up and solving the appropriate seepage differential equations and checking the result against the experimental data from (1) and (2) above.


(5076) MOISTURE MOVEMENT TO VERTICAL SINKS IN WATER-SATURATED SOIL.

(b) Iowa State Water Resources Research Institute.
(c) Dr. Don Kirkham, Agronomy Dept., Iowa State University, Ames, Iowa 50010.
(d) Theoretical and applied research; Doctor's thesis.
(e) Differential equations for the flow of water into vertical sinks such as soil cracks, plant roots, and vertical worm holes will be derived and solved either analytically or by finite differences with the aid of a digital computer. Laboratory soil columns will then be used to test the mathematical theory.

(f) Initiated July 1, 1965.

THE JOHNS HOPKINS UNIVERSITY, Applied Physics Lab.

(2335) APPLICATION OF SWITCHING TECHNIQUES TO HYDRAULIC CONTROL SYSTEMS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical and experimental; applied development and design.
(e) Study the dynamic qualities of an acceleration switching hydraulic servomechanism.
while operating in a closed loop under the presence of various loads and environmental conditions on the transfer valve, actuator and feedback transducer. (g) The operation of a broad bandpass servo-mechanism driving a low resonant frequency linkage has resulted in radial design compromises to prevent instability. Extension or acceleration switching techniques without any mechanical modifications has permitted closed loop operation with bandpasses equal to or exceeding the linkage characteristics.

(h) "Design of a Hydraulic Servo with Improved Bandpass Characteristics When Driving a Resonant Mechanical Load," APL/JHU CN-962, by W. Seamone.

(3456) ADAPTIVE ELECTRO HYDRAULIC SERVOMECHANISMS.

(b) Bureau of Weapons, Department of the Navy.

(d) Theoretical and experimental.

(e) Techniques have been developed for designing linear servomechanisms with a limit cycle instability about a relay type non-linearity. The closed loop characteristics of this servomechanism becomes invariant to any pure gain changes occurring in the linear elements. This servomechanism, categorized as a self-oscillating control servomechanism, appeared to be an evolutionary improvement over the acceleration switching hydraulic servomechanism.

(g) A self-oscillating rate servomechanism has been operated with the loop closed around the valve spool position. Predictable self-oscillation frequency was achieved and dynamic performance bandpass was independent of hydraulic supply pressure between 500 and 2000 psi. The bandpass of both servomechanisms exceeded 60 cycles per second with the latter operating a complex mechanical load system.

THE JOHNS HOPKINS UNIVERSITY, Department of Environmental Engineering Science, School of Engineering.

Inquiries concerning the following projects should be addressed to Dr. John C. Geyer, Chairman, Dept. of Environmental Engineering Science, The John Hopkins University, Baltimore, Maryland 21218.

(3457) RESIDENTIAL WATER USE RESEARCH PROJECT.

(b) Federal Housing Administration and 16 participating Water Utilities.

(d) Field investigation; applied research and design.

(e) This project is directed toward obtaining data on moisture and other large water uses in residential areas having varying populations and located in various climatic regions throughout the country. It also is directed toward obtaining information on the effect of lawn sprinkling and other large water uses on maximum demands. The purpose of the project is to obtain a rational design criteria for water distribution systems, to provide a basis for evaluating water rate structures and a basis for improving system operation.

(f) Field data collection completed as of October 1, 1965.

(g) Water use patterns and demand rates imposed on distribution systems have been measured in forty-one residential study areas throughout the United States during the period between July 1, 1965 and October 1, 1965. The major factors influencing the residential water use have been evaluated, and a mathematical model to represent the phenomenon has been derived. The study shows that in an area with a large number of consumers, the expected sprinkling demand during dry periods approximately equals the potable water distribution rate from the overall irrigable areas. The model is based on the precipitation occurs, an evapotranspiration is met by sprinking from the water system, and, thus, lack of precipitation considerably increases lawn sprinkling. The normal domestic or household use depends primarily on economic level. Residential water use is influenced also by whether consumers are metered on a flat-rate basis, and whether they utilize septic tanks for sewage disposal. Peak demands in flat-rate areas are more than double those in metered areas because of high sprinkling demands. Domestic use is significantly lower in metered areas with septic tanks.


(5171) GROUND WATER STORAGE PROJECT.

(b) National Institutes of Health Research Grant.

(d) Field investigation, applied research.

(e) Application of gravity meter to study of change or storage of ground water in water budget of 38 acre drainage basin.

(g) Commencing collection of data.

(5914) COOLING WATER DISCHARGES PROJECT R49.

(b) Edison Electric Institute, New York 17, N. Y.

(d) Reporting Chairman, Dept. of Environ. Eng'g. Sci., The Johns Hopkins Univ., 513 Ames Hall, Balto., Md. 21218.

(d) The project is a continuation of theoretical development of field investigations and can be classed as applied research. Work on this project is applicable to Masters essays and Doctoral theses.

(e) The purpose of the project is to develop techniques for predicting water temperatures in water bodies receiving the condenser cooling water discharges of thermal electric generating stations. The project, extending from March 1963 to June 1965, was an investigation of existing theory related to water temperature prediction, and an assembly of existing knowledge on the relationship between water temperatures.
Presently the Applied Laboratory "Separation have The Theoretical "A hopper involved A Suspended. General Theoretical The study to Laboratory power-"DRAIN-HOLE" cavitating "Wall-pressure CAVITATING Completed. RP49," steady UNIVERsity Inquiries space (4945) (4151) addressed (h) (d) (b) (b) (g)g) b)g) b) (h) (h) (h) (b) (b) (d) (d) (e) (f) (g) completed. An experimental study of wall-pressure fluctuations in a cavitating turbulent shear flow at a two-dimensional abrupt expansion in a conduit was performed. Four cavitating regimes were observed. Root-mean-square values and frequency spectra of wall-pressure fluctuations were obtained for non-cavitating, incipiently cavitating, and fully cavitating flow with different expansion ratios of the conduit. Wall-pressure Fluctuations in a Cavitating Turbulent Shear Flow," by Sevin Vigander, Studies in an Engineering Mechanics, Report No. 21, June 1965.

UNIVERSITY OF KANSAS, Dept. of Mechanics and Aerospace Engineering.

Inquiries concerning the following projects should be addressed to Dr. Y. S. Yu, Dept. of Mechanics and Aerospace Engineering, Univ. of Kansas, Lawrence, Kansas 66045.

(4151) SEPARATION OF FLOW AT INTERIOR CORNERS.

(b) Kimberly-Clark Corporation, Neenah, Wis. Theoretical and experimental; basic research.

(e) The separation of laminar flow at interior corners is studied to determine experimentally and mathematically the flow pattern and the geometry of the zone of separation. Suspended.

(f) A study of the spatial characteristics of the zone of separation for laminar and transitional flows past an interior corner has been made. The locations of flow separation and reattachment have been determined experimentally for corner angles of 90, 60, 45, and 30 degrees and contraction-ratios of 0.75, 0.50 and 0.25. The values of the Reynolds number based on the maximum main-stream velocity, the duct height, and kinematic viscosity of the fluid ranged from 2 x 10^5 to 4.5 x 10^6.


(4944) SOLUTION OF POTENTIAL FLOW WITH FREE STREAMLINES BY INTEGRAL EQUATION METHOD.

(b) University research grant.

(d) Theoretical; M.S. thesis.

(e) The integral-equation method developed in the previous study is extended to include the effect of gravity.

(4945) SECONDARY MOTIONS IN A "DRAIN-HOLE" VORTEX.

(b) Laboratory project.

(d) Theoretical and experimental basic research for doctoral thesis.

(e) The secondary motions in a steady "drain-hole" vortex flow are being studied to determine the mechanics of its formation and the effects of rotational flow in the tank and the water depth on the secondary motions.

(f) Completed.

(g) An approximate solution to the boundary-layer equations for flow downstream to the flow of the vortex container is obtained. The computed velocity profiles within the boundary layer agree within 10 percent with the measurements. The radial inflow within the boundary layer is found to be greater than that outside the boundary layer. This excess radial inflow probably causes the formation of the large torus-shaped secondary vortices in the vertical flow.

WALL-PRESSURE FLUCTuations IN A CAVITATING TURBULENT SHEAR FLOW.

(5709) (b) Tennessee Valley Authority.

(d) Experimental; basic research for doctoral thesis.

(e) The purpose of this study is to investigate the formation of cavitation pockets and the associated pressure fluctuations downstream from an abrupt expansion.

(f) Completed.

(g) An experimental study of wall-pressure fluctuations in a cavitating turbulent shear flow at a two-dimensional abrupt expansion in a conduit was performed. Four cavitating regimes were observed. Root-mean-square values and frequency spectra of wall-pressure fluctuations were obtained for non-cavitating, incipiently cavitating, and fully cavitating flow with different expansion ratios of the conduit. Wall-pressure Fluctuations in a Cavitating Turbulent Shear Flow," by Sevin Vigander, Studies in an Engineering Mechanics, Report No. 21, June 1965.

INSTABILITY OF NON-NEWTONIAN HELICAL FLOW.

(5710) (b) Laboratory project.

(d) Theoretical and experimental; basic research for doctoral thesis.

(e) The Taylor-Görtler instability of a power-law fluid in an annulus between two rotating coaxial cylinders with and without axial flow is studied both experimentally and theoretically.

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LEHIGH UNIVERSITY, Department of Civil Engineering.

Inquiries concerning the following projects and requests for reprints and technical reports should be addressed to Dr. J. B. Herlich, Professor, Chairman, Hydraulic & Sanitary Division, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa. 18015.

STUDY OF CONDUIT EXIT PORTALS.

(2543) (b) Laboratory Project.

(d) Experimental; M. S. Thesis.

(f) General pressure-distribution study completed.

(g) Tests of square and circular conduit with free-jet, horizontal apron, and three different wall flares, have been completed.

STUDY ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP.

(3084) (b) District Engineer, U.S. Army Engineer Dist., Marine Division, Philadelphia, Corps of Engineers.

(d) Applied and Basic Research.

(e) The immediate purpose of the study is to improve design of a hopper dredge centrifugal pump for pumping salt-clay water mixtures. The long-term objective is to determine the effect of Bellmouth Body-type of fluid on pumping characteristics. The project has been divided into four phases: (1) Model test of existing dredge pump; (2) recommendations for the Institute of Fluid-dynamics and Thermodynamics; (3) model investigation of the modified design of the dredge pump; and (4) analysis of the investigation and final recommendations. Phase I involved installation in the hydraulic laboratory of a 1:8
scale model of the dredge pump now used on
the U.S. Corps of Engineers' dredge types. The
water as well as silt-clay-water mixtures
(Bingham Body-type of fluid) were pumped and
complete characteristics of the pump ob-
tained for a degree of 0 to 1200 gallons per
minute, speed of 1150 to 1900 revolutions
per minute, and liquid concentrations of
1000 and 1500 grams per liter. Phases 2 and
3 involve modifications in the shape of vane
and changes in the exit vane angle of the
impeller. Experimental tests indicate con-
siderable improvement in pump efficiency.
Analysis of the experimental data resulted
in recommendations for changes in pump de-
sign.

(3085) STUDY OF SCALE EFFECT BETWEEN MODEL AND
PROTOTYPE SPIRALS.

(b) Laboratory project.
(d) Graduate students' project.
(e) A 1:100 scale two-dimensional model built
for the experimental study in a fixed-bed model
to determine the desired depths and lengths of
spur dikes to provide uniform velocity
distribution in the waterway between bridge
abutments; (d) experimental study in a
movable-bed model to verify findings in
part c. A spur dike has been defined as a
projection extending upstream from the
bridge abutments.
(f) Phases (a), (b) and (e) completed; phase (d)
active.
(g) Preliminary investigation indicates that a
properly designed spur dike can produce a
fairly uniform velocity distribution between
the abutments.
(h) "Hydraulics of Bridges" - by J. W. Delleur,
D. E. Schnell and H. J. Treby, Joint High-
way Research Project, American Society of
Civil Engineers Task Force, Purdue University,
Lafayette, Indiana.

(3441) STUDY OF SCALE EFFECT BETWEEN MODEL AND
PROTOTYPE 270 DEGREE BENDS FOR PLOW OF Silt-
CLAY-WATER MIXTURES.

(b) Laboratory project.
(d) H. S. Thelis.
(e) Four-, six-, and eight-inch diameter 90
degree elbows assembled to form 270 degree
bends. Head loss measurements obtained for
various flows and concentrations of silt-
clay-water mixture. Equations of prediction equations
have been investigated.
(f) Completed. 
(g) No evidence of appreciable scale effect
observed.

(3442) SUGGESTED DESIGN CHANGES FOR A CENTRIFUGAL
PUMP IMPELLER HANDLING DREDGED MUD.

(b) Research report requirement of master's
degree.
(d) Theoretical.
(e) Design changes in centrifugal pump impeller
for handling mud are suggested on basis of
past research and theoretical considerations.
(f) Completed.

(3746) ANALYSIS OF FLOW PATTERN IN VOLUME OF A
CENTRIFUGAL PUMP.

(b) Research report requirement of master's
degree. District Engineer, U. S. Army
Engineer District, Marine Division, Phila.
Corps of Engineers.
(d) Experimental
(e) High-speed movies of flow taken through a
transparent plexiglas volute casing were
analyzed. Velocity distribution as well as
distribution of the exit angle between the
impeller vanes as fluid leaves the impeller
were determined.
(f) Completed.

(3747) FRICTION HEAD LOSSES IN CIRCULAR PIPES FOR A
BINGHAM-BODY FLUID.

(b) Laboratory project.
(d) Experimental and theoretical.
(e) The object of the study is the determination
of the pipe flow characteristics of slurries
of various concentrations. The slurries do
not behave as fluids of constant viscosity
so that it is not possible to use conventional
methods for prediction of head losses in
pipes conveying the slurries. The experi-
mental tests were carried out on a 1/6 model pump
of the National Bulk Carriers Hopper Dredge,
S. S. Zilla.
(f) Completed. 
(h) Report in preparation.

(4154) DREDGE PUMP DESIGN.

(b) National Bulk Carriers, Inc.
(d) Experimental.
(e) The objective of the study is to obtained the efficiency and head-capacity
curves, to check the effect of the reduced
vane exit angle, and to determine the ef-

ciency of a model dredge pump while
pumping silt-clay-water mixture of specific
gravity equal to 1.17. The experimental
tests were carried out on a 1/6 model pump
of the National Bulk Carriers Hopper Dredge,
S. S. Zilla.
(f) Completed.

(4155) WAVE RUN-UP ON COMPOSITE BEACHES.

(d) Graduate Students' project. Experimental,
applied research for design.
(e) The main object of the study is to verify
existing equations for determining the
height of wave run-up and obtain the limits of
application of the equation for long
beach terms.
The study is conducted in a 67 ft. long, 2 ft.
wide and 2 ft. deep wave channel equipped with
pendulum-type wave generator and efficient
absorbers.

(4156) MULTIPLE DREDGE PUMP SYSTEMS.

(b) National Bulk Carriers, Inc.
(d) Experimental and theoretical.
(e) The study is conducted to determine the ef-

cet of the total production of dredge pumps
with separate discharges and a combined
discharge. The investigation is divided
into two parts: (a) One pair of pumps is
handling a mixture of water and solids, the
other is pumping only water. It is required
to determine what percentage of its normal
output will the dredge pump passing the
mixture attain. (b) If one or a pair of
dredge pumps, both handling water-solids
mixtures, is revolving slower than the other
one, how does the total discharge compare
with the total if the discharges were not
combined?
(f) Completed.

(4644) STUDY OF THE GRAVITY WAVE REFLECTIONS FROM
FLOATING RECTANGULAR BODIES.

(b) Research report requirement of master's degree.
(d) Experimental.
(e) The object of the study is to determine the magnitude of wave reflections from rectangular floating bodies. Tests were conducted on a 1 ft. wide and 2 ft.-deep wave channel equipped with pendulum-type wave generator and efficient absorbers.
(f) Completed.

(565) EFFECT OF LENGTH AND SPACING OF SPUR DIKES.
(b) Laboratory report.
(d) Experimental and theoretical; M.S. Thesis.
(e) The object of the study is to determine the effect of length and spacing of spur dike types on the magnitude of scour in uniform flow. The experiments are conducted in a 10-ft. wide, 35-ft. long open channel with movable sand bed. Scour patterns are observed and analyzed.

(572) MEASUREMENT OF SLURRY FLOW BY USE OF 90° ELBOW METER.
(b) National Bulk Carrier Inc., New York, N.Y.
(d) Applied and basic research.
(e) A 90° elbow meter was calibrated against a magnetic flow meter. A flow range of from 0-1100 gpm was effected in the calibration. Water and fine concentrations of silty-clay-water mixtures are included in the calibration tests. The basic theory of the "elbow" meter is discussed and an empirical mathematical relation between liquid concentration, differential head, and pipe velocity is presented and discussed. The feasibility of use of the elbow meter for flow measurement of slurry type flow is highly possible, but calibration of meter in place is recommended. Also, the viscous properties of the material metered are believed to play an important role in the meter's performance.

(573) SUCTION DREDGING LITERATURE SURVEY.
(b) Ellicott Machine Corp., Baltimore, Maryland.
(d) Applied and basic research.
(e) This report is a brief review and summary of selected literature pertaining to equipment and methods associated with dredging practice and laboratory studies of dredge pumps. It consists of four parts: (1) Summary and discussion section. (2) Selected abstracts. (3) Annotated bibliography. (4) Bibliography. The discussion section consists of 12 parts. Part 1 discusses dredging equipment and dredging in general. Part 2 discusses dredge pumps.

(574) PERFORMANCE STUDY OF A 1:6 MODEL DREDGE PUMP.
(b) Ellicott Machine Corporation, Baltimore, Md.
(d) Applied and basic research.
(e) Performance tests were made on five 1:6 scale model impellers. Each impeller was tested at four constant speeds over a wide range of heads and discharges. Water and two concentrations of a typical dredging mud were tested with each impeller at all four speeds. Various graphs and design application curves were developed for making similar studies and designs in the homologous series of pumps.

(5550) CAVITATION STUDIES OF A MODEL DREDGE PUMP.
(b) Ellicott Machine Corp., Baltimore, Md.
(d) Applied and basic research.
(e) Effect of various pump design parameters on cavitation is being investigated. Water and two concentrations of a typical dredging mud are being tested as dredging material in the laboratory. Other variables, in addition to geometric characteristics of the pump, include pump speed and rate of flow.


(b) Laboratory project.
(d) Experimental and theoretical.
(e) Research requirement of Master's degree.
(f) Completed.
(g) Cavitation tests were performed on three impellers in a model dredge pump. It was found that the impeller with the highest efficiency rated by the manufacturer demonstrated the best cavitation performance. Tests of the impellers in various-clay-water mixtures of various densities indicated that the viscosity of the liquid had a significant effect on cavitation inception. The impeller rotative speed appeared to have no effect on the discharge at which cavitation began for constant head conditions.

(5552) SCOUR OF FLAT SAND BEACHES DUE TO WAVE ACTION.
(b) Laboratory project.
(d) Experimental and theoretical.
(e) Research requirement of Master's degree.
(g) Stability of a horizontal sand bed deposited in shallow water in front of an impervious, smooth seewall under conditions in which the wave height had not yet begun to break was investigated. Experimental studies have been performed in a two-dimensional wave channel to determine the rate, extent, and ultimate amount of the flat sand bed for different conditions of water depth, wave height and length, and slope of seewall.

(h) "Beach Scour Due to Wave Action on Seaweals," by B. Van Weele, Fritz Engineering Laboratory Report No. 293.3, Lehigh University 1965.

(5821) WAVE REFLECTION AND TRANSMISSION FOR CYLINDRICAL PILE ARRAYS.
(b) Laboratory project.
(d) Experimental.
(e) Master's Thesis.
(g) The purpose of the investigation is to determine the relationship between wave reflection and transmission and several pile-group configurations. A total of 16 circular piles were used in different rectangular arrays and a random pattern. In the rectangular arrangements both the spacings transverse to the oncoming wave and the spacings longitudinal to the oncoming wave were investigated. The experimental studies were performed in a two-dimensional wave channel.


(b) District Engineer, U. S. Army Engineer District, Marine Division, Philadelphia, Corps of Engineers.
(d) Applied and basic research.
(e) The overall purpose is to study the effect of gas removal systems on centrifugal dredge pumps. This consists of a program of studies, tests, analysis and reports dealing with ways and means for efficiently removing entrained and dissolved gases from the effluents of dredging with centrifugal pumps in rivers and harbors. The project has been divided into four (4) phases.

(a) Literature Search and Formulation of a Test Program.
(b) Formulation of Specific Test Setup and Schedule of the Tests with Water.
(c) Experimental Study and Analysis of Test Results.
(d) Experimental Study with Solid-Water Mixtures (sand) and Analysis of Test Results.

(e) Phases (a) and (b) are completed; phase (c)


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LOUISIANA STATE UNIVERSITY AND A AND M COLLEGE, Agricultural Engineering Department.

(5915) FACTORS AFFECTING RUNOFF ON SMALL AGRICULTURAL WATERSHEDS IN LOW, FLAT, ALLUVIAL AREAS.

(b) Louisiana Agricultural Experiment Station, Louisiana State University, Baton Rouge, Louisiana 70803, Dr. Doyle C. Chambers, Dir.

(c) Dr. Jerry Chness, Assoc. Prof. Agricultural Engrg. Dept., Louisiana State Univ., Baton Rouge, Louisiana, 70803.

(d) Field investigation.

(e) Sampling gauge on a 50 acre watershed with 0 to 5% slopes on the Mississippi River alluvial flood plain. A study is being conducted to measure the effect of land use and vegetative cover on volume and rate of runoff.

(g) Double peak hydrographs are often obtained. Surface detention appears to be highly influential on outflow rate.

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LOUISIANA STATE UNIVERSITY AND A AND M COLLEGE, Louisiana Water Resources Research Institute.

(5711) FRESH WATER STORAGE IN SALINE AQUIFERS.

(b) Louisiana Water Resources Research Institute.

(c) Dr. Oscar K. Klbmiler, Associate Professor, Dept. of Petroleum Engineering, Louisiana State University, Baton Rouge, La. 70803.

(d) Theoretical and experimental; basic research.

(e) To determine whether it is theoretically feasible to store fresh water in saline aquifers: injecting fresh water, then removing it from storage. The relative effects of diffusion, dispersion, and differences in specific gravity are being studied mathematically and by means of models. The ultimate importance of the work to cities located in flat areas lacking in surface-water storage sites that are underlain by saline aquifers is readily appreciated.

(5713) STUDY OF MEASURES TO BE TAKEN TO ACCOMPLISH PROTECTION OF THE GROUND-WATER SUPPLY OF THE BATON ROUGE AREA FROM DEGRADATION DUE TO SALINE WATER INTO AREA OF OFFSHORE-ENGINEERING ASPECTS.

(b) Louisiana Water Resources Research Institute.

(c) Professor R. G. Kazmann, Dept. of Civil Engrg., Louisiana State Univ., Baton Rouge, La. 70802.

(d) Field investigation and theoretical study; applied research and design.

(e) Evaluate engineering solutions for providing permanent ground-water supply for Baton Rouge area. Make preliminary feasibility studies of most promising projects; coordinate work with that being done in aspects 1-3.

(g) Project started July, 1965. Tentative date of publication, February 1966.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Hydrometrics Laboratory.

Requests for reprints and Technical Reports should be addressed to Dr. Arthur T. Ippen, Professor of Civil Engineering, Hydrometrics Laboratory, Mass. Inst. of Technology, Cambridge, Mass. 02139.

(1509) STUDY OF BEACH PROCESSES IN THE INSHORE AND FORESHORE ZONES.

(b) Coastal Engineering Research Center, U.S. Army Corps of Engineers.

(c) Professor F. S. Eagleson, Mass. Inst. of Tech., Cambridge, Mass. 02139.

(d) Experimental and theoretical; basic research.

(e) Study of the surface profile and internal kinematics of a shoaling oscillatory wave up to and beyond the breaker.

(g) Theoretical phase seeks a finite amplitude, irrotational solution in water of gradually varying depth. The experimental phase involves the development of an instrument package for measuring orbital velocities, static pressure and wave profile.


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INTERACTION OF WAVES WITH SUBMERGED AND FLOATING BODIES.

(b) Office of Naval Research, Dept. of the Navy.

(c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge, Mass. 02139.

(d) Theoretical and experimental; basic research (Sc.D. thesis).

(e) The purpose of the study is to determine the wave reflecting and transmitting characteristics of different types of structures. Applications are made to floating or moored breakwaters and to wave transformation in variable geometry channels.

(1) Tubular Breakwaters. Experiments on a tubular breakwater covered a series of tests on various lengths and number of tubes for a wide range of wave lengths and wave steepness.

The effects of these variables on the transmission and reflection coefficients and on the wave power loss and on the forces on the breakwater are thus defined. (2) Effect of a Gradual Change of Depth and Width on Wave Transformation. A theory has been developed which is applicable to long waves encountering a gradual change in depth.

These investigations are made in connection with a more general study on the transformation of long waves in the presence of subaqueous obstructions. A systematic investigation is now conducted to extend this work analytically and experimentally to the following phases: (a) Reflection and transmission characteristics for gradual changes in depth. (b) Reflection and transmission characteristics for changes in width. (c) Combinations of (a) and (b).

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EXPERIMENTAL STUDY OF WAVE MECHANICS.

(b) Laboratory project.

(c) Professor F. S. Eagleson, Mass. Inst. of Tech., Cambridge, Mass. 02139.

(d) Experimental and theoretical; basic research (S.M. thesis).

(e) A study of the effect of trailing edge geometry and flow-induced body vibration on spanwise correlations of instantaneous wake structure for flat plates. Suspended.

(f) Spanwise spatial correlations of total head fluctuations as obtained from cross power spectrum indicate the feedback from vibratory motion to forcing moment to result primarily from inphase wake coherence.


"Maximum Negative Damping in the Flutter of
Theoretical, field tests; applied research. The development of general utility and proven validity for performing design analyses involving the response of hydro-power plant systems to load fluctuation. The results of these programs compare well with field test measurements. Final reports and a user's manual have been prepared.


**3744** EFFECTS OF BASIN GEOMETRY AND VISCOUS DAMPING ON THE AMPLITUDE OF RESONANT OSCILLATIONS IN HARBORS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Theoretical and experimental; basic research.
(e) Investigation of the response of a harbor to waves incident on the harbor opening, with open ocean conditions simulated in a basin of finite size.
(f) Suspended.
(g) The response of a rectangular harbor connected to the open sea both analytically and experimentally. Solutions were obtained for the harbor response to wave incident from the ocean. Experiments were conducted on fully-open as well as partially-open harbors of different geometrical properties. It was found that the theoretical solutions accurately predict the resonant periods of the harbor. Ingard was also reached regarding the "harbor paradox." Investigations revealed its relation to viscous damping and to the response of a harbor to waves of a continuous power spectrum. Experiments revealed that particular resonant modes could be eliminated by the introduction of partial barriers along modal lines, however, these introduced new and sometimes more severe resonances.

**3745** DISPERSION IN POROUS MEDIUM AND WASTE WATER RECHARGE.

(b) U. S. Public Health Service, Division of Water Supply and Pollution Control
(d) Theoretical and experimental; basic research (doctoral thesis).
(e) A numerical analysis to determine the amount of dispersion between miscible fluids of differing qualities in a confined flow through a porous medium has been completed. An investigation of dispersion arising from the injection of a contaminant through a recharge well in the withdrawal of fresh water through a pumping well, both pumping at the same rate, in an infinite, confined aquifer is being carried out currently. Results will be important to engineering projects in the recharging of aquifers with reclaimed waste water.
(f) Completed.
(g) A general correlation has been made of known measurements of the longitudinal and lateral dispersion coefficients, using the correct dimensionless representation. Measurements have been made of the amount of dispersion (mixing) that occurs when a single well, pumping at a steady rate, discharges reclaimed waste water into an infinite, homogeneous, isotropic aquifer. A numerical solution of the governing differential equation has been obtained. This solution is compared with several approximate methods of solution to the differential equation and to some known field and experimental results. In the final phase, the problem of two-dimensional dispersion, arising from the steady injection of a contaminant through a recharge well and the steady withdrawal of fresh water by a pumping well (both pumping at the same rate), is being investigated experimentally and numerically. A sand model of this two-well flow problem has been constructed.


**3750** WAVE FORCES ON STRUCTURES.

(b) Laboratory project.
(d) Theoretical and experimental; applied research (PhD. thesis).
(e) The objective is the development of design information for wave forces on immersed objects. Included in the investigation is an analysis that will predict the response statistics of a pile supported offshore structure when it is subjected to a random wave train characterized by a narrow banded spectrum. Refinements in the analysis of such structures subjected to harmonic waves are also being investigated. A wave train is composed of a number of individual waves, each with a definite frequency, amplitude, and direction of propagation.
(f) Analytical procedures have been developed to determine the variation with time of the lateral forces developed on a vertical cylinder due to eddy shedding. Experiments are being run to determine the magnitude of the lateral forces as a function of cylinder diameter and flow characteristics. The phasing of the vortex shedding forces is being correlated with the wave motion. An analysis has also been made of one degree of freedom system consisting of a nearly massless vertical cylinder, fixed at the base, loaded with a concentrated mass, subjected to a random wave train. Experiments are being run to verify the analysis.
(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J. F. Kennedy, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental and theoretical; basic research (S.M. thesis).
(e) An experimental study of the turbulent wakes generated by two- and three-dimensional bodies moving beneath the free surface. The effects of density stratification are central to the study.

(g) Velocity distributions have been measured at various distances behind a two-dimensional body moving at different depths or submergence in a homogeneous fluid, and at the interface of a two-layered density-stratified fluid. The turbulent mixing between the two layers has been measured by measuring concentration profiles of the tracer, initially present in only the lower, heavier layer, at various distances behind the body. The vertical-diffusion coefficient has been found to decrease significantly with increasing density difference between the two fluid layers. The density stratification also causes the wake width to decrease with increasing distance behind the body after attaining a maximum value at a moderate distance behind the body. The velocity profiles in the stratified fluid are of the exponential, similar shape, but cannot be predicted using the methods developed for homogeneous fluids, because of the collapse of the wake. Experiments are now being performed to map the concentration configuration in the wake of a 4.2-inch-diameter, self-propelled, three-dimensional body moving in a fluid with continuous (nearly linear) density stratification.


(444a) TURBULENT TRANSFER MECHANICS OF FLUID SUSPENSIONS OF SOLID PARTICLES.

(b) Pioneering Research Program, Institute of Paper Chemistry.
(c) Professor P. Kennedy, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental; basic research S. M. and Ph.D. theses.
(e) Basic investigation of turbulent transfer mechanics of liquid flows with suspended particles.

(g) Velocity profiles and friction factors have been measured for concentrated suspensions of almost-neutrally-buoyant plastic particles in water flowing in a two-inch tube in a special flow facility. Measurements were made with both spherical and non-spherical particles. The friction factor is generally greater for suspensions than for clear water at the same Reynolds number and increasing concentration and increasing particle size, becoming slightly less than the clear water value for the coarser (0.13 inch) particles at larger Reynolds numbers. Experiments performed to measure the velocities of the particles and of the fluid have revealed that the particles move 10 to 15% faster than the fluid. The total head tubes used to measure velocity profiles in earlier experiments were calibrated in flowing suspension using a special nozzle. The coefficients of the probes were found to be 4 to 5% higher for the suspensions than for clear water.


(455a) A NEW METHOD FOR THE SYSTEMATIC INVESTIGATION OF SEDIMENT TRANSPORT.

(b) National Science Foundation.
(d) Theoretical and experimental; basic research.
(e) A research program to develop the general characteristics of the flow of fluid-sediment mixtures and of the interaction of fluid flow with movable boundaries.

(f) A study of sediment transport by shear flow in the annulus between two rotating drums rather than by flow in a channel that has been initiated. A new experimental apparatus which replaces the common employed longitudinal channel by an annular channel between two rotating drums has been designed and built. The normal gravitational field is replaced by a centrifugal force field. With the cylindrical drums rotating at different relative speeds a large variety of flow situations can be established in the "endless" annular channel, covering a wide range of tractive forces on the sediment deposited on the wall of the outer drum under various modes of relative motion. Mean velocities and turbulence characteristics are being measured in the annulus using homogeneous fluids. The structure of the mean velocity field and the fact that the flow is influenced by secondary motions. A theoretical description of the secondary motion in the annular geometry is developed. "The Development of a Rotating Endless..."
The similarity relationships governing surface runoff have been derived and from these the useful range of operation of model catchments has been determined. Instrumentation for a model catchment has been designed and is being built.


(g) The similarity relationships governing surface runoff have been derived and from these the useful range of operation of model catchments has been determined. Instrumentation for a model catchment has been designed and is being built.


duce shoaling in the Maracaibo Navigable Channel and control salt water intrusion into Lake Maracaibo.

Basic research: the special apparatus developed consists of an annular rotating channel and a counterrotating annular ring placed in the channel and in contact with the water surface. The relative motion of channel and ring generates a uniform turbulent flow field. Experiments with kaolinite clay suspensions have revealed two important properties: (1) The existence of a critical flow velocity for clay deposition. (2) For a given flow, the equilibrium concentration is a constant percentage of the initial sediment concentration in the channel. Field investigations: Results point out that most of the sediment coming from the Gulf of Venezuela transported near the bottom by tidal and salinity currents. Also a bottom layer at high salinity has been measured along the way to the entrance to the Lake throughout the year.

A Summary of the Present Knowledge of the Behavior of Fine Sediments in Estuaries, by E. Partheniades, Hydrodynamics Laboratory, Technical Note No. 6, June 1965.


The possibility of rotating models in the study of circulation patterns in large lakes.

Laboratory project.

Theoretical and experimental; basic research.

A study of the feasibility of small scale models in which similarity with respect to gravity and Coriolis forces is obtained. Velocity and time scales are obtained from Prandtl's dimensionless for a distorted model. Model is rotated to obtain effect of Coriolis acceleration.

Surface current patterns on a small model of Lake Michigan have been obtained for a constant wind field both with and without rotation of the model. The effect of a vertical density stratification on current patterns has been studied. The production of a thermocline by infrared heating of the model surface has also been investigated. Results indicate that rotation of the model produces marked differences in circulation patterns when compared to non-rotating model having the same wind pattern over the surface. A small model of lake Maracaibo (Venezuela) has been constructed for the purpose of studying the peculiar pattern of salinity distribution which exists in the lake. Results indicate that pattern as produced by interaction of wind generated currents and Coriolis effect.

Free surface flow over the wave bed. Laboratory project.

Experimental and theoretical; basic research (Master's thesis).

An investigation of a free surface flow of a real fluid over a small-amplitude sinusoidal bed in a rectangular-cross-section channel. Velocity profiles upward from the bed and outward from the vertical side walls have been measured at various locations along a rectangular-cross-section open channel with a sinusoidal-shaped wave bed, and along an isolated sinusoidal hump in the channel bottom for a supercritical flow. It has been found that the displacement thickness of the straight vertical walls varies periodically along the length of the channel with the same period as the wave hump. The undulation in the displacement thickness generates diagonal free-surface waves which cross the flume, a new wave being generated by each wave on the channel bottom. Pressure and velocity measurements indicate that the perturbation in the displacement thickness is caused by secondary currents resulting from the interaction of the boundary layers of the vertical side walls and the distortion of the vertical and lateral pressure gradients caused by the curvature of the bed. The orientation of the diagonal wave is in good agreement with that predicted using small-amplitude wave theory. The form of the vertical velocity-profiles vary markedly along the channel. The data are presented in the troughs (n=4 in the power-low velocity distribution) and bluntest at the crest (n=17 to 19).


Minimum-Cost Design of Pipe Networks.

Unsponsored laboratory project.


Experimental and theoretical (Ph.D. thesis). The influence of riverine distributions of roughness height on cavitation inception in a turbulent boundary layer. Boundary layer and roughness parameters and the role of free stream and boundary layer turbulence will be correlated with cavitation inception. An attempt will be made to determine any advantages of roughness in cavitation design.

Cavitation Near Surfaces of Distributed Roughness.

U.S. Army Research Office - Durham.


Experimental and theoretical (Ph.D. thesis). Experimental and theoretical (Ph.D. thesis). The influence of riverine distributions of roughness height on cavitation inception in a turbulent boundary layer. Boundary layer and roughness parameters and the role of free stream and boundary layer turbulence will be correlated with cavitation inception. An attempt will be made to determine any advantages of roughness in cavitation design.

Dispersion of Pollutants in Heterogeneous and Anisotropic Aquifers.

Public Health Service, Div. of Water Supply and Pollution Control.


Analytical and experimental (Doctoral thesis). The study of the dispersion and mixing in miscible fluid displacement in homogeneous and anisotropic porous media. First phase dealt with dispersion in layered formations. The current phase deals with numerical solutions to the convective-dispersion equations. These results will be applied to problems in layered and anisotropic formations.

Analytical solution for longitudinal dispersion in flow perpendicular to the layers, and lateral dispersion in flow along the layers have been obtained. These solutions have been validated experimentally. The numerical solutions are aimed at obtaining a general and efficient computer program with which a large variety of problems may be solved.

(5544) TECHNIQUES OF MODELLING THE SOLAR POND IN THE LABORATORY.

(b) Laboratory project.
(c) Prof. D. R. P. Harleman, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental and analytical (Doctoral thesis).
(e) The solar pond is used to store solar energy by absorption of radiation in a dense layer at the bottom of a pond. The object of the research is to find an analytic prediction for the temperature distribution in a pond with and without a black body absorber at the bottom for a specified radiation at the surface, and verify the analytic prediction experimentally. (2) Seek methods of obtaining prescribed temperature distributions for distorted models.

(5823) TURBULENCE STRUCTURE OF FLOW IN ROUGH CONDUITS.

(b) National Science Foundation.
(c) Professor J. F. Kennedy, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental; basic research S.M. and Ph.D. thesis.
(e) Measurement of the turbulence structure for pipe flow in the fully rough regime. Particular attention is being directed to the region near the boundary.
(f) An air flow facility with a ten-inch diameter test section is being constructed. The working section can be opened, and 0.13 inch diameter spheres are being cemented to the pipe to give a rough surface. The turbulence structure will be measured using a hot wire anemometer. The goal is to gain more insight into the process of particle entrainment by a turbulent flow by examining the turbulent component of velocity near the bed.

(5824) URBAN HYDROLOGIC SYSTEMS.

(b) Commonwealth of Mass., Dept. of Public Works.
(c) Prof. P. S. Eagleson.
(d) Theoretical and data analysis (S.M. thesis).
(e) Representation of urban drainage basins as optimum linear systems.
(f) Suspended.

(5825) OPTIMAL DESIGN OF SEWER AND DRAINAGE SYSTEMS.

(b) U. S. Public Health Service.
(c) Prof. R. T. McLaughlin, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Theoretical and analytical; basic research.
(e) Unsteady flow in systems of open channels is being analyzed numerically using a digital computer and dynamic programming is being applied to the optimal design of such systems.

(5826) MECHANICS OF VISCOUS STRATIFIED FLOW.

(b) M.I.T., Sloan Basic Research Grant.
(c) Prof. L. W. Kelhar, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Theoretical and experimental, basic research (master's thesis).
(e) General studies of viscous effects in density stratified flows. The present study deals with slow flow of a non-diffusive fluid.
(f) A mathematical model for slow viscous non-diffusive flow has been developed. The resulting ordinary differential equation is being integrated numerically for a number of flow problems including flow toward a line sink and the developing shear layer between stratified fluids moving at different velocities.

(4490) BASIC RESEARCH ON COOLING OF HIGH-PERFORMANCE ELECTROMAGNETS.

(b) M.I.T. National Magnet Laboratory.
(c) Prof. Arthur Bergles, M.I.T., Cambridge, Mass. 02139.
(d) Experimental and theoretical; basic and applied research; bachelor's, master's, and doctor's theses.
(e) This project has been concerned with the prediction of heat transfer and pressure drop under conditions simulating those encountered in high-performance electromagnets. Nonboiling and boiling heat transfer with water are being studied. Techniques of augmenting heat transfer are being considered.
(f) Data have been taken and correlations proposed for the prediction of heat transfer, pressure drop, and burnout for forced-convection surfaces boiling. The conditions for stability in parallel-channel systems have been defined. Investigations of the effects of film boiling and additives, and swirl flow have been performed.

(4498) USE OF ELECTROCHEMILUMINESCENCE IN FLOW VISUALIZATION AND THE MEASUREMENT OF MASS TRANSFER RATES.

(b) Laboratory project.
(c) Mr. George S. Springer, Asst. Prof. M.I.T., Cambridge, Mass. 02139.
(d) Experimental, applied research, Master's thesis.
(e) To study the process of electrochemiluminescence and investigate its usefulness in flow visualization and mass transfer measurements.
(f) Suspended.
(g) The technique shows separation in laminar flow. It can be used to measure mass transfer rates to solid surfaces in laminar flow.

(4982) FUNDAMENTAL INVESTIGATION OF HEAT TRANSFER AND FLUID FLOW INSIDE A HORIZONTAL TUBE EVAPORATOR.

(b) American Soceity of Heating, Refrigerating and Air Conditioning Engineers, Inc, Research Grant No. 41.
(c) Prof. W. Blau, Jr., Assoc. Prof. of Mechanical Engineering, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Basic research; experimental and theoretical.
(e) To conduct a visual and quantitative study of the fluid mechanics of a horizontal tube evaporator in order to clarify the confusion which presently exists in the interpretation.
of experimental results as concerns heat transfer mechanisms.


(5783) DETERMINATION OF THE STATE OF THE ART IN TWO-PHASE GAS-LIQUID FLOW PHENOMENA.

(b) Office of Naval Research (N00014(73)).
(c) S. William Gouse, JR., Associate Prof. of Mechanical Engineering, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Literature search and review.
(e) Conduct a world-wide search of the literature on various aspects of two-phase gas-liquid flow, index the literature and review the state of the art in various problem areas.


(5564) TWO-PHASE DIFFUSER FLOW STUDIES.

(b) M.I.T. Solar Energy Fund.
(c) S. William Gouse, JR., Associate Prof. of Mechanical Engineering, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Basic research; experimental and theoretical.
(e) Analytical and experimental investigation of decelerating two-phase gas-liquid flows.

(5555) WAVE PROPAGATION IN FLEXIBLE TUBES.

(b) National Institutes of Health.
(c) Prof. A. H. Shapiro, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental and theoretical, basic research; master's and doctoral theses.
(e) Pulsatile flow, with reference to the human cardiovascular system; study of wave propagation, non-linear effects, flow patterns, effects of local changes in tube wall properties.

(h) Report is now in preparation.

(5557) MOMENTUM FLUXES IN TWO PHASE (GAS-LIQUID) FLOW.

(b) U. S. Atomic Energy Commission.
(c) Prof. Peter Griffith, Mass. Inst. of Tech., Cambridge, Mass. 02139.
(d) Experimental. Direct measurement of momentum fluxes made for air-water and steam-water in a round pipe. Applied research - doctoral.
(e) A two-phase mixture is turned through 90° and the force on the turning tee is measured.
(f) Homogeneous momentum fluxes are closest to the truth.


(5780) ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF FLOW OSCILLATIONS IN A CLOSED LOOP WITH TRANSPARENT, PARALLEL, VERTICAL, HEATED CHANNELS.

(b) Office of Naval Research (N00014(73)).
(d) Basic research, analytical and experimental.
(e) Examine the details of two-phase gas-liquid flow oscillations with the object of identifying mechanisms and predicting stable operating conditions.

(g) A 250 page report entitled "Hydrology Studies in Massachusetts" was completed for the Mass.
A PHOTOMICROSCOPIC INVESTIGATION OF NON-NEWTONIAN FLOWS AT LOW REYNOLDS NUMBERS.

(b) David Taylor Model Basin.
(c) Prof. V. L. Streeter, Prof. of Civil Engrg., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Experimental; theoretical research.

(e) Laminar velocity profiles have been determined from photomicrographs of the motion of polystyrene latex particles 0.27 microns in diameter dispersed in distilled water and three different aqueous solutions of non-Newtonian additives flowing in a lucite test section 13 x 1.5 mm at a channel Reynolds number of 0.92.

(g) Velocity profile for distilled water agrees within 2% with the theoretical parabolic distribution for laminar flow between parallel flat plates. Profiles for the additives at both concentrations of 0.125% and 0.25% were indistinguishable from that of distilled water except near the boundaries, from 20-50 microns, where the velocity was measurable higher. Experiments are to be repeated for turbulent flow using cinematography.

(b) "Measurement of Laminar Velocity Profiles with Non-Newtonian Additives," in preparation.

EFFICIENCY OF SPRAY AERATION.

(b) National Institutes of Health, U. S. Public Health Service.
(c) Dr. Charles E. Carver, Jr., Prof. of Civil Engrg., Univ. of Mass., Amherst, Mass. 01003.

(d) Experimental; basic research.

(e) Overall oxygen transfer coefficients have been measured for deaerated water droplets falling through the atmosphere as a function of drop size and drop distance. The experiments are repeated with a synthetic detergent added to the water. Transfer coefficients are also measured from fully aerated water droplets falling through a pure nitrogen atmosphere as a function of drop size and drop distance and these experiments are repeated with a synthetic detergent added.

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UNIVERSITY OF MICHIGAN, Department of Civil Engrg.

WATER HAMMER: RESONANCE IN TRIPLEX PUMP SUCTION AND DISCHARGE LINES.

(b) Union Pump Company.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Theoretical and experimental; basic research.

(e) Theoretical determination of resonance-free suction lines and experimental study of actual transients.

PULSATILE FLOW THROUGH ARTERIES.

(b) National Institutes of Health.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Theoretical and experimental; basic research.

(e) Computer simulation of portions of the arterial tree; experimental studies of energy dissipation in pulsatile flow through diameters tubes.

WATER HAMMER, LIQUID COLUMN SEPARATION.

(b) National Science Foundation.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Theoretical and experimental; basic research.

Study of shape of separated liquid free surface in a horizontal pipe.

HORACE H. RACKHAM SCHOOL OF GRADUATE STUDIES, THE UNIVERSITY OF MICHIGAN, FORD FOUNDATION, NATIONAL SCIENCE FOUNDATION.

PROF. V. L. STREETER, PROF. OF CIVIL ENGINEERING.

DEPT. OF CIVIL ENGRG., COLLEGE OF ENGRG., UNIV. OF MICH., ANN ARBOR, MICH. 48104.

THEORETICAL AND EXPERIMENTAL.

STUDY OF GEOMETRY OF PIPELINES AND THE FREQUENCIES FOR WHICH RESONANCE COULD OCCUR.

EFFECT OF FRICITION IN DAMPING RESONANCE.


THE EFFECT OF URBANIZATION ON THE RUNOFF PROCESS.

(b) National Institute of Health.
(c) Dr. E. P. Brater, Prof. of Hydraulic Engineering, Dept. of Civil Engineering, Ann Arbor, Michigan 48104.

(d) Analysis of field data, basic research.

(e) Rainfall and runoff data from six watersheds are being analyzed. Some watersheds are rural, others are urbanized and others are in the process of urbanization. The ultimate goal of the research is the prediction of storm runoff on watersheds in various stages of urbanization.

(g) More than 50 flood hydrographs from six drainage basins were analyzed for shape and timing with respect to rainfall and volume of surface runoff.

RAINFALL-RUNOFF RELATIONS ON URBAN AND RURAL AREAS.

(b) National Institutes of Health.
(c) Dr. E. P. Brater, Prof. of Hydraulic Engrg., Dept. of Civil Engrg., Ann Arbor, Mich. 48104.

(d) Analysis of field data, basic research.

(e) Investigations will be made of rainfall and runoff for 17 small watersheds located in southwestern Michigan in order to determine basic relationships between flood discharge and rainfall and watershed characteristics.

Research is in preliminary stages.

VALVE STROKING TO CONTROL WATERHAMMER.

(b) National Science Foundation.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Theoretical and experimental.

(e) Development of theoretical equations for motion of a valve so that movement ceases the instant the valve motion ceases; confirmation on 4,000 ft. line with servo-operated valve.

UNIVERSITY OF MICHIGAN, Dept. of Civil Engineering.

HYDRAULIC CHARACTERISTICS AND SELF-CLEANING CHARACTERISTICS OF HIGHWAY GRADE INLETS.

(b) Rowland Engineering Co. and Univ. of Missouri, Engineering Experiment Station.
(c) Dr. John J. Cassidy, Civil Engineering Dept., University of Missouri, Columbia, Mo. 65202.
(d) Experimental; applied.
(e) Several commonly used geometric types of grate inlets are being investigated in order to determine the hydraulic characteristics of the grates, and hence provide a rational means of comparison of individual efficiencies.
(f) Completed.
(g) Efficiency of a grate has been shown to be a function of the Froude number and depth of the gutter flow. Grates with vane-shaped bars were found to be more efficient for large Froude numbers than were grates formed from flat bars. Self-cleaning characteristics of the grate appeared to vary with the thickness of the grate bars.
(h) Results have been submitted for publication at the Highway Research Board Meeting in Washington, D. C., Jan. 17, 1966.

(5260) IRROTATIONAL FLOW THROUGH A SPILLWAY BUCKET OF GIVEN SHAPE IN A GRAVITY FIELD.

(b) U.S. Army Corps of Engineers Waterways Experiment Station.
(c) Dr. John J. Cassidy, Dept. of Civil Engineering, University of Missouri, Columbia, Mo. 65202.
(d) Analytical; basic research.
(e) An analytical method is being devised for the determination of free-surface profiles, pressure distributions, and velocity distributions for irrotational flow through a curved spillway bucket of given shape in a gravity field.
(f) Completed.
(g) A FORTRAN program was written for the analysis of flow through a curved spillway bucket. Input to the program included the total head, bucket radius, coordinates of the center of curvature, and the slope of the approaching channel. Output from the program includes pressures on the solid boundary and free-surface coordinates.

(5261) THE Celerity of SOLITARY WAVES OF CONSTANT FORM.

(b) Laboratory project.
(c) Dr. Charles Lenau, Dept. of Civil Engineering, Unv. of Missouri, Columbia, Mo. 65202.
(d) Analytical; basic.
(e) The celerity of solitary waves with large amplitudes is being investigated through numerical solution of a nonlinear integral equation under the assumption that the flow is potential. The wave of maximum amplitude is of particular interest.
(f) Completed.
(g) A solution was obtained for the form of a large solitary wave of constant form. The maximum amplitude and the celerity were obtained as well as that of the solution to the problem for other wave forms.
(h) Results have been submitted for publication in the Journal of Fluid Mechanics.

(5827) EFFECT OF AQUATIC GROWTHS ON THE RESISTANCE TO FLOW IN PIPES.

(b) Missouri State Water Pollution Board.
(c) Dr. John J. Cassidy and Dr. Darrel L. King, Civil Engrg. Dept., Univ. of Mo., Columbia, Missouri 65202.
(d) Experimental; basic; M. S. thesis.
(e) Nutrients are being added to water in order to grow algae and other organisms on the walls of pipes through which the water is being pumped. Change in the resistance coefficient with time is being measured.

(5828) SPILLWAY DISCHARGE COEFFICIENTS AND PRESSURE DISTRIBUTIONS AS A FUNCTION OF SPILLWAY SHAPE.

(b) Univ. of Missouri, Engrg. Experiment Station.
(c) Dr. John J. Cassidy, Civil Engrg. Dept., Univ. of Missouri, Columbia, Mo. 65202.
(d) Experimental, basic, M. S. Thesis.
(e) Discharge coefficients and pressure distributions are being determined experimentally for spillways with varying crest shapes.

(5829) DISCHARGE MEASUREMENT IN TWO-DIMENSIONAL FLOWS.

(b) Laboratory study.
(c) Dr. Henry Liu, Civil Engrg. Dept., Univ. of Missouri, Columbia, Missouri 65202.
(d) Experimental; applied.
(e) A new method of discharge measurement is being studied. The method involves the release of lighter-than-water particles on or near the floor of a channel, and the measurement of the horizontal distance traversed during their rise to the surface.

UNIVERSITY OF MISSOURI AT ROLLA, Dept. of Civil Engrg.

(319) WEIR STUDIES.

(b) Laboratory project.
(c) Prof. E. W. Carlton, Civil Engrg. Dept., University of Missouri at Rolla, Rolla, Missouri 65201.
(d) Experimental; basic research for master's thesis.
(e) Tests on rectangular weirs were made to determine effect of velocity of approach on the relation between crest depth and critical depth of an imaginary open channel having same dimensions as the weir opening. Completed.
(f) Study produced a simple, accurate and quick solution for plotting of M function. Relationship between the M function, and the critical depth is logarithmic. This greatly simplifies determination of critical flow where the critical depth is known or vice versa. A relationship exists between M function of channels of same shape but different dimensions. The velocity of approach does not affect the relationship between physical depth and crest depth.

(3775) VERTICAL WATER JET IMPACTING UPON A STILLING BASIN.

(b) Laboratory project.
(c) Prof. V. A. C. Gevecker, Civil Engineering Department, Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) Tests being conducted on the terminal effect of a 3/8 inch water jet on a cylindrical stilling basin to determine side and bottom pressures, velocities and energy dissipated. Completed.
(f) It was found that the hydraulic behavior of the free jet impacting on a stilling basin can be determined to a degree which may be considered accurate for practical purposes. It was also shown that given the free jet velocity, the magnitudes of the velocities at the critical points inside the stilling basin can be computed by means of the equations presented.
(h) "Velocity Distribution Induced by Free Jet Impact on A Stilling Basin" by Sedat Ozkol, Master's Thesis, Missouri School of Mines, 1962.

(4169) INVESTIGATION OF VERTICAL INTERNAL SPILLWAYS.

(b) Laboratory project.
(c) Prof. G. D. Huff, Assoc. Prof. of Civil Engineering, Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) A scale model rockfill dam containing a vertical internal spillway was studied to determine factors affecting stage-discharge relationships.
(f) Completed.

(4661) A COMPUTER STUDY OF BACKWATER COMPUTATIONS.

(b) Laboratory project.
(c) Prof. C. D. Muir, Associate Professor of Civil Engineering, Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) The effect of some approximations used in backwater calculations on the resulting surface profile were studied by use of a digital computer. Also, several methods of backwater computations were compared.
(f) Completed.
(g) The results of this study indicated that the use of approximations is feasible for curves above critical depth but are dependent on flow regime.

(4662) HYDROLOGY OF SMALL MISSOURI WATERSHEDS.

(b) Laboratory project.
(c) Prof. C. D. Muir, Associate Professor of Civil Engineering, Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) This study was for the purpose of correlating basin characteristics and mean annual flood for Missouri watersheds having a drainage area of less than ten square miles.
(f) Suspended.
(g) It was found that mean annual floods could be predicted and correlated to known data from forty-five Missouri watersheds by use of a shape factor (Aₑ) and basin index (AₑS¹/₂).

(4663) FLOW THROUGH A ROCKFILL DAM.

(b) Laboratory project.
(c) Prof. P. R. Munger, Assistant Professor of Civil Engineering, Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) Model studies are being conducted on a rockfill dam with a sloping internal spillway to determine the characteristics of flow through such dams.
(f) Suspended.
(g) Preliminary studies indicate a relation exists between flow rate, head, core height and rock size.

(5468) INVESTIGATION OF HIGH VELOCITY JETS ON HYDRAULIC JUMP.

(b) Laboratory project.
(c) Prof. Paul R. Munger, Dept. of Civil Engrg., Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) Investigation of tailwater depth, length, and wave formation properties of hydraulic jump due to introduction of high velocity jets from spillway.
(f) Suspended.
(g) Test results indicate: (a) the quantity of water flowing through the submerged jets is a primary factor in determining the specific energy of the water leaving the hydraulic jump, (b) submerged jets can be more effective than baffle piers in reducing the length of the hydraulic jump, (c) submerged jets are not as effective as baffle piers in reducing the wave formation properties of a jump.

(5469) VELOCITY AND KINETIC ENERGY DISTRIBUTION OF A SUBMERGED JET.

(b) Laboratory project.
(c) Prof. V. A. C. Gevecker, Dept. of Civil Engrg., Univ. of Missouri at Rolla, Rolla, Missouri 65401.
(d) Experimental; basic research for master's thesis.
(e) Tests conducted to determine the effect on velocity and kinetic energy by submerging a jet below the surface of a stilling basin.
(f) Suspended.
(g) The entraining effect of the submerged jet is of an order of ten to one times the discharge of the jet itself at the section of the jet opening. The major energy dissipation effects occur in the region of the jet itself. The kinetic energy decreases not linearly but exponentially with depth of penetration.

(5740) DISCHARGE CHARACTERISTICS OF SIDE WEIRS.

(b) Laboratory project.
(c) Prof. V. A. C. Gevecker, Civil Engineering Dept., University of Missouri at Rolla, Missouri 65401.
(d) Experimental, basic research for Master's thesis.
(e) An investigation of the division of flow of water in a flume of rectangular cross-section when the flume is provided with a side weir.
(f) Suspended.
(g) An equation is derived so that the quantity of water flowing over the side weir compared to the quantity of water flowing in the main channel can be predicted. This ratio is acceptable only within the ranges of heads, velocities, and weir lengths imposed by the geometry of the system tested.
(h) "Discharge Characteristics of Side Weirs," by Edgar Snowden IV, Master's Thesis, Univ. of Missouri at Rolla, 1965.

MONTANA STATE COLLEGE, Agricultural Experiment Station.

(4664) EFFICIENT APPLICATION OF IRRIGATION WATER BY SURFACE FLOODING METHODS.

(b) Laboratory project.
(c) Prof. C. C. Bowman, Head, Agricultural Engineering Dept., Montana State College, Bozeman, Montana 59715.
(d) This is a study to develop design criteria for more efficient application of irrigation water by flooding method. This is basic research at the present time, but will be applied research immediately upon completion of the first phase.

UNIVERSITY OF NEBRASKA, Hydraulics Laboratory, Dept. of Engineering Mechanics.

(3776) VORTEX FORMATION AND DRAG IN UNSTEADY FLOW PAST BLUFF BODIES.

(b) National Science Foundation.
(c) Prof. T. Sarpkaya, Dept. of Engineering Mechanics, Bancroft hall 219, University of Nebraska, Lincoln, Nebraska 68508.
(e) Primary objects of the research are: To determine the growth and motion of vortices behind two-dimensional bluff bodies subjected to unidirectional unsteady flow; to determine the various components of corresponding resistance; and to correlate a particular vortex configuration with the instantaneous resistance.
(f) The forces predicted on the basis of the moving and growing vortices are comparable in magnitude to forces which are observed. Resistance to
unsteady flow is not to be thought of as a mere juxtaposition of resistances to steady flow augmented by an inertial force.


(372) INDUCED MASS OF CONFINED FLUIDS.

(b) Laboratory project.

(c) Prof. T. Sarpkaya, Bancroft Hall 219, University of Nebraska, Lincoln, Nebr. 68508.

(d) Theoretical basic research; for master's thesis.

(e) When a confined fluid is suddenly accelerated through an opening, initial average acceleration is determined by the induced mass of the fluid system. Since the equation of the elastic wave propagation cannot be solved for the boundary conditions imposed, solution of Laplace's equation is joined to that obtained from the wave equation through the application of the Schwartz-Christoffel transformation and electrical analogy.

(g) Theoretical and experimental and for master's thesis. Particularly for short conduits. Average times necessary for the reflection of an elastic wave from a given reservoir is determined.

(4983) COUNTER VORTEX OSCILLATOR.

(b) Diamond Ordnance Fuze Laboratories, Wash., D. C.

(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln, Nebraska 68508.

(d) Theoretical and experimental and for master's thesis.

(e) To determine the intensity of pressure fluctuations and frequency of the instability created by two vortices rotating in opposite directions in two vortex chambers connected by a circular tube.

(g) Frequency and intensity of pressure fluctuations are determined as function of fluid properties and the geometry of the system. The counter vortex oscillator unit proved to be usable together with a pneumatic amplifier in controlling the momentum of the jet.


(5263) VORTEX-RATE SENSOR.

(b) Harry Diamond Laboratories.

(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln, Nebraska 68508.

(d) Theoretical and experimental for M. S. thesis.

(e) To use the vortex-sink flow to provide a signal proportional to rate of rotation.

(g) Boundary layer development in vortex-sink flow has been analyzed theoretically. The units built provide sufficiently large signals for very low rates of rotation.


(5264) SEPARATED FLOW ABOUT LIFTING BODIES.

(b) Laboratory project partly supported by NSF and ONR.

(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln, Nebraska 68508.

(d) Experimental and theoretical.

(e) Cross-flow drag and normal-force coefficients are determined for slender bodies at high angles of attack within subsonic to moderately supersonic range.

(g) Cross-flow drag coefficient is about 25% larger near the point of separation than that for steady flow at the same Reynolds number past a circular cylinder. Results indicate that Schwab's data for cylinders set in motion impulsively from rest may be in error.


(5265) DYNAMICS OF A BISTABLE FLUID AMPLIFIER WITH A LATCHING VORTEX.

(b) Harry Diamond Laboratories, Washington, D. C.

(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln, Nebraska 68508.

(d) Theoretical and experimental, M. S. thesis.

(e) To determine the response of a bistable fluid amplifier with a latching vortex to various types of input.

(g) Latching vortex increases the power and pressure-recovery factors but it also increases the noise level of the amplifier.


(5670) EVOLUTION OF SMALL DISTURBANCES IN THE TRANSITION REGION OF HAGEN-POISEUILLE FLOW.

(b) National Science Foundation.

(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln, Nebraska 68508.

(d) Theoretical and experimental basic research.

(e) The purpose of the project is to study the stability of pipe flow to small upstream disturbances.

NEW YORK UNIVERSITY, Department of Chemical Engr.

(5650) THEORETICAL STUDY OF SUSPENSION VISCOITY: BY MEANS OF A MODEL OF THE SLOW MOTION OF SPHERES AND A VISCOUS FLUID THROUGH A CYLINDER.

(b) Laboratory project.


(d) Experimental and theoretical basic research for doctoral thesis.

(e) The slow translational and rotational motion of particles moving through a viscous fluid subjected to the influence of cylindrical boundaries is being studied. This will ultimately enable a theoretical prediction of the frictional drag, rotational moment, permanent pressure drop caused by the presence of these particles in the original Poiseuillian field of flow, and suspension viscosity.

(g) The method of reflections technique for solving boundary value problems is applied to the slow translational and rotational motion of a particle subjected to the influence of cylindrical boundaries. Expressions were obtained for the frictional drag, rotational moment, permanent pressure drop and suspension viscosity.

NEW YORK UNIVERSITY, School of Engineering and Science, Department of Civil Engineering.

(4988) MECHANISM OF GAS ABSORPTION BY TURBULENT LIQUIDS.

(b) Laboratory project.

(c) Dr. William E. Dobbs, Prof. of Civil Engineering, New York University, School of
Theoretical and experimental; basic research (doctoral thesis).

A study of the mechanism by which gases are transferred across a turbulent gas-liquid interface, with particular emphasis on the process as it occurs in natural streams.

Suspended.

A mathematical model for the transfer process has been developed. Experimental work using several gases of varying diffusivities indicates an acceptability of the mathematical model. The present phase is concerned with the effect of impurities in the liquid.

TILTING CHANNEL.

(b) Laboratory project.

(c) Dr. Erick R. Oldlund, Asst. Professor of Civil Engineering, New York School of Engrs. and Science, Univ. Heights, New York, N.Y. 10453.

(d) Development of research facilities.

(e) The channel is 65 feet long, 3 feet wide and 2 feet deep, glass walled and glass bottomed. It has a tilting taper of 1 percent to -2 percent. It is designed as a general purpose facility for studies in open channel and estuary flow problems including dispersion, sediment transport and wave interaction studies.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

OFFICE OF NAVAL RESEARCH ATMOSPHERE INTERACTION AND WAVE PROJECT.

(b) Geophysics Branch, Office of Naval Research, Department of the Navy.

(c) Prof. Gerhard Neumann, Prof. of Oceanography and Prof. Willard J. Pierson, Prof. of Oceanography, New York University, New York 53, New York.

(d) Experimental and theoretical; basic and applied research.


(g) Analysis of data obtained during Equaunt I and II experiments has proved the existence of the Atlantic Equatorial Undercurrent all across the ocean. Detailed studies of the determination of this current in the Bay of Guinea indicate a direct relationship to the African SW-Monsoon.


U. S. NAVAL OCEANOGRAPHIC OFFICE ATLANTIC AND PACIFIC WAVE HINDCASTING PROJECT.

(b) U. S. Naval Oceanographic Office.

(c) Professor Willard J. Pierson, Jr., Prof. of Oceanography, New York University, New York, New York 10453.

(d) Experimental and theoretical; basic and applied research.

(e) Development of various ways to hindcast waves by spectral techniques on an oceanwide basis. The North Atlantic has been completed, and the North Pacific is first being started. Will run for two years. A file of magnetic tape containing wave spectra for every 6 hours at 519 points on the North Atlantic will be available.


NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

STUDY OF CORRELATION BETWEEN BOUNDARY LAYERS AND THE WIND.

(b) Laboratory project.

(c) Dr. M. Amets, Department of Civil Engineering, New York State of the Univ. of No. Carolina, Raleigh, North Carolina 27607.

(d) Experimental and theoretical; basic research.

(e) An experimental investigation on translatory motions with irregular profiles, on bore formations and on the propagation of unsteady motions through non-uniform flows is made in a glass-walled channel. The channel is 14 ft. long, 2 ft. wide with adjustable variable slope. The experimental results are analyzed by the nonlinear shallow water theory. The objective of the project is to seek improvements to the prevalent techniques for the computation of unsteady flows and to provide experimental data for further theoretical investigations.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

STUDY OF VORTEX MOTION IN WAVE FLOWS.

(b) Laboratory project.

(c) Prof. Paul Harrwood, Department of Civil Engineering, North Carolina State of the Univ. of No. Carolina, Raleigh, North Carolina 27607.

(d) Experimental and theoretical; doctoral thesis.

(e) An investigation of the eddy motions present in the wakes of bluff bodies in a streaming fluid, with particular attention given to the periodicity of eddy motions and to vortex strength.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

AN INVESTIGATION OF THE STABILITY OF FLOW IN CIRCULAR SEDIMENTATION BASINS.

(b) Laboratory project.

(c) Professor Charles Smallwood, Jr., Dept. of Civil Engrg., North Carolina State of the Univ. of No. Carolina, Raleigh, North Carolina 27607.

(d) Experimental; master's thesis.

(e) A semi-circular center-fed model basin was built with a transparent back for visual examination of the flow pattern. A uranine dye tracer was used to determine flow through waves for the basin. Stability was measured by the reproducibility of the time-fluence dye concentration waves. In an attempt to stabilize the flow radial baffles were placed in the basin to reduce the angle of divergence and to provide solid boundaries in the divergent flow.

(f) Completed.

The baffles had no detectable effect. The flow pattern was characterized by a short-circuit along the tank bottom and a back-flow in the upper portion of the tank.
(3121) PREPARED DITCH LININGS.

(b) Laboratory project.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
(d) Experimental; applied research and Master's thesis.
(e) Field study of the durability and usefulness of black polyethylene for lining farm irrigation ditches.
(f) Completed.


(4175) WATER INTRATE RATES AND PHYSICOCHEMICAL PROPERTIES OF IRREGULAR SOILS.

(b) Joint laboratory project between Department of Agricultural Engineering and Department of Soils.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
(d) Experimental, basic research, and Master's thesis.
(e) Infiltration tests were made in the field on 8 inch, 16 inch, and 33 inch double ring infiltrometers. Various sized buffer rings were used ranging from no buffer ring to a buffer ring measuring 5 times the inner ring diameter.
(f) Infiltration rate generally decreased as the size of the outer ring was increased.

(5471) CONCRETE DITCH LINING AND PIPE FOR IRRIGATION SYSTEMS.

(b) Laboratory project.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State Univ., Fargo, N. Dak.
(d) Experimental; applied research and Master's thesis.
(e) Soil moisture content and temperature measurements were made in the soil profile adjacent to concrete lined farm irrigation ditches and 12 inch buried concrete pipe during various periods of the past 12 months. The alignment and elevation of the ditch and pipe was also recorded. The study is being conducted to predict the behavior of these conduits under North Dakota conditions.
(f) Pipe and ditch linings have not shown appreciable deterioration after one year of use.

NORTHWESTERN UNIVERSITY, The Technological Institute.

(3476) FLOOD WAVE Routing.

(b) Northwestern Technological Institute.
(c) Prof. M. S. Hamilton, Dept. of Civil Engr., Northwestern University, Evanston, Ill. 60201.
(d) Theoretical and analytical for doctoral and masters theses.
(e) The purpose is to calculate the movement of flood waves in prismatic and natural channels. Finite difference equations based on the method of characteristics have been programmed and solved on a digital computer for the case of a non-prismatic channel. The effect of ignoring certain terms in the basic equations is to be studied next.
(f) Problems of instability have been avoided and reasonable hydrographs obtained.

(3799) FORCES ON SUBMERGED BODIES IN UNSTEADY MOTION.

(b) National Science Foundation.
(c) Prof. Lyle P. Mockros, Technological Institute, Northwestern University, Evanston, Ill. 60201.
(d) Theoretical and experimental, basic research, M. S. and Ph.D. theses.
(e) Investigation of the forces on solid spheres accelerating along a rectilinear path through incompressible viscous fluids. The investigations includes (1) experiments that will be compared with a numerical evaluation of theoretical linear solutions, (2) experiments on the general case of large motions, and (3) a study of the effect of the velocity pattern on added mass.
(g) The complex theoretical solution for the creeping motion case has been put into graphical form. This theoretical solution has been used to study the dispersion of particles in a turbulent fluid. Experiments on large motion oscillations have been performed and the data correlated in terms of velocity (drag), acceleration (added mass) and history coefficients.

plasma denaturation on fluid dynamic parameters have been determined. Further work is indicated. The gas transfer to blood flowing in tubes has been theoretically studied using numerical techniques.

(5475) NOISE SPECTRA GENERATED BY FLOW OF A LIQUID THROUGH VARIOUS ORIFICES.

(b) Bio-Medical Engineering Center, North- western Technological Institute.
(c) Prof. W. S. Hamilton, Dept. of Civil Engrg., Northwestern Univ., Evanston, Ill. 60201.
(d) Experimental; applied research.
(e) Purpose is to identify characteristic flow generated noise in an abnormal heart. The noise spectra generated by steady and pulsating flow through rigid and flexible orifices is being investigated. Water is pumped through orifice valves of sheep’s hearts. The flaps are partly sewn together to restrict the opening.

The noise spectra for steady flow through rigid orifices as reported in the literature has been verified for water flows. The technique of testing natural heart valves is reasonably well developed.

(5714) YIELD OF A NON-LINEAR ELASTIC AQUIFER.

(b) Northwestern Technological Institute.
(c) Prof. W. S. Hamilton, Dept. of Civil Engrg., Northwestern Univ., Evanston, Ill. 60201.
(d) Analytical and experimental for M. S. and Ph.D. theses.
(e) The drawdown of an elastic artesian aquifer is being studied analytically and with a sponge rubber model. The permeability and yield coefficients both are functions of the drawdown. The purpose is to find whether the unsteady state solution using average values differs significantly from a solution that includes the variation of the coefficients.

(g) Compression and permeability tests have yielded preliminary values of the coefficients. The test apparatus for time-dependent measurements is partly constructed.

(5715) LIGHT EMISSION FROM HYDRODINAMICALLY DEPENDENT CAVITATION.

(b) Laboratory project.
(c) Prof. Thomas F. Anderson, Assoc. Prof., Dept. of Mechanical Engineering and Astronautical Sciences, Northwestern Univ., Evanston, Ill. 60201.
(d) Experimental investigation of the fundamental phenomenon for doctoral research requirements.
(e) The light emission produced from cavitation bubbles in water is being spectrally analyzed as related to various dissolved gases. It is anticipated that these results will provide insight into the basic characteristics of the collapse mechanisms.

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, Department of Agricultural Engineering.

(5033) DRAINAGE INVESTIGATIONS FOR AGRICULTURAL LANDS.

(b) Ohio Agricultural Research and Development Center in cooperation with Agricultural Research Service.
(c) Dr. G. O. Schwab, 2073 Neil Ave., The Ohio State University, Columbus, Ohio 43210.
(d) Field investigation; applied research.
(e) Tile flow, surface runoff, water table levels, and crop yields are measured to evaluate various types of drainage systems and to develop improved engineering design criteria.

(g) Fifteen years of tile flow data, partial analysis completed; corn (5 years) and soybean (1 year) yields evaluated from various methods of drainage.


(5223) FLOW OF COLLOIDAL SUSPENSIONS IN POROUS MEDIA.

(b) Laboratory project with partial support by National Science Foundation.
(c) Dr. R. Bruce Curry, Assoc. Prof. Dept. of Agricultural Engineering, Ohio Agricultural Research and Development Center.
(d) Theoretical and experimental; basic research.
(e) To investigate the fundamental principles underlying the flow of colloidal suspensions into or through porous media.

The scope of this study will include the use of several granular materials and suspensions of colloidal materials. Initially, carbonadium will be used as the porous medium and bentonite as the suspended material in order that there will be continuity between the present work and past studies. Materials to be used later will include chemically active materials such as zeolite, natural occurring materials, such as soils and filter sands. The natural occurring materials will be used to determine in the field. Both the porous media and the suspended materials will be characterized completely by determination of various physical and chemical properties.

The granular material will be placed in a permeameter for testing. The actual test procedure will involve three phases: (1) Initial flow of de-aired, de-ionized water through the porous media in the permeameter; (2) followed by the introduction of the suspension into the permeameter; (3) finally the de-aired, de-ionized water will be reintroduced into the permeameter in order to determine the effect of the suspension flow on the system.

A system has been developed to determine the amount of clay deposited from suspension during flow through a porous media using a radioactive tracer. Data obtained are being used to test a mathematical model of suspension flow in porous media. The electrokinetic properties of both the suspension and the media have been measured using electrophoresis and streaming potential techniques, respectively.


HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS.

(b) Laboratory project.
(c) Dr. R. Bruce Curry, Assoc. Prof. Dept. of Agricultural Engineering, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.
(d) Theoretical; basic research.
(e) To investigate the use of mathematical, electrical, and hydraulic models to study hydrologic phenomena of watersheds.
(a) To investigate statistical models as a means of identifying and evaluating the pertinent variables in the runoff process.
(b) To use these variables together with a mathematical model to predict behavior of a small watershed.

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. During the experimental study, small watersheds and runoff plots will be used to test the validity of the model.

Present activity centers around the application of non-equilibrium thermodynamics to the runoff process.

(5672) ELECTROKINETIC REMOVAL OF COLLOIDS FROM SUSPENSION.

(b) Laboratory project with partial support by National Science Foundation.

c) Dr. R. Bruce Curry, Assoc. Prof., Dept. of Agricultural Engineering, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

d) Theoretical and experimental; basic research.

e) The objectives of the study are (1) to improve present theory or to develop new theoretical relationships regarding the electrokinetic removal of colloidal material from water suspensions and (2) to determine the limitations and conditions under which a laboratory pilot model will operate most efficiently.

The purposes of this research are to develop basic theoretical relationships regarding the electrokinetic removal of colloids from water suspensions and to verify this theory with a pilot model in the laboratory. The limitations and conditions for efficient removal will involve measuring the characteristics of the colloids, selecting suitable physical arrangements for the electrodes, and determining the optimum field strength, current, temperature, and flow rate through the system. Migration velocity, conductivity, and electrical charge of the colloids are important properties to be determined. Kaolin and bentonite clays will be initially investigated, but the principle may have application for the removal of bacteria and other microorganisms, as well as chemical contaminants, such as pesticides.

Present activity is devoted to (1) the formulation of a theory for the movement of charged clay colloids in a flowing medium with an electric field impressed on the system by considering the entire ensemble of particles rather than a single particle. A probabilistic approach based on diffusion theory is being considered. The Langevin, Poeker-Planck and Smoluchowski equations and turbulent diffusion equations provide background for these considerations. And (2) the verification of this theory experimentally.


(5716) HYDROLOGIC INVESTIGATIONS OF SMALL WATERSHEDS IN OHIO.

(b) Water Resources Center, Ohio State Univ. In cooperation with Office of Water Resources Research, S. Dept. Interior.

c) Dr. E. Paul Taganides, Assoc. Prof., Agricutural Engrg., Dept., Ohio State Univ. Columbus, Ohio, 43210.

d) Experimental; design research.

e) The application of mathematical models as a means of identifying and evaluating the pertinent variables in rainfall-runoff relationships for small watersheds will be investigated. Nearly 50 years of rainfall-runoff data on the Little Mill Creek Watershed located within the province of the Coshocton, Ohio, Hydrologic Research Station will be used to test the model. Flood peaks and volumes to climatic and physical parameters. The effect of strip mining on water yield will also be studied.

Ohio State University, Department of Agronomy.

(5176) SOIL CHARACTERISTICS AND SUBSURFACE DRAINAGE.

(b) Ohio Agricultural Experiment Station.

c) Prof. George S. Taylor, Dept. Agronomy, Ohio State Univ., Columbus, Ohio 43210.

d) Experimental investigation, applied research.

e) Numerical analysis of soil moisture flow problems in subsurface drainage are made with digital computers. Steady-state and transient analyses are studied for various parameters including depth, spacing of tile and ditch drains and of soil hydraulic conductivity. Similar studies were initiated in 1958 to analyze water table drawdown around a pumped well. Hillside seepage problems are also evaluated. Field evaluations of hydraulic conductivity are made with the aid of lysimeter-type installations. The principal objective is to estimate the above factors in rational design of subsurface drainage systems.

(e) Characteristics of water flow into tile drains have been studied for layered soils. An analysis of hillside seepage into open ditches was made. Agreement between analytical and numerical analysis techniques was established.

Ohio State University, Agricultural Engineering Department.

(2365) HYDROLOGIC STUDIES ON SMALL GRASS-COVERED WATERSHEDS.

(b) Oklahoma Agricultural Experiment Station, cooperative with Agricultural Research Service, U. S. Dept. of Agriculture.

c) Prof. P. R. Crow, Okla. State Univ., Dept. of Agricultural Engrg., Stillwater, Okla. 74075.

d) Field investigation; applied research.

e) Measurements are being made to provide hydrologic data on total watershed runoff and peak rates of runoff from three small grass-covered watersheds (17 to 226 acres) in north central Oklahoma. Highway culverts, modified by the addition of weir sills, are being used as runoff measuring devices. Consideration of soil profile on each of the watersheds is determined weekly.

Thirteen year record of rainfall and runoff record is available. Frequency distributions of runoff rates and amounts have been determined. An analysis of the effect of stock water ponds on total water yield of small watersheds has been completed.

The effectiveness of monomolecular films for reducing evaporation from reservoirs.

(b) Oklahoma Agricultural Experiment Station, cooperative with U. S. Bureau of Reclamation.

c) Prof. P. R. Crow, Oklahoma State Univ., Dept. of Agricultural Engineering,
Experimental; Experimental; Experimental; particular system comprehensive

"An Experimental system has been developed for automatic application of hexacoctadecanol slurry. Current research relates the energy budget to the water budget when the test reservoir is covered with a chemical monolayer.

Evaporation reductions of 25 to 40% have been obtained in long duration tests using slurry monolayer. Curves have been developed relating wind speed and required film application rate. A system of flanking has been used to control the monolayer to reduce frequency of application. Various height/spacing ratios have been tested.

AUTOMATION OF CUT-BACK FURROW IRRIGATION.

Oklahoma Agricultural Experiment Station.
Dr. J. E. Garton, Oklahoma State Univ., Dept. of Agricultural Engineering, Stillwater, Okla. 74075.
Experimental and field investigation; applied research; design for thesis.

The development of a system of cut-back furrow irrigation using level furrow outlet tubing with hooded inlets. The system will irrigate through the furrows at a design initial flow, cut-back to a design cut-back flow, and shut off by the simple removal of sheet-metal back dams. The purpose of the method is to improve the uniformity of furrow irrigation and to drastically reduce the high labor requirement.

Discharge characteristics of various lengths, and diameters of short, level, galvanized pipe with hooded inlets have been determined. Design procedures for applying the system to a particular design situation have been developed. Operating characteristics of a designed system have been calculated. A prototype system has been constructed. The system is completely automated utilizing a time clock control, solenoid operated latches and automatic gates. The labor requirement is about one tenth of that for conventional systems in the area.

REDUCTION OF WATER APPLICATION LOSSES THROUGH IMPROVED DISTRIBUTION CHANNEL DESIGN.

Oklahoma Water Resources Research Institute.
Dr. J. E. Garton, Oklahoma State Univ., Dept. of Agricultural Engr., Stillwater, Oklahoma 74075.
Experimental, applied research for theses.

The determination of Boussinesq and Coulombe coefficients and retardance values for a slip form lined concrete irrigation channel, with and without siphon tubes is being conducted. Values obtained will be used to develop relationships for spatially varied flow water surface profiles. Design procedures will be developed to apply the results to irrigation distribution channel designs.

A comprehensive computer analysis of the problem has been made. Spatially Varied Flow in an Irrigation Distribution ditch, James E. Garton and Albert L. Mink. Paper presented at 1964 Annual Winter Meeting of ASAE, New Orleans, Louisiana.

WATER YIELD AS INFLUENCED BY WATERSHED CHARACTERISTICS AND SMALL UPSTREAM RESERVOIRS.

Oklahoma Water Resources Research Institute.
Dr. J. E. Garton, Oklahoma State Univ., Dept. of Agricultural Engr., Stillwater, Oklahoma 74075.
Experimental and field investigation.

Meager information on the hydrology of small watersheds is available. This project plans to instrument three upstream reservoirs with 0.6 to 3.0 sq. mile watersheds. The objectives are to measure the percent and total volume change in water yield caused by various sizes of upstream reservoirs, and to relate the volume and peak rate of runoff from the waterbodies to urban characteristics. Rainfall will be measured by a network of recording rain gages. Outflow through the spillway will be determined by flood routing technique. The percent reduction in flow due to the reservoirs will be computed for monthly and annual time periods. Correlative procedures will be used to relate percentage and volume of runoff to rainfall, soil texture, plant cover, and soil moisture characteristics.

THE MECHANISM OF DIRECT SURFACE RUNOFF FROM RAINFALL.

Dr. J. E. Garton, Oklahoma State Univ., Dept. of Agricultural Engr., Stillwater, Okla. 74075.
Experimental; applied research.

Now in its initial phase, the ultimate goal of this project is to separate rainfall through the sheet flow phase of runoff; through terrace channels, grassed waterways, detention structures, spillway to the principal outlet of a small watershed using prediction equations based on known laws of fluid behavior. The objectives of the study are: (1) To develop prediction equations for surface profiles of overland flow from rainfall by finite increment computer solutions of the partial differential equations of momentum and continuity for spatially varied unsteady sheet flow. (2) 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.

OREGON STATE UNIVERSITY, Department of Civil Engineering.

INVESTIGATION OF SUPERCRITICAL FLOW CHANNEL JUNCTIONS.

Prof. C. E. Behlke, Dept. of Civil Engrg., Oregon State University, Corvallis, Oregon (on leave); Director of Institute of Water Resources, University of Alaska, College, Alaska.
Theoretical and experimental; applied research.

Wave effects resulting from the junction of two supercritical, open channel flows are being studied to determine the magnitude and the location of the wave pile up on the channel walls. Completed.

The prediction of wave pile-up.


HYDRAULIC INVESTIGATION OF BAFFLED, PIPE TYPE FISH LADDERS.

State of Oregon Fish Commission.
Prof. C. E. Behlke, Dept. of Civil Engrg., Oregon State Univ., Corvallis, Oregon (on leave); Director of Institute of Water Resources, University of Alaska, College, Alaska.
Experimental; applied research.

High energy dissipation, enclosed fish ladders are being studied. Purpose is to
develop relatively short, inexpensive fish ladders for small streams. Prototypes will be constructed and tested with adult salmon by the sponsoring agency.

(f) Completed.

(g) Barriers have been developed which can be placed in pipes to yield large energy dissipation. In a 36-inch pipe, with a fish passage area of 18" by 15", the head loss is 0.55 ft. per foot of pipe, with a mean velocity of 4.5 ft/sec through the fish passage area.

(5785) COMPLEX NUMERICAL INTEGRATION TO FIND STREAM VELOCITY.

(b) Laboratory project.

(c) Asst. Prof. L. S. Slotta, Dept. of Civil Engineering, Oregon State University, Corvallis, Oregon.

(d) Experimental; applied research for Ph.D. thesis.

(e) Complex numerical integration of the Schwartz-Christoffel transformation and application to potential flow.

(f) Completed.

(g) By applying real numerical integration jointly on the real and imaginary parts of the complex integral, this thesis extends the principles and formulas of real numerical integration to include complex analytic functions with a finite number of singularities. The principles of complex numerical integration are then shown to be applicable to problems of potential flow which require a Schwartz-Christoffel mapping. A generalization of the Schwartz-Christoffel transformation is then made to include curved corners. Computational examples and streamline plots of potential flow over irregular boundaries are included.


(5786) MANIFOLD STUDIES.

(b) Laboratory project.

(c) Asst. Prof. L. S. Slotta, Dept. of Civil Engineering, Oregon State University, Corvallis, Oregon.

(d) Experimental; applied research for M. S. thesis.

(e) Study of the effect of the diameter and spacing of manifold outlets on manifold flow.

(f) Completed.

(g) Magnitude of spacing parameter is a function of the lateral diameter ratio as well as the lateral spacing. The results obtained using a two inch lateral (D/D = 0.4) agree well with data obtained by Yanis and indicate that for a spacing exceeding 20 conduit diameters no inter-lateral interference occurs. However, for larger diameter ratios (D/D > 0.5), a spacing equal to the 15 to 20 conduit diameters predicted by previous investigators is necessary before inter-lateral interference is not present.

(h) M.S. thesis by Michael D. Coleman.

(5787) FACTORS INFLUENCING STREAM TEMPERATURES.

(b) U.S.F.H.S.

(c) Asst. Professors John Seaders and L. S. Slotta; Dept. of Civil Engineering, Oregon State Univ., Corvallis, Oregon.

(d) Experimental and field investigation; basic research for M. S. and Ph.D. thesis.

(e) The aims of this research project are: to determine the evaporation from turbulent surfaces; the radiation to and from natural water surfaces; and the effect of turbidity on evaporation.

(f) Model evaporation and radiation studies are designed, instrumented and in progress. Field instrumentation has been tested in a preliminary field evaporation study. Full scale experiments are to follow.

(g) "Factors Influencing Stream Temperatures," Progress Report No. 1, Engineering Experiment Station, Oregon State University, Corvallis, Oregon. February 1965.

(h) THE PENNSYLVANIA STATE UNIVERSITY, Hydraulics Laboratory, Department of Civil Engineering.

Inquiries concerning the following projects, should be addressed to Prof. Sam Shultis, Head, Hydraulics Laboratory, 212 Sackett Building, The Pennsylvania State University, University Park, Penna. 16802.

(5181) ROUGHNESS COEFFICIENTS OF COBBLE-STREWN STREAMS.

(b) Laboratory project.

(d) Experimental; applied research; doctoral thesis.

(e) To provide a quantitative means of determining Manning's n or the coefficient K in V = (Dn) \( \sqrt{g} \) in cobble-strewn streams, particularly for use in the slope-area method of computing flood discharge. In a lucite-walled tilting flume, 1 ft wide, 1.5 ft deep, and 25 ft. long, rough, cobble-strewn bed was placed by large wooden cubes, 1.09 inches on a side. Maximum discharge approximately 2 cfs.

(f) Completed.

(g) Previous work revealed systematic relationships among the roughness coefficient, Reynolds and Froude numbers, and a quantitative parameter of the roughness pattern. See "Large-Scale Roughness in Open-Channel Flow," J. B. Herbold and J. L. Schorr, Journal, ASCE Hydraulics Div., Vol. 90, No. HY5, Proc. Paper 5185, Nov. 1964. Whereas the latter dealt with large scales coarse cobble-strewn bed, the former study was concerned with the effect of small fish passing through 6 or 4 inch cubes, the current research treats the condition of high flows in which the height of the small wooden cubes is a small fraction of the water depth. The similarity between the large blocks and the tiny ones was checked experimentally. Experimental work has been completed, and the search for relationships between Manning's "n" and various hydraulic parameters is now under way.

(5182) TRANSITIONS IN SUPERCRITICAL FLOW.

(b) Pennsylvania Department of Forests and Waters.

(d) Experimental; applied research, design.

(e) See Abstract in (g)

(f) Completed.

(g) Transitions of three different shapes were tested for Froude numbers varying from 1.2 to 3.0, representing test flows of 0.56 to 5.27 cfs. Each transition connected an upstream curved channel with a downstream rectangular channel, all three parts lying on one straight center line and having constant and continuous invert slopes.

(h) The aims of this research project are to determine the transition with plane walls: one with a vertical surface above a sloping one, and the other with a sloping surface above a wall. One transition tested was the ellipsoidal one. The experiments with each of the three shapes covered combinations of five transition lengths with three depths in the tapered approach channel. Twenty-eight different transitions were investigated. Tables and charts summarize the variation of the water surface caused by the wave patterns due to supercritical flow, along the channel wall and the center line. Not only do these tables and charts give a picture of the complex wave pattern, but they also provide a basis for the design of transitions of the three tested shapes. A guide is offered for the application of the extensive data to actual design.

(5183) EKNER EQUATIONS OF RIVER FORM.

(b) Laboratory project.

(d) Theoretical; basic research.

(f) Felix Ekner's simple erosion postulates of the 1920's resulted in equations which produce an equilibrium dune, bed and bank forms of real rivers. The accuracy of his equations and charts of river forms are being verified so that the concept embodied in the postulates can be extended and applied to the
(g) Two equations have been verified; namely, one dealing with dune growth and the other with bankline development. The third equation is concerned with fixed banks and movable bed or, actually, the condition of a revetted contraction with a movable bed. As there seems to be some doubt about the accuracy of Erem's final work, his findings are being checked much more carefully than was originally intended.

(3486) TURBULENCE MEASUREMENTS IN WATER.

(a) Laboratory project sponsored by the Bureau of Naval Weapons.
(b) Dr. John Lumley, Ordnance Research Lab., University Park, Pennsylvania 16802.
(c) Experimental.
(d) Using a constant temperature probe, some turbulent flows at high Reynolds numbers will be investigated with particular attention to homogeneous grid-produced turbulence and turbulent dispersion in a shear flow.
(e) Measurements have been taken in a small water tunnel settling section determining the effect of various screens and honeycombs on turbulence.

(3807) INVESTIGATION OF THE CAVITATION CHARACTERISTICS OF A FEW SIMPLE LIQUIDS.

(a) Laboratory project sponsored by NASA.
(b) Dr. J. William Holl, Ordnance Research Lab., University Park, Pennsylvania 16802.
(c) Experimental, analytical; basic research.
(d) To investigate experimentally the cavitation characteristics of a few simple (as regards to vapor pressure and handling) liquids under conditions occurring in space and aircraft pumping machinery, and analyze the results so that a reliable basis for theory applicable to these conditions can be formulated.
(e) A small high speed water tunnel having test section velocities of 370 feet per second, pressures to 1000 pounds per square inch, temperatures to 300 degrees Fahrenheit, has been constructed and has been in operation since April of 1962.
(f) Investigations of desinent cavitation at very high velocities on 1/4 inch diameter ogive noses indicates that the desinent cavitation number approaches the minimum pressure coefficient. Studies of cavitation hysteresis on ogive noses show that the cavitation delay time is a random function and is of significant duration e.g. 3 to 4 minutes.

(4180) UNSTEADY FLOW INVESTIGATIONS AROUND AN ELLIPSOID OF REVOLUTION.

(a) Laboratory project sponsored by Bureau of Naval Weapons.
(b) Dr. Maurice Sevik, Ordnance Research Lab., University Park, Pennsylvania 16802.
(c) Experimental and theoretical.
(d) A study of unsteady forces acting on an ellipsoid of revolution over a range of Reynolds numbers and body attack angles. Completed.
(e) A theoretical and experimental investigation of the lift and moment on an 8/1 ellipsoid of revolution performing small oscillations in a direction normal to the free stream has been carried out. The maximum circularity lift coefficient is about half that obtained in steady flow. A phase lag of 20 degrees in build-up of lift was observed. The maximum pitching moment is reduced by 16 percent from that predicted by potential theory.

(4181) DETERMINATION OF EFFECT OF TUNNEL BOUNDARIES ON THE FORCES ACTING ON A MODEL.

(a) Laboratory project sponsored by Bureau of Naval Weapons.
(b) Dr. Thomas Peirce, Ordnance Research Lab., University Park, Pennsylvania 16802.
(c) Theoretical and experimental.
(d) Investigation of the errors introduced by the physical boundaries of tunnel walls.
on the measured forces on large models. The investigation covers both the axially symmetric case and when the models are at low angles of attack establishing the means for correcting these errors is also a part of this investigation.

A method has been developed for the prediction of errors in drag caused by water-tunnel wall deviations. It is shown that small deviations in contour can cause a significant error in model drag measurements. Tunnel wall interference effects on model pitching moment have been investigated and a correction procedure established for models of low attack angle and diameters up to 1/3 tunnel diameter.

(4677) THE INVESTIGATION OF TWO-DIMENSIONAL UNSTEADY CAVITY FLOWS ABOUT FIXED SYMMETRIC BLUFF BODIES.

(b) Laboratory project sponsored by Bureau of Naval Weapons.
(c) Dr. J. William Holl, Ordnance Research Laboratory, University Park, Penna. 16802.
(d) Experimental and theoretical.
(e) An investigation of the wake region behind supersonicating, two-dimensional wedges at zero degrees angle of attack is in progress with the purpose of determining the wake characteristics, in particular the Strouhal number as a function of Reynolds number, cavitation number and wedge apex angle.

(4678) HYDRAULIC SERVOMECHANISM FOR AN UNDERWATER MISSILE.

(b) Laboratory project sponsored by the Bureau of Naval Weapons and conducted under Mr. C. L. Aey, Asst. Director, Ordnance Research Laboratory.
(c) Hassar, H. M. Jensen and R. E. Kerawal, Ordnance Research Laboratory, University Park, Pennsylvania 16802.
(d) Experimental, applied development and design.
(e) A high-performance hydraulic servomechanism for control of rudders and elevators in an underwater missile system. Specific design problems were instability caused by a resonant linkage and high-frequency oscillation of the servovalve.
(f) Stability was achieved by increasing the resonant frequency of the linkage, providing hydraulic damping with a bypass orifice, and lag-load phase compensation in the servo amplifier. The high-frequency oscillation was eliminated by increasing the diameter of activator ports.

(5106) INVESTIGATION OF TENSIONS IN LIQUIDS.

(b) Laboratory project sponsored by NASA.
(c) Dr. J. Williams Holl, Ordnance Research Laboratory, University Park, Penna. 16802.
(d) Experimental and theoretical.
(e) Investigation of liquid tensions for a variety of liquids under a range of conditions employing a non-flow apparatus. Results will be compared to those obtained in a flowing system.

(5107) INVESTIGATION OF THE KUTTA CONDITION IN UNSTEADY FLOW.

(b) Laboratory project sponsored by Bureau of Naval Weapons.
(c) Dr. Maurice Sevik, Ordnance Research Laboratory, University Park, Penna.
(d) Experimental, theoretical, and basic research.
(e) The validity of the Kutta-Joukowski criterion is being investigated for the prediction of control surface hinge moments in steady flow, or instantaneous forces on rapidly oscillating air and hydrofoils.

(5108) JET INSTABILITY IN MERCURY.

(b) Laboratory project sponsored by National Science Foundation.
(c) Dr. David P. Hoult, Ordnance Research Laboratory, University Park, Penna. 16802.
(d) Experimental and theoretical.
(e) The study involves the stability of a jet of mercury into mercury in the presence of a magnetic field. The magnetic field acts to stabilize the jet and thus control the rate of amplification of unstable oscillation. The experimental findings are then to be compared with appropriate stability theory in an effort to further understand the instability of jets.

(5590) INVESTIGATION OF SHED WING VORTICES AND THEIR DECAY.

(b) Laboratory project sponsored by the Army Research Office, Durham, North Carolina.
(c) Dr. Barnes W. McCormick, Jr., Ordnance Research Laboratory, University Park, Penna. 16802.
(d) Experimental; analytical; basic research.
(e) The vortex sheet shed by a wind tunnel mounted, semi-span lifting wing has been investigated at various angles of attack and free-stream velocities. The vortex core has been studied by mapping the downstream flow field at distances up to 20 chord lengths. Tangential velocities or vortices have been determined by integrating the vorticity through the vortex core. The local vorticity is measured by a pitchless, cruciform vane which rotates with the rotational flow. Rotational speeds of 40,000 rpm have been measured. Similar investigations will be conducted by mounting the vortex probe behind the wing of a full-scale flight test airplane. Qualitative characters of shed vortices have been studied by flying an airplane adjacent to a large bulb grid and photographing the motion of the busts as the vortex moves across the grid.
(f) It is believed that after completion of the investigations it will be possible to predict the vortex geometry of an arbitrary aircraft as a function of the airplane configuration and distances downstream.

(5591) BOILING BOUNDARY LAYER.

(b) Laboratory project sponsored by the Bureau of Naval Weapons and conducted under Mr. F. A. Williams, Jr., Asst. Director, Ordnance Research Laboratory.
(c) Dr. David P. Hoult, Department of Aeronautical Engineering, The Pennsylvania State Univ., University Park, Pa. 16802.
(d) Theoretical investigation of the boiling boundary layer on a flat plate.

(5592) EXPERIMENTAL INVESTIGATION OF SECONDARY FLOW IN AXIAL FLOW INDUCERS.

(b) Laboratory project sponsored by NASA.
(c) Dr. George F. Wingelmen and Dr. B. Lakshminarayana, Dept. of Aeronautical Engineering, The Pennsylvania State Univ., University Park, Pa. 16802.
(d) Experimental and theoretical.
(e) A three-foot diameter model of an axial flow inducer for a pump was built and will be tested with water, air, using smoke for direct observation of secondary motions in long and narrow vanne passages. In addition, approximate measurements of the velocity distribution at inlet and discharge will be made to obtain at least a qualitative picture of the fluid motions under the predominant influence of viscous fluid friction.

(5593) INVESTIGATION OF LAMINAR BOUNDARY LAYER AND TRANSITION IN THE VICINITY AND BETWEEN SUCTION SLOTS.

(b) Laboratory project sponsored by the Bureau of Naval Weapons and the Office of Naval Research.
(c) Dr. Thomas E. Feirce and Mr. Charles P. Holt.
GRID TURBULENCE IN DILUTE POLYMER SOLUTIONS.

(b) Bureau of Naval Weapons and the Office of Naval Research.

(c) Dr. John L. Lumley and Mr. Henry Bakewell, Ordnance Research Laboratory, The Pennsylvania State Univ., University Park, Pa. 16802.

(d) Experimental and basic research for Ph.D. thesis.

(e) Turbulent velocity measurements will be made behind a grid in a 48-foot towing tank filled with dilute polymer solution. Experimental spectra and correlation functions will be compared with previous measurements in Newtonian fluids and with theory, in order to investigate possible explanations of the Toms effect (the friction reduction in turbulent flow produced by extremely low concentrations of very high molecular weight polymers).

(b) Bureau of Naval Weapons and the Office of Naval Research.

(c) Dr. John L. Lumley and Mr. Henry Bakewell, Ordnance Research Laboratory, The Pennsylvania State University, University Park, Pa. 16802.

(d) Experimental, basic research for Ph.D. thesis.

(e) u-u space-time correlations will be taken in the viscous sublayer under a turbulent boundary layer in glycerin. The sublayer thickness is such that a y = 5 corresponds to 0.25 inches. It is hoped that these measurements will shed light on the dynamics of the sublayer, in particular on the translation velocities of disturbances there.

THEORETICAL INVESTIGATION OF TURBULENCE FLOW OF NON-NEWTONIAN MEDIA.

(b) Office of Naval Research.

(c) Dr. John L. Lumley and Mr. Kirtan Singh, Dept. of Aeronautical Engineering, The Pennsylvania State University, University Park, Pa. 16802.

(d) Theoretical, basic research for Ph.D. thesis.

(e) Machine calculations will be made of the initial effect on the energy budget resulting from a sudden change in the constitutive relation (from Newtonian to any of several non-Newtonian types) of a fluid in isotropic, homogeneous turbulent motion. It is hoped that the investigation will provide insight into the mechanism by which low concentrations of high molecular weight additives markedly change the skin friction in turbulent shear flows (the Toms effect).

PRINCETON UNIVERSITY, School of Engineering and Applied Science.

FALL OF A SPHERE IN A HORIZONTALLY OSCILLATING FLUID.

(b) Laboratory project.

(c) Prof. Lucien W. Brush, Jr., Departments of Civil and Geological Engineering, Princeton University, Princeton, N. J.

(d) Analytical and experimental, basic research, master's thesis.

(e) The purpose of this research is to predict the temporal mean fall velocity of a spherical particle falling in a horizontally oscillating fluid. An analytical solution was derived for particles with a small (0.1) Reynolds number. A numerical solution is possible for large Reynolds numbers. Experimental verification of the appropriate equations is the purpose of the study. The results will be applicable to problems involving turbulent diffusion of sediment.

DYNAMIC STORAGE OF GROUNDWATER.

(b) Laboratory project.

(c) Dr. Roger J. De Wiest, Professor, School of Engineering and Applied Science, Princeton, N. J.

(d) Analytical and experimental, basic research, master's thesis.

(e) Purpose of the research is to investigate the dynamic behavior of a groundwater basin intersected by streams and from which water is withdrawn at a time dependent rate. An electric analog model (R-C) will be constructed.

(g) An electric analog was constructed for the steady case with free boundary and leakage into aquifer. Master's thesis available.

MEASUREMENT OF UNSTEADY PRESSURES.

(b) National Institute of Health, Public Health Service.

(c) Prof. Lucien W. Brush, Jr., Departments of Civil and Geological Engineering, Princeton, N. J.

(d) Theoretical and experimental, M.S. thesis.

(e) The differential equations of motion for a simple manometer system with non-linear damping have been programmed for an IBM 7094 data processing system. An experimental program is in progress to check the computation.

(g) Preliminary experimental results have been in qualitative agreement with the computer solutions for the case of a sinusoidal driving function. A report in the form of a Master's thesis is scheduled for June 1966.

UNSTEADY FLOW BETWEEN OVERLYING PARALLEL AQUIFERS.

(b) Laboratory project.

(c) Dr. Roger J. De Wiest, Prof., School of Engrg. and Applied Science, Princeton Univ., Princeton, N. J.

(d) Analytical and experimental, basic research, Ph.D. thesis.

(e) Purpose is to investigate the flow pattern when overlying parallel aquifers are tapped by several wells.

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THE USE OF A RAINFALL SIMULATOR FOR SOIL AND WATER CONSERVATION MANAGEMENT STUDIES.

Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University. (See Agricultural Research Service, Corn Belt Branch, Project No. 4274.)

Dr. E. J. Monke, ARS-SWC, Agricultural Engineering Department, Purdue University, Lafayette, Indiana 47907.

Field investigation; applied research.

The rainfall simulator is used on runoff plots for comparison of treatments which effect erosion and infiltration. Research includes studies of tillage methods, crop residue management, slope, soil type, crop rotations, and intensity histograms.


TREATMENT OF SURFACE WATERS FOR DOMESTIC USE ON THE FARM.

Laboratory project.

Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana 47907.

Field investigation; applied and basic research.

The treatment of pond water by use of slow sand and diatomaceous earth filters is being evaluated. Improved designs are under investigation. The effects of algae growth and conglutination-sedimentation methods on filtration processes are being studied.

Diatomaceous earth filtration provides a safe and effective treatment process for pond water. With equipment available, however, some supervision of the filtration operation may be needed. A small automated diatomite filter system which was specifically designed for single family operation is being evaluated. This system has proved to be effective and with minor changes could be manufactured and installed in individual homes at a relatively low cost.


INVESTIGATION OF FLOW CHARACTERISTICS IN DRAIN TILES AND THE RELATIONSHIP OF SOIL FLOW CHARACTERISTICS TO SEDIMENTATION.

Laboratory project.

Mr. L. F. Huggins, Agricultural Engineering Department, Purdue Univ., Lafayette, Indiana 47907.

Experimental; basic research.

A 60 foot model drain capable of recirculating sediment-laden flow has been constructed. Drain slopes at which incipient deposition occurs are being investigated.

The percentage of sediment (100 to 400 microns) in the total discharge at which incipient deposition occurred appears to be a simple function of the slope of the drain. Particle shape (very angular to smooth) and size (100 to 400 microns) did not have an observable effect on the slope attained.


DEVELOPMENT AND REFINEMENT OF METHODS FOR ESTIMATING FIELD RUNOFF AND SOIL LOSS.


Mr. Walter H. Wischmeier, ARS-SWC, Agric. Engineering Dept., Purdue Univ., Lafayette, Indiana 47907.

Experimental; development.

The relationships between rainfall characteristics, topographic features, soil characteristics and surface conditions to field runoff and soil erosion are being evaluated from plot data obtained under natural and/or simulated rainfall. Basic plot and small watershed data on an individual storm basis have been assembled in an "ARS central runoff" and soil-loss data lab. at Purdue Univ., from 24 states. The data represent results of cooperative research studies over the past 32 years at 47 locations.

A broadly applicable equation for field soil-loss prediction to help guide farm planning for soil and water conservation has been developed and published. Data for locality evaluations of the equation's factors were disseminated in ready-reference form. Present emphasis is on analyses of data relating to runoff in relation to physical and management factors.


THE MECHANICS OF EROSION BY RAINFALL AND RUNOFF.

Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University. (See Agricultural Research Service, Corn Belt Branch, Project No. 4275.)

Dr. L. Donald Meyer, ARS-SWC, Agricultural Engineering Department, Purdue University, Lafayette, Indiana 47907.

Experimental; basic research.

The influence of slope inclination, slope length, particle size, particle shape, and wind velocity on the resulting splash and runoff erosion are being investigated in the laboratory. Methods for simulating rainfall, slope length, soil and wind have been developed. This study is providing an understanding of the mechanics of the process involved in erosion and the basic relationships of the above variables.


SUBSURFACE DRAINAGE OF BLOUNT SILT loam.

Laboratory project.

Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana 47907.

Field investigation; applied research.

Various spacings between parallel subsurface
drains are under investigation to determine their effectiveness in water removal and crop response. Continuous records of tile discharge are being made and crop yields are determined at harvest time.

EVALUATION OF THE PARALLEL DITCH SYSTEM FOR WATER DRAINAGE ON CLERMONT SOIL.

(b) Laboratory project.
(c) Dr. R. R. Siisson, Agricultural Engineering Dept., Purdue Univ., Lafayette, Indiana 47907.
(d) Field investigation; applied research.
(e) A parallel ditch system of surface drainage is being compared to the conventional drainage practices on Clermont silt loam.
(f) Completed.


TREATMENT OF WATER FROM SMALL RESERVOIRS FOR DOMESTIC CONSUMPTION.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Dept., Purdue Univ., Lafayette, Ind. 47907.
(d) Applied and basic research.
(e) The purpose of the project is to study electrophoretic control as a test for filtration of raw water supplies and to investigate methods for reducing the adverse effects of aquatic weed residues on water treatment processes and water quality.

EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANO-TOXICANTS ON THE QUALITY OF SURFACE AND GROUND WATER RESOURCES.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Dept., Purdue University, Lafayette, Indiana 47907.
(d) Field investigation, applied and basic research.
(e) The purpose of the project is to study the mechanisms by which organo-toxicant materials are held by the mineral and organic fractions in the soil, to determine the fate of organo-toxicant materials in water storage reservoirs, to evaluate the effect of organo-toxicants on terrestrial and farm pond invertebrates and farm pond vertebrates, to determine the role of micromorphisms in the elimination of organo-toxicants from surface and ground waters, and to effect control and removal methods for reducing or eliminating organo-toxicant residues from reservoir water supplies.

PURDUE UNIVERSITY, Department of Agronomy.

FLOW LAWS FOR THE MOVEMENT OF WATER IN SOIL.

(b) Laboratory project.
(c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue Univ., Lafayette, Indiana.
(d) Experimental and theoretical; basic research.
(e) The validity of basic equations for water relationships in soil, such as Darcy's proportionality and Buckingham's capillary potential function, is being tested under various circumstances. Revised equations and mathematical solutions for deviating behavior are also being sought.
(f) Experimental measurements of steady-state water flow in unsaturated soils indicate that Darcy-type proportionality between flow velocity and hydraulic gradient do not hold at a constant soil-water suction. Instead, the flow velocity increases more than proportionally with gradient, in a manner qualitatively similar to waves that have been reported for water-saturated materials containing clay. A study has also been made on the mathematical solution of the nonlinear diffusion equation applied to horizontal water absorption by a uniform, semi-infinite column of soil. An additive type of variable separation is used to show that a recent proposal solution in literature is incorrect. A product-type of variable separation, however, does solve the problem, and is shown to be the equivalent of Boltzmann transformation, which in turn is seen to be a consequence of the governing partial differential equation and the boundary condition, rather than an additional assumption in need of separate justification.


PURDUE UNIVERSITY, Automatic Control Laboratory, School of Mechanical Engineering.

FLUID LINE DYNAMICS.

(b) Laboratory project.
(c) Prof. Rufus Oldenburger, School of Mech. Engineering, Purdue Univ., Lafayette, Ind. 47907.
(d) Theoretical and experimental project; Master's and Doctor's Thesis Research.
(e) Mathematical models in use for systems with significant fluid lines are generally so complicated as to make design with such models impractical. In this investigation models are sought which are as simple as possible but which still adequately re the response of the system to the class of disturbances of interest. Using infinite product expansions of transcendental functions satisfactory solutions have been obtained for single conduits terminating in lumped elements. Viscosity, boundary effects and line vibration are being considered in the analytical work. Frequency response runs to verify the theory are being made to determine
the range for which solutions obtained are applicable. The theoretical and experimental approaches are being extended to systems with two or more lines. Rational approximations to these transfer functions of such systems are sought where the accuracy of the approximation can be seen directly from the approximation, as is the case where infinite products have been applied. Studies so far have been restricted to medium and large diameter lines. They are being extended to very small lines in the capillary class. The rate of dispersion of a pressure wave in a single line of constant cross section is also under study and the reinforcement of such a wave traveling back and forth in conduit closed at both ends.

c) Theory and tests show that for a wide range of operation encountered in practice flow through bends may be treated as flow through straight conduits. Mathematical models developed for straight fluid lines describe their response to high frequency. However, if resonance effects are to be included a certain complication of the model is necessary, beyond which further simplification is not possible.


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Purdue University, School of Mechanical Engineering.

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(4499) ANALYSIS AND DESIGN OF PULSE-WIDTH-MODULATED HYDRAULIC CONTROL SYSTEMS.

(b) Laboratory project.

c) Dr. David E. Boddy, Oakland University, Rochester, Michigan 48063.

d) Experimental and theoretical, basic research for doctoral thesis.

e) The purpose of this investigation was to determine the characteristics of a PWM hydraulic servo and to develop analytical tools and design procedures for treating the PWM hydraulic servo. Theoretical considerations were correlated to measured system performance.

(f) Completed.

(g) A straight-forward design procedure for PWM hydraulic servos was obtained. Analytical methods based on method of Tsyplkin were developed for treating closed loop PWM systems. An analog computer study was carried out and the results compared to the physical system performance.


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Purdue University, Jet Propulsion Center.

(2374) MASS TRANSFER IN ANNULAR, TWO-PHASE FLOW IN A VERTICAL TUBE.

(b) National Science Foundation.

c) Dr. M. J. Zucrow, Jet Propulsion Center, Purdue University, Lafayette, Indiana 47907.

d) Experimental and theoretical, basic research for Master's and Ph.D. degrees.

(e) The problem concerns the analytical and experimental study of mass transfer from an annular liquid film on the inside wall of a vertical circular tube to a concurrent gas flow in the core of the tube. Systematic experiments have been conducted with air and water for determining the effect of the rates of flow of gas and liquid, the length of the tube, and the temperature difference between gas and liquid upon the rate of mass transfer from the liquid film. Characteristics of the gas-liquid interface, including surface area, wave velocity, and liquid film thickness have been measured.

(f) Completed.

(g) The mass transfer data were satisfactorily correlated employing equations for the local rates of heat and mass transfer. The liquid flow rate then had no effect on the dimensionless mass transfer coefficient. There was a negligible (less than 0.1 per cent) increase in surface area due to the presence of waves on the surface of the liquid film.


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Purdue University, School of Mechanical Engineering.

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(5712) AN INVESTIGATION OF THE RADIAL FLOW BETWEEN TWO PARALLEL, NARROWLY SPACED DISKS.

(b) Laboratory project.

c) Dr. E. J. Wellman, Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Indiana.

d) Analytical and experimental basic research for doctoral thesis.

(e) Existing literature on investigations of the radial flow between two parallel narrowly spaced disks was examined and the results analyzed. The studies for compressible choked flow were found to be inconsistent. An experimental and analytical investigation of this flow was carried out. Pressure measurements were obtained for outward radial flow of air between two 5-inch diameter disks with spacings ranging from 0.005 to 6.00 inches and initial pressure of from 5 to 40 psig. A sliding pressure tap permitted continuous pressure readings. Calculated pressure distributions were obtained for mathematical integration of the momentum equations.

(f) Completed.

g) The existence of compression shock was clearly shown by the pressure measurements and also by visual (schlieren) observations. The experimental and calculated results indicated very good agreement except for a small region immediately preceding the shock where a preliminary pressure rise was indicated. The upstream effect of the shock which was apparently due to a shock-boundary layer interaction.


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Purdue University, Jet Propulsion Center.

(5741) A STUDY OF ROTATING FLUIDS BETWEEN PARALLEL DISKES.

(b) Purdue Research Foundation.

c) Dr. E. J. Wellman, Associate Prof. of Mechanical Engineering, Purdue Univ., Lafayette, Indiana.

d) Analytical and experimental basic research for doctoral thesis.

(e) From analytical studies of similar solutions and
existing experimental results a rotating system is being designed for a future study of the flow of liquids between parallel, rotating disks.

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ROCKY MOUNTAIN HYDRAULIC LABORATORY.

(S468) RELIABILITY OF RELEASE OF BURIED FLOATS TO DETERMINE DEPTH OF SOUR.

(a) Laboratory project.
(b) Prof. C. J. Posey, Director, Rocky Mountain Hydraulic Laboratory, Allenspark, Colorado 80510.
(c) Experimental; master's thesis.
(d) Sour model studies were conducted to determine the reliability of release of floats which were either buried or placed through existing jetties to desired depths.
(e) Completed.
(f) Except for the shallower placed jetties, the floats breaking loose as soon as the tops were exposed, all floats remained in place until more than half uncovered, regardless of relative buoyance, lack of soil cohesion, and vibration to which the nearby pier was subjected.

(S768) COMPARISON OF ROCK EROSION-PROOFING WITH AND WITHOUT AN INVERTED FILTER BASE.

(a) Laboratory project.
(b) Prof. C. J. Posey.
(c) Experimental, applied.
(d) Preparation of motion-picture comparison of erosion of overflow chute with varied combination of protection features.
(e) Active during summers.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA.

Inquiries concerning Projects 2144, 3155, 5502, 5804, 4201, 4209, 4700, 5493, 5494, 5495, 5496, 5497, 5498, 5500, 5501, 5502, 5504, 5505, 5506 and 5752 to 5807, inclusive should be addressed to the Director, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue S. E., Minneapolis, Minnesota, 55414.

Inquiries concerning Projects 111, 1168, and 2386, which are conducted in cooperation with the Agricultural Research Service, should be addressed to Mr. Fred W. Blaisdell, Engineer, Soil and Water Conservation Research Division, Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue S. E., Minneapolis, Minnesota, 55414.

Inquiries concerning Project No. 194, which is conducted in cooperation with the Corps of Engineers and the U. S. Geological Survey in the direction of Engineer in Charge, Mr. John V. Skinner, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue, Minneapolis, Minnesota, 55414.

(CLOSED CONDUIT SPILLWAY.

(a) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.
(b) Experimental; generalized applied research for development and design.
(c) A square drop inlet having a hood barrel entrance is being tested to determine entrance loss coefficients for various drop inlet sizes and heights and various barrel slopes. Previous tests have evaluated the performance of this type of inlet. The elbow and transition between the two-way drop inlet and the hood barrel entrance was studied to determine the pressures and the best form to minimize the possibility of cavitation.
(d) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device. For one form of the inlet, tests have been made to determine the critical loss coefficient, the barrel entrance loss coefficient, the pressures on the plate and the drop inlet, the general performance of the inlet, minimum and maximum permissible plate heights, and the head-discharge relationship for plate control. Variables have been the length of the drop inlet, the barrel slope, the height and overhang of the anti-vortex plate, and the sidewall thickness. Tests on the hood drop inlet have shown that the hood barrel entrance can be used to reduce the minimum required height of the drop inlet. Minimum sizes of drop inlet and anti-vortex devices have been determined. Tests of low-stage orifices in the two-way drop inlet have shown that improper location and improper proportioning of the orifices can prevent priming of the spillway. The proper location and size of the orifices have been determined.

To supplement the experiments, potential flow methods have been used to determine the theoretical coefficient of energy loss at the crest of the two-way drop inlet. Anti-vortex wall of a hood drop inlet to a Closed Conduit Spillway," by Charles A. Donnelly, Agricultural Research Service Report ARS 41-102, December 1966.

A STUDY OF CANTILEVERED OUTLETS.

(a) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.
(b) Experimental; generalized applied research for design.
(c) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth. Attempts will be made to determine quantitatively for the size of the scour hole to be expected under various field conditions. The present phase of the study is on rectangular cantilevered outlets with a deflector at the exit to throw the water away from the structure and move the scour hole further downstream.

EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROPOILS.

(a) Office of Naval Research, Department of the
Navy.

(d) Experimental and analytical; basic research.

(e) Investigation of the unsteady flow characteristics of ventilated hydrofoils or finite span in the vicinity of a free surface.

(g) Unsteady force characteristics were investigated for a ventilated foil undergoing sinusoidal heaving motions near a free surface. Lift and drag forces were measured for various heavy amplitudes and frequencies. Fair agreement has been obtained with unsteady computational theory. Force measurements are also being made on a restrained foil with an oscillating trailing edge flap.

(2.86) GENERALIZED DESIGN OF TRANSITIONS FOR SUPERCRITICAL VELOCITIES.

(b) Agricultural Research Service, U.S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.

(d) Experimental; generalized applied research for development and design.

(e) Studies will be made to develop a transition and to determine the rules for its design. The transition will be used to change the flow cross section from circular to rectangular when the velocities are supercritical.

(3153) FLOW ABOUT BODIES AT SMALL CAVITATION NUMBERS.

(b) Office of Naval Research, Department of the Navy.

(d) Experimental and analytical; basic research.

(g) A flat plate and a cambered hydrofoil are tested in a free-jet tunnel under supercavitation conditions. The unsteady flow due to the oscillation of a trailing flap as influenced by one or two free surfaces is being studied.


(3502) MANGLA SPIWALL STUDIES.

(b) Harza Engineering Company, Chicago; Binne and Partners, London; Government of Pakistan.

(d) Experimental; design and operation.

(g) A 1:300 scale section model consisting of half the control structure and basin and a 1:150 scale comprehensive model for study of all important hydraulic features. A 1:216 scale section model consisting of two control structure gates for study of pressures and gate calibration. A 1:500 scale comprehensive approach model for study of flow conditions in approach. Two 1:150 scale section models, one a detailed study of pressures and forces on baffle blocks, one a detailed study of waves on the basin side walls. Typical dimensions of earth fill dam spillway include a drop in water level of 330 ft., and a design discharge of 900,000 cfs through a two-stage stilling basin energy dissipator.

(g) Model studies for design are completed and a final report is being prepared.

(3824) SURFACE CHARACTERISTICS OF AIR ENTRAINMENT FLOW IN STEEP CHANNELS.

(b) Laboratory project.

(d) Analytical and experimental investigation of the air concentration, velocity distribution, and surface layer thickness of water flow in steep open channels, Ph.D. thesis.

(e) Experimental investigation was carried out on the 5A high velocity channel for slopes up to 53 degrees. Velocities were measured by means of a pitot tube and high speed photography. Air concentration was measured by the SAR correction method. The surface elevation was measured by a device which measures the average time the surface is above a given elevation.

(f) Experimental work completed.

(4201) GURU HYDROELECTRIC PROJECT MODEL STUDIES.

(b) Harza Engineering Company, Chicago, Corp. Venezuecano de Guayauna.

(d) Experimental, design and operation.

(e) Study for the design of the Guru Hydroelectric development on the Caroni River, Venezuela using a 1:394 comprehensive spillway model, 1:197 spillway section model, and a 1:197 comprehensive model. Studies include spillway design, channel lining, and hydraulic investigation.

(g) Model studies for design are completed and a final report is being prepared.

(4209) THE INFLUENCE OF ELECTROKINETIC PHENOMENA ON THE HYDRAULIC AND ELECTROOSMOTIC PERMEABILITY OF UNIFORM FINE SANDS.

(b) Laboratory project.

(d) Experimental and theoretical; Ph.D. thesis.

(e) Accurately sized, narrow range, angular quartz particles and spherical glass beads were tightly placed in a permeameter with reversible silver-silver chloride electrodes at the ends of the test section. Streaming potential, streaming current, electrical resistivity of low conductivity liquid, and filter velocity were precisely measured. Studies include: (2) Plate retardation from return electric circuit, (2) analysis of electroosmotic permeability factors with respect to particle characteristics and hydraulic permeability, and (5) comparisons of streaming current and filter velocity at varying Reynolds numbers.

(g) It has been found that the streaming current potential, streaming current, and filter velocity are linearly with hydraulic gradient to a slightly higher Reynolds number than the filter velocity. Lack of complete deaeration causes a larger reduction in the filter velocity than the streaming. When "boiling" action takes place, anomalous relations between the filter velocity and streaming current occur.

(h) Thesis in preparation.

(4700) OSCILLATORY LIFT AND DRAG FORCES ON VENTILATED HYDROFOILS IN REGULAR WAVES.

(b) Office of Naval Research, Department of the Navy.

(d) Experimental; basic research.

(e) Investigation of the force characteristics of a restrained, naturally ventilated hydrofoil moving through regular waves.

(g) Flow visualization studies were conducted to determine the regions of boundary layer separation on hydrofoils with a sharp leading edge near the free surface. The length of the separation bubble was found to vary with velocity, angle of attack, and aspect ratio. Variations of the leading-edge thickness on wedge profiles had little influence on the separation bubble.


(5493) BIG STOUC CROSSING RIVER BRIDGE MODEL STUDY.

(b) Iowa State Highway Commission and South Dakota State Highway Dept.
(e) Model studies to simulate condition of failure of highway bridge due to scour and to determine method of protection and to establish procedure for prevention of scour and bank subsidence. Experiments carried out on a movable bed model. Completed.

(h) "Studies of the Stabilization of the Big Sioux River at the Interstate 29 Bridge Crossing," by A. G. Anderson, St. Anthony Falls Hydraulic Laboratory Project Report No. 78, May 1966. (Not available for distribution.)

(5494) THERMAL POLLUTION STUDIES OF ST. CROIX RIVER.

(b) Northern States Power Company.

d) Experimental applied research.

(e) In a first phase of the project, thermal density currents created by the discharge of heated condenser water from a steam power plant into a broad, deep river were studied in a model and isotherm surfaces were calculated. On the basis of the results obtained from this model, a permit to use the river water for condenser cooling was granted. A second phase of the model is now under way, studying the outlet channel between the plant and river with a view to discharging the warm water in as thin a layer as possible at the river surface. The scale of this model is 1:40.

(f) First phase completed, second phase under way.

(g) The initial studies showed it would be possible to discharge the warm water as a relatively thin layer on the river surface, thereby obtaining maximum heat dissipation to the atmosphere. Present temperature limits on the water were determined.

(h) "Effects of Condenser Cooling Water Discharge from Projected Allen S. King Generating Plant on Water Temperatures in Lake St. Croix," by Edward Silberman and Heinz G. Stefen, St. Anthony Falls Hydraulic Laboratory Project Report No. 76, December, 1964. (Not available for distribution.)

(5495) A STUDY OF IMPACT CAVITATION DAMAGE.

(b) David Taylor Model Basin and Office of Naval Research, Dept. of the Navy.

d) Experimental applied research.

(e) Development of cavitatation damage facility utilizing repeated single liquid drop impacts on a target moving at high speeds in a vacuum. Completed.

(g) Weight loss damage tests yield findings very similar to those for cavitation damage tests. Enhanced ability to control impact conditions permits detailed study of the mechanics of failure.


(5496) STRUCTURE OF TURBULENCE OF NON-NEWTONIAN FLOWS.

(b) David Taylor Model Basin, Dept. of the Navy.

d) Experimental, basic research.

(e) The experimental study includes measurements of Taylor vortices in a non-Newtonian fluid placed between two concentric cylinders when the inner cylinder is rotating. Report in preparation.

(5497) A STUDY OF FLOW NOISE IN A NON-NEWTONIAN FLUID.

(b) David Taylor Model Basin, Dept. of the Navy.

d) Experimental.

(e) An experimental investigation of the influence of a non-Newtonian additive on the flow noise in the boundary layer of a rotating cylinder is proposed.

(f) Experimental work in progress.

(5498) A STUDY OF SURFACE SEALANTS TO REDUCE CAVITATION DAMAGE.

(b) David Taylor Model Basin, Dept. of the Navy.

d) Experimental applied research.

(e) A determination of materials or techniques which will serve to seal cavitating surfaces to either reduce the amount of cavitation or the damage resulting therefrom. Completed.

(g) Gaseous evolution observed from metallic surfaces but various sealants were unable to withstand erosion under standard ASME vibratory cavitation exposure. Report in preparation.

(5499) INFLUENCE OF MICRO BUBBLES ON FLOW NOISE.

(b) David Taylor Model Basin, Dept. of the Navy.

d) Experimental.

(e) An experimental investigation of the flow noise intensity and spectra in the boundary layer of a rotating cylinder with the addition of free gas bubble is contemplated.

(f) Experimental work in progress.

(5500) HYDRODYNAMIC FLUTTER OF SUPERCAVITATING HYDROFOILS.

(b) David Taylor Model Basin, Dept. of the Navy.

d) Experimental, basic research.

(e) Flat-plate hydrofoils are tested in a free-jet water tunnel at supercavitating conditions to determine the critical velocity as a function of the mass density ratio and other variables. The main purpose is to check the existing theories.

(5501) AN ELECTROMAGNETIC VELOCITY PROBE.

(b) A laboratory thesis study.

d) Experimental; M.S. thesis.

(e) The study involves the construction, calibration and demonstration of an electromagnetic velocity probe designed for use in the measurement of the axial component of the turbulent velocity in water. The electromagnetic field is provided by permanent magnets placed outside the flow system, which is a 3/4 in. lucite pipe. The probes are constructed of (0.010 in. platinum wire with an electrode gap of 0.050 in. A total head tube is used in conjunction with the electromagnetic probe in order to obtain mean velocities.

(5502) A STUDY OF BOUNDARY WALL PIEZOMETER TAP ERRORS.

(b) A laboratory thesis study.

d) Analytical and experimental applied research; M.S. thesis.

(e) A determination of the relation between the piezometer tap shape characteristics, flow boundary layer characteristics and the pressure measuring errors. Completed.

(g) Tap errors were found to vary as a function of velocity tap depth-diameter ratio, pipe diameter - tap diameter ratio, and back up diameter - tap diameter ratio.


(5503) BUBBLE AERATION STUDIES.

(b) A laboratory thesis study.

d) Analytical and experimental applied research; M.S. thesis.

(e) A determination of the oxygen transferred to undersaturated water by rising clouds of submerged bubbles. Studies include variation of bubble size, bubble concentration, water depth and oxygen deficiency. Completed.

(g) Transfer found to vary with decreasing bubble size.
Reynold's number, tank depth air flow rate, bubble size and mixing.

A laboratory thesis study.

Analytical and experimental applied research; M.S. thesis.

A determination of the attenuation of gravity waves by rifts of water-filled spherical elastic bags floating at a free surface.

Completed.

A linearized theory was developed which was compared with experimental results of supercavitating flow over wedges in the boundary layer.


ITTTC HEADFORM STUDY.

David Taylor Model Basin, Dept. of the Navy. Experimental applied research.

Determination of the inception cavitation conditions for a standardized headform in the 2-in. closed jet water tunnel of the Laboratory. Results are to be compared with those in other water tunnels. Comparisons being made by International Towing Tank Conference.

Completed.

Value of inception signs found to diminish with tunnel speed and gas content of water.

"Cavitation Inception Evaluation of the ITTC Modified Ellipsoidal Headform" by P. R. Schiebe, J. M. Killen, and J. P. Ripken, St. Anthony Falls Hydraulic Laboratory Memo No. M-102, November 1965. (Not available for distribution.)

TANK FOR OCEANOGRAPHIC CURRENT METER CALIBRATION.

U. S. Navy Oceanographic Office.

Theoretical and experimental, basic research.

A study was made to determine the feasibility of constructing a calibration facility to utilize low speed ocean current meters (0.01 to 1 knot.)

Completed.

A facility in the form of a low-speed jet from a nozzle was recommended.


JET FLAP STUDIES.

David Taylor Model Basin, Dept. of the Navy.

Experimental basic research.

The utility of a trailing-edge jet flap on ventilated hydrofoils in the vicinity of a free surface is to be investigated. The tests are to be primarily conducted in the towing tank facility, and are an extension of previous work carried out in the Laboratory free-jet water tunnel.

NON-NEWTONIAN BOUNDARY LAYER.

David Taylor Model Basin, Dept. of the Navy.

Study of boundary layer structure of laminar, transition and turbulent flows with homogeneous non-Newtonian fluids and Newtonian fluids with injected non-Newtonian additives.

IMPACT CAVITATION DAMAGE II.

David Taylor Model Basin and Office of Naval Research, Dept. of the Navy.

Utilization of facility described under (5493) to clarify fundamental mechanics of failure or solids by impact of liquid drops.

TUNNEL FEASIBILITY STUDY.

David Taylor Model Basin, Dept. of the Navy.

Analytical design study.

Clarification of fluid dynamic problems which might be encountered in providing a new alternate two-dimensional test section for a large existing water tunnel.

Completed.

Limits of feasibility established.

"A Feasibility Study of a High-Speed Two-Dimensional Test Section for the DMB 36-Inch Water Tunnel," by J. P. Ripken and C. S. Song, St. Anthony Falls Hydraulic Laboratory Memo No. M-102, July 1965. (Not available for distribution.)

FLOW CONDITIONS IN SOILS AND FILTERS.

National Institutes of Health.

Project is primarily experimental with some theoretical work; applied research.

A study of the flow of water through unsaturated porous media is being conducted. The variation of the seepage coefficient, K, with the characteristics of the porous media and the degree of saturation is being investigated. Knowledge of the variation in the seepage coefficient with porous media characteristics and degree of saturation will aid in the determination of the pressure gradient as a function of velocity and saturation necessary to maintain a given flow rate through filters, natural soil and capillary flow from groundwater tables to the surface.

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA.

USDI - Water Resources Research.

Professor C. E. Bowers, University of Minnesota, St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota. 1964.

Analytical; basic research.

Project involves an analysis of precipitation, infiltration and runoff from selected watersheds in Minnesota. The objectives of the study will be the procurement of information on peak rates of runoff and infiltration rates for selected areas in the watersheds. An attempt will be made to correlate results with various hydrologic parameters and basic characteristics.
(5800) A STUDY OF THE RELATIONSHIP BETWEEN EROSION AND SOIL PROPERTIES FOR COHESIVE SOIL.

(b) National Science Foundation.

(d) Experimental research.

(e) The soil properties and the erosion characteristics of a series of cohesive soil samples are being obtained. A relationship between the erosion characteristics and the soil properties is being obtained.

(5801) MINNESOTA FLOOD STUDY.

(b) Division of Waters, Dept. of Conservation, State of Minnesota.

(d) Applied Research - Field Investigation.

(e) Project involved motion picture records of the April 1965 flood on the Minnesota River plus the computation of data on discharges, water content of snow and rainfall during the critical runoff period.

(g) Of primary interest is the procurement of photographic records of the flood.

(h) A 1000 ft sound, color motion picture entitled "Flood: The Minnesota River, April 1965," is being assembled.

(5802) STUDIES OF FLOATING OIL TANKS.

(b) Chicago Bridge and Iron Company.

(d) Experimental research.

(e) Tanks for storing oil from wells under the continental shelf would be floated and moored near the wells. The objective of the project is to determine ideal shapes for the tanks to minimize mooring problems during storms.

(f) Suspended.

(g) A first experimental phase of the project has been completed in which mooring forces in shallow water waves created by hurricanes have been measured on several 1 to 48 scale models.

(5803) WATER JET INLET STUDY.

(b) The Boeing Company, Seattle, Washington.

(d) Experimental research.

(e) Determination of performance-limiting cavitation characteristics of the inlet system for a jet propelled high speed hydrofoil boat.

(5804) STUDY OF FLOW TUBES.

(b) Automatic Control Company, St. Paul, Minnesota.

(d) Experimental and analytical development.

(e) Development of new forms of conduit flow meters of the differential pressure type.

(5805) GRIT DISTRIBUTION IN GRIT REMOVAL CHANNELS OF SEWAGE TREATMENT PLANT.

(b) Tolitz, King, Davill, Anderson, and Associates, Consulting Engineers and Minneapolis-St. Paul Sanitary District.

(d) Experimental model study, applied research.

(e) The model study will be directed at determining causes of uneven distribution of grit among several presently operating removal channels. It will also be used to assist in planning future grit channels and in improving operation of the present channels. A 1 to 12 model scale is in use.

(5806) VELOCITY PROFILES IN AN ENCLODED BODY OF WATER DUE TO WIND ACTION.

(b) A Laboratory thesis study.

(d) Experimental, theoretical, M. S. Thesis.

(e) The project involves an experimental study of the velocity profiles in an enclosed body of water due to wind blowing over the water. Of interest will be the equations for the velocity distribution and an evaluation of the effective surface roughness.

(5807) HYDROGRAPH LINEARITY IN AN ELEMENTARY CHANNEL.

(b) A Laboratory thesis study.

(d) Experiments, M. S. Thesis.

(e) The condition of increasing spatially-varied flow in a channel was used to generate hydrographs that would occur in a first order stream in a natural basin with rapid overland flow. Tests were performed in a laboratory channel 80 ft long with uniform lateral inflow along the length of channel with various durations and intensities of lateral inflow.

(f) Completed.

(g) For hydrographs of equal duration of inflow the times of occurrence of peak discharges decreased with increasing inflow. The magnitude of peak discharges for hydrographs of equal duration of inflow were greater than the linear behavior assumed by unit hydrograph theory. The departure from linear behavior was most significant in tests where channel storage was greatest.

(h) "Hydrograph Linearity in an Elementary Channel," by A. F. Faber, M. S. Thesis, University of Minnesota, December 1965. (Available on Inter-Library Loan from University of Minnesota.)

INTER-AGENCY SEDIMENTATION PROJECT IN COOPERATION WITH ST. ANTHONY FALLS HYDRAULIC LABORATORY.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

(b) Subcommittee on Sedimentation, Inter-Agency Committee on River Resources of the U. S. Army Corps of Engineers and the U. S. Geological Survey are actively engaged on the project.

(c) Engineer in Charge, Mr. John V. Skinner, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Ave., S. E., Minneapolis, Minnesota.

(d) Experimental; applied research and development.

(e) Drawings and specifications are available to facilitate the manufacture of suspended-sediment and bed-material samplers, particle-size analyzers, and associated laboratory equipment. Apparatus used for the measurement of suspended sediment include a single-stage sampler, 4-, 22-, and 62- pound depth-integrating samplers, and electrically operated point-integrating samplers weighing 100, 200, and 500 pounds. Samplers for the measurement of bed material include a piston-type hand-operated sampler, a 50-pound hand-line sampler, and a 100-pound sampler for cable suspension. Additional items are a sediment sample splitter, a bottom-withdrawal sedimentation tube for size analysis, and visual-accumulation sedimentation tubes with recording equipment for particle size analyses of sands. The primary objective of the current program is the development of an instrument to automatically record suspended-sediment concentrations in flowing streams.

Field and laboratory tests have been continued on intermittent pumping-type samplers, turbidimeters and electrical and nuclear sensing devices. Field testing of the nuclear density probe was terminated. Preparation of a report on Laboratory Investigation of Pumping Sampler Intakes, designated Progress Report T, and the initial draft of a report on Turbidity Method for Suspended-Sediment Analysis are in progress. The report on the Use of the Sediment Density Probe was revised to include the period 1958 through 1964.


SCIRPS INSTITUTION OF OCEANOGRAPHY, University of California, San Diego.

75
(5920) **A STUDY OF INTERNAL WAVES IN THE OCEAN.**

(b) Laboratory project.

(c) Dr. Charles C. Cox, The Scripps Institution of Oceanography, La Jolla, California 92038.

(d) The project is theoretical, including field investigation and is basic research.


(5922) **MECHANICS OF SEDIMENT TRANSPORT BY WAVES AND CURRENTS.**

(b) Coastal Engineering Research Center and Office of Naval Research.

(c) Dr. D.L. Inman and Mr. A.J. Bowen, Scripps Institution of Oceanography, La Jolla, California 92038.

(d) Field and experimental; basic research.

(e) (1) To measure the threshold of sand motion and suspension under wave action. (2) To measure and compare the sediment transported with measurements of basic parameters such as orbital velocity and longshore currents. (3) To investigate the behavior of granular media under shearing stresses.

(f) Techniques have been established for photographically recording the movement of the sand and water over the ocean floor, using SCUBA divers. These results have then been compared with the pressure recordings taken at the same wave stage and the wave height record above the site.

(h) Coastal Engineering Research Center Quarterly Progress Reports 1 through 9 covering the period 1 August 1963 to 30 September 1965.


(5923) **THE CIRCULATION OF WATER ON BEACHES.**

(b) Laboratory project, Office of Naval Research.

(c) Mr. A. J. Bowen and Dr. D. L. Inman, Scripps Institution of Oceanography, La Jolla, Calif. 92038.

(d) Experimental, theoretical, and field; basic research for Ph.D. thesis.

(e) Field and laboratory study of waves and wave-induced currents on beaches. Theoretical work to study the reasons for the existence of rip currents and their influence on the nearshore regime.

(h) Office of Naval Research Progress Reports for the years 1963 to 1965.

(5924) **INSTRUMENTATION IN THE NEARSHORE REGIME.**

(b) Coastal Engineering Research Center.

(c) Mr. W. A. Koontz and Dr. D. L. Inman, Scripps Institution of Oceanography, La Jolla, Calif. 92038.

(d) Experimental and field; applied research.

(e) The development of a multi-purpose data acquisition system for use in all phases of study in the nearshore region. A multi-channel recorder contains both an analog output channel for immediate appraisal of data and a digital read-out on magnetic tape. The tape can be input to the CDC-3600 computer for extensive analysis.


(5925) **WAVE ATTENUATION.**

(b) Office of Naval Research.

(c) Dr. Walter H. Munk, Associate Director and Frank E. Snodgrass, Research Engineer, Institute of Geophysics and Planetary Physics, University of California, San Diego, Calif. 92038.

(d) A field investigation to measure attenuation of ocean waves over very large distances.

(e) Wave stations were occupied for three months at six points along a great circle between New Zealand and Alaska. On the basis of a spectral analysis of these records the attenuation was studied.

(f) Completed.

(g) The observed attenuation is not inconsistent with the effect of nonlinear interactions between waves generated within the storm area.


(5926) **TIDE PREDICTION.**

(b) U. S. Coast & Geodetic Survey.

(c) Dr. Walter H. Munk, Associate Director, Institute of Geophysics and Planetary Physics, University of California, San Diego, Calif. 92038.

(d) Theoretical.

(e) Application of modern time series methods to prediction of tides.


(5927) **DEEP SEA TIDES.**

(b) Office of Naval Research.

(c) Dr. Walter H. Munk, Associate Director and Frank E. Snodgrass, Research Engineer, Institute of Geophysics and Planetary Physics, University of California, San Diego, Calif. 92038.

(d) Field investigation.

(e) A self recording instrument package is dropped freely to the sea bottom and records, in situ, pressure, temperature and currents to a high degree of precision. The instrument is acoustically recalled from a surface vessel, typically after one month.

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UNIVERSITY OF SOUTH CAROLINA, College of Engineering, Department of Civil Engineering.

Inquiries concerning the following projects should be addressed to Dr. Harold Pilach, Civil Engrg. Department, University of South Carolina, Columbia, South Carolina 29208.

(4) THE DEVELOPMENT OF SURFACE WAVES BY WIND.

(b) Laboratory project.

(d) General theoretical, experimental, and field research.

(e) Research on the theories of surface wave origin and growth, on measurements in the laboratory and in nature, and on the comparative results of theory and measurement. Equipment has been assembled for telemetering and recording wave height, period, and direction.

(g) A lake shore receiving and recording station is under construction.

(1631) **THE EFFECT OF WAVES ON BEACHES.**

(b) Laboratory project.

(d) General theoretical, experimental, and field research.

(e) Research on beach slopes and contours, in the laboratory and in nature.

(g) Eight-directional wave tank has been completed.
SHIP STABILITY AND ROLLING PERIOD.
(a) Laboratory project.
(b) General theoretical, experimental, and field research.
(c) Rolling and pitching period and metacentric height relationships are studied for stationary and moving ships, in still water and under wave action.
(d) Model experiments have been assembled in a brief report.

THE EFFECT OF TIDES ON HARBORS, BAYS, AND ESTUARIES.
(a) Laboratory project.
(b) General theoretical, experimental, and field research.
(c) A study of the scouring or shoaling effect of tidal currents in South Carolina harbors and estuaries.

SOUTHWEST RESEARCH INSTITUTE, Department of Mechanical Sciences.

STUDIES OF FUEL SLOSHING.
(a) National Aeronautics and Space Admin., Marshall Space Flight Center.
(b) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.
(d) Studies of forces and moments in missile fuel tanks resulting from sloshing motions of fuel.
(e) Completed.
(f) Eleven SwRI technical reports have been issued under this project; six of these have been published in technical journals of AIAA.

LIQUID DYNAMIC BEHAVIOR IN ROCKETS.
(a) National Aeronautics and Space Administration, Washington, D. C.
(b) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.

HYDRODYNAMICS OF SHIP ANTI-ROLL TANKS.
(a) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(b) Mr. John P. Dalzell, Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.
(d) Studies of forces and damping effects in passive anti-roll stabilization tanks for ships.
(e) Two SwRI technical reports.

VIBRATION OF HYDROFOIL STRUCTURES.
(a) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(b) Mr. Jack T. Irick, Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.
(d) Study of the vibration characteristics of hydrofoil-type structures.
(e) Completed.

LIQUID DYNAMIC BEHAVIOR IN TANKS UNDER AXIAL OSCILLATION.
(a) National Aeronautics and Space Administration, Marshall Space Flight Center.
(b) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.
(d) Studies of nonlinear liquid motions in rigid and elastic tanks undergoing axial oscillations.
(e) Four Southwest Research Institute technical reports.

HYDROELASTIC STUDIES OF SUPERCAVITATING HYDROFOILS.
(a) Bureau of Ships, Dept. of the Navy.
(b) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical and experimental; applied research.
(d) Design, construction, and testing of dynamic supercavitating hydrofoil models to obtain data on unsteady hydrodynamic lift and moment for a variety of operating conditions.

MONOGRAPH ON LIQUID DYNAMIC BEHAVIOR IN ROCKET PROPELLANT TANKS.
(a) National Aeronautics and Space Administration, Washington, D. C.
(b) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical; applied research.
(d) Preparation of a monograph on stated subject.

MONOGRAPH ON HYDROELASTIC PROBLEMS OF HYDROFOIL CRAFT.
(a) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(b) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206.
(c) Theoretical; applied research.
(d) Preparation of a monograph on stated subject.

STANFORD UNIVERSITY, Department of Civil Engineering.

HYDROLOGIC SYNTHESIS.
(a) National Science Foundation.
(b) Prof. Ray K. Linsley and N. H. Crawford, Dept. of Civil Engineering, Stanford Univ., Stanford, Calif. 94305.
(c) Theoretical and field research.
(d) Detailed digital computer synthesis models are used to investigate the interaction of physical variables in the hydrologic cycle. A simplified mathematical treatment of non-equilibrium overland flow has been developed. Digital computer programs to simulate non-equilibrium overland and channel flow in rivers and streams have been developed. A statistical analysis of soil-moisture frequency has been completed. Synthesis models which calculate continuous streamflow from rainfall, temperature, and potential evapotranspiration data have been developed and application of these models to unaged
STUDY OF INFILTRATION.
(b) U. S. Public Health Service.
(c) Prof. Joseph P. Franzini, Dept. of Civil Engineering, Stanford University, Stanford, California 94305.
(d) Theoretical investigation; laboratory and field studies; basic research; Ph.D. theses.
(e) An attempt is being made to develop relations between soil parameters and infiltration capacities. Investigation is being extended to unsteady, unsaturated flow through soils as experienced in capillary rise, drainage, and infiltration situations.

(4219) SUPERCavitating HYDROFOIL THEORY.
(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Professors R. L. Street and B. Perry, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif. 94305.
(d) Theoretical, basic research for Ph.D. theses and post-doctoral research.
(e) Examination being made of forces acting on fully cavitation bodies. Effects of free surfaces, gravity, angle of attack, rotation, etc. are being studied. Linearized, non-linearized and finite-difference numerical analyses are conducted.
(f) Rotation, gravity, free surface and tandem interference effects between bodies have been shown to have important roles in fully cavitation flows.


DISPERSION OF POLLUTANTS IN FLOW THROUGH POROUS MEDIA.
(b) Laboratory project.
(c) Prof. E. Y. Hau and R. L. Street, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif. 94305.
(d) Basic experimental and theoretical research for Ph.D. thesis.
(e) Study of hydrodynamic dispersion in porous media. Complex variable analysis of flow fields is combined with numerical solution of diffusion equation to define time-space history of pollutant concentrations. Effects of channel boundary shapes on streamlines of dispersion are to be studied also.
(f) Theoretical and experimental analyses in progress.

(4917) MECHANISMS INVOLVED IN WIND-GENERATED WAVES.
(c) Prof. E. Y. Hau and R. L. Street, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif. 94305.
(d) Experimental and theoretical basic research for doctoral theses.
(e) Examination, experimental verification, and extension of available theory are the purpose of this project. A statistical wave model of the wind-wave problem is being constructed in the laboratory.
(f) Miles' wave generation theory has been verified for moving wave boundary in a shear flow.

(5453) STUDIES OF LARGE WAVES.
(b) Field Projects Branch, Earth Sciences Div., Office of Naval Research.
(c) Prof. R. L. Street, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif. 94305.
(d) Experimental investigation; master's and Ph.D. project.
(e) Study of a verification of theory regarding characteristics of large waves-breaking, shoaling, and run-up. Wave-shore interaction. Facility under construction.

(5454) STUDIES ON WIND-WAVE INTERACTIONS.
(b) National Science Foundation.
(c) Prof. E. Y. Hau, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif. 94305.
(d) Experimental; Ph.D. theses.
(e) The experiments include pressure, velocity, wave form, and spectral measurements in the region of, and at, the interface. They are designed to study the mechanism of energy transfer between the air and the water. A Wind, Water-wave Research Facility," by E. Y. Hau. Technical Report No. 57, October 1965, Dept. of Civil Engrg., Stanford Univ.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory.

INVESTIGATION OF HULL BENDING MOMENTS IN WAVES.
(b) Ship Structure Committee.
(c) Mr. Edward Numata, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J. 07030.
(d) Experimental; applied research.
(e) A model of the cargo ship WOLVERINE STATE will be instrumented to measure vertical and lateral wave bending moments at the same location used aboard ship for strain gage measurements during actual voyages. Model will be run at a range of headings to regular waves with a range of lengths. Prediction of ship bending moments in realistic seas will be made for correlation with bending moment data collected aboard ship. Further Investigation of Bending Moments within Midsip Half-Length of a Naverine Model in Extreme Waves," N. M. Maniar and E. Numata (in preparation).

(4226) INVESTIGATION OF SURFACE-PIERCING FULLY VENTILATED DIMEERAL HYDROFOILS.
(b) Office of Naval Research, Department of the Navy.
(c) Mr. Z. Ward Brown, Chief of High Speed Craft Division, Davidson Laboratory, Inst. of Tech., 711 Hudson Street, Hoboken, New Jersey 07030.
(d) Experimental and theoretical; applied research.
(e) A continuing investigation aimed at providing basic design information on three-dimensional hydrofoils operating near a water surface, under conditions of either fully wetted or fully ventilated flow. To date the forces and moments on a...
series of surface piercing dihedral hydrofoils have been measured and the dynamics of systems approaching such foils has been studied, indicating the problem of a hydrofoil impacting on the water surface and the stability of hydrofoil craft, and their response in waves. Analytical and experimental studies of forces and moments on surface piercing fully wetted and fully ventilated dihedral hydrofoils, including the effect of flaps, have been obtained and examined experimentally. Unsteady problems including those of stability, impact and ventilation of such foils have also been dealt with. The conventional linearized supercavitating foil theory has been extended to cover the entire angle of attack range with simplicity and precision. The response of surface piercing hydrofoil systems in irregular waves has been analyzed and developed and proved experimentally for making predictions of the time history of motion response in irregular waves.

**SMOOTH WATER BEHAVIOR OF SURFACE-FIREFING HYDROFOIL VESSELS.**

- Office of Naval Research, Fluid Dynamics Branch, Navy Dept.
- David Strumfield, Head Underwater Weapons Div., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
- Experimental, theoretical; applied research.
- The aim of the study made of the smooth water operation of a 110-ton craft supported by a tandem set of surface piercing hydrofoils is to develop motion equation and determine the hydrodynamic data necessary to predict the motions of such craft in six degrees of freedom. Many of the necessary hydrodynamic coefficients were obtained from rotot-arms experiments, and many of the coefficients also were predicted using formulations based on available theory. Reasonable agreement was obtained between the predictions and measurements. The motions of the craft under the action of the rudder and its stability in six degrees of freedom were determined numerically using the UNIVAC 1105 computer at Stevens Institute of Technology.
- A technical report is in preparation. The experimental phases of this report have been completed.

**THE BOUNDARY LAYER UNDER PROGRESSIVE AND STANDING WAVES.**

- Office of Naval Research, Dept. of the Navy.
- Dr. J. J. Lukasik, Chief, Fluid Physics Division, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
- Experimental, theoretical, and field investigations; basic research.
- The purpose of this work is to study energy loss processes in shallow water waves. Theoretically, this is of interest because unsteady viscous flows have received relatively little attention, particularly the case of an oscillatory flow with no mean flow. Analytical and numerical solutions of the non-linear Navier-Stokes equations are under investigation. Laboratory measurements in the Stevens shallow water wave channel have been made of the wave attenuation coefficient of a progressive wave, the bottom shear stress under a progressive wave, and the time decay of standing waves. Field measurements of the bottom pressure and bottom velocity in 40 foot depths have been made off Block Island, R.I. These field measurements provide the possibility of determining the utility of the laboratory measurements and the theoretical studies to the geophysical problem of the energy loss by ocean waves in shallow coastal waters. The coefficients at Stevens and MIT indicated that the energy dissipation in a shallow water gravity wave exceeded that which would be expected from a linearized laminar solution of the Navier-Stokes equation. Only a revised model is valid in the bottom boundary layer. Several hypotheses have been examined in order to reconcile the discrepancy. It appears that the cause of the excess attenuation lies in the fact that the finite amplitude nature of the wave potential flow must be considered when formulating the boundary layer problem. For small deviations from infinitesimal amplitude theory, the Stokes approximation is valid. The attenuation theory, when revised to include the effect of the first two harmonics as well as the fundamental frequency, is then in much better agreement with the laboratory measurements of the attenuation.

**EFFECT OF PLANIFORM VARIATIONS ON HYDROFOIL FLUTTER.**

- Bureau of Ships, Dept. of the Navy.
- Mr. Charles J. Henry, Research Engineer, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
- Experimental and theoretical; basic research.
- Measurements of flutter speed were obtained.
for a two degree of freedom system including
the effects of sweep, taper and aspect ratio. The results were compared with predictions
using two-dimensional stripwise theory and
will be compared with three-dimensional
lifting surface theory.

(c) Two-dimensional strip theory prediction of
flucture speed did not agree with measured
values for a 15° swept foil nor for two
tapered foils with taper ratio of 2/3 and
1/3. The asymptotic behavior of flutter
speed at low density ratio remains in the
two degree of freedom system even with
sweep and/or taper and is not accurately
predicted by two-dimensional strip theory.
The measured flutter speed on a foil with
rectangular planform increased with de-
creasing aspect ratio.

(h) "Hydrofoil Flutter Phenomenon and Airfoil
Flutter Theory - Volume III: Sweep and
Taper," C. J. Henry and M. R. Ali, to be
published as Davidson Laboratory Report.
"Hydrofoil Flutter Phenomenon and Airfoil
Flutter Theory - Volume IV: Finite Aspect
Ratio," C. J. Henry and M. R. Ali, to be
published as Davidson Laboratory Report.

(5064) INVESTIGATION OF SHIP MOTIONS.

(b) U. S. Naval Training Devices Center, Dept. of
the Navy.
(c) Prof. Earl M. Uram, Staff Scientist,
Davidson Laboratory, Stevens Inst. of Tech.,
711 Hudson St., Hoboken, N. J. 07030.
(d) Theoretical and experimental; basic research.
(e) Development of equations of motion of ships
in very low speed maneuvering condition to
be applied to a simulator for training.
(f) Analysis of general linearized motion
equations including terms of importance at
very low speeds. Experimental model and
full scale program to determine static and
dynamic derivatives of importance for
inclusion in computer programs for calculating
responses to bridge commands.

Completed.

(5309) ESTIMATION OF STABILITY DERIVATIVES AND
INDICES OF VARIOUS SHIP FORMS, AND COMPARISON
WITH EXPERIMENTAL RESULTS.

(b) David Taylor Model Basin, Office of Naval
Research, Dept. of the Navy.
(c) Miss Winnifred R. Jacobs, Research Engr.,
Davidson Laboratory, Stevens Institute of
Technology, 711 Hudson St., Hoboken,
N. J. 07030.
(d) Theoretical; applied research.
(e) An analytical method is devised for esti-
mating stability derivatives which com-
bines Albring's empirical modifications of
simplified flow theory with aerodynamic
wing theory. The method is then checked by
comparing calculated derivatives with those
computed from experimental data obtained
in rotating-arm tests.

Completed.

Comparison with experimental results in 35
cases, including two families of hulls of
6 members each, show that the stability
derivatives and indices determined by the
analytical method are of the right order of
magnitude and indicate correct trends. The
method can predict relative effects of
changes in ship form geometry and effects of
changes in skeg and rudder area.

(h) "Estimation of Stability Derivatives and
Indices of Various Ship Forms and Com-
parison with Experimental Results," W. R.
Jacobs, Davidson Laboratory Report 1035,
September 1954. To be published in the
Journal of Ship Research.

(5310) ACOUSTIC PROPERTIES OF BUBBLES IN PRESSURE
FIELDS.

(b) David Taylor Model Basin, Bureau of Ships.
(c) Professor E. M. Uram, Staff Scientist,
Davidson Laboratory, Stevens Institute of
Tech., 711 Hudson Street, Hoboken, New
Jersey 07030. Experimental; basic research.

(e) Study of the sound produced by a single gas
bubble in the presence of boundaries gener-
ating a varying pressure field in the flow
direction.

(5311) STRUCTURE OF TURBULENT WAKES WITH ASYMMETRIES.

(b) David Taylor Model Basin, Bureau of Ships.
(c) Prof. E. M. Uram, Staff Scientist, Davidson
Laboratory, Stevens Institute of Technology,
Castle Point Station, Hoboken, N. J. 07030.
(d) Experimental; basic research.
(e) Determination of turbulent structure of wakes
very near bodies of revolution with systemat-
ically varied symmetries. Particular atten-
tion to distortion imposed by asymmetries and
circular and eddied structure.

(5312) INVESTIGATE GAIN IN WATER SPEED OBTAINED
BY COUPLING AMPHIBIOUS CRAFT.

(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. Howard Dugoff, Chief, Vehicle Research
Division, or Mr. Robert L. Van Dyke,
Research Engineer, Davidson Laboratory,
Stevens Institute of Technology, Castle Point
Station, Hoboken, N. J. 07030.
(d) Experimental investigation; applied research.
(e) Towing tank scale model tests are being con-
ducted to determine the hydrodynamic drag
reduction attainable through coupling of
amphibious vehicles in train configuration.
Limited tests of directional behavior in
waves alone have been completed.

Results to date are extremely encouraging;
total resistance for a train of five LVTP-5
amphibians is less than twice as great as
the resistance of a single vehicle. Assum-
ing that propulsive efficiency is unaffected
by coupling, this represents a potential
speed gain of almost as performance at sea is concerned, the tests
to date indicate that resistance of the train
to broaching is no worse than the very stable
single LVTP-5.

(5313) HYDRODYNAMIC TRACK PROPULSION.

(b) Office of Naval Research.
(c) Mr. Howard Dugoff, Chief, Vehicle Research
Division or John A. Mercier, Research Engr.,
Davidson Lab., Stevens Institute of Tech.,
Castle Point Station, Hoboken, N. J. 07030.
(d) Experimental and theoretical investigations;
applied research.
(e) The purpose of the study is to investigate
the mechanism by which floating land vehicles
propel themselves through water by use of
their tracks only. Towing tank tests are
being conducted using a non-operating track
section. A theoretical performance analysis
of the test configuration is also being made
for comparison with the experiments. The
results of this initial program are intended
to provide data for the optimum design of an
operating track model to be built and tested
in a subsequent study.

The most promising prospect for improving the
efficiency of the track propulsion appears
to be the application of the Voith-Schneider
propeller principle to the track, i.e., the
use of cams to vary the attitude of the
track cleats as they rotate. It is now prop-
osed to build an operating model track incor-
porating this principle for evaluation of
its feasibility. The results of the tests
with the static model indicate that the
clear spacing should be made as small as
practical and that the influence of their
aspect ratio is not great.

(5314) HYDRODYNAMIC WHEEL PROPULSION OF FLOATING
LAND VEHICLES.

(b) U. S. Army Tank Automotive Center.
(c) Mr. Howard Dugoff, Chief, or H. M. Parekh,
The fluid dynamic mechanism by which a floating land vehicle can propel itself through water by spinning its fully submerged wheels is being investigated. Studies are being conducted on all aspects yet essentially distinct aspects of the problem:

Phase 1-Hydrodynamic Studies of Spinning Disk. Tests are being conducted to determine the thrust force which acts on a disk rotating about an axis parallel to a plane boundary. The experiments are being performed for comparison with a proposed theoretical solution, reported on in the 1964 issue (reference number 5067), intended to provide an insight into the basic elements of the wheel propulsion phenomenon.

Phase 2-Tests on Scale Model of Floating Cargo Truck. Towing tank tests of self-propelled scale model of a five ton army cargo truck are being conducted in an effort to develop a scale model technique for studying the hydrodynamic performance of wheel-propelled vehicles.

Phase 1-The experimental results follow the trends predicted by the theory. In general, however, the measured values of thrust are lower than the theoretical predictions. It is felt that this may be due primarily to deficiencies inherent in the available apparatus and in the test setup employed. Thus additional tests with an improved setup are planned.

Phase 2-Attempts are being made to circumvent the inability to attain total dynamic similarity (due to the familiar Prandtl-Noether incompatibility), by use of some empirical distortion factors in conjunction with tests under partially similar conditions. To date, no satisfactory procedure has been developed, but work is still in progress.

ROUGH WATER TAKE-OFF RESISTANCE OF HYDROPOIL SHIP HULLS.

The longitudinal and transverse oscillations of a flat plate in a stream of viscous liquid is being solved on the basis of Giesek's equations. The problem is reduced to solving coupled integral equations.

The longitudinal and transverse oscillation problem is completely solved and closed form solutions for the drag in terms of Reynolds number $k$ and reduced frequency $\omega$ have been found in the case of large and small Reynolds numbers.

THE OSCILLATION OF A FLAT PLATE IN A STREAM OF VISCOUS LIQUID.

A systematic study of the rough water resistance of hull forms suitable for use with hydrofoils, as a function of wave steepness, and frequency of encounter, with and without a range of foil restoring and damping forces and moments.

THE OSCILLATION OF A FLAT PLATE IN A STREAM OF VISCOUS LIQUID.

HYDROPLANING OF AIRCRAFT TIRES.

A systematic experimental study is being made of the various parameters affecting hydroplaning of pneumatic aircraft tires. Model tests are being conducted on the Davidson Laboratory rolling road facility; tires may be placed above the road so that with the tire mount stationary, the tire behavior may be studied and tire loads measured as functions of rolling speed. The model tires are fabricated of polyurethane foam, whose density is varied to simulate variations in pneumatic tire inflation pressure. Static and dynamic tests of these models indicate that they are geometrically similar to the prototype pneumatic tires as they deform under load. A qualitative theoretical description of the hydroplaning phenomenon also is being sought.

No quantitative experiments have been conducted to date. The results of exploratory qualitative tests, however, have been quite encouraging; hydroplaning of model tires has occurred at speeds predicted fairly well by the currently accepted empirical theory. On the theoretical end, equations have been developed to describe dynamic (non-viscous) hydroplaning phenomena in three dimensions. An approximate solution to these equations has been effected which provides agreement in trend, but not magnitude, with test data.

OFFICE OF NAVAL RESEARCH, Dept. of the Navy.

Mr. Howard Dugoff, Chief, Vehicle Research Div., or Mr. I. O. Kamm, Asst. Manager, Transportation Research Group, Davidson Lab., Stevens Inst. of Tech., Castle Point Station, Hoboken, New Jersey 07030.

Applied research.

The object of this program is to organize, review, and publish a comprehensive study of wheeled amphibious vehicles performed earlier (1956-59) by the Davidson Lab. under a contract with the U. S. Army Ordnance Tank-Automotive Command. The comprehensive study was halted shortly before its completion, when cognizance over amphibious vehicle development was transferred from the sponsor.

MODEL STUDY OF DOCKING CHARACTERISTICS OF LARC AMPHIBIANS.

U. S. Army Mobility Equipment Center.

Mr. Howard Dugoff, Chief, Vehicle Research Div., Davidson Lab., Stevens Institute of Tech., Castle Point Station, Hoboken, N. J. 07030.

Experimental; applied research and development.

Scale model tests have been conducted to determine methods for improving the docking performance of the LARC V amphibian by changing the rudder shape, stem configuration, rudder post location, and mooring line attachment location. Full scale tests are also being conducted by the Army to verify the model results. Davidson Lab. personnel are cooperating in these tests, and also are continuing the model studies in an attempt to extend the present results from the point of view of general applicability to amphibious vehicle design.

It was found that the model tests that the lateral force available to hold the LARC V at dockside could be increased materially, without modification to the hull, by use of a new rudder in the shape of a truncated pyramid with a vertical center plate. The tests also demonstrated that a change in the mooring line attachment location would improve operational performance significantly.

HYDROPLANING OF AIRCRAFT TIRES.

National Aeronautics & Space Administration.

Mr. Howard Dugoff, Chief, Vehicle Research Div., Davidson Lab., Stevens Inst. of Tech., Castle Point Station, Hoboken, N. J. 07030.

Experimental and theoretical; applied research.

A systematic experimental study is being made of the various parameters affecting hydroplaning of pneumatic aircraft tires. Model tests are being conducted on the Davidson Laboratory rolling road facility; tires may be placed above the road so that with the tire mount stationary, the tire behavior may be studied and tire loads measured as functions of rolling speed. The model tires are fabricated of polyurethane foam, whose density is varied to simulate variations in pneumatic tire inflation pressure. Static and dynamic tests of these models indicate that they are geometrically similar to the prototype pneumatic tires as they deform under load. A qualitative theoretical description of the hydroplaning phenomenon also is being sought.

No quantitative experiments have been conducted to date. The results of exploratory qualitative tests, however, have been quite encouraging; hydroplaning of model tires has occurred at speeds predicted fairly well by the currently accepted empirical theory. On the theoretical end, equations have been developed to describe dynamic (non-viscous) hydroplaning phenomena in three dimensions. An approximate solution to these equations has been effected which provides agreement in trend, but not magnitude, with test data.

STUDY OF 1/4-TON TRUCK FLOATING CONCEPTS.

U. S. Army Tank-Automotive Center.

Mr. Howard Dugoff, Chief, or Mr. George M. Worden, Research Engineer, Vehicle Research Div., Davidson Lab., Stevens Inst. of Tech., Castle Point Station, Hoboken, N. J. 07030.

Experimental and theoretical; applied research and development.
This program has two main objectives: (1) To evaluate specific proposed 1/2-ton truck concepts relating to their performance in crossing water obstacles, and (2) to develop general methods for evaluating such vehicles on an objective basis. Specific evaluations will include consideration of expected water speed, rough water characteristics, and water entrance and exit problems.

INVESTIGATION OF SWIMMING PERFORMANCE OF A PROPOSED 1 1/2-TON MARGINAL TERRAIN VEHICLE.

(a) U. S. Army Tank-Automotive Center.
(b) Dr. S. Tsakonas, Head, Fluid Dynamics Div., and Dr. M. J. Mercier, Research Engineer, Vehicle Research Div., Davidson Lab., Stevens Inst. of Tech., Castle Point Station, N. J. 07090.
(c) Experimental development.
(d) The object of this program is to optimize the performance of a proposed 1 1/2-ton marginal terrain vehicle currently under development for the U. S. Marine Corps by the contractor. To this end, experiments are to be made with a working scale model of one of the vehicle's airbag type tracks, in the proximity of a model hull simulator. Parameters to be investigated include bag diameter, bag spacing, bag aspect ratio, bag air pressure, track speed, depth of submergence, and entrance and exit angles.

UNSTEADY LOADS ON DUCTED PROPPELLERS AND NOZZLES.

(b) David Taylor Model Basin, Bureau of Ships, Dept. of the Navy.
(c) Dr. S. Tsakonas, Head, Fluid Dynamics Div., and Dr. M. J. Mercier, Research Engineer, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
(d) Theoretical; applied research.
(e) To develop a method of determining the unsteady and steady loading on a ducted propelle and its accompanying wake operations in a three-dimensional non-uniform flow field. The present phase is concerned with derivation of the pair of surface integral equations governing the interaction problem and their reduction to a pair of corresponding line integral equations by the mode approach and lift operator technique.

PROPELLER-SINGING PHENOMENON AS A SELF-EXCITED VIBRATION SYSTEM.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Div., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
(d) Theoretical; applied research.
(e) To improve the mathematical model introduced in the previous study at Davidson Lab. For the propeller singing phenomenon as a self-excited vibration system and to develop expressions for the acoustic signal produced by the propeller at the singing stage.

PROPELLER-RUDDER INTERACTION.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Div., and Miss W. H. Jacobs, Senior Research Engr., Davidson Lab., Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J. 07030.
(d) Theoretical; applied research.
(e) To evaluate theoretically the loading distribution on a rudder of finite aspect ratio in the presence of a propeller operating in three-dimensional non-uniform flow and to determine the rudder torque and side force.

UNSTEADY LOADS ON A MARINE PROPPELLER.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Div., and Miss W. H. Jacobs, Senior Research Engr., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J. 07030.
(d) Theoretical; applied research.
(e) To determine the loading distributions and vibratory torques and torques on a rotating propeller operating in a non-uniform three-dimensional flow. The resulting integral equation is solved by the mode approach in conjunction with the Glauert lift operator.

BOUNDARY LAYER BEHAVIOR ON ROUGH SURFACES.

(b) Commercial Ship Operator.
(c) Prof. E. M. Urem, Staff Scientist, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, New Jersey 07030.
(d) Experimental, theoretical; basic research.
(e) Study of boundary layer growth and turbulence structure on rough surfaces. Includes various geometrically regular roughness elements and distributions and random roughness atypical of ship hull plates.

DINONATIONAL EFFECTS ON HYDROPHONE OUTPUT IN THE NEAR FIELD.

(b) David Taylor Model Basin, Department of the Navy.
(c) Robert Taggart, President. Robert Taggart Incorporated, 3930 Walnut Street, Fairfax, Virginia 22030.
(d) Experimental; applied research.
(e) Measurements were made of the outputs of two cylindrically shaped hydrophones, 5/8" and 2" in diameter, whose bases formed the active area. The hydrophones were mounted in a closed trunk over a flat flexible plate forming part of the wall of a rectangular water tunnel. The distances between the active face of the plate and the plate were 1", 2", 1/2", 2" and 4", while the flow velocities through the main pipe ranged from 6 to 15 kts. These tests were conducted to determine whether a "distance" effect, previously noted, could be reproduced in a laboratory facility.

It was found that a relation did exist between output levels and distance, the higher level occurring at the closest position. During the process of reducing the data, there was some evidence of an "area" effect also, at least for the two closest positions of the hydrophones.

SEA-CHEST STRAINER PLATE SUCTION.

(b) Bureau of Ships, Department of the Navy.
(c) Robert Taggart, President, Robert Taggart Inc. 3930 Walnut Street, Fairfax, Virginia 22030.
(d) Experimental; applied research.
(e) An experiment was performed in a 2" x 8" plastic water tunnel, to determine the acoustic effects of a fully developed turbulent boundary layer sucked through a model strainer plate. The plate is flush-mounted in the lower tunnel wall with 1100 holes 1/16" diameter. Flow through the plate is by gravity and all throttling and flow control is achieved by upstream valves. Flush-mounted hydrophones and accelerometers provide a measure of the boundary layer pressure fluctuations and the acoustic radiation at several locations near the strainer plate. The ratio of suction velocity through the plate to the maximum velocity across the plate is varied.

The model experiments show that the source of noise in such a configuration is definitely related to the suction through the strainer plate holes. The source spectrum is broadband in nature resulting from the combination of a large series of discrete frequencies comprising jet-tones originating...
(5189) ACoustIC excitation of flat plates by turbulent flow.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Robert Taggart, Undersea Research Center, Robert Taggart, Inc., 3336 Walnut St. Fairfax, Virginia 22030.
(d) Experimental; applied research.
(e) Tests were carried out in a rectangular water tunnel in which flat plates were mounted flush with the tunnel wall. (1) Using a 1/16" thick stainless steel plate, the investigation was directed toward correlation of the boundary layer characteristics with the pressure spectra of a flush-mounted penell-end hydrophone and an accelerometer located on the quarter diagonal point of the plate surface. (2) Experiments were conducted to determine the dimensional effects of cylindrical hydrophones located in a water-filled trunk above the plate. The height above the plate was varied for two hydrophones of different sensitive areas. (3) The effect of damping on the hydrophone pressure is examined for two aluminum and two fiberglass plates. Comparison is made between the four plates (damped and undamped) at a maximum flow velocity of 22 ft.-sec. Acceleration levels were measured.

(f) Completed.

(g) (1) It is demonstrated that unsteady flow excitation from a turbulent boundary layer on a thin flat surface, causes vibration of the plate at many natural modes. Chladni figures are obtained for a frequency range from 200 to 4000 cps. (2) Both the area of a hydrophone and its distance above a vibrating plate have considerable effect on the dimensionless pressure spectra. (3) Measurements on the four damped plates show that the acoustic response of aluminum plates is lowered more than that of fiberglass plates. The ratio of the thickness of the damping material to the plate thickness is 2.

(5912) EFFECT OF NATURAL ROUGHNESS ON THE PRESSURE FLUCTUATIONS IN A TURBULENT BOUNDARY LAYER.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. Matthew Stevenson, Hydromechanist, Research & Development, Robert Taggart Inc., 3336 Walnut Street, Fairfax, Virginia 22030.
(d) Experimental; applied research.
(e) Studies are being conducted concerning the generation of noise by a turbulent boundary layer. The investigation is directed toward measuring the two-point correlations (transverse and longitudinal) of the pressure fluctuations on both smooth and rough walls. It is also planned to determine the effect of hydrophone size by using two or three larger diameter transducers.

(5477) THE MECHANICS OF EROSION BY FLOWING WATER.

(b) Texas A & M University.
(c) Experimental; basic and applied.
(d) The study is to determine relationships between water erosion of soils and the hydraulic characteristics of the flowing water, to develop quantitative relationships between specific soil properties and an acceptable erosion index, and to develop design data based upon which the results can be adequately considered in the design of water control and management systems.
(e) Laboratory research has been carried out on the research flume on channel and sediment transport with shallow flow, both with and without simulated rainfall. The effects of soil compaction on soil erosion have been studied in the flume and the effects of the dispersion and mineralogical data are available on the soils. In addition, a rotating shear apparatus has been constructed and tests performed to measure the erosion character of soils in this laboratory device under carefully controlled conditions. The effect on erosion resistance of changing the cations on the clay are being studied in this apparatus.

(5476) WATER POLLUTION FROM ERODED SEDIMENTS.

(b) U. S. Public Health Service.
(c) Experimental; basic and applied.
(d) The laboratory study is designed to obtain data on the initial transport of eroded sediments from the point of detachment to streams of appreciable size. This transport path considered, which may be only a few hundred feet to a few miles, is that portion of the flow path which is sufficiently shallow to be significantly affected by the existence of rainfall energy on the flow. This stream size limit is unknown but will be determined and related to rainfall energy and other factors affecting the flow and sediment transport capability of the flow.
(e) Rainfall superimposed on shallow open channel flow reduces the sediment transport capacity of the streams. This is caused by at least two effects which are being studied further, i.e., changes in vertical velocity distribution in the flow and changes in settling characteristics of suspended sediments.
EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT AFFILIATION OF WATER.

The objectives are to determine the effect of irrigation stream size, along with characteristics of soil on irrigation system design for most efficient application of water by surface irrigation methods; and to correlate results into design procedures, using hydraulic factors of surface irrigation and design criteria for design.

The results indicate that it is possible to integrate the differential equation for the advance and recession of inflow and outflow by single graphical means (rather than by lengthy and cumbersome numerical calculations or using computers). This will make specific design practical for individuals farms and soil conditions instead of so-called "rule-of-thumb" designs so often used now.


RESEARCH ON THE MORPHOLOGY OF PRECIPITATION AND RUNOFF IN TEXAS.

Water Resources Institute, Texas A&M Univ.

Field and laboratory investigation; applied research.

An investigation of the rainfall-producing mechanism and associated hydrologic regime in Texas. Data obtained from a dense network of recording and non-recording rain gages will be correlated with that obtained from a dual-frequency radar system. This information will then be related to actual data on surface runoff. The network of rain gages is located over the East Yegua Creek drainage basin, 234 sq mi, which is approximately 30 to 45 mi west of the radar system. In addition, a network of 40 rain gages in an urban area of 7 sq mi will be used to study precipitation variation within a small area and the effects of urbanization on surface runoff.

Installation of precipitation networks will be completed by February 1966. Collection and analysis of data from these networks should begin at that time.


CHARACTERISTICS OF A HYDRAULIC JUMP AT AN ABRUPT CHANGE IN BOTTOM ELEVATION.

University of Texas Research Institute and Bureau of Engineering Research.

Dr. Carl W. Morgan, Assoc. Prof. of Civil Engr., Univ. of Texas, Austin, Texas 78712.

Experimental determinations were made of the flow characteristics at two-dimensional channel drops and rises. The velocity distribution and surface profile were determined throughout the length of the jump for various relative changes in bottom elevation. The longitudinal location of the jump in relation to the change in bottom elevation was varied over a broad range in contrast with previous related investigations in which relative location of the jump was held constant.

HYDROLOGIC STUDIES, WALLER CREEK WATERSHED.

Cooperative with U. S. Geological Survey.

Field investigation; applied research.

Measurements of rainfall and runoff for a 4 square mile area and a 2 square mile portion of the Waller Creek watershed made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. The stream flow stations and a rain gage net are in operation.

Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base for comparison with the data as it is collected from the stream.

The records are now long enough to begin comparing with peak discharge estimates previously given at least for short recurrence intervals. A start is being made on this analysis.


EFFECT OF URBANIZATION ON THE RUNOFF FROM SMALL WATERSHEDS IN THE SOUTHWEST.

Laboratory project.

Field investigation (thesis).

For selected watersheds rainfall runoff relations are being developed on a storm by storm basis. Multiple correlation diagrams, based on data before changes in the watershed, have been developed and used to help generate missing data periods. Comparison of these computed runoff values with measured values is taken as an index of the effect of watershed development.

The first results are inconclusive because of random error in the computed values. Further studies are being made on another watershed with an improved method which better accounts for the spatial variation of rainfall.

AN INVESTIGATION OF THE SCOUR RESISTANCE OF COHESIVE SEDIMENTS.

The University of Texas Research Institute.

Dr. Frank D. Rasch, Department of Civil Engineering. The University of Texas, Austin, Texas 78712.

Analytical and experimental (laboratory).

Exploratory tests have been made with two different schemes, one with radially outward flow between a circular disc and the soil sample, and one with a submerged vertical parabolic jet impinging on a horizontal soil surface. With the first scheme it was not possible to obtain the necessary precision of measurement at low scour rates, but with the second scheme satisfactory measurements were obtained. A correlation based on dimensional analysis gave consistent results in evaluating the relative scour resistance of various materials. Apparatus has been fabricated for a new test which permits direct evaluation of the shear stress at the soil

inquiries concerning Projects Nos. 2162, 2397, 3524, 4234, 4235, 4256 and 5457 should be addressed to Dr. Walter L. Moore, Department of Civil Engineering, Univ. of Texas, Austin, Texas 78712.
surface. In this test a cylindrical soil sample is submerged in a transparent
concentric cylinder which can be rotated at a controlled speed to generate a shear
stress on the soil surface. Attempts are being made to relate the scour resistance
to other measurable soil properties, and finally to study the effects in re-
lation to field observations.

Using test procedures previously developed, a series of tests have been run to determine
the effect of moisture content on the critical
shear stress for Taylor Marl. Tests have been run at nearly constant degree of
saturation.

"Measurements of the Shear Resistance of
Cohesive Sediments," P. D. Masch, W. H.
Espey and W. L. Moore, Proceedings, Federal
Inter-Agency Conference, 1965, Agricultural Research Service Miscellaneous
Publication No. 970, June 1965.

LONG TIME FLUCTUATIONS IN STREAM RUNOFF.

(b) Laboratory project.
(c) Dr. Carl W. Morgan, Dept. of Civil Engrg.,
Univ. of Texas, Austin, Texas 78712.
(d) Analytical and field study.

Values of runoff from selected drainage
areas in the lower Mississippi River Basin and in basins of the rivers emptying
directly into the Gulf of Mexico were
studied. Variations in the runoff values for each stream were compared and these
trends compared with solar variations. The relative sunspot numbers were used as
the measure of solar variations and were correlated with the mean annual runoff.
Further correlations are being made with different "lag" periods between solar
activity and surface runoff.

The gradual increase over the centers of
runoff excess and deficiency is consistent
rather than random and appears to represent a gradual cyclic change in the runoff pattern. It
appears that the locations of the centers of runoff deficiency are following roughly
the same path that they did some 22 to 24
years previously. Correlation coefficients of plus 0.6 to plus 0.8 are obtained for
selected rivers in Mississippi, Alabama, Georgia, and Arkansas when sunspot numbers in
the 11-year sunspot cycle are correlated with runoff. Texas streams do not give
significant correlation with the 11-year sunspot cycle but give better correlation if runoff is
compared with the double sunspot cycle in which sunspot numbers are assumed as negative in alternate cycles.

GROUND WATER FLOW AND SEEPAGE IN NON-
HOMOGENEOUS, NON-ISOTROPIC SEDIMENTS.

(b) Laboratory project.
(c) Theoretical, basic.
(d) A relaxation solution for the Laplace
equation has been developed which is
applicable across a boundary between two
doing regions of different permeabilities. It is
believed that the method can be expanded to apply to any specified non-homogeneous and
non-isotropic conditions. It is intended that the solution be set up for
computation on an electronic computer and that selected solutions be checked against those
from an electrolytic tank.

EVAPORATION REDUCTION BY CONTROL OF
ADVECTED ENERGY.

(b) Partial sponsorship by the Lower Colorado
River Authority of Texas.
(c) A Master's thesis involving theoretical and
field investigation.
(d) Measurements have been made to determine the temperature field in Lake Travis for the
1962-63 season. A method was developed to estimate the effect of withdrawing water
from near the lake surface. Monthly esti-

mation of the resulting temperature field and
reduction in evaporation were made.

TWO-PHASE FLOW IN CONDUITS.

(b) Laboratory project.
(c) Dr. Walter I. Moore, Dep. of Civil Engrg.
(d) Experimetal master's thesis.
(e) It is apparent that the two-phase flow
system with a liquid and gas, many dif-
erent types of flow are possible. This
investigation explored the use of sound measurements to detect the type of flow
being present, in a metal pipe. Various types of flow were established in a thin-walled
aluminum pipe, 0.5 in. with a transparent
plastic section at each end. Records of the
sound pattern were made with different
pick-ups and correlated with the visual ob-
servation of the flow type. Magnetic tape
records of the sound were also made.

Study of the recorded sound patterns re-
vealed some identifiable characteristics
related to the type of two-phase flow in the
line. Additional work is needed to refine
techniques and try other sound pick-up
and recording methods.

DRAG FORCES IN VELOCITY GRADIENT FIELDS.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Dr. Frank D. Masch and Dr. Walter I. Moore,
Department of Civil Engineering, The Univ.
of Texas, Austin, Texas 78712.
(d) Theoretical and experimental; basic research.
(e) The investigation is being conducted to
determine the effect of a velocity gradient
on the local and conventional drag coef-
cients for cylinders of varying c/d ratio
and at different Reynolds Numbers. The
study will be extended to other shapes.
(g) Studies have demonstrated that the velocity
gradient along a cylinder affects the drag
coefficient. The local drag coefficient
decreases along the cylinder in the direc-
tion toward the center of the cylinder where
the velocity is high. The reduction in drag
coefficient is related to a dimensionless
measure of the velocity gradient along the
cylinder. The angle at which separation
occurred was found to increase near the
bottom of the cylinder where the free
stream velocity is low.

"The Influence of Secondary Flows on Drag
Forces," Charles Dalton and Frank D. Masch,
No. HYD 04-6503, The University of Texas,
July 1965.

TWO-FLUID FLOW IN A POROUS MEDIUM.

(b) Bureau of Engineering Research, Univ. of
Texas.
(c) Dr. L. R. Mack, Department of Engineering
Mechanics, Univ. of Texas, Austin, Texas
78712.
(d) Theoretical; basic research for masters
thesis.
(e) The velocity distribution within and the
shape of the interface between two im-
imiscible fluids of different densities
flowing through a uniform isotropic porous
medium toward a well is investigated. The
problem is of interest in both petroleum
engineering and ground-water hydrology.

It has been shown how the method of solution
set forth (for the special case when
the upper fluid has zero density) by Kirk-
ham (J. Geophys. Res., Vol. 69, pp. 2537-
2544, June 1964) will not yield meaningful
numerical results.

"Critical Investigation of Kirkham's Theory
of Determining the Shape of Water Table
Near a Well," His-Chun Chang, M. S. Thesis,
Univ. of Texas, August, 1965.

WAVE CHARACTERISTICS IN SHALLOW WATER.

(b) Coastal Engineering Research Center, Corps of
Engineers.
(4991) LOCAL SCOUR IN CHANNELS.

(b) Laboratory project.  

(c) Dr. Frank D. Masch and Dr. Walter L. Moore, Dept. of Civil Engrgs., The Univ. of Texas, Austin, Texas 78712.  

(d) Theoretical and experimental; basic and applied research.  

(e) This project is designed to investigate the characteristics of the three dimensional flow patterns at channel obstructions and to study the extent to which these flows affect local scour. It is believed that a more thorough understanding of the fundamentals of the flow at an obstruction would provide the basis to devise methods for controlling scour. The nature of scour at culverts is also under consideration with efforts being devoted to develop methods for dissipating energy and reducing local scour. The influence of Secondary Flows in Local Scour at Obstructions in Channels," W. L. Moore and Frank D. Masch, Proceedings, Federal Inter-Agency Sedimentation Conference, 1963, Agricultural Research Service, Miscellaneous Publication No. 970, June 1965.  

(5457) A NEW TYPE ENERGY DISSIPATOR FOR CULVERT OUTLETS.  

(b) Texas Highway Dept. and U. S. Bureau of Public Roads.  

(c) Dr. Frank D. Masch, Dept. of Civil Engrgs., Univ. of Texas, Austin, Texas 78712.  

(d) Experimental and theoretical doctoral thesis.  

(e) A study is being made of a culvert energy dissipator based on the principle of a circular hydraulic jump. Apparent advantages of the device are the stability of the jump over a range of discharge and tailwater conditions and the opportunity to spread the culvert discharge back to the original stream width. Problems of practical geometry need to be explored to see what compromises can be made and still achieve satisfactory energy dissipation performance.  

(5458) SEDIMENTATION IN GALVESTON-TRINITY BAYS.  

(b) Texas Parks and Wildlife Commission and Department.  

(c) Dr. Frank D. Masch, Dept. of Civil Engrgs., Univ. of Texas, Austin, Texas 78712.  

(d) Experimental, field; applied research.  

(e) Field investigation to determine the currents, sources of sediment, and sediment movement in Galveston and Trinity Bays, and to determine the effect they may have on the dredging of mud, shell, or clay beds.  


(5459) FINITE-AMPLITUDE GRAVITY WAVES.  

(b) Laboratory project.  

(c) Dr. L. R. Mack, Dept. of Engrg., Mechanics, Univ. of Texas, Austin, Texas 78712.  

(d) Theoretical, basic research for master's thesis and doctoral dissertation.  

(e) In order to obtain better quantitative agreement with the experimental frequency determinations of Pilkington and Reid, the analytical solutions for both two-dimensional standing waves and axisymmetric standing waves are being carried to the fifth order in amplitude. Velocity distribution, free-surface configuration, and frequency of oscillation are being obtained.  

(g) The two-dimensional solution has been carried through the fifth order. Surface configuration, frequency of oscillation, maximum amplitude, and the division of energy have been investigated. For a certain range of depths the oscillation exhibits "hard-spring" behavior for small amplitudes and soft-spring behavior for larger amplitudes. Close correlation is noted between soft-spring behavior of the frequency and the mean poten-
tial energy being greater than the mean kinetic energy.


(c) "Particulate Gravity Waves of Finite Amplitude," Donald F. Sattler, M. S. Thesis, Univ. of Texas, Austin, 1986.

(5460) WIND WAVE OVERTOPPING OF SHORELINE STRUCTURES.

(b) Bureau of Engineering Research, Univ. of Texas, Austin, Texas 78712.

(c) Dr. Frank D. Masch, Dept. of Civil Engrg., Univ. of Texas, Austin, Texas 78712.

(d) Experimental study.

(e) This study is designed to compare overtopping from wind waves with that predicted from criteria based on uniform wave trains. Overtopping is being measured under varying wind and wave conditions. Particular study is being given to beach geometry immediately in the front of the structure and its effect on overtopping rates.

Results obtained to date show that the greater the depth of water at the wall, the greater the overtopping rates. The offshore beach profiles appear to have little or no effect on overtopping from wind generated waves.

(5461) ANALYSIS OF UNIT HYDROGRAPHS FOR SMALL WATERSHEDS.

(b) Laboratory project.

(c) Dr. Carl W. Morgan, Dept. of Civil Engrg., The Univ. of Texas, Austin, Texas 78712.

(d) Field investigation, thesis.

(e) Characteristic, two-hour unit hydrographs were determined for each of three selected watersheds. The derived dimensionless hydrograph shapes were compared with two widely-used empirical hydrographs. Techniques were studied for using the S-curve approach as an aid in estimating the correct duration of rainfall excess by selecting that duration which caused the least fluctuation in the S-curve.

The dimensionless 2 hour unit hydrographs developed in this study indicate that the falling limbs of the Commons and Moore hydrograph shapes may need revision in order to be applied to watersheds of less than 100 square miles in area. However, these differences are only minor suggestions for an average dimensionless graph and reliable estimates of only two parameters, period of rise and peak discharge may be sufficient to define the shape of the unit hydrograph. Results indicate the S-curve can be used to estimate by trial and error the rainfall excess duration if rainfall data is not available.

(5953) MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS.

(b) U. S. Public Health Service.

(c) Dr. Frank D. Masch, Dept. of C. E., Univ. of Texas, Austin, Texas 78712.

(d) Basic and applied research; field investigation.

(e) This investigation has been undertaken to study the mixing and dispersion of contaminants in inland fresh waters. The study includes an investigation of the effects of currents, turbulent wave motion, and periodic overturning on the disposition of waste materials discharged into reservoirs and lakes. The stability effects of temperature and density stratification in reservoirs are also being determined. Mixing processes in both deep and shallow water reservoirs are being studied in the field.

(5954) PHYSICAL EXCHANGE CHARACTERISTICS OF TEXAS BAYS.

(b) Center for Research in Water Resources Project.

(c) Dr. Frank D. Masch, Dept. of C. E., Univ. of Texas, Austin, Texas 78712.

(d) Analytical; field investigation; applied research.

(e) To evaluate the assimilative capacity of Texas Gulf Coast Bays, studies are being carried out to determine a mathematical model which is descriptive of the mixing, dispersive and exchange characteristics of these bays. Preliminary analysis has proceeded on the basis of a modified tidal prism exchange model. Study is now under way to improve this type model.

(5955) PERFORMANCE OF CIRCULAR CULVERTS ON STEEP GRADES.

(b) Texas Highway Department.

(c) Dr. Frank D. Masch, Dept. of C. E., Univ. of Texas, Austin, Texas 78712.

(d) Experimental and theoretical research.

(e) This study is concerned with the behavior of the hydraulic jump in circular break-back culverts. Of particular concern is the effect of culvert conditions under which a jump will form in the culvert. The study is also concerned with methods to insure that the jump forms in the culvert.

(5956) SPILLWAY MODEL STUDIES - TOLEDO BEND DAM.

(b) Forrest and Cotton Consulting Engineers.

(c) Dr. Frank D. Masch, Dept. of C. E., Univ. of Texas, Austin, Texas 78712.

(d) Applied research; laboratory investigation.

(e) Model studies on the spillway section of the Toledo Bend Dam were carried out for the purpose of determining the hydraulic performance characteristics of the spillway section of the dam including stilling basin effectiveness, flow behavior in the upstream and downstream channels, and gate operating sequence for a range of discharges including the normal flood, the design flood, and the maximum probable flood.


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THERM ADVANCED RESEARCH, INC.

(5197) SPECIAL PROBLEMS IN FLUID DYNAMICS.

(b) Office of Naval Research, Dept. of the Navy.

(c) Dr. A. Ritter, President, Therm Advanced Research, Inc., 100 Hudson Circle, Ithaca, N. Y.

(d) Theoretical basic research.

(e) This is a continuing project of analytical studies which to date have consisted of:

(1) The Hydrodynamics of Free-Surface Crossings, concerned with predicting the hydrodynamic forces acting on bodies in vertical motion across an air-water interface, and includes examination of the accuracy of the standard assumptions of infinite Froude number and small disturbances; and (2) The Jet-Flap Hydrofoil Near a Free Surface, a study which will provide expressions for the forces and moments acting on a two-dimensional jet-flap hydrofoil in close proximity to a free surface as well as determining the degree of submergence at which free-surface effects may be neglected.

(f) 1. Completed, 2. Active.

(e) A second-order, small-perturbation theory for the water-exit and entry of slender symmetric bodies, including Froude number and air-density effects, has been developed. The effect of the nearby free surface on a two-dimensional jet-flapped hydrofoil is found to
be negligible, for practical purposes, at sub-
mergence depth-to-hydrofoil chord ratios

greater than the Froude number.

On the Small-Perturbation Theory of Water-
Exit and -Entry," by John P. Moran and Keith P.
Kerney, Developments in Mechanics, Southam,
Editor, Pergamon Press, Oxford, Pp. 478-506,
1965.

On the Hydrodynamic Theory of Water-Exit and
-Entry," by John P. Moran, Therm Adv. Research,

LOW-ASPECT-RATIO JET-FLAP CONTROL SURFACES.

LOW-ASPECT-RATIO JET-FLAP CONTROL SURFACES.

(b) David Taylor Model Basin, Dept. of the
Navy.

(c) Mr. G. R. Hough, Staff Scientist, Therm
Advanced Research, Inc., 100 Hudson Circle,
Ithaca, N. Y.

(d) Theoretical basic research.

(e) The objective of this project is to develop a
theory which will predict satisfactorily the
forces and moments acting on a fully
wetted, low-aspect-ratio jet-flap control
surface.

Previous studies in this area found that the
application of the conventional Jones low-
aspect-ratio approximation was unsatisfactory for
predicting control surface lift and drag for
rectangular planform and/or deflected jet blowing. During
the present contract, the improved low-aspect-ratio
approximation of Lawrence is being em-
ployed to obtain a solution.

PREDICTION OF SHIP SLAMMING LOADS.

(b) David Taylor Model Basin, Dept. of the Navy.

(c) Dr. M. Greenberg, Staff Scientist, Therm
Advanced Research, Inc., 100 Hudson Circle,
Ithaca, N. Y.

(d) Theoretical basic research.

(e) The object is to develop computer codes for the
accurate prediction of the pressures and
forces on ship sections at arbitrary slaming
angles during slamming. Finite air density will be
retained to avoid the unrealistic impact
singularity predicted by simplified theory, in
contrast with the water-compressibility
artifice which is often employed. The analy-
sis is based upon a discrete vortex
representation of the body and water surface, and pro-
cesses in finite time increments. The free
surface conditions are linearized only in the
calculation of the starting values, when the body is
sufficiently far above the water.

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UTAH STATE UNIVERSITY, College of Engineering.

DYNAMICS OF FLOW IN STEEP, ROUGH, OPEN CHANNELS.

(b) Laboratory and field projects; National
Science Foundation.

(c) Dr. Dean F. Peterson, Dean of Engineering,
Utah State University, Logan, Utah 84321.

(d) Experimental, theoretical, field investig-
ation; basic research for doctoral theses.

(e) A basic study of relationships involving
flow in steep, rough channels where the
roughness is relatively an appreciable part of
the depth, and where channels are
sufficiently deep to be considered as a slope
such that supercritical flow can occur in
connection with contractions caused by the
roughness. The work is basic, however,
it will have application to steep mountain
streams and to hydraulic structures.

The objective of the work is to relate
descriptive parameters describing the shape
and configuration of the bed roughness to
slope, depth and discharge of channels of this
class. Studies began using simple bar
and cube elements and have progressed through
the use of forms formed by growing natural
gravel elements of various size, gradation
and intensity to the bed. Nineteen field
sites have been installed in streams, prin-
cipally in northern Utah in the Wasatch
Mountains, but also in New Mexico and
Colorado. Eleven test wells have been installed at thirteen sites and
discharge and depth measured. Bed element
configuration and size have been studied at
all sites. Collection of field data has been
completed and analysis is continuing.

A laboratory flume study using natural gra-
vel elements to be submerged in the flow
as the fluid, was completed. The flume
study is being continued using the same beds
only in a mirrored effect to eliminate the
free surface influence, with air as the fluid.

In the flume studies, discharge and slope
were varied and depth was measured for each
of the ten beds. Two sizes of material with
eight different spacing arrangements were
used. Experimental results show a continuous
change in relative dominance of the factors
of gravity, and the stress acting, and turbulent
mixing as the kinematic and relative depth
changes. Six flow zones defined by Froude
number and relative depth were suggested. It
was not practical to develop a single equation
to describe a conductance coefficient, C' (g/ took
over all ranges of flow, but one equation
was found to be satisfactory. C is from Chezy's
equation for uniform bed material, and is based
on a depth-averaged parameter, roughness,
height, and length of flow. A measure for describing spacing was
developed and a method of field application
is also discussed.


HYDRAULICS OF SURFACE IRRIGATION.

(b) Public Health Service.

(c) Dr. Vaughn E. Hansen, Director, Utah Water
Research Laboratory, Utah State Univ.,
Logan, Utah 84321.

(d) Experimental, theoretical, basic research;
doctoral dissertation.

(e) Hydrodynamic and flume study of movement of
water over a porous surface when intake
varies with time. The free surface and the
rates of advance are defined.

(f) Completed.

(g) Differential equations have been developed
which define the free surface and rates of
advance. High speed computers have been
used to obtain solutions which have
been compared with field measurements of
the rate of advance. The results are within
one percent of field observations. A dimension-
less plot has been constructed which will
predict the advance for any given set of
known soil conditions. A companion study is
based upon utilizing empirical relationships
as a foundation for subsequent development
of a rate of advance function. The results
compare well with measured values.

"Hydrodynamics of Unsteady Open-Channel Fluid
Flow Over a Porous Bed Having a Variable In-
filtration Rate," by Edwin C. Olsen, III,
Ph. D. dissertation, Utah Water Research

THE EFFECT OF SEDIMENT PROPERTIES ON THE
ATTENUATION OF AN ULTRASONIC PLANE WAVE.

(b) National Science Foundation.

(c) Dr. Gordon H. Flammer, Civil and Irrigation
Engineering Department, Utah State Univ.,
Logan, Utah 84321.

(d) Theoretical and experimental; basic research.

(e) Some theoretical and experimental work has
been performed to study the attenuation of an
ultrasonic plane wave passing through a
sediment suspension. However, experimental
work is still very limited in scope, particularly
for certain naturally occurring sediments.
This study uses a standard pulse technique
to investigate a wide range of natural and
manufactured sediments over the various loss

86
ranges. Of primary concern is the effect of the various sediment properties on the attenuation.

Completed.

Natural sediments have been completed and an MS thesis has been prepared giving the results. Manufactured sediments of known properties have been tested, and a PhD dissertation has been completed and is available at the Utah State University Library.

WATER REQUIREMENTS OF MARSHLANDS.

(a) Utah State Fish and Game Dept.
(b) Prof. Jerald E. Christiansen, Professor of Civil and Irrigation Engineering, Utah State Univ., Logan, Utah 84321.
(c) Field investigations; applied research, Master's theses.
(d) Large areas of marshy lands adjacent to Great Salt Lake have been developed and improved by the State Fish and Game Dept., and the Federal Wildlife Service, as Migratory Bird Refuges. Available stream flow from several of the major streams flowing into these areas where the water is impounded behind dikes to create habitats suitable for nesting, feeding and resting of water fowl. Millions of ducks and geese utilize this area each year during their migratory flights.

Completed.

The basic purpose of the study was to determine the quantities of water necessary for marshlands in order to maintain them in a productive state.

Eight progress reports have been written. Three MS theses and one PhD dissertation have been completed.

WATERSHED MODEL STUDIES.

(a) Agricultural Research Service, U. S. Dept. of Agriculture.
(b) Dr. Jay M. Bagley, Utah Water Research Lab., Utah State University, Logan Utah 84321.
(c) Experimental; basic research for Master's and Doctoral theses.
(d) The purpose is to establish techniques and model-prototype processes that water systems can be intensively studied in a laboratory. A small watershed has been modeled. A rainfall simulator has been constructed for which design or actual rainfall events can be programmed to occur automatically over the model. The dominant factors influencing the characteristic shape of the run-off hydrography are being studied. Efforts have been aimed at determining effect on modeling relationships resulting from changes in the physical properties of water-chemical mixtures used in the rainfall simulator. Test runs are being made using a physical model with an impervious surface. Subsequent tests will incorporate the relationship between infiltration and runoff by providing for permeability changes in the model.

Completed.

Satisfactory mechanical performance and electronic control has been achieved. Verification tests to date are highly encouraging. Experimental tests are continuing.


CALIBRATION OF IRRIGATION HEADGATES BY MODEL ANALYSIS.

(a) D.N.A.D. Irrigation Companies, Delta, Utah.
(b) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State Univ., Logan, Utah 84321.
(c) Experimental; applied research.
(d) The D.N.A.D. Irrigation Companies have approximately 500 of these headgates in their distribution system and would like to use the headgate as a measuring device. Standards for the installation of such a headgate will be developed along with flow rate curves and tables.

Completed.

A general method of analysis was developed for rating submerged gates. The coefficient of discharge of the structure was markedly affected by the degree of relative submergence. Also, the location of the gate guide angles, whether facing upstream or downstream, affected the coefficient of discharge by 15 percent.


Irrigation Structures.

(a) Laboratory project.
(b) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State Univ., Logan, Utah 84321.
(c) Laboratory research.
(d) A compilation of the material pertaining to the design of small irrigation structures that would be found on a farm. Will also determine gaps in information which will require additional research.

A STUDY OF THE STRUCTURE AND EDDY DIFFUSIVITY OF TURBULENT SHEAR FLOWS IN ROUGH OPEN CHANNELS.

(a) Laboratory project.
(b) Dr. Calvin G. Clyde, Civil Engineering Dept., Utah State University, Logan, Utah 84321.
(c) Experimental and theoretical; basic research for PhD. Thesis.
(d) The objectives of the project are: (1) To describe the structure of the turbulent shear flows in rough open channels; (2) To see if local isotropy exists in the turbulence under study; and (3) To investigate the relationship of the structure of the turbulence to the process of diffusion in the flow. Work on (1) and (2) is mostly completed and is continuing on (3). The experimental studies have been conducted in a 3 foot flume artificially roughened on the bottom with expanded metal mesh. A total head tube with barium titanate as a piezoelectric sensor has been used to measure turbulent velocity fluctuations in the direction of the mean flow. The signal was analyzed with a random signal indicator and correlator, a delay line, and a spectrum analyzer. Measurements were made at a section where the boundary layer growth had reached the free surface and the flow was essentially two dimensional. A hot wire system is being developed so that all components of velocity can be measured.

Continuing

In the outer region of fully developed turbulent flow in the rough open channel, the wave number at which the transition between locally isotropic and anisotropic turbulence occurs is independent of Reynolds Number, but varies inversely with the depth of flow. Even in fully developed turbulent flow, local isotropy does not exist near the bed in the presence of steep mean velocity gradients. Hence, the concept of local isotropy is inadequate for obtaining the distribution of the rate of dissipation of turbulence energy and its use to evaluate the local rate in the outer region. The structure of the turbulence in the flows studied has been described in terms of longitudinal macroscale and microscale, relative intensity, and energy spectrum. The channel roughness has only an indirect influence on the structure of turbulence by transforming the flow into fully developed turbulent flow at a lower Reynolds Number. A procedure has been developed for estimating the statistical characteristics of the turbulence in fully developed turbulent shear flow in channels.

97
A Laboratory (semi-infinite) Development involving free formation materials.

(b) U. S. Bureau of Reclamation.
(c) Dr. Vaughn E. Hansen, Director, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.
(d) Experimental; applied research and development.
(e) Development of equipment and techniques for the aerial application of monolayer-forming materials.
(f) Completed.
(g) The performance of the equipment has been most satisfactory. Techniques have been developed for the use of alcohols in moisture and the use of powdered alcohols. Further research and development will be concerned only with powdered alcohols.


(5135) TECHNIQUES OF AERIAL APPLICATION OF EVAPORATION-REDUCING MATERIALS TO LARGE LAKES AND RESERVOIRS.

(b) National Science Foundation grant.
(c) Dr. Gordon H. Flammer, Professor of Civil Engineering, Utah State University, Logan, Utah 84321.
(d) Experimental and theoretical research leading to a doctoral dissertation.
(e) Lift forces on a hemisphere attached to a boundary will be studied for the following conditions: (1) an infinite uniform flow field; (2) a semi-infinite non-uniform flow field; (3) a finite uniform flow field without free surface; (4) a finite non-uniform flow field without free surface; (5) a finite uniform flow field with free surface; and (6) a finite uniform flow field with a free surface.

(f) This project was completed January 1, 1965.
(g) The objectives stated in item (e) have been realized.

(h) A doctoral dissertation has been published and is available at Utah State University. It is entitled, "Analysis of Drag Forces on a Hemisphere With Free Surface Effects," by Earl S. Mason, 1965.

(5136) STATE WATER PLAN INVESTIGATIONS.

(b) Dr. Jay M. Bagley, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.
(c) Dr. Jay M. Bagley, Civil Engrg., Dept., Utah State University, Logan, Utah 84321.
(d) Field investigation, applied research.
(e) Water supply and use determinations and projections, frequency analyses of various kinds of hydrologic data.
(f) Hydrologic inventories of major study areas of state completed.


(5137) DRAG ON A HEMISPHERE IN A THREE-DIMENSIONAL INFINITE FLOW FIELD WITH FREE SURFACE EFFECTS.

(b) National Science Foundation Project.
(c) Dr. Gordon H. Flammer, Professor of Civil Engineering, Utah State University, Logan, Utah 84321.
(d) Experimental and theoretical research toward a Ph.D. dissertation.
(e) The objectives are to study and compare drag on a hemisphere attached to a boundary for: (1) A three-dimensional infinite non-uniform flow field where viscous forces are important; (2) a semi-infinite non-uniform flow field where viscous forces and shape of the velocity profile are important; (3) a finite uniform flow field without free surface where viscous forces, relative submergence, and relative submergence profile shape are important; (4) a finite non-uniform flow field without free surface where viscous forces, relative submergence and Froude number are important; (5) a finite non-uniform flow field with a free surface where viscous forces, relative submergence, and Froude number and velocity profile shape are important; and (6) a finite non-uniform flow field with a free surface where viscous forces, relative submergence, Froude number and velocity profile shape are important.

(f) The objectives stated in item (e) have been realized.

(h) A doctoral dissertation has been published and is available at Utah State University Library. It is entitled, "Analysis of Drag Forces on a Hemisphere With Free Surface Effects," by Earl S. Mason, 1965.
will provide the basis on which to predict the effect of future development so that alternative resource use patterns for the lake and its tributary system can be evaluated.

Complete.

Water budget for lake and tributary areas has been completed. Mean annual inflow to Great Salt Lake calculated to be: Bear River drainage, 910,000 a.f.; Weber River drainage, 480,000 a.f.; Jordan River drainage, 270,000 a.f.; other tributaries, 30,000 a.f. Total surface and groundwater inflow, 1,650,000 a.f. Report in process.

(5440) ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS.

(b) Dr. Jay M. Bagley and Prof. Duane G. Chadwick, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(c) Dr. Jay M. Bagley, Assoc. Prof., Civil Engineering Dept. and Prof. D. L. Chadwick, Asst. Prof. Electrical Engineering Dept., Utah State Univ., Logan, Utah 84321.

(d) Experimental.

(e) An electronic analog model of a river basin is being used to study hydrologic processes of precipitation, snowmelt, surface and subsurface runoff, groundwater storage and movement, evapotranspiration, streamflow, etc. The model is being used to predict performance of various parts of hydrologic system resulting from proposed water and development schemes.

(f) Model completed. Continuing liaison in the operation and utilization.

(g) Completed model being effectively utilized in the Sevier River Basin Investigations of the Soil Conservation Service. Final report in process.

(5444) EVALUATION OF EVAPORATION RETARDANTS FOR AERIAL APPLICATION.

(b) The Proctor and Gamble Company.

(c) Dr. Vaughn E. Hansen, Director, Utah Water Research Laboratory, Utah State Univ., Logan, Utah 84321.

(d) Applied research and field investigations.

(e) Evaluate various chemical compositions and particle size gradations of evaporation retardants to determine suitability for aerial application techniques. Particular emphasis will be given to the longer chain fatty alcohols, C<sub>20</sub> and C<sub>22</sub>.

(f) Suspended.

(5445) NEW CONCEPTS OF HYDROLOGIC INSTRUMENTATION.

(b) Laboratory project.

(c) Professor Duane G. Chadwick, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(d) Experimental and field investigation; applied research and design.

(e) Theoretical measurement or evaporation, evapotranspiration, and sublimation is being attempted by the application of new electronic, sonic, and optical techniques.

(5442) EVAPORATION AND CLIMATIC STUDIES.

(b) Laboratory project.

(c) Professor Joel E. Fletcher, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(d) Experimental; applied research.

(e) Evaporation and land, snow, and water surfaces constitutes the principal losses of water to the United States. The investigation of factors which affect the quality, quantity, and timing of these losses from a climatic standpoint are being investigated in order to assist in the more precise formulation of plans of water utilization.

(f) On the basis of disregarding, it appears that many of Utah's irrigation projects have been designed on the basis of a short, wet cycle.

(g) Improvements have been made on the developed equations and the solutions.

(5443) MICROCLIMATIC HYDROLOGY.

(b) Laboratory project.

(c) Professor Joel E. Fletcher, Utah Water Research Laboratory, Utah State Univ., Logan, Utah 84321.

(d) Experimental and field investigation; applied research.

(e) For evaluating and measuring the microclimatic factors associated with water supply and use are being investigated.

(5444) DESIGN AND CALIBRATION OF A SUBMERGED RECTANGULAR FLUME.

(b) D.H.A.D. Irrigation Companies, Delta, Utah.

(c) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(d) Design; applied research.

(e) A rectangular flume was designed to operate under submerged flow conditions throughout the entire range of discharges between 20 and 500 cfs. The flume is to be calibrated in place.

(f) Completed.

(g) The flume has been constructed and field calibration data obtained.


(5445) TRAPEZOIDAL MEASURING FLUMES.

(b) Laboratory project.

(c) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(d) Design; applied research.

(e) A proposed trapezoidal measuring flume with a design discharge of 300 cfs has been modeled in the laboratory. The purpose of this investigation is to arrive at proper design and also to determine the feasibility of using this type of flume with both critical depth and submerged flow.

(f) Testing program has been completed. Results to date do not look very promising regarding the use of this type of flume for discharge measurement under submerged flow conditions.


(5446) THEORY OF INFILTRATION AND FLUID MOVEMENT IN UNSATURATED POROUS MEDIA.

(b) Laboratory project.

(c) Dr. Yu-Si Pok, Utah Water Research Laboratory. Utah State Univ., Logan, Utah 84321.

(d) Theoretical, experimental; basic research, applied research.

(e) To develop mathematical relationships expressing the phenomena of infiltration. Primary interest is the infiltration of water into the soil. Further development is to extend the developed theory to other fluid and media.

To develop mathematical relationships expressing the fluid movement in unsaturated porous media. The primary interest is the movement of water in unsaturated soil. To evaluate the validity and applicability of the relationships developed from the mathematical analysis by field and laboratory tests.

(f) Improvements have been made on the developed equations and the solutions.

89
HYDRAULICS AND EFFICIENCY OF IRRIGATION APPLICATION.

Laboratory project.

Dr. A. Alvin Bishop, Dept. of Civil and Irrigation Engineering, or Dr. Yu-Si Pok, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

Theoretical with field investigation; applied research.

To develop basic mathematical relationships expressing the hydraulic properties of the irrigation system.

To evaluate the validity and reliability of these relationships which have been developed from mathematical analysis by field and laboratory tests.

To develop the nomographs for use with these equations developed.

To develop the relationships for application efficiency and distribution efficiency, which will specify the irrigation rate, advance rate, and the ratio of the required irrigation time to the required irrigation water advance time to cover the whole area of a field.

Improvements have been made on the developed equations.

Analysis of water advance in surface irrigation, by Yu-Si Pok and A. Alvin Bishop, Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, paper No. 4859, March 1966.

EVALUATION OF ELECTRONIC ANALOG DEVICES TO SOLVE HYDROLOGIC AND RIVER BASIN PLANNING PROBLEMS.

Office of Water Resources Research.

Dr. Jay K. Bagley and Prof. Duane G. Chadwick, Utah Water Research Lab., Utah State Univ., Logan, Utah 84321.

Experimental, design, and development.

A comprehensive study and new development of hydrologic relations employed in current model. Design improvements will be made in order to handle a greater range and variety of problems with more flexibility, reliability, and speed of operation.

SEQUENTIAL WATER USE WITHIN A HYDROLOGIC COMPLEX.

Laboratory project.

Dr. Calvin G. Clyde, Prof. of Civil Engrg., Utah Water Research Lab., Utah State Univ., Logan, Utah 84321.

Theoretical, applied research, for Ph.D. dissertation.

Past studies of conjunctive use of surface and ground waters have usually involved a selection of the best alternative among a number of different plans. The purpose of this project is to develop a true conjunctive use methodology for conjunctive use systems utilizing operations research and involves the following steps:

1. General definition of the problem.
2. Development of the mathematical model of the hydrologic system.
3. Selection of the optimization technique.
4. Detailed statement of the parameters, equations, and constraints.
5. Use of a digital computer for the actual optimization.

OPTIMIZING CONJUNCTIVE USE OF SURFACE AND GROUND WATERS.

Laboratory project.

Dr. Calvin G. Clyde, Prof. of Civil Engrg., Utah Water Research Lab., Utah State Univ., Logan, Utah 84321.

Theoretical, applied research, for Ph.D. dissertation.

Past studies of conjunctive use of surface and ground waters have usually involved a selection of the best alternative among a number of different plans. The purpose of this project is to develop a true conjunctive use methodology for conjunctive use systems utilizing operations research and involves the following steps:

1. General definition of the problem.
2. Development of the mathematical model of the hydrologic system.
3. Selection of the optimization technique.
4. Detailed statement of the parameters, equations, and constraints.
5. Use of a digital computer for the actual optimization.

ATMOSPHERIC WATER RESOURCES IN UTAH.

United States Bureau of Reclamation.

Prof. Joel E. Fletcher, Utah Water Research Lab., Utah State Univ., Logan, Utah 84321.

Project is experimental and could be classed as both basic and applied research.

Cloud seeding is to be done along the Wasatch Front to determine the feasibility of increasing water supplies, delineating the areas affected by individual generators, and determining the unique characteristics of the water producing storm systems.

HYDRODYNAMICS OF FREE SURFACE FLOW OVER HYDRAULIC STRUCTURES.

Laboratory project.

Dr. Gary Z. Watters, Assistant Professor of Civil Engineering, College of Engineering, Utah State University, Logan, Utah 84321.

Theoretical and experimental, theoretical and applied.

An approximation to real-fluid flow over simple hydraulic structures is being attempted by using a rotational ideal fluid. It is hoped that eddies and separation patterns will be somewhat similar locally to those of a real fluid. The theoretical results will be compared with the actual flows.

A change in the direction of the project has resulted in an effort to duplicate more closely real-fluid flows.

EVALUATION OF REMOTE ELECTRO-MAGNETIC SENSORS FOR DETECTING TRANSPIRATIONAL WATER USE BY PLANTS SUBJECTED TO VARIOUS POLAR CHEMICAL TREATMENTS DESIGNED TO REDUCE TRANSPIRATIONAL LOSSES.

Utah Center For Water Resources Research.
(c) Research Engineer, Frank W. Haws, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.

(d) Experimental, applied research, development,

(e) Objects on the earth, both living and lifeless, are selective absorbers or reflectors of the electro-magnetic energy emitted by the sun. The presence of water in some of these substances such as plant tissue or soils changes the spectral reflectance or absorption characteristics of the substance. It is the purpose of this project to be changed and to determine if spectral differences can be detected by remote sensors in such a manner that transpiration of water by native forest vegetation can be measured photometrically, methods, including film-filter combinations, and image-forming devices using infra-red detectors will be investigated. Field plots have been established on the forest in order to manipulate the vegetation and measure the resulting alteration of transpiration.

Overland Flow.

Laboratory project.


Theoretical; basic research.

The general differential equation for overland flow describes a great variety of practical problems such as surface irrigation, the hydrologic analysis of basins and the spreading of water over infiltration areas for ground-water recharge. The objective of this research is to determine the general solution to the equation by finite difference methods and illustrate the dependence of the solution on the parameters involved by presenting the important phases of the solution in dimensionless form.

Preliminary and simplified studies of the equation reveal that the solution is strongly affected by the inflow and outflow conditions as well as the roughness and slope of the channel.

Resistance to sediment-laden turbulent flow over schematic dunes.

Laboratory project.


Theoretical and experimental; basic research.

Sediment-laden turbulent flows in alluvial streams are the complex flow phenomena in which the effects of the bed interface to deposit and scour the sediments thereby shaping a variety of movable beds. This research is to apply the principles of sediment-laden turbulent flow to a sediment-laden turbulent flow over a rigid boundary to the problem of flow in an alluvial channel.

A preliminary analysis has indicated that the contributions to the resistance from bed-surface roughness, bed configuration, instability of free surface waves, and interference of the suspended sediments are so interrelated that any study of the individual effect will not entirely describe the trends in the variation of the universal constant in the Karman-Flamand law and the Darcy-Weisbach friction coefficient, f.

Ultrasonic measurement of the size distribution and concentration of natural sediments in suspension.

Engineering Experiment Station Project, Utah State University.

Dr. Gordon H. Flammer, Prof., Civil Engrg., Dept., Utah State Univ., Logan, Utah 84321.

Experimental study; applied research.

One of the most difficult problems in the study of sediment mechanics is that of instrumentation. This study applies the ultrasonic technique to the measurement of sediment size distribution and concentration for suspended sediments.

The results of the National Science Foundation Project entitled "The Effect of Sediment Properties on the Attenuation of an Ultrasonic Plane Wave" have been a significant measurement technique for natural sediments. An MS. thesis has been prepared giving the results. The results of the thesis show surprisingly good accuracy of the measurement of both size distribution and concentration.


Pressure, shear and velocity distribution around a hemisphere on a boundary in a finite three-dimensional flow field with free surface effects.

National Science Foundation grant.

Dr. Gordon H. Flammer, Prof. of Civil Engrg., Utah State University, Logan, Utah 84321.

Experimental and theoretical research leading to a doctoral dissertation.

The objectives of this study are to determine the flow characteristics in the immediate vicinity of a hemisphere located on a boundary in a finite three-dimensional flow field with free surface effects. Such flow characteristics as the velocity distribution, the pressure distribution, the stream stress distribution and boundary layer development and separation patterns will be studied.

This project will be completed by January 1, 1967.

Turbulence characteristics of flow around a hemisphere in a velocity gradient field with free surface effects.

National Science Foundation Project.

Dr. Gordon H. Flammer, Prof., Civil Engrg., Dept., Utah State University, Logan, Utah 84321.

Experimental and theoretical research leading to a doctoral dissertation.

To study such instantaneous properties of the flow field in the near vicinity of the hemisphere as the measurement of turbulence intensity, space correlations, cross correlations, the auto correlation curve, the instantaneous lift and drag forces on the hemisphere as related to turbulence characteristics near the hemisphere surface. The influence of the free stream turbulence of the hemisphere placed in the flow upstream, and to deduce the relative decay of turbulence behind the hemisphere, also, to investigate the turbulence near the hemisphere for the semi-infinite non-uniform flow field, the finite non-uniform flow field without a free surface, and the finite non-uniform flow field with a free surface.

Turbulence characteristics of flow around an isolated cube in a velocity gradient field in a free surface effects.

National Science Foundation Project.

Dr. Gordon H. Flammer, Prof., Civil Engrg. Dept., Utah State University, Logan, Utah 84321.

The project is experimental and theoretically in nature leading to a doctoral dissertation.

To study the instantaneous properties of the flow field in the near vicinity of the cube such as intensity of turbulence, space correlations, cross correlations, the auto correlation curve, instantaneous drag and lift forces correlated with the turbulence characteristics of the hemisphere wake turbulence decay; and to compare the intensity of turbulence decay for the hemisphere for (1) a semi-infinite non-uniform flow field; (2) the finite non-uniform flow field without a free surface; and (3) a finite non-uniform flow field with a free surface.

Analysis of lift and drag forces on a cube in a velocity gradient, finite flow field with free surface effects.

91
(b) National Science Foundation.
(c) Dr. Gordon H. Flammer, Prof., Civil Engrg. Dept., Utah State University, Logan, Utah 84321.
(d) The project is experimental and theoretical in nature leading to a doctoral dissertation.
(e) This project is to determine the laws governing the lift and drag forces on a cube in (1) and infinite uniform flow field; (2) a semi-infinite non-uniform flow field; (3) a finite uniform flow field without a free surface; (4) a finite non-uniform flow field without a free surface; (5) a finite uniform flow field with a free surface; and (6) a finite non-uniform flow field with a free surface. (5762)

ENERGY DISSIPATION IN HIGH GRADE OPEN CHANNELS WITH SEMI-CIRCULAR DISK ROUGHNESS ELEMENTS OF SIZE ORDER EQUIVALENT TO THE DEPTH OF FLOW.

(b) Laboratory project.
(c) Dr. Gordon H. Flammer, Prof. of Civil Eng., Utah State University, Logan, Utah 84321.
(d) Experimental and theoretical research for a M. S. Thesis.
(e) This study was made to gain further information on flow characteristics around semi-circular roughness disks of the order of the depth in high grade channels. This information will be of value in the design of energy dissipators and in better understanding of the laws governing flow in high grade streams such as mountain streams. The friction factors were to be studied and also the effects of spacing, size and distribution of the roughness elements on the flow characteristics. Also, the flow regimes were noted, both as defined by Dean Peterson and by Morris. "Energy Dissipation in High Grade Open Channels With Semi-Circular Disk Roughness Elements of Size Order Equivalent to the Depth of Flow." by Robert Krallatter, M. S. Thesis, Utah State Univ. Logan, Utah, 1966.

DRAG COEFFICIENTS AND PRESSURE DISTRIBUTION FOR SEMI-CIRCULAR DISK ROUGHNESS ELEMENTS FOR VARIOUS ROUGHNESS PATTERNS AND FLOW CONDITIONS.

(b) Laboratory project.
(c) Dr. Gordon H. Flammer, Prof. of Civil Engrg., Utah State University, Logan, Utah 84321.
(d) Experimental and theoretical research for a M. S. Thesis.
(e) The objectives of this study were: to determine drag coefficients on individual roughnesses using various roughness patterns and flow conditions; and to determine the friction factor for each roughness pattern and flow condition in order to correlate these results with those of previous studies carried on at Utah State University; and further to determine the pressure distribution around a semi-circular disk using various roughness patterns and flow conditions. Semi-circular disk roughness elements were used as large roughnesses in four different patterns. An empirical equation was developed to relate the friction factor, the roughness density and the drag coefficient. A theoretical equation was also derived and compared with the empirical. Close agreement was found to exist. "Drag Coefficient and Pressure Distribution for Semi-Circular Disk Roughness Elements for Various Roughness Patterns and Flow Conditions." by German Uzostegui-Griseno, M. S. Thesis, Utah State University, Logan, Utah, 1965.

DRAG AND SURFACE WAVE CHARACTERISTICS FOR THE ISOLATED SEMI-CIRCULAR DISK IN A FINITE THREE-DIMENSIONAL FLOW FIELD WITH FREE SURFACE EFFECTS.

(b) National Science Foundation Project.
(c) Dr. Gordon H. Flammer, Prof., Civil Engrg. Dept., Utah State University, Logan, Utah 84321.
(d) Experimental and theoretical leading to Ph.D. dissertation.

To study the drag on an isolated disk on a boundary for (1) an infinite uniform flow field; (2) a semi-infinite non-uniform flow field; (3) a finite uniform flow field without a free surface; (4) a finite non-uniform flow field without a free surface; (5) a finite uniform flow field with a free surface; and (6) a finite non-uniform flow field with a free surface. The surface wave characteristics will be studied for items (5) and (6).

SUBMERGED OPEN CHANNEL FLOW MEASUREMENT STRUCTURES.

(b) Office of Water Resources Research, U. S. Department of Interior.
(c) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.
(d) Experimental; applied research.
(e) A hydraulic model study is being undertaken to provide calibration curves. An experimental model is being designed and constructed wherein the length of the entrance, throat, and exit may be varied; the width of the throat may be varied; the sides of the model may be placed in various ways to form either rectangular or trapezoidal shapes; and the degree of convergence and divergence may be varied. In addition to the above quantities, the effects of conditions in the channel both upstream and downstream from the flume, the scale factor, and roughness of the flume walls and floor will be evaluated.

SUBMERGED FARSHALL FLUMES.

(b) Laboratory project.
(c) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Lab., Utah State University, Logan, Utah 84321.
(d) Experimental; applied research.
(e) An approach previously developed for analyzing submerged flow in rectangular and trapezoidal measuring flumes will be verified in the laboratory for Farshall flumes. In addition to the laboratory tests, existing data reported by Farshall and other investigators will be analyzed.

The method of analyzing submerged flow previously developed has been found valid for Farshall Flumes.


MODIFICATIONS TO GATE-PARSHALL FLUME STRUCTURE.

(b) Utah Highway Department.
(c) Mr. Gaylord V. Skogerboe, Asst. Research Engineer, Utah Water Research Laboratory, Utah State University, Logan, Utah 84321.
(d) Experimental; applied research.
(e) Twin turnout structures have been constructed from the Davis-Weber Canal which employ a gate followed by a four-foot Parshall flume four feet deep. The flow passing through the flume is supercritical. Modifications to the turnout structures will be studied with a prototype structure constructed in the laboratory.

(5763)

(5764)
THE EFFECT OF SEEPAGE ON THE HYDRODYNAMIC FORCES ACTING ON NON-CHEESE BED PARTICLES IN A FLOWING CHANNEL.

Laboratory project.
Dr. Gary Z. Watters, Asst. Prof. of Civil Engrg., College of Engrgr., Utah State Univ., Logan, Utah 84322.
Experimental and basic research.
This project is to investigate the effect of seepage flow on the pressure forces (shear forces are negligible) acting on one of a number of hemispheres on a flowing stream bed. The change in the forces, namely, the lift and drag, is to be noted and the gross effect on the flow pattern past the hemispheres will be observed. These hemispheres are to represent qualitatively the natural bed material.
Completed.
Seepage was found to have an effect on the lift and drag forces. The dynamic forces (in addition to buoyancy) were found to decrease up to 45% for seepage from the bed into the flow. However, for seepage from the flowing channel into the porous bed, no measurable change in lift or drag was noted.

VANDERBILT UNIVERSITY, Dept. of Civil Engineering.

SINGLE PHASE FLUID FLOW THROUGH POROUS MEDIUMS.

Laboratory project.
Dr. Donald Dean Adrian, Assist. Prof. of Sanitary and Water Resources Engineering, Box 1625-Station B, Vanderbilt University, Nashville, Tenn. 37203.
Basic research of a theoretical nature using published experimental data.
This work is being carried out to better understand the flow of fluids through a porous medium in the presence of air. The air is assumed to remain stationary. The soil moisture diffusivity and a pore size distribution factor, called the "randomicity" function, are evaluated from published experimental data.
The diffusivity varies over several orders of magnitude with changes in the moisture content. The randomicity function follows a similar variation. Calculations using these functions are subject to instabilities due to the large changes which occur with small changes in the moisture content.


TURBULENT DIFFUSION AND RIVER WATER ASSIMILATIVE CAPACITY.

Division of Water Supply & Pollution Control, U. of Public Health Service.
Dr. Peter A. Krenkel, Assoc. Prof. and Director (5690)
Sanitary and Water Resources Engineering, Box 1670-Station B, Vanderbilt University, Nashville, Tenn. 37203.
Field and laboratory observations are used to verify theoretical considerations of the relation between turbulence and gas absorption. The investigations involve basic and applied research and both Master's and Ph.D. theses will result from the studies.
The project objectives are: To determine the applicability of the various mixing models describing turbulent diffusion to river flow, to examine laboratory and field methodology for determination of the various mixing coefficients in the laboratory and field under controlled conditions, utilizing pulse testing techniques, VIDYA DIVISION, Itek Corp.

THE EFFECT OF FLOW SEPARATION FROM THE HULL ON THE STABILITY OF A HIGH SPEED SUBMARINE.

Office of Naval Research, David Taylor Model Basin (Naval) under the Bush Foundation Hydrodynamics Program.
Mr. S. B. Spangler, Vidya Division, 1450 Page Mill Road, Palo Alto, Calif. 94304.
Theoretical; applied research.

The previous work on hull flow separation and the vortex interference on the hull and stern control surfaces due to the lift on the fairwater and fairwater planes is being extended to the case of steady pitching and yawing angular motions of the submarine. The purpose of this work is to obtain methods for predicting the variation, particularly the nonlinear portion, of forces and moments with angular rates.

Results for low angular pitching and yawing rates at zero angles of attack and sideslip indicate that forward appendage interference effects are significant for the steady yawing angular velocity case, due to the fairwater load distribution, but are not significant for the steady pitching case.

(5500) INTERFERENCE BETWEEN A HULL AND A Stern-MOUNTED DUCTED PROPELLER.

(b) Dept. of the Navy, Bureau of Ships Fundamental Hydrodynamics Research Program.

(c) Dr. A. R. Kriebel, Staff Engineer, Vidya Division of Itek Corp., 1450 Page Mill Road Palo Alto, Calif. 94304.

(d) Theoretical Investigation; applied research.

(e) A hydrodynamic analysis of a sideline of an underwater hull and a stern-mounted ducted propeller in steady axially symmetric flow. Singularity distributions are used to represent a typical hull, the hull wake, a thin cambered duct, and a propeller which adds a uniform velocity to the streamwise. The pressure distribution and boundary layer of the duct are predicted along with the interference forces between the hull, duct, and propeller versus the length, thrust, loading distribution, and Reynolds number of the duct. The purpose of the analysis is to determine how much thrust can be carried by a duct. A highly loaded duct might reduce the sound generated by the pressure field rotation with the propeller and the induced vibration of the hull.

(f) Discontinued.

(g) Duct camber lines are chosen to minimize the duct leading-edge suction, hull-duct interference, and separation of the duct boundary layer. Under the assumed conditions, computed results show that the duct can carry only about 7 percent as much thrust as the propeller without flow separation from the outer duct surface. Boundary layer control appears to be required to obtain more duct thrust.


(5541) PREDICTED AERODYNAMIC COEFFICIENTS AND DYNAMIC DERIVATIVES FOR DUCTED PROPELLERS.

(b) Bureau of Naval Weapons, Dept. of the Navy.

(c) Dr. A. R. Kriebel, Staff Engineer, Vidya Div. of Itek Corp., 1450 Page Mill Road, Palo Alto, California 94304.

(d) Theoretical investigation; applied research.

(e) The main purpose of the current analysis is to express the previous theoretical results (1965 Reference Number 5201) in terms of an arbitrary ducted-propeller configuration. The aerodynamic characteristics of the duct have been predicted previously in terms of the thrust coefficient of the propeller with the assumption of uniform blade loading. The extended analysis will predict the inflow to the propeller, radial and azimuthal variations of blade loading, and the effect of these variations on the duct force and moment. The previous analysis of the aerodynamic interference between a pair of ducted propellers is also being extended, and a duct stall criterion is being developed.

(f) Preliminary results indicate that the effects of azimuthal variations of propeller loading are small. Radial variations of propeller loading appear to have little effect upon the duct thrust, but the duct lift force increases rapidly when the propeller blade loading is shifted toward the blade tips.

Virginia Polytechnic Institute, Dept. of Civil Engineering.

(5533) USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION.

(b) Virginia Council of Highway Investigation and Research and U. S. Bureau of Public Roads.

(c) Dr. H. M. Morris, Professor and Head, Dept. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 24061.

(d) Analytical and experimental; basic research.

(e) Studies are being made to develop general design criteria for flow dissipation in steep channels with large roughness elements. The characteristics of the "tumbling-flow" regime are of special interest. Design applications for chutes, culverts, and other highway drainage structures are in view.

(g) Two programs reports have been issued.


(5554) HYDRAULIC EFFECTS OF BOUNDARY ROUGHNESS.

(b) Laboratory project.

(c) Dr. H. M. Morris, Professor and Head, Dept. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 24061.

(d) Analytical and experimental; basic research.

(e) Systematic studies are being made to delineate the various regimes of turbulent flow in rough pipes in terms of each dimension of the boundary roughness geometry, with the aim of attaining comprehensive quantitative criteria for all regimes.

(f) Experimental work completed. Turbulent flow regimes have been delineated and quantitative criteria for recognition established.

(5566) SEPARATION OF SOLIDS AND LIQUIDS AT FLOW TRANSITION BOUNDARIES.

(b) National Science Foundation.

(c) Dr. H. R. Bungay, Prof. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 24061.

(d) Analytical and experimental; basic research.

(e) A study was made of the hydraulic characteristics of "clear zones" (zones of clear liquid appearing in suspensions) as produced in vessels filled with a fluid suspension set in motion by stirring action and in flow of the fluid suspensions around obstacles in a channel.

(f) Completed.

(g) Characteristics of the clear zones have been studied and a simplified theoretical analysis has been developed, based on the migration of particles across laminar flow streamlines induced by unequal Bemoulli pressures. Applications to sediment transport, flow of blood corpuscles, flow of disease bacteria, and the handling of fibers as in papermaking seem to be indicated.


(5566) HYDRAULIC DISRUPTION AND RE-ENTRAINTMENT OF FROTH.

(b) Division of Water Supply and Pollution Control, U. S. Public Health Service, and Virginia Engineering Experiment Station.

(c) Dr. W. A. Parsons, Prof. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg,
(d) Analytical and experimental; basic and applied research; Ph.D. Thesis. 
(e) Studies are being made to develop methods to disrupt froth generated in aerobic fermentation processes; hydraulic methods are desired in order to avoid use of bioresistant chemical antifoams which would retard oxygen transfer.

(f) Completed.

(g) Experimental measurements have been completed.

5957 SURGE AND ROLL WAVE PHENOMENA IN STEEP, ROUGH CHANNELS.

(b) Laboratory project, supported in part by Virginia Council of Highway Investigation and Research in cooperation with U. S. Bureau of Public Roads.

(c) Dr. H. M. Morris, Professor and Head, Dept. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

(d) Analytical and experimental; basic research; Ph.D. thesis.

(e) Unsteady flow phenomena in the form of surges and roll waves are experienced under some conditions in steep channels with rough beds. The characteristics of these phenomena and criteria for their formation are being studied.

(g) Experimental studies are in progress, using a large flume with various bed roughness geometries and electronic recording equipment for the transient phenomena.


5958 VELOCITY DISTRIBUTIONS IN OPEN CHANNELS WITH LARGE BED ROUGHNESS.

(b) Laboratory project, supported in part by Virginia Council of Highway Investigation and Research in cooperation with U. S. Bureau of Public Roads.

(c) Dr. H. M. Morris, Professor and Head, Dept. of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.

(d) Analytical and experimental; basic research; Ph.D. Thesis.

(e) Velocity and pressure distributions are directly related to loss coefficients and surface phenomena in open channels, but very little information is available of this sort for hyper-rough beds. Detailed flow profiles are being obtained and analyzed for the tranquil, tumbling and rapid regimes in such channels.

(g) Experimental studies are in progress, using a large tilting flume and pitot traversing equipment; data are programmed for processing on digital computer.


WILLIAM HUTCHISON, Virginia Polytechnic Institute, Dept. of Mechanical Engineering.

5537 PLUID JET CONTROL.

(b) National Science Foundation (Grant OK 34).

(c) Dr. Robert A. Comarin, Assoc. Prof. of Mechanical Engineering, Virginia Polytechnic Inst., Blacksburg, Virginia 24061.

(d) Analytical and experimental study in part for Master's thesis.

(e) This project is a study of jet reattachment phenomena at low Reynolds Numbers. Detailed flow studies will include both parallel and inclined walls and the effects of aspect ratio, offset, and wall angle.

(g) Data have been obtained for reattachment distances as a function of Reynolds number for an inclined wall at various angles. Significant three-dimensional effects have been noted with an aspect ratio of ten.

(h) "Jet Reattachment to an Inclined Wall at Low Reynolds Numbers," by Robert Brent Moore Jr., M.S. thesis, Virginia Polytechnic Institute, September 1965.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Dr. E. Roy Tinney, Head, The R. L. Albrook Hydraulic Laboratory, Division of Industrial Research, Washington State University, Pullman, Washington 99163.

1669 STUDY OF FLUID FLOW IN PIPE NETWORKS.

(b) Personnel responsible for the design and/or operation of water and gas distribution systems.

(d) Analyses by analogue and digital computers.

(e) Flow distributions have been made with the Mellroy Analyzer for over 50 cities, several gas systems, and several water systems. Losses throughout the system are obtained. Engineers use the analogue to design pump systems, tank sizes, and piping additions or revisions.

5948 CALIBRATION OF FLOW METERING FLUMES.

(b) Agricultural Research Service, Boise, Idaho.

(d) Experimental, development.

(e) A standard weir design is being studied to determine whether or not calibration curves can be developed for specific stream gaging stations without requiring extensive field or laboratory experimental calibration.

(g) Data analysis indicates that gaging site condition and flume size do not influence the discharge characteristics of the flume at discharges less than a certain percentage of the design capacity. Upstream bed slope and flume orientation affect these characteristics at larger flows if these parameters are greater than given magnitudes.


4721 MODEL CALIBRATION OF ROCK ISLAND SPILLWAY.

(b) Public Utility District of Grant Co., Washington.

(d) Experimental; analytical.

(e) A 1:50 scale model of the west section of the Rock Island Dam spillway was constructed. Tests were made to determine the discharge coefficients for each bay as they may be influenced by adjacent and nearby bays, tailwater and apron elevations, and distribution of flow approaching the spillway discharges. Accurate discharge ratings were required in connection with power losses due to tailwater encroachment at Rock Island by the Wanapum pool.

(f) Complete.

(g) A technique was developed to compute discharge through the western section of the spillway. Effects of upstream topography, tailwater elevation, and spillway gate opening are noteworthy.


4724 WELLS COMPREHENSIVE MODEL.

(b) Bechtel Corporation.

(d) Experimental; design.
(e) A 1:78 model of the Wells Hydrocombine has been constructed to study potential erosion, wave action, passage of migratory fish, spillway safety, and construction sequences. Since the power house and spillway are combined into one structure, several unique problems in design and operation must be investigated. The model is 44 feet wide and 66 feet long and will pass the equivalent of 1,300,000 cfs.

(f) Completed.

(g) Tests on project layout and operation provided a sound basis for modifying original plans. Additional stream channel protection was required to prevent undue erosion. A rather unusual fish attraction system including several strategically placed, high-velocity jet streams was developed. Downstream geometric formations will permit the spillway flow to scour its own escape channel thereby reducing costly machine excavation.


(5519) SOUND SUPPRESSOR-HYDRAULIC MODEL TESTS.

(b) George C. Marshall Space Flight Center, NASA.

(d) Experimental, development.

(e) Development of a vane system to produce uniformly distributed flow around a clover-shaped weir was studied. Surges produced by the rocket exhaust at ignition were investigated with a simulated vacuum chamber.


(5521) HILLS CANYON HYDROELECTRIC PROJECT.

(b) Idaho Power Company.

(d) Experimental; applied research.

(e) A 1:60 scale, comprehensive hydraulic model was utilized to study fish attraction flows for the fish transportation facilities.

(f) Complete.

(g) A simulated barge above the draft tubes of the powerhouse provides attraction flow through a weir and jet combination.


(5522) FLOW AROUND SHARP BENDS.

(b) Laboratory project.

(d) Theoretical, experimental, applied research.

(e) Project is being conducted to determine the optimum geometry of channel bends to minimize flow losses. Hydrodynamic theory is being developed to consider flow near the inside curve.

(h) Paper in preparation.

(5523) MECHANICS OF MASS DISPERSION AND ENERGY DISSIPATION IN FREE LAMINAR AND TURBULENT LIQUID SHEETS.

(b) Laboratory project.

(d) Theoretical, experimental, basic research.

(e) Two laminar or turbulent jets, colliding from opposite directions, form a thin expanding sheet or water-bell. G. I. Taylor's equation for the shape of a water-bell has been extended to include partial viscosity. Possible mechanisms for mass dispersion and energy dissipation in these sheets are being investigated.


(5524) HYDRAULIC MODEL STUDIES FOR THE ROCK ISLAND FISH ATTRACTION FACILITIES.

(b) Public Utility District of Grant County, Washington.

(d) Experimental.

(e) The purposes of the model study were, (a) to develop a method of opening and closing sequence to facilitate the passage of anadromous fish through the center and right bank fishladder, and (b) to document flow patterns and velocities in the spillway region under crevacement conditions caused by the construction of Wanapum Dam.

(f) Completed.

(g) The gate operating sequence appears to be adequate under field conditions.


(5742) CAVITATION AND BUBBLE FORMATION IN NEARLY SATURATED WATER FLOW.

(b) Laboratory project.

(d) Experimental, theoretical.

(e) The purpose of this project was to determine, if possible, the relationship between the scale of an object and the size of the bubble which forms behind it in the flow of water which is very close to its separation temperature.


(5743) FLUID MECHANICAL FORCES PRODUCING VIBRATION IN TRANSMISSION LINE CONDUCTORS.

(b) Bonneville Power Administration.

(d) Experimental, theoretical, master's thesis.

(e) This model study was conducted to investigate the fluid forces which produce vibration in electric transmission line conductors.

HYDRAULIC MODEL STUDIES OF THE IRON GATE DAM.

Bechtel Corporation.
Experimental-Applied Research.
Hydraulic Model studies were utilized to determine the hydraulic characteristics of a side-channel spillway, chute, and terminal structure.

Complete.


HYDRAULIC MODEL STUDIES OF POWERDALE DAM.

Pacific Power and Light Company.
Experimental - Applied Research.
The model study was performed to evaluate various hydraulic characteristics of the Powerdale Dam.

Complete.


HYDRAULIC MODEL STUDIES OF SULLIVAN CREEK DAM AND HEAD WORKS.

Pend Oreille County PUD No. 1, Washington.
Experimental - Applied Research.
A hydraulic model study performed to verify estimated spillway capacity, investigate performance of spillway tunnel entrance, and investigate stilling basin efficiency.

Complete.


UNIVERSITY OF WASHINGTON, Charles W. Harris

HYDRAULICS LABORATORY.

SALT WATER ENTRAINMENT FOR DILUTION IN SEWER OUTFALLS.


Prof. R. E. Nece, Dept. of Civill Engineering, University of Washington, Seattle, Wash., 98105.

Experimental; basic and applied research.
The mechanism of the entrainment of a fluid from an infinite region of ambient fluid through discrete ports in a conduit flowing full is to be studied experimentally and analytically. One possible application is for pre-dilution in marine sewer outfalls.

Data have been obtained for a range of single circular ports of varying sizes for zero and small density differentials between conduit and entrained fluids. Multi-port data have been obtained for the zero density difference case. Annular port data are being obtained.

Three M. S. theses completed (available on loan).

A STUDY OF INFILTRATION BENEATH A FOREST FLOOR.


Professor Thomas H. Campbell, Dept. of Civil Engineering, Univ. of Washington, Seattle, Washington 98105.

Field laboratory investigation.

Instrumentation permits continuous recording of flow past points in unsaturated flow field. Moisture content is also monitored by neutron probe. Transpiration is prevented and evaporation inhibited. Flow data obtained at various plan locations and at various depths can be displayed as hydrographs. Data is being obtained for a number of rainfall events.

Small anomalies in soil structure are proving to cause major anomalies in the soil moisture flow pattern.


HYDRAULICS OF FLOW OVER AN INCLINED, POROUS PLATE.

Laboratory project.

Prof. E. P. Richey, Dept. of Civil Engrg., Univ. of Washington, Seattle, Wash. 98105.

Flow distribution, surface profile determined as depending upon bed slope and porosity.

Completed.

BED SHEAR AS AN INDEX OF HYDRAULIC JUMP EFFICACY.

Laboratory project.

Prof. R. E. Nece, Dept. of Civil Engrg., Univ. of Washington, Seattle, Wash. 98105.

Experimental; basic research.
(e) Boundary shear stresses are used as an index of determining energy dissipation efficiency of hydraulic jump in rectangular stilling basins; the procedure provides another description of the effective length of the jump as that within which the bed shear is reduced to safe limits.

(g) Data have been obtained for jumps on a horizontal floor and with jumps having approach slopes of 1 in 5, 1 in 3, and 1 in 1.5. Limited shear data are available for two basin configurations containing end sills and baffle piers.

(h) One M.S. thesis completed (available on loan).

(5697) FLUID MECHANICS OF DOWNSTREAM FISH PASSAGE STRUCTURES.

(b) State of Washington Water Resources Research Center.
(c) Professor E. F. Richen, Dept. of Civil Engrg., Univ. of Washington, Seattle, WA 98105.
(d) Experimental, applied research; Master's thesis.
(e) Certain wedge-shaped obstructions in an open channel have been used to develop models of guidance to small, migrant fish. A laboratory experiment is being designed to determine the role of convective acceleration and other hydraulic parameters in the guidance phenomenon.

(5698) EFFECT OF DAM CONSTRUCTION ON DOWNSTREAM WATER TEMPERATURE.

(b) Office of Water Resources Research, and State of Washington Water Resources Research Center.
(c) Prof. R. E. Nece, Dept. of Civil Engrg., Univ. of Washington, Seattle, WA 98105.
(d) Field investigation; applied research.
(e) The object of this study is to correlate downstream water temperatures before and after dam construction with topographical, hydrological, and meteorological parameters of the drainage basin. Such data would provide a "model" for future dam development effects on certain aspects of water quality in comparable areas of the Pacific Northwest.

(g) Instrumentation being installed.

WEBB INSTITUTE OF NAVAL ARCHITECTURE.

(5202) DETERMINATION OF SHIP WAVE RESISTANCE.

(b) David Taylor Model Basin, Bureau of Ships, Dept. of the Navy.
(c) Dr. Lawrence W. Ward, Prof. of Engineering, Webb Institute of Naval Architecture, Glen Cove, Long Island, New York 11542.
(d) Experimental and theoretical; basic research.
(e) Investigation of means for direct experimental determination of wave resistance from measurements of the wave pattern during a model test. Purpose includes improvement in scaling model test results to full size as well as basic understanding of nature of ship resistance.

(g) Method utilizing forces exerted by the wave pattern on a long vertical cylinder has been developed and tests are run. Results are encouraging and in agreement with other investigators. Experimental wave resistance when added to estimated skin friction is less than measured total resistance. New method utilizing wave slope records is being investigated.


(5203) ASSESSMENT OF SEAKEEPPING CHARACTERISTICS OF SHIPS.

(b) Society of Naval Architects & Marine Engineers, Panel H-7 of Hydrodynamic Committee.

(c) Prof. Edward V. Lewis, Research Prof. of Naval Architecture, Webb Institute of Naval Architecture.
(d) Theoretical application of available experimental results and confirmation by model tests; applied research.
(e) Application of available knowledge of ship model behavior in regular waves to the prediction of trends of ship performance in realistic irregular wave patterns. Experimental confirmation by means of model tests in waves. Purpose is to provide the ship designer with guidance in the selection of hull characteristics.

(f) Theoretical work is completed; experimental phase is active.

(g) The advantage of a high length/draft ratio in permitting higher speeds before shipping water forward is clearly shown. A corresponding disadvantage in terms of likelihood of slamming is found, requiring a balance to be made in selecting optimum ship characteristics.


(5942) MODEL STUDIES OF SHIP SLAMMING IN WAVES.

(b) American Bureau of Shipping.
(c) Prof. Walter Maclean, Prof. of Engrg., Webb Inst. of Naval Architecture, Glen Cove, Long Island, New York 11542.
(d) Experimental study making use of ship models in waves; applied research.
(e) Two 5-foot models, joined at amidships for measurement of wave bending moments, are being run in waves to determine the conditions for bottom slamming to occur and to compare with theoretical predictions.

THE WESTERN COMPANY, Research Division.

(5291) EFFECT OF POLYMER COILING ON DRAG REDUCTION.

(b) David Taylor Model Basin, Fundamental Hydromechanics Research Program.
(c) Dr. H. R. Crawford, The Research Div. of The Western Company of North America, 1171 Empire Central, Dallas, Texas 75247.
(d) Experimental; basic research.
(e) Turbulent friction loss of dilute solutions of polymers in various solvent systems are being determined to relate the degree of polymer coiling to the turbulent drag reduction.

(5960) TURBULENT HEAT TRANSFER CHARACTERISTICS OF VISCOELASTIC FLUIDS.

(b) NASA Physics of Fluids Branch.
(c) Dr. H. R. Crawford, The Research Division of The Western Company of North America, 1171 Empire Central, Dallas, Texas 75247.
(d) Experimental; basic research.
(e) Turbulent heat transfer coefficients are being determined for viscoelastic solutions of various polymers in distilled water, to allow prediction of turbulent heat transfer characteristics for this type of fluid.

(5961) EFFECT OF MOLECULAR WEIGHT AND SEGMENTAL CONSTITUTION ON DRAG REDUCTION.

(b) David Taylor Model Basin, Fundamental Hydromechanics Research Program.
(c) Dr. H. R. Crawford, The Research Div. of The Western Co. of North America, 1171 Empire Central, Dallas, Texas 75247.
(d) Experimental; basic research.
(e) The turbulent drag reduction of dilute water solutions of various polymers were determined to relate drag reduction to the molecular weight and constitution of the polymer.
dimensions of the molecule.

(f) Correlation between molecular dimensions and drag reduction is presented in the report.


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UNIVERSITY OF WISCONSIN, Hydraulics and Sanitary Laboratories.

(556) ENERGY LOSS IN LIQUID FLOW IN PIPES AND FITTINGS UNDER HIGH PRESSURE.

(b) Laboratory project in cooperation with the Ladish Company, Cudahy, Wisconsin, and the Wisconsin Alumni Research Foundation.

(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, Univ. of Wisconsin, Madison, Wisconsin 53706.

(d) Theoretical and experimental; applied research and design for B.S., M.S. and Ph.D. theses.

(e) Energy loss measurement in straight pipes and fittings have been completed on sizes 1/4 inch to 2 inches. Pressure range 0-2500 psi, temperature range 60 to 120°F. Reynolds number range 50 to 150,000.

(f) Completed.

(g) If viscosity, density, and temperature relations are known, the standard pipe friction theory applies at high pressures. The fitting loss constants for laminar flow are about 5 times those for turbulent flow when Nu = 0000. The loss gradually reduces to zero at Nu = 150.

(1181) VORTEX FLOW FROM HORIZONTAL THIN-PLATE ORIFICES.

(b) Laboratory project.

(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, Univ. of Wisconsin, Madison, Wisconsin 53706.

(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.

(e) The effects of vorticity on orifice discharge are being studied over a wide range of vorticity, head, orifice size, and fluid viscosity.

(f) A new parameter, the vorticity number, was developed as the ratio of inertial and centrifugal forces. A general correlation procedure was also developed for estimating discharge through orifices with varying degrees of vorticity.


(5559) DISTURBED LAMINAR AND TURBULENT FLOW.

(b) Wisconsin Alumni Research Foundation.

(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, Univ. of Wisconsin, Madison, Wisconsin 53706.

(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.

(e) The equation of motion has been applied to several situations of disturbed laminar and turbulent flow and compared with experimental results. Flows are disturbed using orifices and screens. Turbulence is measured by a newly developed magnetohydrodynamic probe in conjunction with analog and digital computers to give the turbulence energy spectra.

(f) New equations have been developed for estimating losses due to combined and divided flow as well as losses due to other disturbances. Turbulence energy spectra have been developed for a wide variety of boundary configurations. The new probe permits the observation of the distribution of turbulent energy across the section of flow.


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MODELS OF PUMP INLET STRUCTURES (see page 106).

HYDRAULIC CHARACTERISTICS OF GRAVITY SEPARATION BASINS (see page 106).

REACTION JET INLET FOR OIL-WATER SEPARATORS.

The American Petroleum Inst.

Prof. O. A. Rohlic and Dr. J. R. Villemonte Hydraulics and Sanitary Laboratories, Univ. of Wisconsin, Madison, Wis. 53706.

(d) Experimental; basic research and design for master's and doctoral theses.

(e) Studies were conducted in a transparent basin 5 ft wide, 10 ft long and 3 ft deep. Investigations were made using various sizes and spacings of a reaction jet at the entrance to the basin to determine the effects of jet inflow on the hydraulic characteristics. Completed.

The hydraulic characteristics for rectangular basins with reaction jet inlet devices were observed using a wide range of flows.

CHANNEL DYNAMICS ABOVE GULLY CONTROL STRUCTURES.

(b) U.S. Department of Agriculture, Agricultural Research Service.

(c) Dr. Arno T. Lenz, Chairman, Dept. of Civil Engineering, University of Wisconsin, 1513 University Ave., Madison, Wisconsin 53706.

(d) Theoretical study and field investigation of basic research in channel dynamics for Ph.D. thesis.

(e) Data from field surveys of 44 gully control structures in Southwestern Wisconsin have been analyzed to develop procedures for estimating quantitatively the dynamic changes in channel profiles which occur when a gully control or sediment detention structure is built.

(f) Completed.

(g) An equation has been developed for the ratio of the average deposition slope to the original channel slope as a function of past and present hydraulic and sediment parameters.

CHARACTERISTICS OF A DENSITY STRATIFIED FLUID.

(b) U.S. Public Health Service and Laboratory Project.

(c) Dr. F. L. Monkmeyer, 12631 Engineering Bldg., Univ. of Wisconsin, Madison, Wis. 53706.

(d) Theoretical; basic research for Ph.D. thesis.

(e) Dynamic characteristics of density-stratified fluids are being investigated. Particular emphasis is being placed on a study of the mechanics of Langmuir Vortices, in an effort to explain the phenomenon of foam lines on lakes. Steady flow problems relating to standing internal waves are also under investigation.

(f) Linearized equations for steady, inviscid, compressible flow in atmospheres with various density distribution have been developed and solved for simple boundary configurations.

UNIT HYDROGRAPH VARIATION WITH STORM HYDROGRAPH SHAPE.

(b) Laboratory project.

(c) Dr. Arno T. Lenz, Chairman, Department of Civil Engineering, 1513 University Avenue, Madison, Wisconsin 53706.

(d) Theoretical study and field investigation of the unit hydrograph. Basic research for Ph.D. thesis.

(e) A general one-hour dimensionless unit hydrograph derived from 16 Illinois basins was used successfully to derive 92 one-hour unit hydrographs for four Midwest basins of 22 to 77 square miles in area for storms of 1 to 15 hours duration. Computations were made.
using IBM 1620 and CDC 1604 computers.

(e) The following problems in unsteady flow through a porous medium are under investigation: use of sound waves to determine permeability; effect of stream bank clogging on unsteady flow of ground water; unconfined, unsteady flow of groundwater toward a surface stream.

(4735) THE TRANSPORTATION OF RAINFALL ON THREE BASINS IN NORTH CENTRAL WISCONSIN.

(b) Laboratory project.
(c) Dr. A. T. Lenz, Chairman, Dept. of Civil Engineering, University of Wisconsin, 512 University Avenue, Madison, Wisconsin 53706.
(d) Experimental and theoretical; with field investigation; basic research for Ph.D. thesis.
(e) This study is to determine the relationships existing between rainfall, stream runoff, infiltration, groundwater, and evaporation with respect to three drainage basins in North Central Wisconsin which have both similar and dissimilar soil types and aquifers. Results based on published data.


(5011) HYDRAULIC CHARACTERISTICS OF CYLINDRICAL SLOT ORIFICES.

(b) W. A. Kates Company.
(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, Univ. of Wisconsin, Madison, Wisconsin 53706.
(d) Experimental; design.
(e) The effects of viscosity, head, and slot type and shape on the coefficient of discharge are being studied.

(5597) HYDRAULIC CHARACTERISTICS OF DROP INLETS.

(b) U. S. Department of Agriculture, Agricultural Research Service and Laboratory Project.
(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, Madison, Wisconsin 53706.
(d) Experimental; applied research for M.S. Thesis.
(e) Model studies will be made of a drop inlet structure located in the head waters of the Kickapoo River Valley, Chippewa, Wisconsin. The objective is to determine operating characteristics for several types of crest configurations.

(5598) CHARACTERISTICS OF GRAVITY WAVES.

(b) U. S. Army Mathematics Research Center.
(c) Dr. P. L. Monkmeier, 1261C Engineering Bldg., Univ. of Wisconsin, Madison, Wisconsin 53706.
(d) Theoretical; basic research.
(e) Higher order theories for finite height gravity waves are under study.

(g) A higher order non-linear theory for deep water waves of finite amplitude has been developed.


(5790) DISPERSION AND RE-CHARGE IN GROUND WATER FLOW.

(b) University of Wisconsin Alumni Research Foundation and the University of Wisconsin Water Resources Center.
(c) Dr. J. A. Hoopen, 1212 Engineering Building, University of Wisconsin, Madison, Wisconsin 53706.
(d) Theoretical and Experimental; Basic Research.
(e) Dispersion of a tracer in flow through non-homogeneous porous media is under study. Theoretical predictions; coupled with experimental confirmation for different patterns of non-homogeneity are being sought.

(5791) CIRCULATION AND MIXING PROCESSES IN LAKES.

(b) University of Wisconsin Water Resources Center.
(c) Dr. R. A. W. Batiste, 225 Science Hall, Univ. of Wisconsin, Madison, Wisconsin 53706.
(d) Theoretical and experimental; basic and applied research for Ph.D. thesis.

(7559) UNSTEADY FLOW IN FORCUS MEDIA.

(b) Wisconsin Water Resources Center.
(c) Dr. P. L. Monkmeier, 1261C Engineering Bldg., Univ. of Wisconsin, Madison, Wisconsin 53706.
(d) Theoretical and experimental; basic and applied research for Ph.D. thesis.
University of Wisconsin, Madison, Wisc. 53706.

This investigation deals with field and laboratory models of the current and temperature profiles of Lake Superior. These studies will be integrated and combined with mathematical models in an effort to understand and predict motions within the lake and the resulting distribution of substances introduced at various points in the lake.

Woods Hole Oceanographic Institution.

Hydromechanics of Rotating Liquids.

Office of Naval Research, Dept. of the Navy.

Dr. Alan Ibbetson, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.

Experimental, for design.

Hydromechanics of rotating liquid systems having variable depth, including blocking action by bottom topography ("Taylor columns") and measurements on Rosby waves in an open rotating basin.

Measurements on Rosby waves in liquid annulus, including surface relationship, damping coefficient, reflection properties.


Worcester Polytechnic Institute, Alden Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Professor Leslie J. Hooper, Director, Alden Hydraulic Laboratory, Worcester Polytechnic Institute, Worcester, Mass. 01609.

METER CALIBRATIONS.

Foxboro, Company, Foxboro, Mass.

Experimental, for design.

Calibration of various sizes of magnetic flow tubes (1" to 36") diameter and a variety of nozzle and orifice plate assemblies.

Tests in progress.

METER CALIBRATIONS.

B-I-F Industries, Providence, R. I.

Experimental, for design.

Calibration of open flow nozzles and flow tubes up to 48" in diameter. Tests performed in standard test loop and also in mock-up of particular field installations.

Tests in progress.

METER CALIBRATIONS.


Experimental, for design.

Calibration of open flow nozzles and flow tubes from 2" to 48" in diameter in the standard test loop. In addition, tests have been performed to determine characteristics in a variety of field installation mock-up include a number of pipe surface finishes.

Tests in progress.

CHONG FyONG HYDROELECTRIC PROJECT.


Experimental, for design.

A 1/75 scale model of a reach of the North Han River in the Republic of Korea was constructed for the Korea Electric Company. The model included the spillway and powerhouse as well as river topography up and downstream of the development. Studies were made of a number of changes designed to improve spillway and powerhouse operation. In addition a number of schemes for the different river diversions and construction planning were studied.

Completed.

Report completed and on file with clients.

CORNWALL PUMPED STORAGE DEVELOPMENT.

Hul, Hall and Rich, Boston, Mass.

Experimental, for design.

A 1/80 scale model of the intake at the upper reservoir was constructed including local topography at the intake. The studies involved the flow patterns and possible surface disturbances in the reservoir and also the flow in the first few diameters of the vertical shaft of the intake.

Tests completed.

Report completed and on file with clients.

METER CALIBRATIONS.

Hagan Chemicals and Controls, Inc., Pittsburgh, Penn.

Experimental, for design.

Calibration of a variety of sizes and designs of flow nozzles and flow nozzle assemblies.

Tests in progress.

CARDINAL STEAM PLANT.

American Electric Power Service Corp., New York, N. Y.

Experimental, for design.

A 1/120 by 1/40 distorted scale model of a section of the Ohio River upstream and downstream from the Cardinal Plant of the Ohio Power Co. The plant inlets and outlets for condenser cooling water were installed for both the present unit and three future units. The studies were performed on the hot water flow patterns in order to insure a minimum of hot water from either the old or the new units re-entering the cooling water system. In addition bed load movement of the river and barge handling techniques were studied over a range of river stages.

Additional tests completed during 1965.


MUDDY RUN PUMPED STORAGE DEVELOPMENT.


Experimental, for design.

A 1/50 scale model of the intake structure, the immediate topography in the reservoir and a section of the vertical tunnel below the intake were modeled to study the flow characteristics and evaluate the losses in both the pumping and generating cycles.

Work completed.

Report completed and on file with clients.

DYNAMIC EFFECTS IN FLOW METER COEFFICIENT PREDICTION.

Laboratory project.

Experimental, for M.S. thesis.

A number of differential producer type flow meters are being studied under different Reynolds Number levels with the same volume flow rate. It is planned to evaluate the dynamic effects on the discharge coefficient.

Suspended.

VELOCITY DISTRIBUTION INFLUENCE ON BEND LOSSES.

Laboratory project.

Experimental for M.S. thesis.

An experimental and theoretical study of the variation in energy loss in a 30 pipe bend.
was carried out and evaluation of the loss set up in terms of the upstream velocity distribu-

(f) Work completed. (f) Tests completed.


(5024) CORNWALL PUMPED STORAGE DEVELOPMENT.

(b) Uhl, Hall and Rich, Boston, Mass. (b) Consolidated Edison Co., New York.

(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/60 scale model of the manifold and pen-
stock sections was constructed of plexiglass and PVC pipe in the appropriate diameters. The sections varied in diameter (full scale) from 40" for the manifold to 10' for the penstocks at the powerhouse. Measurements of pressure head at each change in section and alignment were made to evaluate the loss coefficients in both the generating and pumping situations. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5266) LITTLE GOSSY STEAM POWER PLANT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/12 scale model of the condenser cooling water intake of the Louisiana Power Co., including the sump and vertical pump bell mouth was constructed. The studies included various modifications to insure a uniform velocity distribution at the pump intake for the required flows. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5269) CABIN CREEK PUMPED STORAGE DEVELOPMENT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/100 scale model of the upper reservoir of the development of the Public Service Corp. of Colorado was constructed. The model included the reservoir, upper face of the dam and the water intake to the tunnel. The studies involved the flow patterns in the reservoir for various phases of operation including both pumping and generating. A qualitative study of ice flows in the reservoir under the influence of wind was conducted. Treatment of intake location and flow at the intake was evaluated. Test completed. (f) Test completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5270) KASTRAKI HYDROELECTRIC DEVELOPMENT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/100 scale model of the Kastraki development of the Public Power Corp. on the Acheloos River was constructed. The model included a section of the reservoir, the gravity dam, spillway, powerhouse and river bed downstream including the confinement with the Zervas Torrent. The studies include the approach conditions to the side spillway, the supercritical flow in the spillway chute and the conditions in the tailrace area. Tests completed. (f) Tests completed.


(5271) CAMPELL STEAM POWER PLANT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/10 scale model of the intake at the Campbell Plant of the Consumers Power Co. on Lake Michigan was constructed. The local lake section was duplicated in a steel head box and the intake structure was mounted outside to allow viewing of flow patterns through the transparent wall. Studies were aimed at reducing the head loss and disturbed flow in the screenhouse and gate structure. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5273) CICEROZ HYDROELECTRIC DEVELOPMENT.


(d) Experimental, for design. (d) Experimental, for design.

(e) The 1/10 scale model was constructed of the Ciceroz development of the Electric Power Generating Co. of Turkey. The model included the streamabove and below the site, the arch dam, spillway and powerhouse and all water passages. The studies were conducted with the approach flow to the spillway and powerhouse intake and the flow results in the tailrace for a variety of flow conditions. Penstocks were fabricated of clear plastic to allow observation of flow in various sections. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5274) KEBAN HYDROELECTRIC DEVELOPMENT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/100 scale model of the project on the Euphrates River was constructed for the Electric Power Generating Co. in Turkey. Included in the model was the river above the dam, the dam, water intakes, spillway, fuse plug, penstocks, spillway chute, powerhouse and a section of river downstream including the tailrace. The studies involved intake operation, spillway and gates, fuse plug performance, spillway chute and wall design and tailrace flow patterns. Test completed. (f) Test completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5275) PETERSBURG STEAM POWER PLANT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/120 by 1/40 vertical scale model of a section of the White River has been constructed for the Indianapolis Power and Light Co. The model represents a section of the river above and below the Pittsburgh plant. Studies are being conducted on bed load movement necessary protective works at the intake, and possible recirculation of hot condenser cooling water. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.

(5276) HOLYOKE POWER DEVELOPMENT.


(d) Experimental, for design. (d) Experimental, for design.

(e) A 1/15 scale sectional model of the gate house structure at the canal entrance was constructed in the 3 foot glass sided flume. Studies were made of flows in various sections including gates and flow and velocity patterns were studied. The experimental work involved representatives of Stone and Webster, Holyoke Water Power and Aiden Hydraulic Laboratory. Tests completed. (f) Tests completed.

(f) Report completed and on file with clients. (f) Report completed and on file with clients.
METER CALIBRATIONS.

(b) Potter Aeronautical Corp., Union, N. J. Experimental, for design.

e) Calibration of turbine type flow meters from 2" to 24" in diameter of both the volume and mass flow design have been calibrated. Piping arrangements include standard loop tests and variations such as tandem mounting.

Tests in progress.

METER CALIBRATIONS.

(b) ITT General Controls, Warwick, R. I. Experimental, for design.

e) Calibration of flow tubes in a range of sizes from 6" to 48" has been carried out. Field piping as well as standard test loop installation have been used.

Tests in progress.

METER CALIBRATIONS.

(b) Bailey Meter Company, Wickliffe, Ohio.

e) Calibration of flow tubes in a range of sizes from 1" to 16" diameter.

Tests in progress.

Fischer and Porter Company. Experimental for design.

e) Calibration of various sizes of magnetic flow tubes from 2" to 18" diameter.

Tests in progress.

BRUNNER ISLAND STEAM POWER PLANT.

(b) Ebasco Services, Inc., New York. Experimental for design.

e) A 1/10 scale model of the cooling water intake of the development on the Susquehanna River was modeled for Pennsylvania Power and Light Co. The model in addition to the intake structure included some topography at the inlet and the pump bell mouths. Measurements of velocity were obtained at a number of sections in the structure and in the pumps. Photographs and observations of dye patterns in the flow were made during the program.

Tests completed.

REPONT.

(b) Report completed and on file with clients.

KANAWHA RIVER STEAM POWER PLANT.

(b) Union Carbide Co., Niagara Falls, New York. Experimental for design.

e) A distorted model (1/100 horizontal and 1/50 vertical) of a section of the Kanawha River at Alloy, West Virginia was constructed. This model included river topography from approximately three miles above the plant to one mile below the plant as well as the plant intake (with flow) and other pertinent structures. Possible variations in the intake structure were studied in order to reduce the amount of bed load and suspended material drawn into the plant. Dune-shaped sand, water soaked sawdust and fine sand were used as materials to reproduce the foreign material during the studies. Velocity measurements at a number of sections on the model were also made during the tests.

Tests completed.

Report completed and on file with clients.

SUPERCRITICAL BOILER STUDY.

(b) Riley Stoker Co., Worcester, Massachusetts. Experimental for design.

e) A 1/10 scale model of the boiler representing the tubular walls with clear lucite was constructed. The study was initiated to study flow patterns and residence time in boiler for a variety of fuel burner locations and combinations. Flow patterns were determined using dye and plastic balls while residence time was obtained from continuous counts of plastic particles.

Tests completed.

MILLSTONE STEAM POWER PLANT.

(b) Bechtel Corp., Gaithersburg, Maryland. Experimental for design.

e) A distorted model (1/3000 horizontal and 1/400 vertical) was constructed of a section on Long Island sound in the vicinity of Millstone Point. Approximately 12 miles of the Conn. shore was reproduced and tidal variations in this area were simulated. The study resulted in flow patterns over the area covered and allowed evaluation of dilution and distribution of effluent from Millstone Point.

Tests completed.

CHALK POINT STEAM POWER PLANT.

(b) Potomac Electric Power Co., Washington, D.C. Experimental for design.

e) A 1/10 scale model of the water box and tube banks of a steam condenser have been modeled in clear plastic. The model also included the water passages upstream of the water box beyond the two 90° bends toward the pumps. The study involved determining flow patterns in the water box and velocities and velocity distribution in the tubes.

Tests in progress.

WILLOW GLEN STEAM POWER PLANT.

(b) Stone and Webster Engineering Corp. Experimental for design.

e) A 1/21.8 scale model was constructed for the Gulf States Utility Co. The model included the discharge flume, stilling basin and river topography in the immediate area of the stilling basin. The studies involve evaluation of the effectiveness of the stilling basin for present loads plus future projected loads. Velocity measurements and water surface elevations as well as indications of scour in the river beyond the stilling basin have been recorded.

Tests in progress.

WILLOW GLEN STEAM POWER PLANT.

(b) Stone and Webster Engineering Corp. Experimental for design.

e) A 1/12 scale model of the proposed circulating water pump intake has been constructed for the Gulf States Utility Co. The model studies are to evaluate the alternative designs for the intake and water passages. Velocities and flow distribution will be measured and other critical phenomena near the pump intake will be observed.

Tests in progress.
LARGE BULBOUS BOWS ON FULL SHIP FORMS.

(b) Laboratory project.

(c) Prof. R. B. Couch, Ship Hydrodynamics Lab., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Experimental; applied research.

(e) Investigation of the effects on resistance and on flow of large bulbous bows on a full ship hull model. Variables are size, shape and position of bulb as well as displacement and trim of the model.

(f) Significant reductions in form and wave resistance are possible with proper combination of bulb, displacement and trim.

(g) To be published by the Society of Naval Architects and Marine Engineers.

SCALE EFFECT ON RESISTANCE AND SELF-PROPELLION FACTORS OF MERCHANT SHIP FORMS.

(b) Maritime Administration, Dept. of Commerce.

(c) Prof. R. B. Couch, Ship Hydrodynamics Lab., Univ. of Mich., Ann Arbor, Mich. 48104.

(d) Experimental; basic research.

(e) Ship models of series 60 forms and variations and corresponding propeller models of varying size are being tested for resistance and propulsion characteristics in order to investigate effects of scaling. More accurate full scale predictions are sought.

(f) Full scale predictions of propulsion factors from tests of 17 ft. long models of conventional cargo ship forms are sufficiently free of scale effects as to be of desirable accuracy.

(g) "Resistance and Propulsion Scale Effect Investigation on Two Cylindrical Hull Forms," R. B. Couch and J. L. Moss, The University of Michigan Ship Hydrodynamics Laboratory Report OS920-L-P. To obtain report, contact Prof. R. B. Couch.

BLOCKAGE CORRECTION IN A SHIP MODEL TOWING TANK.

(b) Maritime Administration, Dept. of Commerce.

(c) Prof. F. C. Michelsen, Dept. of Naval Architecture and Marine Engineering, Univ. of Michigan, Ann Arbor, Michigan 481.04.

(d) Experimental and theoretical; basic research.

(e) The restricted channel effect is being investigated both theoretically and experimentally, the latter by geosim series towing tests of models in the University of Michigan tank and by comparison with tests from other tanks.

(f) A semi-empirical formula has been developed for normal merchant ship forms and is being refined.

DETERMINATION OF VISCOS DRAG OF SHIP MODELS BY WAKE SURVEY.

(b) Maritime Administration, Dept. of Commerce.

(c) Prof. F. C. Michelsen, Dept. of Naval Architecture and Marine Engineering, Univ. of Michigan, Ann Arbor, Michigan 481.04.

(d) Theoretical and experimental; basic research.

(e) A five-hole spherical pitot tube is used to determine the wake velocity field. Momentum considerations allow calculation of the viscous drag taking into account the free surface.

(f) Test data being analyzed by high speed analog to digital conversion techniques.

(g) "Experimental Techniques for Determination of Viscous Resistance Using the High Response Five Hole Pitot Tube," J. C. Gehhardt, F. C. Michelsen and J. L. Moss, 1965 American Towing Tank Conference, for copies contact authors at above address.

DEVELOPMENT OF A LOW-RESISTANCE, HIGH DISPLACEMENT-LENGTH RATIO MERCHANT HULL FORM.

(b) Maritime Administration, Dept. of Commerce.

(c) Prof. F. C. Michelsen, Dept. of Naval Architecture and Marine Engineering, Univ. of Michigan, Ann Arbor, Michigan 48104.

(d) Theoretical and experimental; applied research.

(e) To develop a minimum wave resistance hull form of higher than generally designed displacement-length ratio from theoretical considerations and model tests.

(f) Utilization of low resistance and large bulbous bow yield powering requirements generally lower than otherwise comparable hull forms.

(g) Final report in preparation.

HYDRODYNAMICS OF SEA-GOING BARGES.

(b) Society of Naval Architects and Marine Engineers.

(c) Prof. R. B. Couch, Ship Hydrodynamics Lab., Univ. of Michigan, Ann Arbor, Mich. 48104.

(d) Experimental; applied research.

(e) Determination of resistance and directional stability of large barges and floating structures is sought to provide design tool and recommended hull forms. Experimental model studies and computer regression techniques are used.

(f) On the basis of data from tests of unrelated forms it is possible to predict performance of an arbitrary barge.

(g) Final report in preparation.

PURDUE UNIVERSITY, School of Civil Engineering.

HYDROLOGY OF SMALL WATERSHEDS IN INDIANA.

(b) Purdue Water Resources Research Center, (since June 1965) State Highway Department of Indiana and Indiana State Flood Control and Water Resources Commission (prior to June 1965).

(c) Dr. J. W. DeLeille, Hydromechanics Laboratory, School of Civil Engineering, Purdue University, Lafayette, Ind. 47907.

(d) Analysis and field investigation for Ph.D. thesis.

(e) The purpose of the research is to study the hydrology of watersheds less than 200 square miles throughout the State of Indiana to improve the existing methods for estimating the runoff from these watersheds.

(f) Peak discharges were analyzed statistically and a correlation was obtained between the 25 year peak discharge and geomorphological characteristics of the watersheds. Peak discharges for other frequencies may also be obtained. A synthetic design hydrograph was developed on the basis of the instantaneous hydrograph theory. The hydrograph is determined by two parameters which have been related statistically to geomorphological characteristics of the watershed. The theory of overland flow has been investigated from a hydrodynamics standpoint.


MEANDER FLOODPLAIN MODEL.

(b) Purdue Water Resources Research Center; Lab. Project.

(c) Dr. G. H. Tooeles, Hydromechanics Laboratory, School of Civil Engineering, Purdue University, Lafayette, Ind. 47907.

(d) Analytical and experimental research for Ph.D. thesis.

(e) A meander floodplain model is being constructed to replace 5' x 30' model used in first phase of project. Also data collection equipment is being improved to obtain greatly increased efficiency. Experimental and analytical study of three-dimensional flow patterns in meandering channel with adjacent flood plains. Collection of energy loss data and study of distribution of shear stress and scour. Work applicable to channel pro-
HOT-WIRE PHYSICS IN LIQUIDS.

Purdue Research Foundation.

Theoretical and experimental for Ph.D. thesis.

Experimental and analytical for M.Sc. and Ph.D. theses.

Analytic and experimental study aimed at correlating the hydroelastic loading of structural components and the turbulent structure of the generated wake and separating boundary layers; study of energy transfer between fluid and structure.

Force, displacement and wake turbulence measurements are being made for variety of cylindrical components and plate-like structures. Reduction of data by means of spectrum analysis equipment.


TURBULENCE MEASUREMENTS IN LIQUIDS.

David Taylor Model Basin, Dept. of the Navy.

Analytic and experimental investigations aimed at optimizing hot-wire anemometer measurements in liquids using hot-wire anemometer equipment and to compare performance characteristics of hot-wire equipment with hot-film thermistor, electro-magnetic, and pressure transducers. Dynamic calibration of hot-wire probes.

Collecting of liquid anemometry data is in progress. Special calibration and test equipment has been built. Spectral analysis equipment has been adapted for above studies. Special recirculation equipment for laboratory water supply has been built.


URBAN HYDROLOGY FOR SELECTED SITES IN INDIANA.

Indiana Flood Control and Water Resources Commission.

Dr. J. W. Deller, Hydromechanics Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Ind., 1967.

For M.S. Thesis.

Rainfall-runoff relationships are studied for selected sites in Indiana in order to test scientific methods of estimating the surface runoff and to obtain design criteria that can be used by practicing engineers.

An urban watershed is being instrumented in West Lafayette, Indiana.

x 3' tilting glass-lined flumes. The largest flume will accommodate sediment recirculation. A number of design problems is being studied in the equipment. The main problems are: uniformity of inflow from headbox; residual turbulence in inflow; the boundary layer development in free surface flow and the length of flow establishment.

Data collection systems for flumes have been completed and are being tested. Equipment designed for connection with central hybrid computer facility is aimed at greatly increasing both the accuracy and the speed of data collection.

**MEAN VELOCITY VECTOR MEASUREMENTS.**

**Laboratory project.**

Dr. G. H. Toebes, Hydromechanics Laboratory, School of Civil Engrg., Purdue University.

**WIND TUNNEL DEVELOPMENT.**

(a) Laboratory project.

(b) Dr. W. M. Goldschmidt, Hydromechanics Lab., School of Civil Engrg., Purdue University.

(d) Theoretical & experimental for M.S. thesis.

(e) Under separate work insight into the turbulent and convective dispersion of contaminants in the atmosphere and ocean is sought. Under this project a wind tunnel is being designed to provide the flow conditions for the necessary experimental studies.

**ADDENDUM**

**UNIVERSITY OF WISCONSIN, Hydraulics and Sanitary Laboratories.**

See page 99 for other projects of the Univ. of Wis.

**MODEL STUDIES OF PUMP INLET STRUCTURES.**

(a) Wisconsin Alumni Research Foundation in cooperation with the Government of West Bengal, India.

(c) Dr. J. R. Villemonte, Director, Hydraulics and Sanitary Laboratories, University of Wisconsin, Madison, Wis. 53706.

(d) Experimental; design for M.S. thesis.

(e) A 1/16-scale model of the inlet structure for one of four axial flow pumps at the Uttarbhag Pumping Station (Sonarpur, India) has been made. Studies of inlet flow patterns and pressure coefficients for a wide variety of flow situations are being made for the purpose of reducing the cavitation threshold.

(f) Completed.

(g) Pressure coefficients were computed at 37 points on the model over a wide range of flows.


**HYDRAULIC CHARACTERISTICS OF GRAVITY SEPARATION BASINS.**

(d) Experimental, for M.Sc. thesis.

(e) Optimization of velocity meter based on Pitot-sphere principle and associated read out equipment.

(g) Probe construction completed. Calibration is being pursued. Digital data reduction program nearly complete.

**WIND TUNNEL DEVELOPMENT.**

(b) Laboratory project.

(c) Dr. W. M. Goldschmidt, Hydromechanics Lab., School of Civil Engrg., Purdue University.

(d) Theoretical & experimental for M.S. thesis.

(e) Under separate work insight into the turbulent and convective dispersion of contaminants in the atmosphere and ocean is sought. Under this project a wind tunnel is being designed to provide the flow conditions for the necessary experimental studies.

(b) National Institutes of Health, Wash., D. C.

(c) Drs. J. R. Villemonte and G. A. Rohlich, Hydraulics and Sanitary Laboratories, Madison, Wisconsin 53706.

(d) Experimental; basic research and design for M. S. and Ph.D. theses.

(e) Hydraulic characteristics of the model circular basins and one model rectangular basin are being studied using a wide range of flow and types of inlet and outlet design, using the fluorescent tracer technique and the automatic recording of dimensionless dispersion curves.

Field tests on actual basins are also being undertaken where dispersion curves and removal efficiencies are being observed simultaneously, so that correlations can be studied. The principles of similarity which apply to gravitation separation basins are also being studied in the laboratory and in the field. Hydraulic characteristics have been determined for a wide range of overflow rates and basin types both in the laboratory and field using newly developed criteria. Comparison of actual removal efficiencies and those derived from a new rational approach has been made of several lab. and field basins.


CORN BELT BRANCH, 108 Soils Building, University of Minnesota, St. Paul, Minn., Dr. C. A. Van Doren, Branch Chief.

(66) HYDROLOGIC STUDIES, BALSTON CREEK WATERSHED.

See Iowa Institute of Hydraulic Research, page 37.

(1723) THE HYDRAULICS OF CONSERVATION STRUCTURES.


(b) Cooperative with the Minnesota Agricultural Experiment Station, the St. Anthony Falls Hydraulic Laboratory, and the Illinois State Water Survey.

(c) Mr. Fred W. Blaisdell, Hydraulic Engineer, St. Anthony Falls Hydraulic Laboratory, 3rd Ave. S. E., at Mississipi River, Minneapolis, Minnesota 55414.

(d) Experimental; applied research for development and design.

(e) Research dealing with the design, construction, and testing of structures for conserving and controlling soil and water are carried out. Cooperation with and coordination of the tests at the Stillwater, Oklahoma, Outdoor Hydraulic Laboratory and the Illinois State Water Survey are maintained.

A square drop inlet having a hood barrel entrance is being tested to determine entrance loss coefficients for various drop inlet sizes and hood and various barrel slopes. Previous tests have evaluated the performance of this type of inlet. The elbow and transition between the two-way drop inlet and the barrel is being studied to determine the pressures and the best form to minimize the possibility of cavitation. The transition between a circular pipe and a rectangular cantilevered outlet is being studied to determine the best form of the transition. Studies are also being conducted on a rectangular cantilevered outlet with a deflector at the exit to throw the water away from the structure and move the scour hole further downstream.

(g) If the anti-vortex plate is too low, undesirable orifice flow will control the discharge. If the anti-vortex plate is too high, harmful vortices will form under the plate. Rules for determining appropriate plate heights have been determined. The overhang of the plate must be greater than a certain minimum to insure satisfactory performance. The action of the two-way drop inlet is that of a self-regulating siphon. The tests using air agree with the results obtained from the water tests and are much easier to perform. Air is used as the model fluid only for the condition of full conduit flow. Tests on the hood drop inlet have shown that the hood barrel entrance can be used to reduce the minimum required height of the drop inlet. Minimum sizes of drop inlet and anti-vortex devices have been determined. Tests of low-stage orifices in the two-way drop inlet have shown that improper location and improper proportioning of the orifices can prevent priming of the spillway. The proper location of the orifice and the sizes of the orifices for satisfactory spillway performance have been determined. To supplement the experiments, potential flow methods have been used to determine the theoretical coefficient of energy loss at the crest of the two-way drop inlet.


RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

See University of Illinois, Department of Agricultural Engineering, page 32.

(2316) HYDROLOGIC STUDIES ON AGRICULTURAL WATERSHEDS IN WISCONSIN.

(b) Laboratory project, cooperative with the Wisconsin Agricultural Experiment Station and the Wisconsin Valley Improvement Co. (c) Mr. N. E. Minshall, Hydraulic Engineer, P. O. Box 4248, Madison, Wisconsin 53711.

(d) Field investigation and office analysis.

(e) Various records of runoff, ground water, precipitation, climatic and local factors, soil moisture, land use, and agricultural conditions and practices are maintained for 50 agricultural watersheds ranging in size from 25 to 5000 acres in the vicinity of Fennimore, Colby and at other locations in southwestern Wisconsin. Analyses are made to evaluate the factors affecting flood flows, hydrograph characteristics, and the yield of stream flow.


PREDICTION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ON THE UNGlaciated ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with Ohio Agricultural Experiment Station.

(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, North Central Experimental Watershed, USDA, ARS-SWC, Coshocton, Ohio 43012.

(d) Field investigation and office analysis.

(e) To develop methods of estimating watershed precipitation related to runoff rates and volumes and to evaluate "normalcy" of sample periods.

(g) In 24 years of record, storm sizes ranged from 0.01 to 2.30 inches. About half of the storms were 0.10 inch or less in amount. Less than 0.5 percent of the number of storms were over 2.00 inches. The rate of sampling of these severe storms is slow, yet their influence in floods and water yield is highly important. A network of weather recording gauges over a four-county area along with U.S.W.E. radar pictures has proven valuable in defining the extent of local, severe thunderstorms. One small area has experienced two "rare" storms in two successive years. Over 4.5 inches of rain fell in each of these two events.


(4266) SURFACE RUNOFF AND INTERFLOWS STUDIES IN THE UNGlaciated ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with the...
Ohio Agricultural Experiment Station.

(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, North Appalachian Experimental Watershed, USDA, ARS-SWC, Coshocton, Ohio 43812.

(d) Field investigation and office analysis. To study the factors affecting the volume of surface runoff and interflow from various combinations of upland watershed soil, cover, and treatment, and to study the basic factors affecting the hydrograph on these flows under various soil-cover combinations.

(g) Work is continuing on these studies. Interflow occurred when the soil was quite wet and its volume generally exceeded those of surface flow. Interflow hydrographs showed sharp rises and recession patterns. Spinkler pluviometers have been instrumented with tensiometers, piezometers, and soil moisture devices in order to detect systems.

(4267) STUDIES OF RUNOFF FROM COMPLEX WATERSHEDS IN THE UNGlaciated Allegheny Plateau.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.

(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, North Appalachian Experimental Watershed, USDA, ARS-SWC, Coshocton, Ohio 43812.

(d) Field investigation and office analysis. To determine how flows from incremental areas combine to produce hydrographs of stream flow on larger complex watersheds; determine the effects of climate and watershed characteristics on rates and amounts of runoff; and develop methods for predicting the magnitude and frequency of flows from ungaged watersheds.

(g) Work is continuing on these studies. Preliminary analyses showed that flood runoff volume on a 4,560-acre watershed was equivalent to the moisture saturation deficit in the 0- to 7-inch soil depth. Pore depth in the soil at greatest depth was not available quickly enough to retain more of the storm rainfall. Maximum monthly flood peaks as shown by 24 years of record from a 4,560-acre watershed are most likely to occur in June. The amount of rain falling at rates in excess of 1.0 inch per hr. was the greatest in June. July rainfall was about the same as for June, but its peak flows were 60% less than those for June.


(4268) STUDIES IN SUBSURFACE HYDROLOGY IN THE UNGlaciated Allegheny Plateau.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.

(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, North Appalachian Experimental Watershed, USDA, ARS-SWC, Coshocton, Ohio 43812.

(d) Field investigation and office analysis. To evaluate ground-water and interflow contributions to stream discharge of agriculture watersheds and the recharge to aquifers under various watershed and climatic conditions.

(g) Geologic studies showed that secondary features of the rock such as joints and fractures appear to influence subsurface flow more than their physical characteristics. Rock strata near outcrops are fractured more extensively than those farther beneath the hill, the outflow versus water table relationship of springs is much better defined than that of the latter.


MOISTURE REGIMES OF SOILS IN THE UNGlaciated Allegheny Plateau.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.

(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, North Appalachian Experimental Watershed, USDA, ARS-SWC, Coshocton, Ohio 43812.

(d) Field investigation and office analysis. To maintain the soil moisture inventory of agricultural watersheds; to evaluate the effect thereon of soil, land use, and climate, to develop methods of estimating soil moisture deficits under various land use and climatic conditions; and to determine the influence of frozen soil and frost structure on water movement.

(g) Nuclear soil-moisture equipment is now providing good data on soil moisture down to 90-inch depths. They show material variations in moisture within a small watershed. Presently, methods of evaluating watershed soil moisture are being studied. Effect of vegetation of different rooting depths on soil moisture is being evaluated. Deep-rooted crops extract moisture to depths unaffected by shallow-rooted crops. In dry seasons, the former consumes more water than the latter, the latter relying in less relation to ground water reservoirs. Lysimeters, 8 feet deep and 1/500 acre area of undisturbed soil record weight changes and percolation.

(h) "How much Water Do You Need to your Crops?" F. R. Dreibelbis and C. R. Amerman. Cropping and Soils, Volume 17, No. 5, pp. 8-9, April-May 1965.

(4271) PLASTIC-LINED NOLE DRAIN STUdIES.

(b) Laboratory project in cooperation with the Ohio Agricultural Experiment Station.

(c) Mr. James L. Fouss, Research Agricultural Engineer, Agricultural Engineering Dept., Ohio State University, Columbus, Ohio.

(d) Experimental and field investigations, both basic and applied.

(e) The purpose of these investigations is to improve plastic mole drainage techniques and test the effectiveness of other subsurface and surface drainage systems. Tile, mole and other subsurface drainage systems are being developed and their effectiveness determined.

(g) The work is continuing on improving plastic mole drainage materials and equipment. Recent field tests showed that thin-walled plastic mole lining installed 30 inches deep, deformed much more when the soil (silty clay loam) was saturated for prolonged period of submergence operations when the soil was drier. Research has also begun on the use of corrugated plastic tubing for lining mole-drain channels; this material looks promising.


(4273) SURFACE AND SUBSURFACE DRAINAGE.

(b) Laboratory project in cooperation with the Minnesota Agricultural Experiment Station.

(c) Mr. Lee Hermann, Agricultural Engineer, North Central Soil Conservation Field Station, Morris, Minnesota 56267.

(d) Experimental and field investigations, both basic and applied.

(e) The purpose of these investigations is to develop engineering techniques that will provide maximum effective control and management of water. Techniques are developed for managing surface flow through land forming and surface drainage systems. Tile, mole and other subsurface drainage systems are developed and their effectiveness determined.
(f) Discontinued.

(4274) NATIONAL SUMMARIZATION AND ANALYSIS OF RUNOFF AND SOIL-LOSS DATA.

See Purdue University, Agricultural Engrg. Dept., Project No. 3808.

(b) Laboratory project, cooperative with the Purdue Agricultural Experiment Station.

(c) Mr. W. H. Wischmeier, Research Statistician, ARS, Agricultural Engineering Dept., Purdue Univ., Lafayette, Indiana 47907.

(d) Data analyses, applied research.

(e) Objectives: The purpose of current analyses of the summarized and analysis project are (1) to consolidate all available past, current, and future runoff, soil loss and related data in standardized form to make available for application of current methods of hydrologic and statistical analyses; (2) to analyze the data on an over-all basis, with special emphasis on identification and evaluation of significant factor interactions and (3) to develop bases for prediction of runoff and soil losses from different landscapes under various land use and management conditions. In analyses of the assembled data, special emphasis is directed toward identification and evaluation of factors and interaction effects responsible for the frequent wide differences in results of localized studies at various locations. Over-all results are reduced to charts and tables readily usable by application technicians.

(g) Improvements in the area of field soil-loss prediction techniques to help guide farm planning for soil and water conservation were summarized in Agriculture Handbook No. 293. The goal of current analyses of the assembled data is an empirical equation for prediction of surface runoff from agricultural areas. Mathematical relationships of several physical and management factors to runoff have been derived. The analyses have shown that, over a broad range of medium-textured soils, runoff was inversely related to crop productivity, surface roughness, residual soil organic-matter content, and quantity of plant residues incorporated annually; directly related to slope steepness and kinetic energy of the raindrops; and only very slightly related to length of slope and particle-size distribution. Work under objective (1) is kept continuously current.


(4275) BASIC MECHANICS OF RAINFALL, RUNOFF, SOIL MOVEMENT, AND LOSS.

See Purdue University, Agricultural Expt. Station, Project No. 4182.

(b) Laboratory project, cooperative with the Minnesota, South Dakota and Purdue Agricultural Experiment Stations.

(c) Dr. L. D. Meyer, Agricultural Engineer, ARS, Agricultural Engineering Building, Purdue Univ., Lafayette, Indiana 47907.

(d) Experimental laboratory investigations, basic research.

(e) The mechanics of the soil erosion process have been studied at Ames, Iowa. At Morris, Minnesota, the geometry of raindrop splash patterns is being described mathematically, using high-speed photography. At Brookings, South Dakota, the effect of wind on the trajectory of falling drops was studied. At Lafayette, Indiana, fundamental mathematical relationships of erosion to various soil, crop, and topographic factors are being determined.

(g) The geometry of raindrop splash was appreciably influenced by drop size, surface softness, surface inclination, surface roughness, and water depth. The trajectory of falling water drops in wind can be related to drop diameter, wind velocity, and fall distance. Runoff erosion increased with increased particle roughness, slope steepness, and slope length associated with increased particle size. Rainfall plus runoff, as compared to runoff alone, increased the erosion of particles smaller than medium-size sand.


(4276) IMPROVED PRACTICES FOR CONTROL OF RUNOFF AND EROSION.

(b) Laboratory project in cooperation with the Purdue Agricultural Experiment Station.

(c) Mr. J. V. Manning, Soil Scientist, ARS, Department of Agronomy, Purdue University, Lafayette, Indiana 47907.

(d) Experimental; field investigations, applied research.

(e) The purpose of these studies is to determine the effects of soil properties, slope characteristics, type and extent of canopy cover, quantity and management of crop residues, and field and tillage practices, and various factor interactions on infiltration and erosion. Replicated tests are conducted on selected plots on Purdue-owned and privately-owned farms in Indiana and adjoining states under simulated rainfall applied with the ARS-Purdue "Raininator".

(f) Residue mulches that dissipated some of the rainfall energy and reduced the flow velocity of runoff were highly effective. Even small amounts of surface residue significantly reduced erosion. Recent tests have shown that improved productivity and annual incorporation of large quantities of residue material at plowing time have increased infiltration and substantially reduced erosion from continuous corn, but they have not replaced the very substantial reductions in soil and water loss that are effected by meadow and turned under before corn. Wheeltrack planting on rough-plowed land and cultivating only when needed to destroy surface crusts significantly reduced both runoff and erosion throughout the entire growing season, increased available soil moisture in periods of deficient rainfall, and did not significantly affect corn yield average.


Laboratory project, cooperative with the Purdue, Iowa, and Minnesota Agricultural Experiment Stations.

(e) Purpose is to evaluate soil and crop management practices in relation to water management and erosion control on the major Iowa soils. After soil in, soil loss, and related data, under natural rainfall, are taken on fractional-acre plots on Grundy, Ida, and Carrington silt loam soils.

Consistency and crop productivity and good management of abundant residues have very effectively reduced soil erosion from both small grain and corn during intense rains that caused some severe erosion on check plots. However the effectiveness of large amounts of corn or small-grain residue incorporated by plowing has not equalled that of a general residue of grass and before corn. In a 7-year period, soil loss from corn after oats with sweetclover intercrop averaged 0.4 times that from corn after two full years' meadow.

Laboratory project, cooperative with the Wisconsin Agricultural Experiment Station.

(g) Technical reports have been listed in previous years. A 50-year summary report is in preparation.

Rainfall energy and soil erosion relations.

Raindrops were photographed to determine sizes and impact energies. Runoff was measured and soil loss determined from fallow and continuous corn plots. Various characteristics of rainstorms are being related to the resulting erosion.

Suspended.

Runoff and erosion studies in Iowa.

Runoff and erosion investigations in Minnesota.
Numerous serious Experimental; Laboratory Mr. Laboratory Practices Experimental; "Improved

Heinemann weight Experiment pp. and differences. reservoir procedures Mutchler Vegetal various Cropplng-f

deposits both on and greatest and SEDIMENT. however, rainstorms slope dense growing-canopy or loams periods of rainstorms, occurring during the first 2 months after planting. The greatest water loss from hay plots resulted from melting snow. Therefore, a small portion of the moisture from snow contributed to replenishment of soil moisture. Snowmelt runoff from hay plots has equaled from 80 to 90 percent of the water equivalent of the measured snowfall.

Numerous small reservoirs form the basis for this study. The objectives of this project are: (1) Determine the amount, rates, and character of sediment yields from agricultural watersheds; and (2) relate sediment accumulation in the reservoirs with sediment yield, precipitation, runoff, watershed characteristics, and cultural practices; (3) explain variations in the volume-weight of reservoir sediment; (4) make recommendations on determination of the total weight of reservoir sediment; (5) develop procedures for predicting the volume-weight of sediment in a proposed conservation structure; (6) to determine the distribution of sediment accumulation in vertical and horizontal planes in the reservoir and relate this to reservoir shape, amount and rate of runoff, storage depletion, soils, topography and normal water level of the reservoir; and (7) to evaluate all equipment and procedures used in reservoir sedimentation surveys.

DRAINAGE INVESTIGATIONS FOR AGRICULTURAL LANDS.

See Ohio Agricultural Experiment Station, Dept. of Agricultural Engineering, page 59.

HYDROLOGIC STUDIES ON WATERSHEDS IN MISSOURI VALLEY DEEP LOESS.

(b) Laboratory project, cooperative with the Iowa Agricultural Experiment Station.
(c) Mr. K. E. Saxton, Hydraulic Engineer, P. O. Box 208, Columbus, Missouri 65201.
(d) Field investigations, basic and applied research.
(e) Two sets of paired agricultural watersheds are instrumented to observe the hydrologic budget of watersheds having deep loessial

(4817) EROSION AND MOISTURE CONSERVATION STUDIES ON BANMISS SILT CLAY LOAM.

(b) Laboratory project, cooperative with the Minnesota Agricultural Experiment Station.
(c) Mr. R. K. Buntin, Hydraulic Engineer, P. O. Box 208, Atlanta, Georgia 30322.
(d) Experimental; field investigations, applied research.
(e) Field plots under natural rain are used to characterize runoff and erosion on the Barnes soil of the North Central Region and to evaluate moisture conservation aspects of soil and crop management practices. Automatically controlled devices to heat the collecting equipment". The measurement of runoff from snowmelt and thaw soil moisture is measured by neutron probe techniques. Wind direction and velocity are automatically recorded.

Four years of measurements have shown that these soils are highly erodible in periods of concentrated rainfall and that erosion damage is of a serious problem. Moisture conservation for crop use is also of primary concern in this climatic area. About 50% of the runoff from corn and about 90% of the runoff from from plots occurred during the first 2 months after planting. The greatest water loss from hay plots resulted from melting snow. Therefore, a small portion of the moisture from snow contributed to replenishment of soil moisture. Snowmelt runoff from hay plots has equaled from 80 to 90 percent of the water equivalent of the measured snowfall.

(4825) RESERVOIR SEDIMENTATION STUDIES.

(b) Laboratory project, cooperative with the Soil Conservation Service and State Agricultural Experiment Stations.
(c) Mr. H. G. Heinemann, Hydraulic Engineer, P. O. Box 208, Columbus, Missouri 65201.
(d) Field investigations, basic and applied research.
(e) Numerous small reservoirs form the basis for this study. The objectives of this project are: (1) Determine the amount, rates, and character of sediment yields from agricultural watersheds; and (2) relate sediment accumulation in the reservoirs with sediment yield, precipitation, runoff, watershed characteristics, and cultural practices; (3) explain variations in the volume-weight of reservoir sediment; (4) make recommendations on determination of the total weight of reservoir sediment; (5) develop procedures for predicting the volume-weight of sediment in a proposed conservation structure; (6) to determine the distribution of sediment accumulation in vertical and horizontal planes in the reservoir and relate this to reservoir shape, amount and rate of runoff, storage depletion, soils, topography and normal water level of the reservoir; and (7) to evaluate all equipment and procedures used in reservoir sedimentation surveys.

(5033) DRAINAGE INVESTIGATIONS FOR AGRICULTURAL LANDS.

See Ohio Agricultural Experiment Station, Dept. of Agricultural Engineering, page 59.

HYDROLOGIC STUDIES ON WATERSHEDS IN MISSOURI VALLEY DEEP LOESS.

(b) Laboratory project, cooperative with the Iowa Agricultural Experiment Station.
(c) Mr. K. E. Saxton, Hydraulic Engineer, P. O. Box 208, Columbus, Missouri 65201.
(d) Field investigations, basic and applied research.
(e) Two sets of paired agricultural watersheds are instrumented to observe the hydrologic budget of watersheds having deep loessial

(5204) HYDROLOGIC STUDIES ON WATERSHEDS IN MISSOURI VALLEY DEEP LOESS.

(b) Laboratory project, cooperative with the Iowa Agricultural Experiment Station.
(c) Mr. K. E. Saxton, Hydraulic Engineer, P. O. Box 208, Columbus, Missouri 65201.
(d) Field investigations, basic and applied research.
(e) Two sets of paired agricultural watersheds are instrumented to observe the hydrologic budget of watersheds having deep loessial
soils. Level terracing will be introduced as a variable on one of the watersheds of one of the pairs. A comparison of level terracing and control cover will be made on the other pair. Another mixed-use watershed is being observed. Variables observed are precipitation, soil moisture to 20-foot depths, surface flow, ground water recharge and outflow, air temperature and pan evaporation.

(52605) ANALOG STUDIES OF SUBSURFACE DRAINAGE.

(b) Laboratory project in cooperation with the Ohio Agricultural Experiment Station, Dept. of Agronomy.

(c) Dr. George S. Taylor, Dept. of Agronomy, Ohio State Univ., 1885 Neil Ave., Columbus 16, Ohio.

(d) Theoretical and experimental; basic and applied.

(e) An electrical resistance network analog is used to study the placement of subsurface drain tubes to provide optimum water table control for plant growth.

(f) Discontinued.

(g) Removal of excess rainfall and artesian water from a surface peat horizon, underlain with a thick slowly permeable silt layer, can be better achieved with tile drains on 40-foot spacings in the peat layer than with artesian relief 'wells' into the aquifer.

(5561) EROSION AND MOISTURE CONSERVATION STUDIES IN EASTERN SOUTH DAKOTA.

(b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.

(c) Mr. C. Olson, Soil Scientist, Agronomy Dept., South Dakota State Univ., Brookings, South Dakota 57007.

(d) Experimental; field investigations, applied research.

(e) Field plots under natural rain are used to characterize runoff and erosion on the Poinsett soils of eastern South Dakota and to evaluate moisture conservation aspects of soil and crop management practices. The surface water storage capacity of various types of tillage is being studied, and watersheds are being developed for evaluating improved terrace designs for moisture conservation and erosion control.

(g) Three years' measurements have shown these soils to be susceptible to very serious erosion by rainfall when not protected by erosion-control measures. Runoff from conventionally plowed soils on 73-foot slope length ranged from 1.3 to 3.6 inches and soil loss ranged from 4.9 tons per acre in 1963 to 18.9 tons in 1968. Mulch tillage reduced soil loss, and in a year of low moisture supply it increased yields. Six major storms accounted for 77% of the 3-year soil loss.


(5562) RESERVOIR TRAP EFFICIENCY.

(b) Laboratory project, cooperative with the Soil Conservation Service and Iowa and Missouri Agricultural Experiment Stations.

(c) Mr. D. L. Rausch, Agricultural Engineer, P. O. Box 208, Columbia, Missouri 65201.

(d) Field investigations, basic and applied research.

(e) The purpose of this research is to evaluate those parameters that affect the sediment trapping ability of water-retarding structures. This will enable prediction of the trap efficiency of structures. Measurements are made of the sediment content of the inflow and outflow and the volume retained in the reservoir. Characteristics of the sediment, watershed, reservoir, and other parameters are also used in the analyses.

(5563) GULLY EROSION STUDIES IN DEEP LOESS.

(b) Laboratory project, cooperative with the Iowa Agricultural Experiment Station.

(c) Mr. Robert P. Fleist, Hydraulic Engineer, P. O. Box 208, Columbia, Missouri 65201.

(d) Field investigations; basic and applied research.

(e) Measurements are being made on several actively-eroding gullies in controlled watersheds in the Missouri Valley deep loess. The objectives are to learn the causes of gully and channel erosion, the rate of this erosion, and the effect of surface terraces on gully growth. Measurements include amount eroded, changes in dimensions, surface flow, soil moisture, and ground water elevations.
to determine the channel capacity required to carry this runoff. Runoff measurements are being made on four terraces near McCredie, Missouri.

(5975) MOISTURE RETENTION CHARACTERISTICS OF SELECTED SOILS IN THE CORN BELT.

(b) Laboratory project, cooperative with the Agricultural Experiment Stations of Missouri and other Corn Belt States.

(c) Dr. V. C. Jamison, Soil Scientist, F. O. Box 206, Columbia, Missouri 65201.

(d) Field investigation, basic and applied research.

(5976) THE DISTRIBUTION OF SOIL MOISTURE IN LEVEL TERRACE FIELD IN MISSOURI VALLEY DEEP LOESSAL SOILS.

(b) Laboratory project, cooperative with the Agricultural Experiment Stations of Missouri and Iowa.

(c) Dr. V. C. Jamison, Soil Scientist, F. O. Box 206, Columbia, Missouri 65201.

(d) Field investigation, basic and applied research.

(e) The purpose of this project is to determine the soil moisture distribution in the soil profile under the terraces and the terraces, terrace intervals in deep loessal soils. Numerous measurements of soil moisture at a depth of twenty feet are being made on watersheds near Troyon, Iowa.

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NORTHEAST BRANCH, Plant Industry Station, Beltsville, Maryland 20705. Dr. Jesse Lulin, Branch Chief.

(3867) LEAF AREAS, LEAF WEIGHTS AND TOTAL DRY MATTER PRODUCTION OF TOBACCO AS AFFECTED BY ENVIRONMENTAL CONDITIONS.

(b) Cooperative project with the Virginia Agricultural Experiment Station.

(c) Mr. J. N. Jones, Agricultural Engineer, Agricultural Engineering Dept., Virginia Polytechnic Institute, Blacksburg, Va. 24061.

(d) Field investigations.

(e) Irrigation studies are designed to determine the effect of irrigation practices on the yield and quality of tobacco. Plant response, as measured by Leaf Area Index, is related to consumptive use of water and evapotranspiration.

(g) Maintenance of a high soil moisture regime gave lower leaf area than for a soil moisture regime which was allowed to fluctuate from 10% to 25% of the available soil water. Dry matter yield and value per hundredweight were both favored by the treatment allowing the soil moisture to fluctuate. The relationship between LAI and marketable yield indicated that only 50 percent of the variation as measured by cured leaf weights could be associated with variations of LAI.

(4284) DEVELOPMENT AND EVALUATION OF METHODS FOR CHANNEL STABILIZATION.

(b) Cooperative project with Soil Conservation Service and Cornell University.

(c) Mr. R. P. Apmann, Hydraulic Engineer, Civil Engrg. Dept., Parker Engng. Bldg., State Univ. of New York at Buffalo, Buffalo, New York 14214.

(d) Experimental field investigations.

(e) To determine the important streamflow qualities which materially affect the intensity of attack upon the stream channel periphery material and the variation throughout the flow boundary of forces destructive to the channel periphery material. Investigations are conducted on selected natural reaches of Buffalo Creek and tributaries in the vicinity of East Aurora, New York and on the Pequest River in Warren County, New Jersey.

(f) Thorough studies and analyses are continuing on stream geometry and of hydraulic characteristics of channel improvements and stabilization works constructed by Soil Conservation Services on Buffalo Creek. The analysis of the March 30, 1960 and other floods is being carried out by assembling an atlas of high water data and preparing a topographic map showing the contours of the stream channel and of the flood plains. A method is being developed for estimating discharge by using the superelevation of the water surface in an open channel bend. This method is based on the principle that the transverse difference in water surface at an open channel bend is related to the geometry of the bend and to the velocity head of the flow.


(4285) A STUDY OF FLOOD FLOWS AND THEIR EFFECTS ON STREAM CHANNELS.

(b) Cooperative project with Soil Conservation Service and Cornell University.

(c) Mr. R. P. Apmann, Hydraulic Engineer, Civil Engineering Dept., Parker Engng. Bldg., State Univ. of New York at Buffalo, Buffalo, New York 14214.

(d) Experimental field investigations.

(113)
 CHANNEL HYDRAULICS AND FLOOD ROUTING IN STEEP MOUNTAIN STREAMS.

Cooperative project with the Vermont Agricultural Experiment Station, the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.

Mr. R. F. Apmann, submitted to Agron. Jour. for publication.

STUDY OF THE SLEEPERS RIVER CHANNEL. (e)

Studies on a 1.5-mile reach of the Sleepers River channel involving determination of travel speed of controlled waves of different volumes; profiles of natural and controlled waves of different volumes; practical field methods of measuring the friction slope of mountain channels; comparisons between results obtained with flood routing formulas and observed flood wave data, and the relationship between channel efficiency, flow duration curves, and watershed morphology.

Short reaches within the 1.5-mile reach were found to have a Manning's 'n' value of between 0.035 and 0.040 for the bank-full conditions and a maximum of about 0.20 for very low flows. Channel roughness and geometry are intricately related to each other and to the lithology and climate of the watershed. This mountain stream is characterized by a relatively narrow and deep cross-section. It is postulated that this geometry causes a rapid increase in velocity with increasing discharge, providing the erosional energy required for the eventual attainment of a most probable state. There is an upper limit to roughness in a stream channel, and this is approached in the length of stream studied. Addition of more roughness elements would only create a new bed with similar characteristics.


INFLUENCE OF SNOW AND FROZEN SOIL ON RUNOFF.

Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service and College of Technology of the University of Vermont.

Mr. M. L. Johnson, Hydraulic Engineer, Route 2, Danville, Vermont 05828.

Experimental field investigations.

This study on the 43-square mile Sleepers River Watershed is concerned with the factors influencing the accumulation and melting of snow; the relationship of frozen soil to runoff; and the development of methods for predicting runoff associated with snow melt. Data are collected and analyzed from snow courses, precipitation gages, temperature gages, soil moisture and frost measurements, and snow melt in conjunction with streamflow records at nine stations in the subdivided watershed.

A 12-foot diameter snow pressure pillow, made of nylon reinforced butyl, was installed in 1964 to measure accurately changes in snow accumulation and snowmelt. The pillow was filled with about 200 gallons of a 2:1 mixture by volume of methylene blue and water.

The use of a 6-inch iron pipe stilling well and water level recorder minimized the mechanical and electrical difficulties which other scientists have had in measuring between water equivalent as measured by the snow pillow and cumulative precipitation as measured by a recorder is excellent during periods of snowmelt in the 1964-65 season. Agreement between the snow course data and the snow pillow is good. Comparison of snow pillow and precipitation gage for storm periods indicates that the snow pillow responds instantaneously with no measurable time lag. Preliminary results indicate that the water equivalent snow pillow can be measured to ±0.02 inches.


PRECEPtATION PATTERNs AND CHARACTERISTICS.

Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.

Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont 05828.

Experimental field investigations.

The purpose of this study is to develop a method for calculating average precipitation on the 43-square mile Sleepers River watershed and its subdivisions in relation to elevation, storm source and direction; to study the behavior of summer convective storms in the northeastern United States; and to provide information on rainfall depth-area-duration in relation to point rainfall in this part of the northeast.

An analysis was made to determine what effects precipitation-intensity patterns, storm duration, and areal distribution of precipitation have on hydrograph timing or basin lag. No correlation was found between storm-intensity patterns (advanced, uniform, and delayed) and basin lag. It was not determined whether correlation was due to close grouping.


INFLUENCE OF SOIL AND LAND USE ON STREAMFLOW FROM AGRICULTURAL WATERSHEDS.

Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.

Mr. G. H. Dravnieks, Hydraulic Engineer, Route 2, Danville, Vermont 05828.

Experimental field investigations.

Investigations of the influence of land use,
climatic factors, and physical characteristics such as soils, geology, and topography upon runoff rates and water yields from the 43-square mile Sleepers River watershed and its important subdivisions to derive relationships for predicting the hydrologic performance of ungaged watersheds in the other parts of the physiographic area.

g) Discontinued.

(4293) SUBSURFACE CONTRIBUTIONS TO STREAMFLOW IN SLEEPERS RIVER WATERSHED.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Agriculture of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.

e) Experimental field investigations.

(g) Preliminary analyses of Brush Creek and Crab Creek watersheds have indicated that extreme differences in their hydrologic behavior, even though they are similar in size, shape, topography, and are within 11 miles of each other. The annual precipitation of Brush Creek averages consistently about 10 percent higher than that for Crab Creek. The annual runoff for Brush Creek is 19.63 inches and that for Crab Creek, 7.11 inches. The same largest and second largest peak flow appears to be more related to amount and distribution of poorly drained soils than to the size of watershed, which varies from 116 acres to 43-square miles.

(4294) GROUNDWATER AERATION AND MOVEMENT IN RELATION TO WATERSHED CHARACTERISTICS.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.

c) Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont 05828.

e) Experimental field investigations.

(f) Discontinued.

(4295) TILLAGE AND OTHER MANAGEMENT PRACTICES FOR WATER AND EROSION CONTROL AND THE FIELD DETERMINATION OF EROSION OF CERTAIN SOILS.

(b) Laboratory project, cooperative with the New York Agricultural Experiment Station, and the Soil Conservation Service.


e) Field investigations. The purpose of one part of these investigations has been to determine under natural rainfall the effectiveness of certain tillage practices on the control of runoff and erosion. A similar objective is part of a continuing series of investigations using a rainfall simulator. These latter investigations are to develop procedures based upon watershed characteristics, climatic factors, and various land use practices for the prediction of flood peaks and seasonal and annual water yields in three physiographic areas. Hydrologic, geologic, soils, plant cover and cultural data are being obtained on unit source watersheds varying in size from 3.5 to 1.93 acres in the Appalachian Valleys and Ridges and on 10 complex watersheds from 182 to 3,956 acres in the Appalachian Valleys, Ridges, Blue Ridge Mountains, and the Piedmont Plateau.

(g) Preliminary analyses of Brush Creek and Crab Creek watersheds have indicated that extreme differences in their hydrologic behavior, even though they are similar in size, shape, topography, and are within 11 miles of each other. The annual precipitation of Brush Creek averages consistently about 10 percent higher than that for Crab Creek. The annual runoff for Brush Creek is 19.63 inches and that for Crab Creek, 7.11 inches. The same largest and second largest peak flow appears to be more related to amount and distribution of poorly drained soils than to the size of watershed, which varies from 116 acres to 43-square miles.
natural rainfall were found associated with minimum tillage compared to conventional. A formal report is being prepared. Results of the diversion terrace study cited in 1965 showed that dual-purpose diversions for erosion control and interception drainage were an effective drainage-improving practice on Triage and agricultural watersheds were an important determinant of effectiveness.

**DEVELOPMENT AND EVALUATION OF DRAINAGE PRACTICES IN THE NORTHEAST.**

(b) Laboratory project cooperative with the Vermont Agricultural Experiment Station and the Soil Conservation Service.

(c) Mr. Joseph Bornstein, Agricultural Engineer, Univ. of Vermont, Burlington, Vt. 05401.

(d) Field investigation both basic and applied research.

(e) The purpose of this study is to develop and evaluate drainage practices for sloping lands of the Northeast. This involves development of techniques for determining directional components of subsurface water flow before and after installation of drainage treatments. Surface drainage practices are instrumented to measure runoff from rainfall and snowmelt. Measure the seasonal changes in soil moisture in relation to drainage treatment; evaluation of crop root development above and in fragipan layer, characterization of moisture-tension relationships of disturbed undisturbed fragipan samples, including through the freeze-thaw cycle.

(f) Instrumentation of this project is completed and two years data are available on diversion ditch runoff and the surface flow. piezometric data, crop yield and soil moisture changes are also available.


**HYDROGRAPH LABORATORY.**

(b) Laboratory project. Cooperative efforts on occasion.

(c) Mr. H. N. Holton, Director, Hydrograph Lab., A.R.S., Beltsville, Md. 20705.

(d) Basic and applied research.

(e) The purposes of this project are to evaluate and test new concepts, theories and principles for understanding the hydrologic processes on agricultural watersheds; to test and adapt information from various sources for application to water control and related problems encountered in watershed engineering; to conduct special analyses involving A.R.S. data from more than one station or more than one branch that can be more adequately carried out at a central location which has available a full-time staff of scientists with specialized training in hydrologic, hydrology, meteorology, and mathematics; and to provide case assistance to field personnel detailed to the laboratory for specific analyses as requested by the field.

In a continuation of a study reported last year, watershed storage-flow relationships are being developed for synthesis of upland runoff hydrographs. As an alternative development, a mathematical expression describing simple runoff hydrographs is being utilized. Currently, the Hydrograph Laboratory has completed a field sampling program of selected soils occurring on Agricultural Research Service experimental watersheds. Laboratory studies are now determining moisture-holding capacities and hydraulic conductivities. These data are intended for use in computing rainfall excesses and water-shed retentions. Low level aerial photography on seven experimental watersheds is being processed for stream and valley cross sections and for watershed topography. Numerical analysis studies are continuing in the hydraulics of flood flow utilizing both kinematic and kinetic formulations. Computer programs (IBM 1620) are readily available for prismatic or nonprismatic channel geometry. Depth-area duration studies of rainfall expectancies are underway using data from dense network of watersheds as supplied by various participating agencies. Distribution patterns for major storms are also under study.


(h) "Automated System for Analysis of Runoff Hydrographs," D. L. Brakensiek. USDA-ARS 41-120. (in press)


**EFFECTIVENESS OF STREAM BANK STABILIZATION AND PROTECTION MEASURES IN REDUCING SUSPENDED SEDIMENT LOAD.**

(b) Cooperative project with Soil Conservation Service and Cornell University.

(c) Mr. H. H. Roth, Hydraulic Engineer, Civil Engrg., Dept., Parker Engrg., Bldg., State Univ. of New York at Buffalo, Buffalo, New York 14214.

(d) Experimental field investigations.

(e) To develop procedures for estimating effectiveness of streambank stabilization and other measures in reducing the sediment discharge of a stream. It is postulated that the total sediment load of a stream is directly related to the mean concentration of the stream flow and streambed sediments, and that changes in time of the mean concentration resulting from installation of streambank stabilization measures are indicative of the effectiveness of the stabilization measures. The streambank stabilization measures are being installed by Soil Conservation Service as part of the authorized flood prevention experiments and projects in the Buffalo River watershed. Measurements of suspended sediment load
concentration and of stream discharges are made for all floods above a certain magnitude.

(c) Completed.

A STUDY OF THE MOVEMENT OF COARSE-TEXTURED BED MATERIAL OF TWO NEW YORK MOUNTAIN STREAMS.

(b) Cooperative project with Soil Conservation Service and Cornell University.

(c) Mr. R. P. Apin, Hydraulic Engineer, Civil Engrg. Dept., State Univ. of New York at Buffalo, Buffalo, New York 14214.

(d) Experimental field investigations.

(e) To relate the quantities of transported bed materials to flood discharge rates and durations, to determine applicability of bed load equations in coarse material transport problems and, if appropriate, devise new or revised relationships. In 1963 a stream reach was instrumented and debris basin was placed on the Little Hoosic River near Berlin, New York. In 1964 a stream reach and debris basin were instrumented on Dean Creek, Tioga County, New York.

The first significant movement of bed material on the Little Hoosic River occurred on March 5, 1964 when a peak flow of 250 c.f.s. was measured. The amount of bedload material trapped in debris basin was about 260 cubic yards. When the hydraulic characteristics were used in the Kreyer-Peters formula it was found that the weighted mean particle size was so large that no bedload transport should have taken place under the observed conditions. However, when the mean size of the bank material was substituted for that of the bedload material, then the formula produced almost exactly the amount of material deposited in the debris basin.

COMPILATION AND PUBLICATION OF SELECTED HYDROLOGIC DATA.

(b) Cooperative project with various State Experiment Stations and Land Grant Colleges and with the Soil Conservation Service.

(c) Mr. W. W. Nance, Hydraulic Engineer, Plant Industry Station, Beltsville, Md. 20705.

(d) Office assembling and processing of current hydrologic data.

(e) To provide information on monthly precipitation and runoff, annual maximum discharges and volumes of runoff, and selected runoff events with associated data on rainfall, land use and practices, soils, geology, and antecedent conditions for all current ARS research watersheds in the United States. Hydrologic Data publications will be published at regular intervals.


DRAINAGE PRACTICES FOR LEVEL AND SLOPING LANDS.

(b) Cooperative project with the Virginia Truck Experiment Station and the Virginia Agricultural Experiment Station.

(c) Mr. Truman Goin, Agricultural Engineer, P. O. Box 2160, Norfolk, Virginia 23501.

(d) Laboratory and field investigations including both theoretical and applied phases.

(e) Drainage studies for level land include a study of drainage requirements of various vegetable crops with emphasis on the various factors related to high soil water contents and their effect on plant growth. Land-forming will be studied as a means of minimizing the need for surplus runoff. Investigations in Flat Coastal Plains areas, and for more efficient soil and water management practices on sloping lands of the Piedmont.

(g) The effect of water table levels on the growth of tomatoes, snapbeans and sweet corn is being reported and prepared for publication and will be available in the near future. Water use efficiency and nutrient uptake by plants as affected by water table is included.

FACTORs AFFECTING MOISTURE CONSERVATION AND Crop GROWTH ON EXPOSED SUBSOIL.

(b) Laboratory project, cooperative with the Virginia Agricultural Experiment Station.

(c) Mr. A. R. Batchelder, Soil Scientist, Agricultural Engineering Dept., Virginia Polytechnic Institute, Blacksburg, Va. 24061.

(e) Field investigations.

The study included mulch management with and without irrigation to evaluate factors affecting soil moisture storage in exposed subsoils, infiltration, surface crusting and runoff.

Initiated in 1965.


NORTHERN PLAINS BRANCH, F. O. Box E, Fort Collins, Colorado 80522, Dr. C. E. Evans, Branch Chief.

DEVELOPMENT AND IMPROVEMENT OF WATER MEASURING DEVICES.

Cooperative with Colorado Agricultural Experiment Station. See Colorado State University, Civil Engineering Section, Fort Collins, Colo., page 15.

HYDROLOGIC STUDIES OF GROUND WATeR IN THE RED RIVER VALLeY OF NORTH DAKOTA.

(b) Laboratory project.

(c) Mr. L. C. Benz, Agricultural Engineer, F. O. Box 1644, Grand Forks, North Dakota 58201.

(d) Field investigation. Applied research.

(e) A field investigation covering more than 200 square miles to determine possible causes for a saline condition on a large area of land. Measurements consist of water tables, artesian conditions, soil and water physical and chemical data.

(g) Salt-affected soils are caused by high water tables, poor drainage conditions and saline artesian waters. High water tables are caused by precipitation. The salt source is the Dakota sandstone artesian aquifer.

HYDRAULICS OF SUB-CRITICAL FLOWS IN SMALL, ROUGH CHANNELS.

See Colorado State University, Civil Engrg. Section, Project No. 3400.

(b) Laboratory project, cooperative with the Colorado Agricultural Experiment Station.

(c) Mr. E. Gordon Kruze, Agricultural Engineer, Engineering Research Center, CSU Poultry Center, Ft. Collins, Colo. Channel slope, for turbulent flows, resistance was a logarithmic function of

(5979)
Laboratory project, cooperative with Soil Conservation Service, USDA, and the Bureau of Reclamation, USDI.

Mr. A. L. Sharp, (Collaborator), 1697 S. W. 19th, West Linn, Oregon 97068.

Office analyses -- applied research.

to develop and test methods for use by field engineers to evaluate the downstream effects of upstream conservation use and treatment of land on runoff from creeks and rivers. The project is one purely of analytic hydrology. The project uses available hydrologic and other data wherever it is available. It seeks data such as streamflow data, climatic data, or land-treatment data. The project is nearing completion.

Studies have demonstrated that it cannot be proved statistically significant that there are downstream effects on stream flow of upstream conservation treatment and use of land, although it is axiomatic that in subhumid to arid areas such effects must exist. A rational method of evaluating such effects has been developed and tested. A summary of the studies performed and presentation of the rational method will be published through Department of Agriculture media during 1964.

Comparisons of rates and amounts of runoff from small single-cover watersheds.

Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.

Mr. Frank J. Dragoun, Hydraulic Engineer, ARS-NRCS, P. O. Box 1000, Hastings, Nebraska 68901.

Field investigations -- applied research.

to determine the effects of conservation farming, land use, climate, and physiography on rates and amounts of runoff and sediment yields. Two 400-odd-acre watersheds, one conventionally farmed and the other conservation farmed, are equipped with recording rain gages, weirs and stage recorders, and sediment samplers, to measure precipitation, runoff, and sediment yields. The two watersheds were operated the same during a calibration period from 1953 to 1947. One was then treated by terracing, contour tillage and seeding eroded cultivated land to grass. Current data substantiate previous analyses indicating conservation measures are effective in controlling soil erosion from average to intense events. Six years of continuous measurement show that annual sediment yield from the area under conservation was 5.4 tons/acre compared with 8.7 tons/acre from the conventionally farmed area or a difference of 38 percent. In 1957, a year of above normal rainfall with intense storms, no significant reduction in sediment yield was realized under conservation practices whereas in 1963, a year of above normal rainfall but no intense storms, the sediment yield from the area under conservation was only 14 percent of that from the conventionally farmed area. The significance of kinetic energy in streamflow and sediment yield determinations is indicated.

Laboratory project, cooperative with South Dakota Agricultural Experiment Station.

Mr. Clayton L. Hanson, Agricultural Engineer, Newell Irrigation and Dryland Field Station, Newell, South Dakota 57760.

Field investigations -- applied research.

to determine the effects of light, moderate and heavy grazing and other factors such as precipitation, antecedent soil moisture, soil frost and snow accumulation, on rates and amounts of runoff from fine-textured range soils in southwestern South Dakota.
Replicated plots of about 2 acres in each of the lightly, moderately and heavily grazed pastures are instrumented to observe runoff and sediment yield. Rainfall-runoff rates and amounts of precipitation (recording rain gages), soil moisture, soil frost and vegetative conditions. The studies are being made near Denver, Colorado, and at the South Dakota Range Experiment Station near Cottonwood, South Dakota.

Rainfall-runoff events during the first year of study indicate that grazing intensity materially influences range recovery and that runoff is normally higher from heavily grazed areas where storm sequences and antecedent moisture conditions can significantly influence the normal trend.

Medicine Creek Watershed Investigations.

Laboratory project, cooperative with the Soil Conservation Service, U. S. Geological Survey, Bureau of Reclamation, and Nebraska Agricultural Experiment Station.

The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in eastern Nebraska; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.

Sediment Distribution in Floodwater Retarding-Type Reservoirs.

Laboratory project, cooperative with the Soil Conservation Service and State Experiment Stations.

The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in eastern Nebraska; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.

Isolation and Relative Evaluation of Runoff Producing Potential of Range Sites of Western South Dakota.

Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.

The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in eastern Nebraska; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.

Water Yield and Sediment Accumulation from Rangeland Watersheds.

Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.

The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in eastern Nebraska; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.

Sarabeth Lake Watershed Sedimentation Studies.

Laboratory project, cooperative with the Soil Conservation Service and Kansas Agricultural Experiment Station.

The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in eastern Nebraska; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.
textured soils has continued to average 4 times that from medium-textured soils. In 1962, 6 inches of runoff or 27 percent of the 22.6 inches of precipitation occurred in a 90 acre fine-textured soil area which is the highest percentage measured since the studies were initiated in 1957. The highest runoff during 1962 from the medium-textured soils areas was 6 percent of the annual rainfall.

(4824) EVAPORATION AND SEEPAGE FROM RANGELAND STOCKPONDS.

(b) Laboratory project, cooperative with the South Dakots Agricultural Experiment Station.
(c) Mr. Clayton L. Hanson, Newell Irrigation and Dryland Field Station, Newell, South Dakota 57760.
(d) Field investigations -- applied research.
(e) To differentiate total stockpond water dissipation from evaporation or seepage and develop a basis for predicting expected stockpond water losses. The purpose of this study is to aid in the development of practical methods to reduce losses of water from stockponds to provide dependable water supplied for livestock.
(g) Data show that the ratio of the total pond evaporation (floating pan) to that from the Class A pan is 0.64. Seepage and deep percolation in ponds in the medium-textured soils region amount to 25% of the total pond dissipation. In 12 ac. ft. capacity stockpond the volume of daily seepage loss over a 3-7 day period averaged 910 cu. ft. per day or an equivalent volume to water more than 600 cows each day. Stockponds on medium-textured soils are continuing to show water losses exceeding inflow up to 80 percent of the time resulting in dry ponds nearly 50 percent of the time.

(4826) HYDRAULIC CHARACTERISTICS OF PARTIALLY SATURATED POROUS MEDIA.

(b) Laboratory project, in cooperation with Colo. Agricultural Experiment Station.
(c) Mr. R. H. Broocks, Agricultural Engineer, Engineering Research Center, CSU Foothills Campus, Ft. Collins, Colorado 80521.
(d) Basic research.
(e) Certain hydraulic characteristics of porous media must be known for laboratory modeling of complicated field problems involving water movement in soils. Problems involving flow of fluids in partially saturated soils often cannot be solved except by inferences derived from the performance of models. The purpose of the study is to be able to predict from equations how any porous medium will behave with respect to the functional relationship between permeability, degree of saturation (or rapid pressure) when certain media properties are known. A thorough understanding of the way permeability is affected by measurable properties of porous media might eliminate the necessity of selecting a porous medium by trial for use in model studies.
(g) Theory showing how the variables capillary pressure, water and air permeability are related to degree of saturation has been developed. Methods and equipment have been developed for measuring these variables using steady state experiments. Verification of the theory with experimental results has been good. It appears that hydraulic properties of partially saturated media can be described by three parameters: the bubbling pressure, \( P_b \); a measure of the uniformity of the pores \( m \); and the saturated permeability \( k \).

(4827) HYDRAULICS OF FLOW IN BORDER CHECK IRRIGATION SYSTEMS.

(b) Laboratory project, in cooperation with Nebraska's Agricultural Experiment Station.
(c) Mr. O. W. Schoner, Agricultural Engineer, USDA-ARS-SWC, P. O. Box 786, Grand Junction, Colorado 81502.
(d) Field investigation; applied research.
(e) This is a study of the operational characteristics of low-gradient border check systems on a medium textured soil. It involves measurement of the efficiency of irrigation, uniformity of distribution, effect of uneven grade, kind of crop, stage of crop development, etc., upon irrigation efficiency. Soil moisture samples are taken before and after irrigation at intervals in the length of the run. Continuous measurements are taken of depth of water at these stations throughout the set. The purpose is to obtain relationships regarding the effect of crop retardance, slope, surface configuration, intake rate, on rate of advance of irrigation water. Such relationships will be useful in designing and operating low-gradient border check irrigation systems. Samples of irrigation efficiencies, around 90 percent, when crop retardance to the flow of water was small and 90 percent were needed to offset the high retardance caused by fully developed sugar beet foliage.

(4828) DESIGN DATA FOR LEVEL OR NEARLY LEVEL BENCH IRRIGATION SYSTEMS ON CLAY SOILS IN WESTERN SOUTH DAKOTA.

(b) Laboratory project, in cooperation with South Dakota Agricultural Experiment Station.
(c) Mr. C. J. Erickson, Soil Scientist, Newell Irrigation and Dryland Field Station, Newell, South Dakota 57760.
(d) Field investigations. Results will be used for design purposes.
(e) This is a study of the operational characteristics of low-gradient border checks on a fine textured soil. It involves measurement of the efficiency of irrigation, uniformity of distribution, and effect of uneven grade, kind of crop, stage of crop development, etc., upon irrigation efficiency. Soil moisture samples are taken before and after irrigation at intervals in the length of the run. Continuous measurements are taken of depth of water at these stations throughout the set. The purpose is to obtain relationships regarding the effect of crop retardance, slope, surface configuration, intake rate, on rate of advance of irrigation water. Such relationships will be useful in designing and operating low-gradient border check irrigation systems.
(f) Discontinued.
(g) No significant findings have been obtained as yet since this project was just initiated in 1962.

LAND FORMING ON SALT-AFFECTED LACUSTRINE SOILS IN THE RED RIVER VALLEY HAVING AN INTERSECTING MINOR RIDGE-DEPRESSION TYPE OF MICRORELIEF.

(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 1644, Grand Forks, North Dakota 58201.
(d) Field experiment; applied research.
(e) Consists of four 5-acre plots under cultivation in a saline ridge-depression micro-relief area. Two plots are leveled and one having slightly drainage, the other having only internal (tile) drainage (precipitation is impounded). One leveled plot has internal drainage, the second one has none. Purpose of work is to determine effects of land forming and tile drainage on salt-affected land.

A STUDY OF THE FALLING WATER TABLE, SOIL MOISTURE, AND SOIL SALT TRANSLOCATION DURING WINTER MONTHS.
(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 164, Grand Forks, North Dakota 58201.
(d) Field experiment; basic research.
(e) Experiment consists of two treatments (straw mulch and fallow) each replicated 3 times. Field plots are 60' x 60'. Measurements obtained are: soil moisture (neutron method), water tables, soil temperatures, freezing depth, water and soil physical and chemical data. Purpose of the experiment is to determine translocation of water table waters which recede during the winter months.

RELATIONSHIP OF MEASURED EVAPOTRANSPIRATION TO SOLAR RADIATION IN WESTERN U.S.A.

(b) Laboratory project, (joint project with Mr. E. Jenann, Northwest Branch)
(c) Dr. H. R. Halse, Soil Scientist, Agricultural Research Service, P. O. Box E, Fort Collins, Colorado 80522.
(d) Analytical and theoretical; basic and applied.
(e) Measurements of evapotranspiration rates for one- to three-week periods made by USDA personnel during the past 35 years have been re-evaluated and selected data for field and orchard crops are being related to solar radiation and air temperature using an energy balance approach. Solar radiation data for 20 locations in the Western U.S.A. have been summarized and procedures developed for estimating radiation for 24 periods. The resulting correlations can be used for estimating evapotranspiration for various crops.
(f) Completed.

VOLUMETRIC EROSION AND DEPOSITION ON A COMPLEX WATERSHED.

(b) Laboratory project, cooperative with the Soil Conservation Service and Nebraska Agricultural Experiment Station.
(c) Mr. Frank J. Dragoun, Hydraulic Engineer, ARS-SWC, P. O. Box 1000, Hastings, Nebraska 68901.
(d) Field investigations and office analysis; master's thesis study.
(e) To develop a method of determining volumes of erosion and deposition within a watershed using topographic maps data derived from aerial photographs, and to delineate the areas, determine the volumes and indicate the depths of erosion and deposition with time. It is expected that from this research new method will evolve for use in conservation work.

DEVELOPMENT OR CHANGES OF VEGETATION ON PERMANENT GRASS WATERSHEDS AS AFFECTED BY USE AND AS RELATED TO WATER YIELDS.

(b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.
(c) Mr. Warren L. Rice, Engineering Technician, ARS-SWC, P. O. Box 1000, Hastings, Nebraska 68901.
(d) Field investigations—applied research; compilation and analysis of data.
(e) Objectives of the research are: (1) To follow deterioration of vegetation when converting from meadow to pasture; (2) to follow development of vegetation on cropland seeded to native grasses; and (3) to follow changes in vegetative cover of a permanent pasture watershed. In all cases the effect on water yields will be determined. It is the purpose of this research to provide needed information on the effect of changes in pasture and meadow land use on runoff and water yields.


LABORATORY STUDY OF DELTA DEVELOPMENT IN-

DUCED BY FLOOD-WATER RETARDING AND SEDIMENT DETENTION STRUCTURES.

(b) Laboratory investigations cooperative with the Colorado Agricultural Experiment Station.
(c) Mr. R. H. Brooks, Engineering Research Center, OSU-Pothills Campus, Ft. Collins, Colorado 80522.
(d) Experimental investigations; basic and applied.
(e) Purpose of project is: (1) To investigate the dynamic processes involved in delta (topset bed) development above floodwater or debris storage structures, and (2) to develop equations and graphical representations describing the delta development processes in terms of the variables involved.
(f) Project initiated September, 1964. As yet, no data have been obtained.

AUTOMATION OF SURFACE IRRIGATION SYSTEMS.

(b) Laboratory and field investigations.
(c) Dr. H. R. Halse, Soil Scientist, Agricultural Research Service, P. O. Box E, Fort Collins, Colorado 80522.
(d) Laboratory and field project. Applied research. Development, design and operation of automated surface irrigation systems. To develop labor-saving devices for surface application of irrigation water to farm fields for more efficient use of existing water supplies. Study involves development and testing of remote operation of a pneumatic valve (patents pending) capable of controlling water in open ditch and closed pipe systems.

In early stages of development. Water has been successfully applied to irrigation fields by radio control of pneumatic valves at distances up to one mile or more. Further studies are to be initiated at five locations where automatic systems will be operated and tested on a total farm basis.


THE EFFECT OF SLOPE WITHIN A WATERSHED ON WATER INTAKE AND RUNOFF FROM RAINFALL.

(b) Laboratory project cooperative with Nebraska Agricultural Experiment Station.
(c) Dr. Norris P. Shannon, Agricultural Engineer, ARS-SWC, Lincoln, Nebraska.
(d) Field investigations; basic and applied.
(e) Purpose of the project is: (1) To measure and compare intake, runoff, and erosion from plots on slopes of approximately 3, 6, and 10 percent, located within small 4-acre watersheds using simulated rainfall; and (2) to construct runoff hydrographs using simulated rainfall data for comparison with hydrographs obtained from natural rainfall.
(f) Discontinued.

HYDRAULICS OF FLOW IN SUB-SURFACE DRAINS.

(b) Laboratory project.
(c) Dr. E. Gordon Kruse, Agricultural Engineer, SWC-ARS-USDA, Engineering Research Center, Colorado State University, Fort Collins, Colorado 80521.
(d) Experimental, laboratory investigation.
(e) Head losses are being determined for uniform flow in different underground drainage materials. Lines of clay and concrete tile are laid with varying joint spacings and alignments. Resistance is also being measured in new plastic and composition drain materials.

IRRIGATION BORDER DESIGN ON A SHALLOW, SANDY SOIL.

(b) Laboratory project.
(c) Dr. E. Gordon Kruse, Agricultural Engineer, SWC-ARS-USDA, Engineering Research Center,
Colorado State Univ., Fort Collins, Colorado 80521.

(d) Experimental, field investigation.
(e) Varying rates and times of water application are being made to irrigated borders of different lengths. Water applied, soil moisture and runoff are measured to determine proper design for maximum irrigation efficiency.

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NORTHWEST BRANCH, P. O. Box 1096, Boise, Idaho 83701.
Mr. Dean G. Muckel, Branch Chief.

(3550) THE EFFECT OF SPRINKLER PATTERN VARIATION ON IRRIGATION EFFICIENCY.

(b) Laboratory project.
(c) Mr. Claude H. Fair, Research Engineer (Irr.), Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.
(d) Experimental; applied research and design.
(e) To determine the effect of sprinkler pattern on field irrigation efficiency and develop a method for calculation of field water application efficiency for a sprinkler system from sprinkler pattern, wind velocity, humidity, temperature, irrigation period, and related factors. Another phase of this project is to test typical sprinkler heads for reproducibility of water distribution pattern.
(f) Completed.

(3552) HYDRAULICS OF SURFACE IRRIGATION.

(b) Laboratory project.
(c) Mr. James A. Bondurant, Agricultural Engineer, Agricultural Research Service, Route 1, Box 186, Kimberly, Idaho 83341.
(d) Experimental; field investigation, basic research.
(e) To investigate the factors that influence the advance and recession of water in an irrigation border strip.

(3553) DEVELOPMENT OF AUTOMATIC SURFACE IRRIGATION EQUIPMENT.

(b) Laboratory-field project.
(c) Mr. Allan S. Humphreys, Agricultural Engineer, Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.
(d) Experimental; design and development.
(e) To develop automatic and semi-automatic control structures for surface irrigation.
(f) Completed.

(4311) FLOOD HYDROGRAPHS BY ELECTRONIC ANALOG.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho 83844.
(d) Analytical, basic and applied.
(e) Further development and adoption of electronic analog methods in the solution of flood routing problems and the prediction of flood hydrographs from agricultural and Pothill range watersheds of the northwest.

(4312) WATER YIELD AS INFLUENCED BY WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho 83844.
(d) Analytical.
(e) Regional analysis of water yield as affected by climate, topographic, geologic, soil, land use and other characteristics of rangeland watersheds in the Northwest.

(4313) SNOWMELT HYDROGRAPHS AS INFLUENCED BY CLIMATIC FACTORS AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho 83844.
(d) Analytical; basic and applied.
(e) To develop improved methods for estimating daily hydrographs of streamflow from mountainous watersheds where the supply is from snowmelt and occasional rain.

(4314) PRECIPITATION CHARACTERISTICS OF A NORTHERN SEMI-DESERT WATERSHED.

(b) Laboratory project.
(c) Mr. Freeman M. Smith, Research Botanist, P. O. Box 2724, Boise, Idaho 83701.
(d) Experimental, basic and applied.
(e) The 93 square mile Reynolds Creek Experimental Watershed, Owyhee County Idaho, has recording raingages to a density in excess of one per square mile. From this network, methods for evaluating rainfall amounts and intensities for different areas are being developed. Seasonal distribution with respect to amounts, character, and areal extent of precipitation are being measured.
(f) Topography greatly influences precipitation in the Snake Valley. The regression equations for the relation of precipitation to elevation, computed for the east and west half of the watershed are parallel, but there is a five inch difference in the constant term in the equations. This is attributable to the position of the valley in relation to incoming storm patterns. Precipitation is extremely variable in the semi-arid Northwest. To estimate mean precipitation in a stream basin in the mountainous Northwest similar to Reynolds Creek in relation to precipitation to elevation, topography, elevation, storm patterns and rainfall with 95 percent confidence of being or - 1 inch would require approximately 55 rain gages.

(4315) THE DESIGN OF SELF-PROPELLED SPRINKLER SYSTEMS.

(b) Laboratory project.
(c) Mr. Claude H. Fair, Research Engineer (Irr.), Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.
(d) Experimental, applied research, design.
(e) Determine water application patterns of self-propelled sprinkler systems. Determine the effect of wind on application patterns of self-propelled sprinkler laterals, and develop method of designing self-propelled sprinkler laterals from theoretical formulas.
(f) Completed.

(4386) WATER BUDGET OF A UNIT SOURCE AREA.

(b) Laboratory project.
(c) Mr. Freeman M. Smith, Research Botanist, P. O. Box 2724, Boise, Idaho 83701.
(d) Experimental; basic and applied research.
(e) Determine as fully as possible the fate of water falling on a small representative watershed throughout the year and estimate evaporation and transpiration from readily obtained instrumental and meteorological data. Such a general understanding of the disposition of precipitation on an area is basic to an understanding of the effects of soils, geology, vegetation and climate.
(f) Combined with project: WATER BUDGET OF WATERSHED (556).

(4557) FACTORS AFFECTING SNOW ACCUMULATION AND MELT ON UNIT SOURCE AREAS.

(b) Laboratory project.

c) Mr. Freeman W. Smith, Botanist, P. O. Box 1072, Boise, Idaho 83701.

d) Experimental and applied research.

e) Determine physical and meteorological factors contributing to non-uniformity of snow accumulation and melt in a shrub covered hillside area of the sagebrush zone of Owyhee County, Idaho. Any improvement in the quantity or timing of flow from snow fed streams by manipulation of vegetation and other practices requires a thorough understanding of the behavior of snow under these conditions. Such information must be derived from research.

(4556) A STUDY OF SURFACE WATERS DIVERSIONS AND RETURN FLOW IN REYNOLDS VALLEY.

(b) Laboratory project.

c) Mr. Clifton W. Johnson, Hydraulic Engineer, P. O. Box 1074, Boise, Idaho 83701.

d) Experimental and field investigation; basic and applied research.

(e) This investigation is designed to find the consumptive use of water by an upstream irrigated area as it affects downstream water supplies. All of the inflow to Reynolds Valley is measured as is the outflow and general ground water levels.

(g) About 50 per cent of the water diverted for irrigation is used on the land with the remainder returning to the stream by valley and ground water flow.

(4559) GEOLOGIC CONTROL OF SUBSURFACE STORAGE AND FLOW CHARACTERISTICS OF BASALT TERRANE.

(b) Laboratory project.

c) Mr. Gordon R. Stephenson, Geologist, P. O. Box 1274, Boise, Idaho 83701.

d) Experimental and field investigation; basic and applied research.

(e) An intensive hydrogeologic study of the Reynolds Creek Experimental Watershed is being made, using various geologic, geophysical, and hydraulic methods to evaluate the hydrologic characteristics of the basalt terrane in this portion of Owyhee County, Idaho. One objective is being approached by studying the water balance on a closed basaltic basin.

(g) Boundaries of aquifers located, recharge rates computed, and baseflow and transmissibility values determined for these basaltic aquifers. The latter values for these upland basalt areas are low when compared to the aquifers in the basaltic areas of the Snake River Plains.


(4840) THE DEVELOPMENT OF A PORTABLE IRRIGATION SPRINKLER EVALUATION DEVICE.

(b) Laboratory project. See project 4558, page 100.

c) Mr. Claude H. Fair, Research Engineer (Irr.), Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 106, Kimberly, Idaho 83341.

d) Experimental; applied research.

(e) To design a portable device that can be used in the design and evaluation of sprinkler irrigation systems. To determine procedures for the use of this device.

(f) Completed.

(5209) DEVELOPMENT OF IRRIGATION WATER MEASURING DEVICES AND METHODS.

(b) Laboratory and field project.

c) Mr. A. H. Robinson, Director, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, (Twin Falls) Idaho 83341.

d) Experimental design and development.

(e) To develop devices and methods for accurate measurement of flow of water.

(g) Improved devices will be developed to measure flow in pipes, channels, and underground. Specifically, devices to be or being studied include: (1) Combination headgate and measurement structure, (2) Improved measuring flumes, (3) runoff measuring structures for watersheds, (4) devices utilizing drag or deflection principles, and (5) dye diffusion techniques.


(5568) IRRIGATION WATER MANAGEMENT ON SUGAR BEETS.

(b) Laboratory project.

c) Mr. Marvin E. Jensen, Investigations Leader (Water Management), Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(d) Experimental, applied research.

(e) Two moisture levels each with 3 nitrogen rates irrigated for 8 weeks to simulate the upper, middle and lower parts of a field. The influence of these practices on yield, sugar percentage, nitrogen recovery, and deep percolation water losses will be evaluated.

(5570) FACTORS AFFECTING FARM AND PROJECT IRRIGATION EFFICIENCIES.

(b) Laboratory project.

c) Mr. Marvin E. Jensen, Investigations Leader (Water Management), Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(d) Field investigation; applied research.

(e) Detailed measurement of the disposition of irrigation water on selected farms will be made by the U.S.B.R. and A.B.S. to evaluate the factors affecting farm and project irrigation efficiencies.

(5571) DESIGN OF RECIRCULATING IRRIGATION SYSTEMS.

(b) Laboratory project.

c) Mr. James A. Bondurant, Research Agricultural Engineer, Agricultural Research Service, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(d) Field investigation; applied research and design.

(e) This project will develop criteria for design of pumping systems to return irrigation run off water to the distribution system. Possible amounts and rates of runoff waters will be determined, both theoretically and on a field basis. Size of systems, (pump, sump, pipeline, etc.) as well as system operation are being investigated.


(5580) WATER BUDGET OF WATERSHEDS.

(b) Laboratory project.

c) Mr. W. Russell Hanson, Research Hydraulic Engineer, Agricultural Research Service, P. O. Box 1274, Boise, Idaho 83701.

(d) Experimental; basic and applied research.

(e) Each hydrologic component is to be evaluated and the parameters of predictive equations related to easily determined physical characteristics and climate. Such equations will be used in combination with hydrologic storages to develop a hydrologic model for predicting the water budget on ungaged watersheds. These procedures will be developed principally for semi-arid range lands.

123


(5891) TRANSIENT VERTICAL DRAINAGE IN IRRIGATED SOIL.

(b) Laboratory project.

c) Dr. Marvin E. Jensen, Investigation Leader (Water Management), Agricultural Research Service, Snake River Conservation to the Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(d) Theoretical and experimental; and basic and applied.

(e) Numerical solutions for nonsteady state vertical drainage were obtained using a computer and independently determined hydraulic properties of the porous materials. These were compared with experimental data and used to evaluate approximate solutions. Deep percolation losses encountered when maintaining soil moisture within specific limits under various rates of evapotranspiration and root zone depth will be evaluated in a similar manner for developing practical methods of predicting the magnitude of these losses.

(g) Under drainage, without evapotranspiration, two flow regimes occurred in coarse-textured materials. During the first stage, the outflow rate from a column was related to the position and fluid pressure at the saturated front. Only a portion of the drainable fluid drains during this period. An approximate solution presented by Youngs in 1960 predicts the drainage rate adequately during this period, but only during this period. During the second stage, the change in outflow rate was not dependent on the movement of the saturated front but was now dependent on the unsaturated hydraulic conductivity and differential fluid capacity of the porous materials.

(h) "Nonsteady-State Drainage of Fluid from Porous Media and Drainable Porosity," Marvin E. Jensen, Ph.D. Dissertation, Colorado State University, Civil Engineering Department, August 1965.

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SOUTHERN BRANCH, P. O. Box 1039, Athens, Georgia 30601. Dr. A. R. Bertrand, Branch Chief.

(5870) AGGRADATION AND DEGRADATION AS RELATED TO CHANNEL STRUCTURES.

(b) Laboratory project, cooperative with the Univ. of Miss. and Miss. State University.

c) Dr. Joe G. Willia, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655, and Mr. Paul Yates, Hydraulic Engineer, P. O. Box 33, Watkinsville, Georgia 30677.

(d) Field and laboratory investigations; basic and applied research.

(e) It is necessary for proper planning and design of agricultural watershed conservation work to have knowledge of the extent of aggradation or degradation that is likely to occur with placement of structures in alluvial channels. Studies of deposition and scour as related to actual structures at various locations in Mississippi, Georgia, Wisconsin and other selected locations to provide the needed field data are underway to develop procedures and criteria useful in predicting channel adjustments with structural installations and accompanying changes in sediment transport and flow pattern.

(g) Channel surveys show a slow rate of degradation of the streambed of Barber Creek, Georgia, where channel flows by flood water detention structure is greatest. Here the watershed is about 95 percent controlled. The degree of channel scour and channel changes in rates of degradation have been determined in connection with several structural installations in Mississippi. Case histories of over 70 gully control structures in Wisconsin have been established. Laboratory studies of degradation have been started. The rates of degradation of laboratory sand-bed channels following suspension of sand were measured. Three different sands were used.

(5871) LABORATORY STUDIES OF SEDIMENT TRANSPORT.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

c) Mr. Joe G. Willia, Hydraulic Engineer and Mr. Neil L. Coleman, Geologist, USDA Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

(d) Experimental; basic and applied research.

(e) Laboratory flume experiments are conducted to determine bed material transport, bed level settlement, and hydraulic characteristics.

(g) In laboratory tests with a 400-micron median-diameter sand and depths of flow ranging between 0.4 ft. and 1.1 ft. the variable $V_{1}$ is related to the type of bed form, the mean dune height, and the Darcy-Weisbach friction factor rather well. Total load and bed load was determined by mean velocity when moving dunes were present on the bed. When mean velocity was larger than the value of minimum bed friction factor, total load was a function only of mean bed shear stress. A comparison of transport rates with those calculated by certain formulas, showed Schoklitsch's to be preferable because of applicability and ease of computation. Further tests with a 100-micron median-diameter sand are planned to test these relationships.


(4305) TRAP EFFICIENCY OF RETARDING-TYPE RESERVOIRS.

(b) Laboratory project, cooperative with the Soil Conservation Service and the U. S. Geological Survey.

c) Mr. D. A. Parsons, Director, Sedimentation Lab., P. O. Box 30, Oxford, Miss. 38655.

(d) Theoretical and field investigations, and office analysis.

(e) The trap efficiency of a reservoir is a measure of the effectiveness of the structure in retaining incoming sediment. Structures need to be designed and built with different degrees of trap efficiency, and information is needed so that the influencing parameters can be adjusted to provide the desired trap efficiency. In this study we are endeavoring to (1) collect and study data from retardation-type reservoirs in order to determine what factors influence trap efficiency, and (2) derive and test methods for predicting the trap efficiency of retardation-type reservoirs.

(4516) HYDRAULICS OF CHANNELS RELATIVE TO CHANNEL STABILITY.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

c) Mr. D. A. Parsons, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30,
(d) Experimental, field investigations, applied and basic research.

(e) The determination of flood flow qualities in selected reaches of Pigeon Roost Creek, Mississippi, as related to the resistance to erosion of streambank and bed materials, and streambank vegetation. Measurements of the boundary shear stresses in curved channels as affected by bend radius, bed angle, and Proud number.


(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Dr. Earl H. Grissinger, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

(d) Experimental, applied and basic research.

(e) To study the properties of cohesive materials that determine their stability to flowing water. Rate of erosion by subjecting remolded materials to a constant erosive flow of water. Objectives are: (1) to determine the reasons for the resisting ability of soil and streambank materials to erosion by flowing water; (2) to determine the kinds of tests needed to measure this resistance; and (3) obtain the quantitative values of the resistance for natural and synthetic materials.

(g) The stability of cohesive material was found to be dependent upon the type, amount, and orientation of the clay minerals; the bulk density, antecedent moisture, and wetting time of the sample; and the temperature of the eroding water. In general, stability increases with increasing clay mineral content and with increasing density. Stability was greater for the 2:1 type clay mixture than for the 1:1 type.


(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Dr. L. L. McDowell, Soil Scientist, Sedimentation Lab., P. O. Box 30, Oxford, Mississippi 38655.

(d) Experimental, basic research.

(e) Runoff and sediment production are measured from a small gully typical of the Yazoo-Tallahatchie Watershed. Sediment produced from this gully will be related to gully area, thereby providing information on the rate of gully erosion. When applicable, comparisons will be made between the estimated sediment discharge utilizing radioactive tracer sand, and the measured sediment discharge.

(g) Runoff and sediment measuring equipment have been installed. A detailed topographic survey has been made of the gully area. Surveys will be made periodically to observe changes in gully shape.


(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Mr. F. E. Dendy, Research Agricultural Engr., and Mr. Paul H. Hawks, Geologist, USDA Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

(d) Experimental and field investigation for basic research and developmental work.

(e) To relate sediment accumulation in
reservoirs to sediment yields, runoff, and physical parameters of the watersheds. The nature of the sediment, its origin, mineralogy, chemistry, and biology are studied in relation to distribution and deposition within the reservoir. Nuclear methods are used where applicable.

A number of reservoirs have been periodically surveyed for sediment accumulation. Nuclear means of determining in situ densities have been employed.


(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Dr. J. R. McHenry, Soil Scientist and Dr. L. L. McDowell, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

(d) Experimental basic research.

(e) To devise, develop, and utilize procedures for tagging sediment particles with radioisotopes and identifying same in the laboratory and in the field. Results are to be used in predicting sediment production, transport, and deposition in reservoirs.

(f) A satisfactory method has been developed for tagging quartz particles with scandium-46, silver-110, cerium-144, and antimony-124.


(b) Laboratory project, in cooperation with Georgia State Highway Dept., Soil Conservation Service USDA, the University of Georgia College of Agriculture Experiment Stations, and Bertow County, Georgia.

(c) Mr. Ellis G. Biseker, Agricultural Engineer, P. O. Box 335, Cartersville, Georgia 30120.

(d) Experimental, field; applied.

(e) Measurements are made of runoff and soil losses from one pair of bare roadbank plots and two pairs of plots vegetated in early 1963 (approximately 1/1, 2/1, and 3/1) on Cecil clay subsoil using 6X H-flumes and Coshocton vane samplers. On the two pairs of vegetated plots, annual soil loss was approximately 15 times less than before the plots were vegetated. Metal hub stakes are used to measure deposition or scour in the channel flows. Over 35 plant species have been tested for erosion control on 1,000 roadbank plots.

(f) Losses on bare banks have varied from 25 to 453 tons per acre per year for the last 6 years, varying according to rainfall, frost action, bank aspect, and slope. Bank aspect and frost action are major factors in the erosion process. Northwest-facing banks, on an average, have lost 2.2 times as much soil as southeast-facing banks. Pea, common Bermuda, lovegrass, broomedge, Pensacola and Williamson Bahiagrasses, crowntvet, sericea lespedezas, honeysuckle, and kudzu have proven to be satisfactory for erosion control. Methods of high efficiency have been developed using a liquid scintillation counter. Laboratory studies have shown the precision and accuracy of the methods are adequate. Some field tests have been conducted. Results have not been conclusive. Tests designed to date water in limestone aquifers have not been completed.

RUNOFF FROM AGRICULTURAL WATERSHEDS.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Mr. A. J. Bowle, Hydraulic Engineer, USDA
Field investigations; basic and applied research.

To develop procedures for predicting flood runoff, water yield and hydrograph characteristics for ungauged upstream watersheds. Runoff and precipitation are observed for two sub-basins in the Pigpen Roost Creek Watershed in Northern Mississippi including 11 sub-watersheds, and for four un-gauged upstream basins in size. These data, accumulated over the past four years, are being processed by computer and analyzed to develop synthetic unit hydrographs and to incorporate soil moisture and watershed characteristics. The predicted hydrographs will be used to establish flow-duration curves.

Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

Mr. P. E. Dendy, Agricultural Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

Experimental and field investigations; basic and applied research.

To study the hydraulic characteristics of geologic strata and develop methods for predicting ground water ascension and movement; subsurface and ground water contribution to streamflow; to develop a knowledge of geology, soils, topography, climate, land use and treatment of agricultural watersheds; and to evaluate hydrogeologic factors governing transmission gains and losses in stream channels. A portable drilling rig is utilized to obtain geologic samples, establish a ground water observation wells, and conduct permeability field tests.

Mapping structural and stratigraphic characteristics and groundwater contours of the Pigeon Roost Creek watershed have been prepared. Estimates have been made of ground-water storage and outflow from the watershed.

Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

Mr. John Kozachyn, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.

Field investigation; applied research.

To provide soil moisture data for the development of prediction techniques for runoff and water flow from sub-basins. These techniques are related to the moisture regimes of agricultural watersheds to soil, climate and vegetative parameters. Field observations of soil moisture to depths of 10 and 20 feet are obtained by the neutron probe method for different cover, slope, and soil complexes.

The superiority of the neutron probe procedure over other similar methods was established from laboratory and field tests. A method of installing access tubes has been perfected.

Relation of climate and soil moisture levels to plant growth and water use.

Laboratory project, cooperating with the Central and Southern Florida Flood Control District and the Florida Agricultural Experiment Station.

Mr. E. H. Stewart, Soil Scientist, P. O. Box 9087, Ft. Lauderdale, Florida 33310.

Laboratory and field investigations, both basic and applied for evaluating measured environmental conditions.

Laboratory and field procedures are employed to determine soil moisture intake and transmission characteristics of mineral and organic soils. Controlled water table studies in non-weighing lysimeters are conducted to determine evapotranspiration, crop growth, and soil physical properties as influenced by various water table depths. Field and plot investigations in organized and unorganized watersheds are conducted to determine soil subsidence.

Laboratory studies with porous tile used for subirrigation have shown that treating the irrigation water with sodium carbonate prevented the tile from becoming clogged by filamentous-type water bacteria. Tile that usually clog, however, with fine sand with a 24-inch water table show a mean annual water consumption of 43 inches.


Laboratory project, cooperating with the Central and Southern Florida Flood Control District and The Florida Agricultural Experiment Station.

Mr. E. H. Stewart, Soil Scientist, Attention W. H. Speer, Engineering Technician, P. O. Box 9087, Fort Lauderdale, Fla. 33310.

Experimental, field investigations; basic and applied research.

To collect, analyze, and correlate basic hydrologic data on agricultural watersheds ranging in size from 4,000 to 63,000 acres in the Coastal Plain of Florida. The 0.55-acre watershed at 9087, Sept. 1960, was 2.28 inches-over-area with an instantaneous peak rate of 71 c.f.s./sq. mile, and for the 15.7-sq. mile upper sub-basin the respective rates were 3.14 inches and 161 c.f.s./sq. mile. For an improved 78 square mile watershed the maximum daily discharge (Sept. 1960) was 2.57 inches-over-area with an instantaneous peak rate of 86 c.f.s./sq. mile. For an improved 6.2 square mile watershed the maximum daily discharge (Sept. 1960) was 2.33 inches-over-area with an instantaneous peak rate of 123 c.f.s./sq. mile. The ratio of runoff to rainfall averaged 0.43 for the artesian-irrigated 78 sq. mile watershed until 1959. During 1959 increased use of irrigation water increased this ratio to 0.55 after 1959. For the 98.7 sq. mile unimproved watershed this ratio has averaged 0.32 and for the 15.7-sq. mile sub-basin, 0.27 since 1955. For the 6.2 square mile watershed the ratio has averaged 32% since 1956. This includes seepage runoff from pumped irrigation during dry periods. For the 98.7 sq. mile watershed basic flow was averaged 66%, interflow 25%, and overland flow 9% of total streamflow. The 78-sq. mile watershed these flow components have averaged 61%, 8%, and 11%, respectively. For the 15.7 sq. mile watershed they averaged 26%, 50%, and 42%. Storm rainfall in central and southern Fla. was characterized by analyzing records of 30 high-intensity rainfalls that occurred on 2 agricultural watersheds in that area. Periods of rainfall recorded on the watersheds were approximately 9 years and 13 1/2 years. Watershed areas were 96.6 sq. mi. and 78 sq. mi. Storm time distribution patterns were established for storms of long duration (greater than 12 hours) and short duration (less than 12 hours). Depth-area relations were established for both long-duration storms and the short-duration storms for both watersheds.
(4330) **RUNOFF AND EROSION CHARACTERIZATION OF BROWN LOAM SOILS.**

(b) Laboratory project.

d) Mr. Cade E. Carter, Agricultural Engineer, North Mississippi Regional Experiment Station, P. O. Box 156, Holly Springs, Miss. 38635.

d) Experimental, field; basic and applied.

e) Rates and amounts of runoff and soil losses from small plots are measured. The plots range in size from 1/45 acre to 4 acres. The slopes of the smaller areas are 2-1/2 percent, 5 percent, and 10 percent. Land use varies from fallow and cultivated to pasture, with good and poor management conditions for the cultivated and pastured areas.

(g) Both water and soil losses are excessive on bare land, and are reduced as the degree of ground cover is increased.

(4331) **HYDRAULICS OF FARM WATER CONTROL IN THE SOUTHERN PIEDMONT.**

(b) Laboratory project in cooperation with the University of Georgia, College of Agriculture Experiment Stations.

(c) Mr. A. P. Barnett, Research Agricultural Engineer, Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Ga. 30677.

(d) Experimental laboratory; basic and applied.

(e) Basic research on the mechanics of erosion and hydraulic flow in individual crop rows and in terraced channels will be developed for both terrace systems and individual row systems for the different soils of the Piedmont.

(g) Initial studies are underway.

(4332) **SURFACE DRAINAGE -- ROW LENGTHS AND GRADES FOR REMOVAL AND APPLICATION OF SURFACE WATER ON FURROSSED AGRICULTURAL LAND OF THE MISSISSIPPI DELTA.**

(b) Laboratory project in cooperation with the Louisiana Agricultural Experiment Station.

(c) Mr. Irwin D. Sisson, Agricultural Engineer, P. O. Drawer I, University Station, Baton Rouge, Louisiana 70803.

(d) Experimental; basic and applied research.

(e) Approximately 60 acres of land have been formed with four different slopes, in two replications, of 0.1', 1.15', 0.2', and 0.25'. For each slope class, row lengths of 500', 700', 900', and 1,100' will be used to determine the maximum row length for formed land as related to slope.

Runoff, time-of-concentration, infiltration, soil temperature, and soil moisture data will be gathered and correlated with rainfall, wind, humidity, and sunshine radiation.

Future studies are contemplated to evaluate flow characteristics of surface water in furrows on agricultural land. This information will be used to develop a furrow cross-section with the best hydraulic characteristics.

(g) An evaporation recorder has been developed.

Data have been collected and are being analyzed for years 1963, 1964 and 1965.

(4333) **RUNOFF AND EROSION STUDIES FOR THE SOUTHERN PIEDMONT.**

(b) Laboratory project in cooperation with the University of Georgia, College of Agriculture Experiment Stations.

(c) Mr. A. P. Barnett, Research Agricultural Engineer, Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Ga. 30677.

(d) Experimental field investigations, development and applied.

(e) The purpose of these studies is to determine the interrelations of climate, soil, topography, management, row direction, runoff, soil movement and loss from Southern Piedmont soils. The work is conducted on fractional acre field plots under both natural and simulated rainfall.

The natural rainfall plot study includes six cover, two row direction and three slope steepness treatments on a total of 42 plots. Total amount of runoff and soil loss are measured for individual rainstorms. Meteorological data are also secured.

The rainfall simulator designed to apply rain at 5, 10-1/2 and 1-1/2 inches per hour simultaneously to three adjacent plots is used to secure runoff, soil loss, and pesticide data on irrigated soil, slope, crop, and management complexes through the application of designed storms. These data are used to evaluate their runoff and erosion control effectiveness.

(4334) **RUNOFF AND EROSION STUDIES FOR SOUTHERN COASTAL PLAINS SOILS.**

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations.

(c) Mr. Adrian W. Thomas, Agricultural Engineer, ARS-SMC, Coastal Plains Experiment Station, Tifton, Georgia 31794.

(d) Field investigations; applied, for design.

(e) The purpose of these studies is to determine runoff and soil loss from Southern Coastal Plains soils. The work is conducted on 10 fields located on young and mature soil, under natural rainfall. There are four cover treatments. Total amount of runoff and soil loss are measured for individual storms. Meteorological data are also secured.

(g) Grass-based rotations and continuous corn have been evaluated, showing protective effects of perennial grass sods and annual crop residues.

(4341) **SURFACE WATER STORAGE AND SUPPLY ON FARMS IN THE COASTAL PLAINS.**

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations and Soil Conservation Service, USDA, in Georgia.

(c) Mr. Adrian W. Thomas, Agricultural Engineer, ARS-SMC, Georgia Coastal Plains Experiment Stations, Tifton, Georgia 31794.

(d) Field investigation; applied for design and development.

(e) Purpose of the studies is to determine pond storage interrelations of climate, soil, and topographic conditions as affected by watershed yield, pond surface evaporation, seepage into and out of the impoundment, farm use of storage, and related factors. Initial study to be on one rather typical farm pond in the coastal plain, with anticipation of extending the work to other ponds.

(g) Study currently in progress.

(4342) **SHALLOW WELLS AND IRRIGATION PITS FOR IRRIGATION AND OTHER FARM WATER SUPPLY IN THE COASTAL PLAINS.**

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations and Soil Conservation Service, USDA, in Georgia.

(c) Mr. Adrian W. Thomas, Agricultural Engineer, ARS-SMC, Georgia Coastal Plains Experiment Station, Tifton, Georgia 31794.

(d) Field investigation; applied for design and development.

(e) The purpose of the studies is to develop criteria by which engineers and soil scientists can classify sites for irrigation pits, shallow wells or access to shallow ground water aquifers in the coastal plains on the basis of topography and soils. Initial study is concerned with excavated shallow wells.
irrigation pits, their adequacy of supply, the relation of rainfall and soils, and other related influences. Investigations now involve 3 pits, each under somewhat different soil and topographic situation. Study currently in progress.

(a) Laboratory project in cooperation with the Louisiana Agricultural Experiment Station.
(b) Mr. Irvin L. Savelson, Agricultural Engineer, P. O. Drawer U, University Station, Baton Rouge, Louisiana 70803.
(c) Experimental research.
(d) The present conventional system of sugarcane land requires considerable land occupied by ditches and is costly to maintain. Experimental work is being done to develop a more efficient drainage system which will consume less land and be more economical to maintain. This is an adaptation of the cotton drainage system to sugarcane land.
(e) This system reduces the amount of land in ditches from 4 to 7 percent with a $5.22 per acre per annum savings in cost of maintenance.
(f) Radio-carbon DATING OF SEDIMENTS.
(g) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(h) Dr. L. L. McDowell, Soil Scientist (Chemistry), Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.
(i) Laboratory and field investigations; basic research.
(j) To establish and maintain a radio-carbon dating laboratory meeting the requirements of sedimentation research. The program is used to supplement geomorphologic investigations by providing information on (1) the age of sediments, e.g., buried soils and geologic horizons, and (2) the past rates of sediment aggradation and degradation.
(k) The carbon in samples to be dated is processed to benzene (C₆H₆) and the number of beta particles 14C is determined by liquid scintillation spectrometry. The necessary equipment for synthesis of benzene has been built and tested for operation. The liquid scintillation spectrometer has been modified and stabilized for radio-carbon.
(l) The overall program has been standardized and calibrated using conventional carbon-14 standards (NBS) and inter-laboratory "check" samples from other dating laboratories. A few unknown samples have been dated; additional samples are now being processed.
(n) Channel Behavior Following Channel Dredging.
(o) Laboratory project of USDA Sedimentation Laboratory, Oxford, Mississippi in cooperation with the Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Georgia, and the Univ. of Georgia, College of Agriculture Experiment Stations.
(p) Mr. Paul Yates, Research Hydraulic Engineer, Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Georgia 30677.
(q) Experimental field investigations; basic research.
(r) Basic research to determine the effects of stream channel dredging and realignment on channel geometry, flow velocities, sediment transport, conveyance and deposition, and retardation factors.
(s) Influence of Flood-Retarding and Sediment Detention Structures on Channel Regimes.
(t) Laboratory project of USDA Sedimentation Laboratory, Oxford, Mississippi in cooperation with the Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Georgia, and the Univ. of Georgia, College of Agriculture Experiment Stations.
(u) Mr. Paul Yates, Research Hydraulic Engineer, Southern Piedmont Conservation Research Center, Box 33, Watkinsville, Georgia 30677.
(v) Experimental field investigations; basic and applied research.
(w) Basic research to study stream channel adjustments that are induced by changes in water-and sediment-discharge characteristics, resulting from imposed channel alternations, dams, and other modifications. Also to develop procedures for predetermining channel changes likely to occur with structural installations and channel modifications.
(x) A MODEL STUDY OF THE FORCES EXERTED ON A PARTICLE ON A STREAM BED.
(y) Laboratory project cooperative with the Univ. of Miss. and Miss. State Univ.
(z) Dr. Neil L. Coleman, Geologist, U. S. Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.
(aa) Experimental project; basic research.
(bb) An enlarged R. B. N. M. of a section of stream bed has been constructed in a water tunnel. Transducers for measuring the force exerted on an exposed individual particle on the model bed are being developed. Attempts will be made to determine whether the force applied to the particle by the flow has lift and yaw components as well as a drag component. If the study is successful, the data obtained will be represented as plots of lift, drag, and yaw coefficients against Reynolds number. This information could then be used, with certain limitations, to predict the forces to be expected under various flow conditions on particulate beds of material ranging in size from that of sand grains to that of rip-rap stones.
(cc) The development of transducers is progressing.


A STUDY OF BED FORMS IN SAND BED CHANNELS.
(b) Laboratory and field project, cooperative with the Univ. of Mississippi and Mississippi State University.
(c) Dr. Richard A. Stein, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.
(d) Basic and applied research.
(e) Relate the median and the standard deviation of the bed material and hydraulic conditions that are related to types and size of bed configurations. The parameter

\[ Y = -1.75 + 1.25 \]

appears to describe the median values of the dune properties studied. The standard deviations of these dune properties appeared to be independent of mean velocity and depth except for the depth of water over the dune crest, which increased with depth.

A STUDY OF BOUNDARY IRREGULARITY IN A CHANNEL WITH A SAND BED.
(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Dr. Neil L. Coleman, Geologist, U. S. Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi 38655.
(d) Experimental investigation, basic research.
(e) Flows with various bed regimes (dunes,
antitunis, or other) were established in a laboratory flume. An echo-sounding instrument called the Dual Channel Stream Monitor was used to take detailed bed and water surface profiles over a 50-foot reach in the flume. The profiles are now being analyzed by means of a computer program that yields the mean depth of each flume section, the standard deviation about the mean depth, and a depth autocorrelation function for each flow. The autocorrelation function can be integrated to yield a length which may be considered a wave length of the boundary irregularities. The depth standard deviation is an expression of the amplitude of the irregularities. The purpose of the study is to determine if these length scales will adequately portray the geometry in studies of flow mechanics, the transport processes, and the influences on open channel flow resistance.

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SOUTHERN PLAINS BRANCH, ARS-USDA, Bushland, Texas, Dr. J. R. Johnston, Branch Chief.

(3879) CHARACTERIZATION OF THE "HOT SPOT" PROBLEM IN THE LOWER RIO GRANDE VALLEY OF TEXAS.

(a) Laboratory project.
(b) Mr. Ronald R. Allen, Agricultural Engineer, P. O. Box 257, Weslaco, Texas 78596.
(c) Experimental and field investigation - applied research.
(d) The purpose of the study is to determine the extent of salinity problems; characterize and correlate the water table, soil, topographic and related measurable factors associated with salinity problems in the area.
(e) Completed.
(f) Extensive water table observations show a fluctuating seasonally high saline water table beneath the area. The water table and ground surfaces slope approximately one foot per mile to the northeast in the general direction of the Gulf Coast.

(3880) THE MICROMECHANICS OF UNSATURATED MOISTURE FLOW.

(a) Laboratory project.
(b) Dr. Craig L. Wiegand, Soil Scientist, P. O. Box 257, Weslaco, Texas 78596.
(c) Experimental, basic research.
(d) The objectives are to obtain evidence on the generality of the parabolic moisture distribution with respect to the interface of extraction and to interpret unsaturated moisture flow in terms of molecular level mechanisms of flow. The experimental technique is that of inducing moisture flow by various techniques at a series of temperatures and measuring the flow rate. The Arrhenius equation is applied to the data and an activation energy calculated. The activation energy is interpreted in terms of energy barriers to molecular level flow mechanisms. The soil columns are sampled at the end of the runs to determine the moisture distribution with respect to the interface of extraction.
(e) The results to date indicate that the resulting moisture distribution is a function of peculiarities of the microdynamic flow processes involved and independent of the method of extraction.

(4355) THE HYDRAULICS OF STRUCTURES USED IN SOIL AND WATER CONSERVATION WORKS.


(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 285, Stillwater, Oklahoma 74074.
(d) Experimental and field investigation, applied research for design.
(e) Experiments employ small scale models as well as field scale structures. Full scale structures are determined under simulated natural conditions to develop designs for structures needed for soil and water conservation. Closed conduit spillway entrances including drop inlets, hood inlets, and orifice plates are tested. Debris guards are tested using full size structures to provide verification of the small models.
(f) Air flow required in vents to prevent priming of drop inlet closed conduit spillways equipped with orifice plates was determined by full-scale experimentation. A 30-inch square drop inlet was fitted with different orifice plates with orifices 10, 15, 16, and 20 inches in diameter. Air was provided to the underside of the plate through a 4-inch pipe with valve control. Air requirements for various flow rates were determined.

(4356) DESIGN AND CALIBRATION OF DEVICES FOR THE MEASUREMENT OF RUNOFF.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 285, Stillwater, Oklahoma 74074.
(d) Experimental, basic research.
(e) The measuring devices tested are used in the hydrology research program of the Agricultural Research Service. Sites for runoff measuring stations are surveyed and then modeled in the laboratory. Proposed structures are placed in the model and tested to develop a satisfying design. The final design is calibrated by model tests. All current work is on specific sites and no general experiments are done.
(f) Model calibrations were completed during the past year for two supercritical flow flumes for measuring discharge rates up to 8,000 cubic feet per second. A V-notch and highway sluice flume combination measuring station was rated by model test. A 5-inch H-flume was calibrated to measure runoff from a water harvesting catchment.

(4357) HYDRAULICS OF FLOW IN VEGETATION LINED CHANNELS.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 285, Stillwater, Oklahoma 74074.
(d) Experimental, applied research.
(e) Channels or portions of channels are built full size on the outdoor hydraulic laboratory grounds. The vegetation being investigated and then tested by flowing water at selected times. Friction factors and permissible velocities or traffic volumes are determined. In recent years the establishment phase of vegetal channels has received the greater emphasis. This has included the evaluation of temporary fabric liners of jute, glass fiber, and asphalt.
(f) Analysis of data.

130
HYDRAULICS OF UNSTABLE FLOW IN OPEN CHANNELS.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. W. O. Roe, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma 74074.
(c) Experimental, applied research.
(d) Studies are made of unstable flow phenomena occurring in the runoff process. Included are investigations of overland flow, spatially varied unsteady flow in channels, and flash floods in channels. The initial phase of the study is an analytical one utilizing existing knowledge and theory. This phase involves large scale outdoor laboratory study to test hypotheses and evaluate coefficients.
(e) Water surface profile and velocity distribution measurements have been taken in a 400-foot long by 30-foot wide, V-shaped, grass-lined channel conveying a spatially varied flow. Momentum and velocity-head coefficients have been determined for different grass lengths for both nonuniform and spatially varied steady flow. A series of spatially varied unsteady flow tests has been conducted in the channel.

RUNOFF CHARACTERISTICS OF AGRICULTURAL AREAS IN THE RED RIVER BASINS OF OKLAHOMA.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. W. O. Roe, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma 74074.
(c) Field investigation, applied research.
(d) Three watersheds, 17 acres, 92 acres, and 206 acres in size and covered with native grass, are instrumented to measure rainfall and runoff. Annual water yield as well as peak flood flows. Selected runoff events provide data for distribution graphs or unit hydrograph development.
(e) Data are on hand from continuous measurements since 1951.

SEDIMENT PRODUCTION, MOVEMENT AND DEPOSITION IN THE WASHITA RIVER BASIN, OKLAHOMA.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. W. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Field investigation, applied research.
(d) Suspended sediment sampling and total sediment tracings are made at selected tributary and main stream locations in the Washita River Basin. These samples are analyzed for size distribution.
(e) Analyzing available data.

STREAM CHANNEL STABILIZATION AND SEDIMENT CONTROL WORK IN CHANNELS OF THE WASHITA RIVER BASIN.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. W. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Field investigation, applied research.
(d) Selected reaches of channels representing different geologies, soils, and flow regimes are being established for detailed studies of stream channel morphology. Information is being obtained on cross-sections, slopes, thalweg lengths, alignments, vegetation, and bed and bank materials. Any control structures are compared as to location, orientation, shape, size, and materials. Flow history will be recorded, including both water and sediment. Changes in channel conditions, or lack of change, will be related to flow history and other controlling factors for the development of criteria for stable channel design.
(e) Analyzing available data.

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE WASHITA RIVER BASIN, OKLAHOMA.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. N. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Field investigation, applied research.
(d) A network of 170 recording precipitation gages has been established on a 5-mile grid in an 1100-square mile area in the central portion of the Washita River Basin. The precipitation characteristics will be analyzed to determine and evaluate precipitation parameters useful in estimating runoff.
(e) Analyzing available data.

RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE WASHITA RIVER BASIN, OKLAHOMA.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. N. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Field investigation, applied research.
(d) Small watersheds generally not exceeding 100 acres in size, each representing a single soil-cover combination are being instrumental to measure rainfall, runoff, and soil moisture. Information on the runoff producing characteristics of the unit source areas will be useful in the development of equations for predicting runoff from ungauged complex watersheds.
(e) Analyzing available data.

RELATION OF INTEGRATED CLIMATIC AND WATERED ISSUES TO STORM RUNOFF AND WATER YIELD OF THE WASHITA RIVER AND TRIBUTARIES, OKLAHOMA.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. N. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Field investigation, applied research.
(d) A reach of the Washita River extending from Ardarko, Oklahoma, to Alex, Oklahoma, has been selected for study. This reach has a length of 76 river miles and a drainage area along this length of 1228 square miles. Gaging stations are being established near the mouth of 10 tributaries and at 6 sites along the main stem of the Washita River in this reach. Watershed characteristics are being measured and defined. The watershed and structures development will be inventoried periodically. Flood peaks, total flow and its rate-time distribution will be determined and related to climatic and land factors.
(e) Analyzing available data.

EXPLORATORY STUDY OF THE REGIMES OF WASHITA RIVER MAIN STEM FLOWS.

(a) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(b) Mr. N. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.
(c) Analysis of record, applied research.
(d) The flow history of the Washita River, Oklahoma, for the 10-year period 1941 to 1950 is being analyzed to determine parameters characterizing the regime flows prior to development of upstream flood abatement measures; and (2) establish a base for reference in determining any future changes in flow regimes associated with conservation and treatment programs in tributary watersheds.
(e) Analyzing available data.

AQUIFER-STREAMFLOW RELATIONS, GROUND WATER
Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.

Laboratory project.

Laboratory project.

Laboratory project.

Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 400, Chickasha, Oklahoma 73018.

Field investigation, applied research.

Field investigation, applied research.

Field investigation, applied research.

The alluvia and underground flow system of the Washita River Basin are being defined by use of drilling equipment and existing well logs. Permeability coefficients will be determined and ground water observation wells established. This is one part of a comprehensive research study of the total water budget in a portion of the Washita River Basin.

Sediment yield in relation to climatic and watershed characteristics of agricultural areas in the Texas Blacklands and the Edwards Plateau.

Sediment yield in relation to climatic and watershed characteristics of agricultural areas in the Texas Blacklands and the Edwards Plateau.

A laboratory project.

Laboratory project.

Laboratory project.

Laboratory project.

Mr. Walter G. Knisel, Research Hydraulic Engineer, P. O. Box 1147, Nisels, Texas 76685.

Precipitation characteristics influencing runoff from selected areas in Texas.

Precipitation characteristics influencing runoff from selected areas in Texas.

Reported in USDA Misc. Pub. 945.

Relation of climatic and watershed factors to storm runoff and to water yield from agricultural watersheds in the Blacklands of Texas.

Relation of climatic and watershed characteristics to storm runoff and water yield in the Edwards plateau area of west central Texas.

Relation of climatic and watershed characteristics to storm runoff and water yield in the Edwards plateau area of west central Texas.

Runoff production by unit source areas in the Blacklands of Texas.

Runoff production by unit source areas in the Blacklands of Texas.

Evaluation of operation and design criteria of old tile drain systems.

Evaluation of operation and design criteria of old tile drain systems.

Runoff, tile, infiltration, and other characteristics of these single soil, sub-watersheds or unit source areas.
accumulate soil over a long period of time until they become plugged or only partially effective. This process is dependent on the occurrence of the salinity—clay mineral complex and interactions that influence movement of soil particles into drain lines.

(4534) INFILTRATION RATES AND PROFILE CHARACTERISTICS IN RELATION TO THE OCCURRENCE OF SALINITY.

(b) Laboratory project.
(c) Dr. Craig M. Lyles, Research Soil Scientist, P. O. Box 267, Weslaco, Texas 78596.
(d) Field investigation; applied research.
(e) The purpose of the work is to relate infiltration to the occurrence of salt-affected profiles. Infiltration rates are to be determined on about a dozen salt affected and adjacent non-affected profile pairs which have been chemically and physically characterized. The infiltration rates will be related statistically to the severity of salinization and to the chemical and physical properties of the profiles.
(f) Completed.
(g) The final intake rate (5 hours) in the non-saline sites averaged about 3 times those of the adjacent saline sites. Analysis of variance revealed that saline profiles were higher in percent clay, are slightly elevated relative to the non-saline sites and have greater surface slope than do the non-saline sites. Multiple regression analyses predicted a significant relationship in final intake rate. Differences in clay content surface elevation and soil slope are concluded to result in differences in leaching effectiveness of rainfall due to their influences on infiltration and runoff.
(h) Interspersed Salt-Affected and Unaffected Dryland Soils in the Lower Rio Grande Valley: 

(4535) EFFECTS OF BENCHING AND TERRACING ON MOISTURE CONSERVATION ON SLOPING HARDLANDS OF THE SOUTHERN GREAT PLAINS.

(b) Laboratory project.
(c) Mr. Victor L. Hauser, Agricultural Engineer, USDA Southwestern Great Plains Research Center, Bushland, Texas 79012.
(d) Field investigation, applied and design research.
(e) 1. To test the feasibility of altering the configuration of the land to intercept, spread, and infiltrate surface runoff in contour basins. 2. To determine the extent to which such intercepted runoff will add to available soil moisture supplies and how such additional soil moisture may be best utilized for crop production. 3. To determine the relative value of the three types of terrace systems, conservation benching, and contour terraces on soil moisture conservation and crop production. 4. To measure runoff from well managed contour farmed hardland soils.
(g) It has been found that grade and level terraces are equally effective in conserving runoff water under semi-arid conditions where 10 or 11 months of fallow periods planting either wheat or grain sorghum. It has been found that the conservation bench terrace system is superior to either graded or level terraces in the conservation of runoff water.

(4537) EFFECT OF CROPPING SYSTEMS AND CLIMATE ON RUNOFF, EROSION, AND CROP YIELDS UNDER BLACKLAND CONDITIONS.

(b) Laboratory project.

(c) Mr. D. W. Fryrear, Agricultural Engineer, P. O. Box 748, Temple, Texas 76502.
(d) Experimental — applied research.
(e) Runoff and soil loss are measured from 12 plots on plots representing a typical cultivated slope of Blackland Prairie soils. These plots are in three cropping systems with row cropping every year, in alternate years, and every third year. By taking soil moisture and crop residue measurements in the future the interaction of varying climatic influences with crops and management are determined as a basis for determining runoff and erosion on farms and watersheds.
(f) Terminated.
(g) Statistical analysis of runoff results for a year period 1960-61 indicated a significant difference between plot replications or cropping systems but a significant difference in runoff for different years. Similar analysis of soil loss data for the period showed no significant difference between cropping systems and a significant difference between plot replications and years. Complete statistical analysis of all data will be made after the 1964 harvest.

TESTING OF MATERIALS FOR IMPROVED SUBSURFACE DRAINAGE.

(b) Laboratory project.
(c) Mr. Victor I. Myers, Research Agricultural Engr., P. O. Box 267, Weslaco, Texas 78596.
(d) Experimental; applied research.
(e) Laboratory tank studies will be made to evaluate drainage materials with particular emphasis on filters and new drain tube materials. One or more field installations will be made in which drainage materials will be compared and evaluated. Electric analogue studies will be made for predicting flow rates into the line lines.

(f) Laboratory studies with semi-rigid plastic lines have shown that the material can withstand loads imposed by deep installation, to be placed in a narrow 10-inch width trench and if installed in an excavated cradle to provide some lateral strength.

SOIL-WATER-PLANT RELATIONS OF IRRIGATED COTTON AS INFLUENCED BY DEPTH TO WATER TABLE.

(b) Laboratory project.
(c) Mr. L. N. Namken, Research Soil Scientist, P. O. Box 267, Weslaco, Texas 78596.
(d) Field investigation; applied research.
(e) A set of thirty-six lysimeters, one meter square and ten feet deep, are being utilized to study the influence of soil moisture level, water table depth and water table levels on evapotranspiration, vegetative growth and yield of cotton. The objectives of the project are: (1) to determine the contribution of a water table to the water requirement of cotton; (2) to study soil moisture use and extraction by cotton as influenced by various water table depths; and (3) to study the effect of water table salt concentration on salt movement and moisture uptake by the cotton plant.
(g) In the 1964 data, following closely the 1963 results obtained under relatively high salinity conditions. There was not such a significant difference in total moisture use by cotton due to moisture level or water table treatments in 1964; however, total moisture use was nearly twice as great in 1964 under low salinity conditions as in 1963 under high salinity conditions. Mean total moisture use for moisture levels I and II were 32.8 and 31.2 inches, respectively, in 1964 compared to 16.6 and 16.2 inches, respectively, in 1963. Lint cotton yields were also much greater in 1964 than in 1963. Mean line cotton yields for the 3-, 6-, and 9-foot water table treatments were 1520,
because of recency of plot installation, averaged 2.1, 1.9, and 3.0 tons per acre for the 300-, 600-, and 900-foot rows respectively.

(4849) EVALUATION OF DRAINAGE METHODS FOR THE NONIRRIGATED AREA OF THE LOWER RIO GRANDE VALLEY OF TEXAS.

(b) Laboratory project.

(c) Mr. Ronald R. Allen, Agricultural Engineer, 1st Lt. Mr. W. Musick, Agricultural Engineer, P. O. Box 257, Weslaco, Texas 78596.

(d) Experimental and field investigation; applied research.

(e) The purpose of the study is to compare the effectiveness and cost of installation operation and maintenance of three drainage methods: open drain ditches, subsurface drain tile, and drainage wells in reduction of soil salinity and control of a ground water table.

(g) An underlying permeable sand aquifer limits installation depth and effectiveness of open drain ditches and subsurface drain tile. Pump drainage by wells has incurred considerable expense for the small area affected.

(5211) LIMITED IRRIGATION OF GRAIN SORGHUM IN THE SOUTHERN PLAINS.

(b) Laboratory project.

(c) Mr. J. T. Musick, Agricultural Engineer, Southwestern Great Plains Research Center, Bushland, Texas 79012.

(d) Field investigation; applied research.

(e) To determine number and timing of irrigations for most efficient use of limited irrigation and expected precipitation; plant spacing for most efficient use of limited water; and soil moisture-plants growth-yield relationships under limited soil moisture conditions.

(g) One or two well-timed seasonal irrigations combined with efficient use of limited irrigation water which permitted a reduction in irrigation water requirements. In addition to considering soil moisture, proper timing of limited irrigation should consider expected seasonal rainfall and stage of plant development. Narrow row and plant spacings are necessary for most efficient use of water at higher yield levels.

(5212) SOIL LOSS FROM THE ENDS OF LEVEL TERRACES AND THE EROSION OCCURRING BETWEEN TERRACES.

(b) Laboratory project.

(c) Mr. M. B. Cox, Agricultural Engineer, P. O. Box 128, Cherokee, Oklahoma 73728.

(d) Field investigation; applied research.

(e) Purpose of work is to determine soil losses from terraces and from different sections down slope within terrace intervals. Runoff and soil loss are measured from a system consisting of 8 terraces and 20 small plots. Half of the area is clean tilled and half stubble mulched terraces. Terraces are grouped in pairs, one concrete and one soil channel. Concrete lined channels are used to provide a permanent base for measuring soil movement into terrace channels. Plot located at the ends of the pairs of terraces, permit determination of all contribution from three prominent terrace intervals.

(g) Terrace installations are completed and 1963-64 runoff and soil loss data have been obtained. Data showed some variation between different pairs of terraces but marked similarity of both runoff and soil loss was obtained within pairs, i.e., between concrete and regular soil channel terraces. The small plot installation of the study is installed but no data have been obtained.

(5213) WATER INTAKE AND DISTRIBUTION OF SOIL MOISTURE UNDER GRADED FURROWS ON FULLMAN SILTY CLAY LOAM.


This soil has a high initial intake rate which rapidly drops to a very low basic rate. One to two inches of执意 intake occurs during and soon after water passes a point in the furrow. The intake rate then declines rapidly to about 0.6 inch per hour for the first hour after running begins. This supports two furrow segment to a basic rate of 0.1 inch per hour or less about 4 hours later. Cutting off the water soon after it reaches the end of long furrows results in high application efficiencies, relatively good distribution and decreases tailwater runoff losses.

Detailed Analysis and Test of a SIMPLE SYSTEM TO CLARIFY PLAYA WATER WITH FLOCCULENTS AND THE USE OF AN IRRIGATION DITCH AS A SETTLING BASIN.

Laboratory project.
Mr. Victor L. Hauser, Agricultural Engineer, USDA Southwestern Great Plains Field Station, Bushland, Texas 79012.

Field investigation; applied research.

The purpose of the project is (1) to adapt remote sensing procedures for multispectral characterization of crops and soils under natural conditions, (2) to study the effects of environmental factors and greenhouse conditions on reflectance and emission characteristics of plants and soils, and (3) to identify factors and mechanisms affecting reflectance and emission from plants and soils.

Spectral Reconnaissance in Agriculture.

Laboratory and field project, cooperative with NACA, Purdue University and University of Michigan.

Mr. Victor L. Hauser, Research Agricultural Engineer, USDA Southwestern Great Plains Research Center, Bushland, Texas 79012.

Determine the stratigraphy of a playa and its watershed using surface electrical resistivity and gamma-ray well logging equipment.

The playa will be surveyed with the electrical resistivity equipment on a 500 foot grid. Data will be collected and analyzed according to standard practice. Each bore hole drilled on the playa watershed will be logged electrically and these data were correlated with the drillers log and the stratigraphy and properties of each lithologic member.

Initiated in 1963, field and laboratory work is continuing.

Aeration Measurements for Determining Drainage Needs.

Laboratory project.

Dr. Ross W. Lesmer, Research Soil Scientist, P. O. Box 267, Weslaco, Texas 78596.

Determine the suitability of (1) bare platinum electrodes, (2) stainless-steel tube, (3) glass electrode, and (4) 4-inch polyethylene pipe with teflon and with filtered gravel envelopes, and a 4-inch steel, plastic, and fiberglass drain tube.

Effect of Wind on a Falling Waterdrop.

Laboratory project.

Dr. E. L. Skidmore, Agronomy Dept., Waters Hall, Kansas State University, Manhattan, Kansas 66504.

Purpose of research is to determine influence of wind on the velocity of a falling raindrop, to determine effect of wind on path of drop, to determine effect on horizontal acceleration
of drop; and to determine effect of wind on kinetic energy and momentum of raindrops. The experimental data being handled in a wind tunnel-rain tower facility where conditions of wind and other variables can be rather precisely controlled.

Air flow through the rain tower has been studied and modified with screening devices to develop a turbulent boundary layer and to provide a wind with profile characteristics similar to natural wind. Drop formation and lighting problems have been resolved and experimental data will be taken in 1966.

(5580) LIMITED IRRIGATION OF WHEAT AND SORGHUM IN A PALLOW-WHEAT-MORIUM SEQUENCE.

(b) Laboratory project.
(c) Mr. J. T. Musick, Agricultural Engineer, Southwestern Great Plains Research Center, Bushland, Texas 79012.
(d) Field investigation; applied research.
(e) Determine response to limited irrigation of winter wheat and grain sorghum at two critical stages of plant growth on yields, water use efficiencies, and plant characteristics; and to evaluate the ability of an extended pre-seasonal crop period (11 to 12 months preceding both sorghum and wheat) to supply soil moisture storage at planting and thus decrease irrigation water requirements.

(g) Irrigation water requirements of inter wheat and grain sorghum can be reduced by growing the crop in the "dryland" pallow-wheat-sorghum sequences which permits eliminating the preplant or emergent irrigation in most years.

(5581) TIMING OF PRESEASONAL IRRIGATION IN RELATION TO EFFICIENCY OF SOIL MOISTURE STORAGE.

(b) Laboratory project.
(c) Mr. W. H. Sletten, Agricultural Engineer, Southwestern Great Plains Research Center, Bushland, Texas 79012.
(d) Field investigation; applied research.
(e) Determine relationship between the storage efficiency of pre-seasonal irrigation water and timing of irrigation and the effect of antecedent soil moisture on storage efficiency of pre-seasonal precipitation and/or irrigation.

(g) Results based on 1 year's data indicate that a late fall water application after harvest and initial tillage resulted in more available soil moisture at plant emergence (June 29) than pre-seasonal application during winter, or early, mid or late spring. Pre-seasonal applied water that remained in the soil root zone for plant use ranged from 22 to 30 percent, depending on time of application.

(5582) WATER REQUIREMENTS OF MARRS ORANGES, RED BLUSH GRAPEFRUIT, AND VALENCIA ORANGES IN THE RIO GRANDE VALLEY.

(b) Laboratory project.
(c) Marvin D. Heilman, Research Soil Scientist, P. O. Box 267, Weslaco, Texas 78596.
(d) Field investigation - applied research.
(e) This field investigation is designed to provide quantitative information on moisture use of Marrs and Valencia oranges and red blush grapefruit in the Rio Grande Valley. From this data water management recommendations will be made for citrus production grown under conditions of a limited water supply. In addition, the investigations will determine the effects of the various citrus varieties.

(5583) VARIATION OF SATURATED HYDRAULIC CONDUCTIVITY OF HOUSTON BLACK CLAY WITH SOIL DEPTH AND WITH DIAMETER OF SOIL CORES.

(b) ABS-WGC, Blackland Conservation Experiment Station, Temple, Texas. Laboratory project.
(c) Dr. Earl Burnett, Research Soil Scientist, P. O. Box 748, Temple, Texas 76502.
(d) Experimental and basic research.
(e) Saturated hydraulic conductivity will be determined for each 6-inch interval of undisturbed 9-foot soil column of 16- and 29-inch diameter and for 3-inch long soil cores of 3 7/8-inch, diameter. The purposes will be (1) to determine the saturated flow rate of water through disturbed cores of Houston Black clay profiles and through various layers of this profile, (2) to develop methods and procedures for utilizing large diameter cores for measuring the hydraulic conductivity of soils, (3) to study the relationship between core size and saturated hydraulic conductivity, and (4) to determine the relation between direction of water flow and hydraulic conductivity.

(f) Completed.

Data analysis and interpretations are underway.

(5583) EVALUATION OF CONTINUOUS WHEAT AND SORGHUM IN AN ALTERNATE DOUBLE-BED SYSTEM FOR EFFICIENT USE OF LIMITED IRRIGATION AND PRECIPITATION IN THE SOUTHERN PLAINS.

(b) Laboratory project.
(c) Mr. J. T. Musick, Agricultural Engineer, Southwestern Great Plains Research Center, Bushland, Texas 79012.
(d) Field investigation; applied research.
(e) Determine yield potentials and water use efficiencies of wheat and sorghum in an alternate double-bed system under varied soil moisture management and to determine the ability of wheat and sorghum to utilize soil moisture from adjacent double-bedted areas during the non-growing period of the adjacent crop.

(5583) MEASUREMENT OF RUNOFF AND SOIL LOSS DIFFERENCES BETWEEN ESTABLISHED PLOTS.

(b) Laboratory project.
(c) Mr. Ralph M. Baird, Hydraulic Engineer, P.O. Box 1147, Riesel, Texas 76662.
(d) Field investigation; applied research.
(e) Runoff and soil loss are measured from 12 field scale (1 1/2 acre) plots representing a typical cultivated slope of Blackland Prairie soils. All plots have the same cropping treatment. Data will be collected for 3 years to determine variability in runoff and soil loss between plots with a uniform cropping system.

(f) Started in 1966.

(5584) EFFECT OF SURFACE MODIFICATIONS ON SOIL SALINITY IN A NONIRRIGATED AREA.

(b) Laboratory project.
(c) Mr. Ronald R. Allen, Agricultural Engineer, P. O. Box 267, Weslaco, Texas 78596.
(d) Field investigation; applied research.
(e) To determine the effect of lowering the surface of salt spots by soil removal (to retain precipitation and collect runoff) on the total salt balance in selected non-irrigated, leveled fields of the Lower Rio Grande Valley of Texas.

(f) Started in 1966.

(5585) EFFECT OF SOIL SALINITY AND RATE OF LOWERING OF WATER TABLE ON GROWTH OF VEGETABLES.

(b) Laboratory project.
(c) Dr. Ross W. Lamer, Research Soil Scientist, P. O. Box 267, Weslaco, Texas 78596.
(d) Experimental and applied research.
(e) Vegetables will be grown in a greenhouse where water table levels can be controlled. About three weeks after planting all treatments will be flooded and maintained one inch deep on the surface for 24 hours. The water table will be lowered by pumping water from the drain lines each day to give the variable rate of lowering of the water table. The flooding cycle will be repeated each 30 days. A low soil moisture tension
will be maintained between floodings. Variables or soil salinity will be established prior to planting each crop.

(f) Active, initiated 1955.

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SOUTHWEST BRANCH, P. O. Box 2326, Riverside, Calif. 92502. Mr. W. W. Donnan, Branch Chief.

(181) LINING OF IRRIGATION CANALS AND RESERVOIRS.

(b) Laboratory project in cooperation with the Utah State University and Bureau of Reclamation.

(c) Dr. O. V. Lauritzen, Soil Scientist, Utah State University, Mechanic Arts, 130, Logan Utah 84321.

(d) Experimental; basic and applied research.

(e) Lining for irrigation systems are being tested to develop more effective and lower cost methods of reducing seepage losses in irrigation systems. Investigation included:

(1) Evaluation of physical properties of lining materials; (2) modeling of lining in an outdoor laboratory; and (3) field testing at selected sites to determine relative durability under varying subsurface and climatic conditions.

(217) WATER REQUIREMENTS IN IRRIGATED AREAS OF SOUTHWEST.

(b) Laboratory project in cooperation with State and Federal agencies.

(c) Mr. William W. Donnan, Branch Chief, P. O. Box 2326, Riverside, California 92506.

(d) Fluid experiments and office analysis. Applied research.

(e) To determine the consumptive use of water by crops, phreatophytes, and other vegetation, and to mitigate irrigation supply requirements. To develop empirical formula from climatological and other data for determining rate of consumptive use.

(f) Discontinued.

(h) "Consumptive Use and Water Requirements in New Mexico," Harry F. Blaney and Eldon Q. Hanson, Technical Report 92, New Mexico State Engineer, Santa Fe, New Mexico 1965.

(2180) EVAPORATION LOSSES FROM RESERVOIRS AND LAKES.

(b) Laboratory project in cooperation with State of California, counties and other agencies.

(c) Mr. William W. Donnan, Branch Chief, P. O. Box 2326, Riverside, California 92506.

(d) Experimental; compilation and analysis of data. Applied research.

(e) To determine evaporation losses from reservoirs and lakes and develop empirical formulas from climatological data for computing monthly evaporation. Cooperative field measurements are being made of pan evaporation at stations in California ranging from Manteca levee level 9,134 feet elevation at Kaiser Pass in the Sierra-Nevada Mountains.

(f) Discontinued.

(2181) ARTIFICIAL RECHARGE OF GROUND WATER FOR IRRIGATION IN CALIFORNIA.

(b) Laboratory project in cooperation with the California Department of Water Resources.

(c) Mr. Leonard Schiff, Hydraulic Engineer, 4016 East Shields Ave., Fresno, Calif. 93726.

(d) Experimental; laboratory and field investigations, applied research.

(e) To efficiently store imported water underground in quantity and at a quality needed in various locations. The objectives are:

(1) To determine the physical and chemical characteristics of surface soil and substrates on selected recharge sites and to relate these characteristics to infiltration and percolation rates, and to lateral aquifer flow; (2) to determine the feasibility of recharge by heavy irrigation of crops or by methods of percolation; (3) to determine the effect on recharge of the quality of water standing on the groundwater table under selected site conditions, and on the quality of the groundwater; and (4) to provide for recharge which permits the evaluation of a site for recharge, suggests methods and systems of recharge to be used and indicates the quality of groundwater that may be expected as a result of recharge.


(3566) PARK CONVEYANCE AND WATER APPLICATIONS.

(b) Laboratory project, in cooperation with the Utah State University.

(c) Dr. C. V. Lauritzen, Soil Scientist, Utah State University, Mechanic Arts 130, Logan Utah 84321.

(d) Experimental; basic and applied research.

(e) New methods and equipment for conveying and applying irrigation water are being developed. The hydraulic properties of lay-flat tubing are being studied and new materials are being evaluated to determine their use in conveyance structures.

(g) Two devices for regulating and measuring water delivery to irrigation canals and ditches have been developed. These devices are essentially leakproof and simple to regulate.


(3558) LABORATORY MODEL AND FIELD STUDIES OF REDUCING SEEPAGE IN SANDS WITH BENTONITE.

(b) Laboratory and field project, in cooperation with the Nevada Agricultural Experiment Station.

(c) Mr. Hyron B. Rollins, Research Soil Scientist, Agricultural Research Service, P. O. Box 9014.

137
laboratory, and field investigations. Mr. Anthony S. Dylla, Agricultural Engineer, F. F. Box 9044, University Station, Reno, Nevada 89507. Experimental, field investigation. To measure the evapotranspiration of meadow vegetation in the Humboldt Basin area which subsists primarily under shallow water table conditions. The data will be used to determine arable use of ground waters by native vegetation and phreatophytes and to develop methods of more efficient utilization of those water supplies. (g) Evapo-transpiration rates are being obtained by water use measurements of meadow grasses growing in plastic lysimeters. Vegetative growth, soil moisture, water table, and weather data are being collected to which evapo-transpiration rates from tanks can be related. (3560) EVAPOTRANSPIRATION OF HUMBOLDT MEADOW VEGETATION AS MEASURED WITH LYSIMETERS.

(b) Laboratory project. Dr. C. W. Lauritzen, Soil Scientist, Utah State University, Mechanics Art, Logan, Utah 84320. Experimental and applied research. (e) There are areas in many regions where water for livestock and even culinary uses is scarce or nonexistent. In such areas, water in the form of precipitation falls each year. As an example, the precipitation on one acre of land in an 8-inch rainfall area amounts to 217,244 gallons. This is enough to supply water to more than 200 head of cattle for 100 days. This study includes the development and testing of materials for ground covers and storage facilities to be used for the collection and storage of water in low rainfall areas together with the design and operation of these facilities. Ground covers and closed storage structures have been developed to contain and store evaporating water and storing precipitation. To satisfy the need for a name this combination of structures has been termed a "Rain Trap." Butyl sheeting continues to be the most satisfactory material for both the interceptor and the storage reservoir. Other materials are being investigated. (f) There are indications that some of these will be less expensive and reasonably serviceable as ground covers. Modifications have been made in the design and fabrication of ground covers and storage bags made of butyl to improve their performance. (3561) FLOOD WAVE MOVEMENT AND ROUTING IN ALLUVIAL CHANNELS.

(b) Laboratory project, cooperative with the University of Nevada and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service. Mr. R. V. Keppel, Agricultural Engineer, F. O. Box 3526, Tucson, Arizona 85717. (c) Experimental, field investigation. (d) Water level recorders are located at 2,000-foot intervals in a 3-mile reach of natural channel. Ten rain gauges are located at the inlet and at the outlet, and major tributary inflow is gaged. Flood waves generated by high intensity thundertorm type thunderstorms are being studied.

(g) The velocity of a wave front on a dry channel bed was found to be relatively independent of the discharge, and is probably more dependent on the moisture content of the channel alluvium. Velocity of the flow peak increased with the 0.56 power of the discharge. Peak velocities were considerably higher than the wave front velocities. For the first time since the study was initiated, an abrupt translatory wave varying in height from 1.0 to 2.9 feet occurred. Observation indicates a velocity of 11.1 feet per second compared with a theoretical pure gravity velocity of 10.2 feet per second. (3562) DYNAMIC SIMILARITY IN PIPE ELBOW FLOW METERS.

(b) Laboratory project. Mr. Lloyd E. Myers, Director, U. S. Water Conservation Laboratory, 4331 East Broadway, Phoenix, Arizona 85040. (d) Experimental; applied research. (a) A, 12 in. cast iron, 45-degree flanged elbows of 2, 2.5, 3, 4, 5, 6, and 12-inch diameters from five manufacturing sources were calibrated to determine the expected accuracy of flow measurements made with uncalibrated elbows. Effects of various fittings and installations on the calibration were determined for 3-inch diameter elbows. Uncalibrated elbows can be expected to be accurate within 5 percent if properly installed.

(3563) GROUND COVERS AND OTHER STRUCTURES FOR COLLECTING AND STORING PRECIPITATION.

(b) Laboratory project, in cooperation with the Utah State University. Dr. C. W. Lauritzen, Soil Scientist, Utah State University, Mechanics Art, Logan, Utah 84320. (d) Experimental and applied research. (e) There are areas in many regions where water for livestock and even culinary uses is scarce or nonexistent. In such areas, water in the form of precipitation falls each year. As an example, the precipitation on one acre of land in an 8-inch rainfall area amounts to 217,244 gallons. This is enough to supply water to more than 200 head of cattle for 100 days. This study includes the development and testing of materials for ground covers and storage facilities to be used for the collection and storage of water in low rainfall areas together with the design and operation of these facilities. Ground covers and closed storage structures have been developed to contain and store evaporating water and storing precipitation. To satisfy the need for a name this combination of structures has been termed a "Rain Trap." Butyl sheeting continues to be the most satisfactory material for both the interceptor and the storage reservoir. Other materials are being investigated. (f) There are indications that some of these will be less expensive and reasonably serviceable as ground covers. Modifications have been made in the design and fabrication of ground covers and storage bags made of butyl to improve their performance. (g) The velocity of a wave front on a dry channel bed was found to be relatively independent of the discharge, and is probably more dependent on the moisture content of the channel alluvium. Velocity of the flow peak increased with the 0.56 power of the discharge. Peak velocities were considerably higher than the wave front velocities. For the first time since the study was initiated, an abrupt translatory wave varying in height from 1.0 to 2.9 feet occurred. Observation indicates a velocity of 11.1 feet per second compared with a theoretical pure gravity velocity of 10.2 feet per second. (3564) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM SEMIARID WATERSHEDS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service. Mr. H. B. Osborn, Hydraulic Engineer, F. O. Box 3526, Tucson, Arizona 85717. (d) Experimental, field and laboratory; basic research. (e) Rainage networks with densities of one recording gage per square mile are being operated on the 56-square-mile Walnut Gulch watershed in southeastern Arizona and the 87-square-mile Alamogordo Creek watershed in northeastern New Mexico. The Walnut Gulch study is augmented by horizontal-search S-S radar. Objective of the study are to determine precipitation parameters of importance in predicting runoff and sediment yield, and to give particular attention to the small areas, highly intense, convective summer thunderstorms typical of the region. (e) Data from Walnut Gulch watershed for a 7-year period of record indicate that summer convective thunderstorms are elliptical in shape with the major axis approximately 1.5 times the minor axis. The rainfall associated with any of the Walnut Gulch watershed, 60% of the storms cover less than 4 1/2 square miles in area, and 96% cover less than 10 square miles. Highest runoff events are typically the result of multi-celled storms separated in space and time. On the Alamogordo Creek watershed, convective thunderstorms are of greater intensity and larger areal extent than at Walnut Gulch. The difference is due
to the greater amount of precipitable water in the air mass in eastern New Mexico as compared with southeastern Arizona, and to the fact that frontal action is more common thus giving an added lift to convective storm cells.


(4360) RUNOFF FROM COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATIC AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona 85717.

d) Experimental; applied research.

e) On semiarid rangeland watersheds up to 43,000 acres in size, runoff measurements are being maintained, and an attempt is being made to relate water yield to climatic and watershed characteristics, and to evaluate the effects of a range conservation program on rates and amounts of flood runoff and on net water yields. A new design of critical capacity areas up to 22,500 cfs is being used to gage the flashy, sediment-laden flows.

(g) On Walnut Gulch Watershed in southeastern Arizona, 862 in size from 550 to 36,900 acres are under study. Annual water yield decreases exponentially with the 0.6 power of the watershed area. Peak discharges of 2.46 inches per hour (5030 cfs) has been recorded on the grass covered 3.2 square mile watershed. All of the water yields to run off from June to September as a result of small diameter, highly intense convective thunderstorms. At the Alamogordo Creek Watershed in eastern New Mexico (43,000 acres), flow events originating on the central and upper portions of the valley floor cause flat-top hydrographs with sustained peaks of 2 or 3 hours duration. On the other hand, runoff events originating on the southeast and southwest branches have sharp hydrograph peaks typical of the semiarid Southwest. These differences can be explained on the basis of channel morphology and valley storage.

(4361) THE ROLE OF VALLEY AND CHANNEL MATERIALS AND VEGETATION IN THE HYDROLOGY OF SEMI-ARID WATERSHEDS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

c) Mr. R. D. Cherry, Jr., Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona 85717.

d) Experimental; field investigation.

e) Measurements from tandem gaging stations are utilized to losses that occur as runoff traverses ephemeral stream channels. Records from shallow wells show depletion patterns of the transmission loss water.

(g) Transmission losses of up to 50 acre-feet-per-mile of channel have been measured on one reach of channel in a single high flow. Because of these high losses, the annual volume of surface runoff is sometimes greater from a subwatershed than from the entire area. Not only net runoff but also peak rates and the hydrograph shape are affected by the losses. Records from wells in both local and regional water tables indicate that the disposition of the loss water depends largely on the geology in and adjacent to the channels. Where imperious material underlies the channel, much of the water is lost by groundwater percolation. In other portions of the channel some recharge of regional water table occurs.


(4362) THE HYDROLOGY OF SEMI-ARID WATERSHEDS AS INFLUENCED BY CHARACTERISTICS OF SOIL AND NATIVE VEGETATION.

(b) Laboratory project; cooperative with Ariz. and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

c) Dr. J. L. Gardner, Botanist, P. O. Box 3926, Tucson, Arizona 85717.

d) Experimental; field and laboratory; basic research.

e) Interrelations of soils and native vegetation as they influence water and sediment yield are being evaluated on rangeland watersheds of 100 to 45,000 acres in Arizona and New Mexico. Supplementary to studies on entire watersheds, infiltrometer studies on 6 x 12' plots are in progress. A primary objective of the infiltrometer studies is determination of parameters of rangeland vegetation most effective in evaluating its influences on runoff and sediment production on watersheds.

(g) Cover of shrubs was shown to be negatively correlated with clay and silt in the soil crust, surface horizon and subsoil; positively correlated with three strata. Grass cover was positively correlated with clay and silt. On small watersheds above stock ponds, average annual sediment production --but not runoff--is logarithmically correlated with basal area of grass cover. It may be that this influence of grass cover in reducing soil yield has been responsible for these correlations.

(4363) HYDROLOGIC DATA REDUCTION WITH ANALOG-TO-DIGITAL CONVERTER.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.

c) Mr. R. D. Cherry, Jr., Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona 85717.

d) Experimental; field and laboratory; basic research.

e) Hydrologic records in analog form are being reduced to digital form by means of an automatic analog to digital converter. Information is transferred primarily from rainfall charts to punched cards for future computer programs.

(4364) RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS AS INFLUENCED BY MICROCLIMATE, WATER BALANCE, SOIL AND VEGETATION.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

c) Mr. H. B. Osborn, Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona 85717.

d) Experimental; field and laboratory; basic research.

e) Runoff and sediment yields are being measured from several small, single soil-cover subwatersheds located within larger experimental watersheds having mixed soil-cover situations. Objectives are to evaluate the effects of various soil-vegetation complexes, microclimatic, water balance phases on local runoff and sediment production, and to identify and characterize unit source-areas controlling the net storm runoff and sediment yields of larger, more complex watersheds.

(g) Average annual sediment yield from small predominantly grass-covered watersheds is about 1%, by weight, of water yield upward. Sediment yield measured from predominantly brush-covered watersheds ranges from around 2%, by weight, of water yield upward.
(4355) SEDIMENT MOVEMENT ON COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATE AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Mr. Kenneth G. Renard, Hydraulic Engineer, P. O. Box 3566, Tucson, Arizona 85717.

(d) Experimental, field and laboratory.

(e) The objectives of this study are: (1) to determine the relationship of sediment production over unit source areas to sediment yields of complex watersheds, (2) to develop methods for sediment yield prediction, and (3) to develop methods for reducing sediment yields from semiarid range and watershed in the Southwest. Integrated depth samples of suspended sediment are being collected, and single-stage samples by automatic samplers. Total load is determined for correlation with storm and runoff measurements on several experimental watersheds with varying soil, vegetation characteristics, and drainage features. Studies will be carried out over a number of years during which effects of changing range cover and corresponding changes in flow regimes of the watersheds may be evaluated.

(f) Suspended sediment samples collected to date do not indicate inter-sedimentation relationship for a flashy ephemeral stream such as Walnut Gulch. Because of the rapidly changing stages, samples are generally collected at one position in the cross-section. Suspended sediment samples collected in the mainstream of Walnut Gulch have been found to vary between 2 and 8 percent by weight. Unfortunately, these results have been confined so far to relatively small discharges. The following are indications from the samples analyzed to date: (1) The sediment peak precedes the hydrograph peak. (2) The sand load is relatively low in the samples collected before the hydrograph peak, and beyond the peak the sand load is higher and it seems to be more closely related to the actual discharge than are the small soil fractions. (3) Silt load is heavy at the sediment peak and drops off thereafter, i.e., silt ratio rises after the sediment peak. (4) Correlation of consecutive depth-integrated samples is very good when the stage is not fluctuating rapidly. (5) The single stage samples on the main channel appear to agree well with the depth-integrated samples taken during the same period. (6) There is a considerable increase in the percentage of clay for samples taken in the mainstream as compared to samples taken upstream in the good grasslands. Greater gullying on other areas and bank erosion along the main channels are probably responsible for this increase.

(4356) DEVELOPMENT OF A PORTABLE IRRIGATION SPRINKLER EVALUATION DEVICE.

(b) U. S. Dept. of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division.

(c) Mr. Rhy's Tovev, Agricultural Engineer, ARS, Box 8014, Univ. Station, Reno, Nevada 89507.

(d) Experimental, applied research.

(e) (1) To develop a portable device that can be used in the design and evaluation of sprinkler irrigation systems and (2) to determine procedures for the use of the portable irrigation sprinkler evaluation device in measuring soil intake rates, sprinkler application rates and other factors pertinent to the efficient design of sprinkler irrigation systems.

(f) Discontinued.

(g) A portable irrigation sprinkler evaluation device has been designed and constructed. Tests show that the device works satisfactorily. Procedures for measuring soil intake rates for sprinkler irrigation system design have been developed.

(4350) WATERSHED RELATIONS TO RECHARGE OF DIRECTLY ASSOCIATED GROUNDWATER BASINS.

(b) Laboratory project, cooperative with Calif. Dept. of Water Resources, California Agric. Experiment Station, and the U. S. Soil Conservation Service.

(c) Mr. G. Paul Lawless, Soil Scientist, P. O. Box E, Lompoc, California 93436.

(d) Basic and applied research.

(e) Soil moisture measurements (made with neutron scattering moisture meters to depths of ten to twenty-eight feet) together with measurements of precipitation and other climatological factors are being made on a watershed near Lompoc, California, to determine how much, if any, of the rainfall in certain areas of the root zone, to recharge groundwater. The thirteen sites now being studied represent various cover, soil, and topographic conditions. A study is made of movement of water in various soils to help determine net contribution to ground water recharge by deeply penetrating rainwater. A technique for predicting ground water recharge by the penetration of rainwater is being developed which will provide probability estimates of seasonal range bases soil conditions and climatological records.

(g) Downward translocation of moisture has been observed to continue during the dry season following winter precipitation of magnitude of this migration is predictable and amount of downward movement of moisture through the root zone can be estimated fairly accurately without the benefit of periodic moisture determinations; provided monthly precipitation data are available and the range of available moisture in the root zone is known.

(4351) WATERSHED EVAPOTRANSPIRATION LOSSES IN CENTRAL AND SOUTHERN CALIFORNIA.

(b) Laboratory project, cooperative with Calif. Dept. of Water Resources, California Agric. Experiment Station, and the U. S. Soil Conservation Service.

(c) Mr. G. Paul Lawless, Soil Scientist, P. O. Box E, Lompoc, California 93436.

(d) Experimental, field investigation, basic and applied research.

(e) Measurements of soil moisture content are being made at 15 neutron scatter metering sites on a watershed near Reno, Calif. Soil suction is measured at one site by tensiometers. Precipitation is measured within a complex of four of the soil moisture sites. Outside of the watershed, in a plot (approx. one acre) of perennial ryegrass, soil moisture data are obtained by an electronically weighing lysimeter, neutron scatter meter, tensiometers and moisture blocks. Soil temperature, soil heat flux, drainage from the lysimeter, wind velocity and direction, solar, total hemispherical, and net radiation, albedo, air temperature and humidity are measured in or near the lysimeter. Most of this data is automatically recorded. Data is also obtained from an adjoining USWB class A type climate station, which contains extra instruments consisting of a hygrothermograph, spherical thermometers, and recording rain gages. Purpose of this work is to determine the relationships between evapotranspiration and various climatic, soil, and plant influences as these relationships are influenced by performance with respect to net water yield.

(g) Much of the available water in the root zones of California was quickly used after each dry season started. The lack of available water reduced evapotranspiration rates. It was found that these rates of evapotranspiration correlated to...
siderable degree with the soil moisture content of the root zones.

(4853) **SALINITY BALANCE INVESTIGATION OF CITRUS IRRIGATION ON RESIDUAL SOILS, USING COLORADO RIVER WATER.**

(b) Laboratory project, in cooperation with the U. S. Soil Conservation Service, and Riverside County (California) Flood Control Dist.

(c) Mr. Sterling Davis, Agricultural Engineer, 102 Irrigation Bldg., University of Calif., Riverside, California 92502.

(d) Experimental.

(e) The salinity of the soil and drainage water from this watershed is compared with total Colorado River water irrigation application plus rainfall to determine the salinity trend within a large watershed planted primarily to citrus orchards. Granodiorite rock underlying these soils minimizes loss of effluent to deep percolation. Biannual soil samplings are taken of selected sites within the watershed. Intensive investigations including flow recorders, flumes, and recording rain gages, were activated in May 1962. The program was expanded in 1966 to include sufficiently large flumes to measure winter storm runoff. The project was established as a five-year program.

(f) Salt accumulates in the soil during the summer growing season and leaches out during the winter runoff season. Chemical analyses of the soil saturation extract and of the drainage water show an equilibrium is being established which is favorable to the continued growth of citrus trees.

(4854) **EFFECT ON TIE DRAINs OF MANGANESE AND IRON SOLUBILITY IN SOILS.**

(b) Laboratory project, in cooperation with the U. S. Soil Conservation Service.

(c) Mr. L. B. Gross, Soil Scientist, Southwestern Irrigation Field Station, P. O. Box 1559, Brawley, California 92227.

(d) Experimental.

(a) A study to determine the ability of various soils to yield ferrous or manganous ions in drainage effluent under varying conditions of reduction and pH and to develop an index for soils in the reduction potential. The line deposits of manganese and ferric oxide now represent a serious threat to irrigated agriculture, particularly in the Coachella and Imperial Valleys of California. SCS and ARS technicians have collected and forwarded soil samples from 11 locations throughout the United States. This problem has been observed in agricultural drain lines.

(5213) **WATER DISCHARGE MEASUREMENTS WITH CHEMICAL TRACERS.**

(b) Laboratory project.

(c) Mr. Lloyd E. Myers, Director, U. S. Water Conservation Laboratory, 4331 East Broadway, Phoenix, Arizona 85040.

(d) Experimental; applied research.

(e) Techniques and equipment for the integrated sample method of water discharge in open channels and in pipelines using fluorescent chemical tracers are being developed.

(f) A sensitive laboratory fluorometer has been adapted for field use. Preliminary field measurements indicate that uniform mixing of tracer with flowing in an open channel is difficult to obtain.

(5220) **UNSATURATED FLOW CHARACTERISTICS OF AGRICULTURAL SOILS.**

(b) Laboratory project.

(c) Dr. S. L. Rawlins, U. S. Salinity Laboratory, P. O. Box 276, Riverside, California 92502.

(d) Experimental; basic research.

(e) The objectives are (1) To develop improved techniques (in terms of effort, reliability, and time) for measuring the water transmitting properties of agricultural soils at various moisture values; and (2) to determine the unsaturated flow properties of a variety of agricultural soils. Diffusion theory and linear flow systems are being utilized.

(5221) **THE ROLE OF SOIL MOISTURE IN SEMIARID RANGELAND HYDROLOGY AND SEDIMENT PRODUCTION.**

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Dr. H. A. Schreiber, Soil Scientist, P. O. Box 3026, Tucson, Arizona 85717.

(d) Experimental; field and laboratory.

(e) The objectives of this study are: (a) To determine the relation of soil moisture to vegetation and soil characteristics; (b) to determine and evaluate effects of soil moisture and related vegetation conditions on detention, retention, and deep penetration of rainfall; (c) to compare the naturally occurring moisture regime the effects produced by two imposed moisture regimes on soil and vegetation characteristics relating to the hydrology and sediment production of semiarid rangelands; (d) to study the effects and interactions with soil moisture of maintaining a higher than normal or more frequent on soil and vegetation characteristics affecting the runoff net water yield, and sediment yields and forage production of semiarid rangeland watersheds.

(f) Runoff produced from high intensity, short duration, convective thunderstorms increases with increasing precipitation quantity and intensity. Antecedent soil moisture has a significant, but very minor effect on runoff produced from these storms in the area under study.

(5222) **PRECIPITATION CHARACTERISTICS AFFECTING HYDROLOGY AND SEDIMENT PRODUCTION OF SMALL AGRICULTURAL WATERSHEDS IN CENTRAL AND SOUTHERN CALIFORNIA.**

(b) Laboratory project, cooperative with Tehachapi Soil Conservation District, and California Agricultural Experiment Station.

(c) Mr. G. Paul Lawless, Soil Scientist, P. O. Box E, Lompo, California 93438.

(d) Experimental; some investigations; basic and applied research.

(e) Objectives of this study are to develop storm time-depth-area relationships of rainfall in Central and Southern California to geographic location in the detail needed for design of flood runoff control works on agricultural watersheds of 400 square miles or less; and to characterize other precipitation parameters relating to the net water yields, flood runoff and sediment production of such watersheds.

(f) Additional instrumentation has been installed and data collection is underway.

(5223) **DETERMINING THE EFFECTS ON PHYSICAL WATERSHED MODELING RELATIONSHIPS CAUSED BY MANIPULATING THE PHYSICAL PROPERTIES OF THE FLUID USED IN THE MODEL'S MAINSTORM SIMULATOR.**

(b) Laboratory project, cooperative with the Utah Water Research Laboratory, Utah State
University.

(c) Mr. D. L. Cherry, Jr., Hydraulic Engineer, F. O. Box 3926, Tucson, Arizona 85717.

(d) Experimental laboratory. Applied research (also for a doctoral thesis) to determine the effect on model-prototype relationships of changes in the physical properties of water-chemical mixtures used in a model watershed rainstorm simulator. (5226)

Data from the model are compared with records of the prototype watershed (97-acre semiarid watershed near Albuquerque, New Mexico) to ascertain which water-chemical mixtures give the best model verification. The watershed model consists of a 1:175 fiberglass topographical model and an automatically operated rainstorm simulator. To the storm simulator, the liquid is applied in several independent subunits by positive displacement pumps driven by variable speed D.C. electric motors. The fluid is distributed evenly by subsurface by a seبع length polyethylene tubing (0.011 inch ID).

(h) "Construction, Instrumentation, and Preliminary Verification of a Physical Hydrologic Model," D. L. Cherry, Jr., Utah Water Research Laboratory, 152 pages, July 1965. (Obtain from Utah Water Resources Laboratory, Utah State University, Logan, Utah 84321.)

(5224) GROUND WATER AS A FACTOR IN THE WATER BUDGET OF SEMIARID WATERSHEDS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Mr. D. B. Wallace, Geologist, F. O. Box 213, Tombstone, Arizona 85638.

(d) Experimental field; applied research.

(e) Objective of the study is to provide information on ground water accretion and movement and aquifer-streamflow relationship as affected by surface and subsurface geologic conditions.

Research will include: (1) Preparing maps and stratigraphic sections of the watershed and associated areas; (2) keeping an accurate annual log on groundwater fluctuations in the watershed and adjoining areas; (3) collecting cores and samples of the various materials for laboratory analysis; (4) utilizing drilling techniques and sensory methods to determine porosity, permeability, and transmissibility of aquifers and valley material. Pumping tests and tracers will also be utilized in determining flow movement in subsurface strata. Neutron-scattering, borehole logging equipment will be used in an attempt to determine water movement from ephemeral streambeds to regional water table. These seepage losses from subsurface ground beneath the channels. The magnitude of this contribution to regional groundwater has not yet been determined.

(5225) HYDROLOGIC EFFECTS OF RANGE CONSERVATION TREATMENTS.

(b) Laboratory project, cooperative with Agricultural Experiment Stations of Arizona and New Mexico, U. S. Soil Conservation Service, local ranch owners.

(c) Mr. D. R. Kincaid, Research Botanist, F. O. Box 3926, Tucson, Arizona 85717.

(d) Experimental; field; applied research.

(e) Treatments comprise combinations of brush removal, soil pitting and reseeding to perennial range grasses. They are applied to replicated 6x12-foot plots, and to drainage areas up to 10 acres. Objective is to investigate effects of a practical range conservation program on yields of water and sediment.

(g) Twenty-four 6x12-foot surface runoff plots were treated by combinations of brush removal, soil pitting and reseeding to perennial range grass. Summer rainfall reduced the roughness produced by pitting to less than half the pre-rainy-season condition. Seeding the plots to grass reduced runoff more than did pitting. Cleared brush extended the period moisture was available for plant growth following the rainy season to day 1360-acre watershed was contour furrowed with a soil ripper in Spring 1965.

DYNAMICS OF WATER AVAILABILITY TO PLANTS.

(b) Laboratory project.

(c) Dr. W. R. Gardner, U. S. Salinity laboratory, F. O. Box 672, Riverside, California 92502.

(d) Experimental and theoretical; basic research.

(e) Principles involving uptake of water from soil by plants and subsequent loss to atmosphere under study. A mathematical model for the soil-plant atmosphere system has been derived. Experiments are conducted in the greenhouse and growth chamber to test the validity of the model.

(g) The unsaturated conductivity of the soil as well as the soil suction has been shown to be important in governing water uptake by plants. The mathematical model has been extended to provide a quantitative relation between transpiration and soil moisture.


(5584) SEDIMENT SOURCES AND DELIVERY PROCESSES ON AGRICULTURAL WATERSHEDS.

(b) Laboratory project in cooperation with Soil Conservation Service.

(c) Mr. Joseph B. Murphy, Geologist, F. O. Box 3926, Tucson, Arizona 85717.

(d) Basic and applied research.

(f) To determine sediment producing characteristics of watershed lands as related to their geology, soils, land use, and treatment; their stream sediment movement and depositional characteristics as related to hydraulic and hydrologic influences; and to develop methods for prediction of sediment deposition on agricultural floodplain areas and sediment carried out of agricultural watersheds.

(g) None. Preliminary investigations are being developed.

(5585) WATER REQUIREMENTS OF LAWN GRASSES.

(b) Field project in cooperation with the U. S. Navy and the Nevada Agricultural Experiment Station.

(c) Mr. Roy Tovey, Research Agricultural Engineer, Agricultural Research Service, F. O. Box 6014 University Station, Reno, Nevada 89507.

(d) Experimental; applied research.

(e) 1. Determine minimum water requirements, including depth and frequency of application, to maintain a lawn in a top well-structured condition.

2. Determine minimum water requirements, including depth and frequency of application, to maintain a lawn where it is desirable to reduce maintenance operations to a minimum. Good turf must be maintained that will go dormant in hot seasons and revive when watered by precipitation or irrigation.

Study being carried on with nonweighing lysimeters.
WATER BUDGET OF Ephemeral STREAM CHANNELS IN Relation TO WATER DYNAMICS, GEOLOGY, AND VEGETATION.

Field and laboratory project in cooperation with Arizona Experiment Station.
Mr. D. R. Kincald, Botanist, P. O. Box 3926, Tucson, Arizona 85717.
Laboratory and field research, basic and applied.
The investigations are aimed at (1) assessment of ground water in local, water tables, and development of management practices for sustained supply and improved quality of usable water, and (2) basic research on the relation of temperature variation and fluctuation of the water table to soil moisture movement and evaporation. During the summer rainy season, large proportions of the ephemeral flows are absorbed by the stream channel, resulting in a rise of the water table. Many channels with deep alluvial deposits overlying these perched water tables support dense stands of phreatophytes. Evapotranspiration from such areas on the Walnut Gulch Experimental Watershed is being studied by means of both the water budget and the heat balance approach. Amounts of water storage and rates of recharge are determined in the field. Outflow from the area is recorded to the nearest cubic foot, and diurnal fluctuation of the water table and of the surface of the water table is continuously noted. Using Darcy's Law and a combination of methods for determining soil permeability and hydraulic conductivities, rates of subsurface inflow are computed. By use of a portable seismic unit and 26 observation wells, extent of the aquifer has been determined and an area-depth curve has been prepared.

RELATION OF SEDIMENTS AND STRATIGRAPHY TO THE HYDROLOGY OF SEMIARID WATERSHEDS.

Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations and the U. S. Soil Conservation Service.
Dr. Philip Seff, Research Geologist, P. O. Box 3926, Tucson, Arizona 85717.
Experiments, field and laboratory; basic research.
Sediment collection stations are located at half-mile intervals where good surface exposures exist near the various experimental watersheds. Detailed sample collections of individual stratigraphic units are subsequently analyzed in the laboratory. This procedure coupled with a fluvial geomorphic analysis of the existing stream channels provides the necessary data for geologic interpretations, and recognition of changing climatic conditions.

Subsurface water flow is restricted on both the Alamogordo and Walnut Gulch watersheds by high to medium indurated beds of Mesozoic age and older. There are three major stratigraphic formations, each displaying varied degrees of cementation. The older covers the upper part of the study area and is very tightly cemented, being relatively impermeable. The youngest is largely unconsolidated and covers the lower part of the watershed. It is very permeable and is a source of water loss through seepage. Additional studies reveal the bulk of the present sediments in Walnut Gulch are supplied through erosion of the older gravel. The weathered sediments are supplied by the adjacent mountainous areas.


EVALUATION OF SUBSURFACE IRRIGATION SYSTEMS.

Laboratory project, in cooperation with the Soil Conservation Service and the California Agricultural Experiment Station.
Mr. Sterling Davis, Agricultural Engineer, 102 Irrigation Building, University of California, Riverside, California 92502.
Experimental.
Objectives are to evaluate a variety of devices, such as porous tubes and conduits, as to their ability to supply irrigation water beneath the soil surface thereby reducing water loss attendant to conventional water application in citrus groves.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Central States Forest Experiment Station.
Inquiries concerning the following projects should be addressed to R. D. Darby, 111 Old Federal Bldg., Columbus, Ohio 43215.

SUBSURFACE WATER MANAGEMENT ON NORTHERN HARDWOOD FOREST AREAS.

Laboratory project.
R. L. Whipple, Project Leader, Forest Service, U.S.D.A., Pennsylvania State Hydrology Laboratory, 2240 North High Street, Columbus, Ohio 43201.
Experimental and field investigations; basic and applied research.
Movement of subsurface water will be studied in various geologic and soil types to: (1) Develop techniques for quantitatively measuring subsurface water movement and discharge from small plots; (2) learn the effect of artificial rainfall on quantity and timing of subsurface water movement; and (3) develop a flow equation including coefficients for the significant variables affecting that flow. This information will aid watershed technicians in making land management decisions on areas that have lots of subsurface stormflow.

A plot 125 feet long by approximately 18 feet wide was bordered by a trench 18 inches wide by 30 inches deep. This plot is described in the Central States Publication CS-29 and the cover, soil, and topography in the 1965 issue of Hydraulic Research in the United States. The plot was wetted by a sprinkler system consisting of five separate manifolds, each controlling five sprinkler heads. Artificial rainfall could be applied over the entire plot or at any 25-foot segment of the plot, i.e., from 0-25, 25-50, 50-75, etc., or combinations of the above. Rainfall intensities applied ranged from 0.5 to 1.0 inch per hour in steady applications. Storm lengths varied from 90 to 150 minutes. Seepage was measured in a trough system described in the 1965 issue and in Publication CS-29. The following results were noted: (1) No surface runoff occurred during 30 storms. Observation showed occurrence of flow over the litter in a few instances, but distances involved were usually less than 25 feet. The flow disappeared into the permeable A horizon. This surface runoff sometime occurs where leaf litter is thick and saturated from previous wetting rains. The Turkey Run occurred under these conditions is due to the "shingle-effect" of the imbricated leaves. (2) Patterns of flow were as measured in previous years. i.e., greatest volumes of seepage occurred from the uppermost soil horizon. Where upper-slope portions of the plot were wetted, little or no flow occurred from the downslope face, no flow seeped from the face. However, where the 25 to 50 foot section was wetted, flow did occur through the unmowed 0-25 foot section and seeped from the downslope face into the collection system. (3) Seepage occurred in the trench surrounding the trough in every run. This seepage came from root channels, along root courses,
through about 4 lateral feet of unwatered soil, it was felt that the biological and structural changes within this forest soil are important sources of turbulent subsurface flow occurring through shallow depths of forest soil in the Allegheny-Cumberland plateau. (4) To learn something of the effect of opening the fine-textured, relatively tight subsols, a pit was dug across the plot from 40 to 50 feet above the downslope face. This pit extended laterally from the boundary trenches and was approximately 11 feet deep. The material removed was then replaced in a haphazard manner, with care taken to minimize mechanical layering and compaction. Our objective was to see if disturbance of natural bedding planes and the impeding layers affected subsurface stormflow. This will be tested in detail after the disturbed area has settled over the winter season. (5) Observed subsurface stormflow coming from forested drainageways and from plots during simulated storms has been of the turbulent type. While it seems logical that Darcy's law does not hold for this type of flow, we are testing several methods of measuring hydraulic conductivity of permeable forest soils. These are: (a) an oversized, 6-inch core sampler that will give four times the core area but only twice the perimeter of the standard 3-inch core, (b) the 6-inch Bower double-ring apparatus for measuring hydraulic conductivity above a saturated zone, and (c) a meter-square block equipped in place with outlet and inlet reservoirs. In the latter small head differences will be employed to measure movement rates. We hope to compare these techniques and perhaps learn if there is a practical, sound method for determining hydraulic conductivity of highly permeable forest soils. "Measuring Subsurface Stormflow from Simulated Rainstorms - A Plot Technique," by R. Z. Whipkey, Central States Forest Experiment Station Note CS-29, 29 pp., 1965. "Subsurface Stormflow from Forested Slopes," by R. Z. Whipkey, Bulletin, IASH, Fall 1965, pp. 41-50. "Theory and Mechanics of Subsurface Stormflow," by R. Z. Whipkey, Proceedings, Int'l Symposium on Forest Hydrology, held at Penn. State Univ., Sept. 1965, (in press).

USE OF NUCLEAR RADIATION EQUIPMENT FOR MEASURING FOREST SOIL MOISTURE AND DENSITY.

(4753)

(b) Laboratory project.

(d) Experimental and field investigations; basic and applied research.

(e) This is an intensive soil-moisture study initiated to discover some basic tree stand characteristics that are closely related to tree growth and to water available for streamflow. Preliminary results are not yet analyzed; in the process of compiling and analyzing during winter 1965-66.

FOREST RESTORATION AND WATERSHED MANAGEMENT ON SURFACE MINED AREAS IN THE APPALACHIAN COAL FIELDS.

(b) Laboratory project.

(d) Experimental and field investigations; basic and applied research.

(e) This study on spoil banks, freshly disturbed during strip mining in the Appalachian coal fields, has a high soil erosion and sediment transport potential. This seriously affects water quality and can cause deleterious effects on watersheds in which coal is harvested. It is highly desirable to establish a vegetative cover as quickly as possible after mining disturbance in order to minimize erosion and maintain water quality. The purpose of this project is to (1) develop practical methods of reducing damage to watersheds values during surface mining operations and (2) find feasible ways to restore mined areas to productive forest uses.

Studies by individual scientists are divided among five disciplines including (1) Spoil Placement, (2) Soil Chemistry, (3) Ruins, (4) Revegetation, and (5) Hydrology. General hydrology studies recently started include (1) a study of stormflow and sediment yield from stripmined terraces; (2) a study of stormflow and sediment yield from downslopes of stripmined soil banks; and (3) a study of the hydrology of ponds originating on stripmined lands. In these studies a number of small San Dimas flumes have been installed to measure storm runoff from a number of terrace and coal mining drainage areas. The pond hydrology study a number of stilling wells and recorders have been installed on ponds. Raingage networks have been installed to cover each sample drainage area.

Design criteria have been established for piling spoil overburden on hillside. Assuming complete drainage control and a fill material free of trespass material, spoil material can safely be piled on slopes up to 33°. The amount of material piled should vary with the slope, with 25 feet being considered safe. At 14° a bench width of 250 feet should be free from slides. The soil solution composition in acid producing coal mine spoil has been related to the soil pH. Concentrations of Ca, Al, Mn, Zn, Cu, and Ni were found to be high in low pH materials especially below pH 5. Maximum concentrations were: Ca, 20,000 ppm; Al, 8,000 ppm; Mn, 1,600 ppm; Zn, 145 ppm; Cu, 51 ppm; and Ni, 26 ppm.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Intermountain Forest and Range Experiment Station, Ogden, Utah.

(5296) SOILS STABILIZATION IN RELATION TO LOGGING ON STEEP TIMBERED SLOPES IN THE NORTHERN ROCKY MOUNTAINS.

(b) Laboratory project.
Experimental and field investigations; basic and applied research.

To identify and quantify the interrelations of soil, water, and vegetation to soil stability; the direct and indirect soil and vegetation requirements for stabilizing soil; and to determine effects of timber harvesting and roadbuilding on soil movement and water yield.

From the inception of a study of cutting ponderosa pine on 16 small watersheds in the Boise Basin, Experimental. Further study was recommended after harvest. Sediment that reached the stream channels originated primarily on haul roads. Proximity of a road to a stream affected the frequency with which sediment flows reached that stream. Sediment reached channel bottoms through undisturbed buffer strips averaging 8 feet wide, but did not reach them if the strips were more than 30 feet wide. After 3 years, movement of sediment "en route" had almost halted.

Six different surface treatments were applied to the fill section of a newly constructed road in the Zena Creek area of the Fayette National Forest, Idaho. Treatments were: (1) one layer of "Erosionet" plus grass seed and fertilizer, (2) three layers of "Erosionet" plus grass seed and fertilizer, (3) asphalt-straw mixture plus grass seed and fertilizer, (4) chipped slash plus grass seed and fertilizer, (5) surface holes plus grass seed and fertilizer, (6) control, no treatment. Best soil stabilizing results were obtained in the use of "Erosionet" and the application of an asphalt and straw mixture.

Steep rugged terrain is characterized of millions of acres of forested land in central Idaho. Natural rates of soil movement are high, and may be increased by improper land use. The project is one of one of several to determine natural rates of soil movement and to ascertain change in rates caused by different methods of logging: jammer versus high-head, high-head versus no movement near small watersheds and on 1/100-acre plots. Roads were built in the jammer area in 1961, and then both jammer and high-head areas were logged in 1962. Immediate following road construction, heavy soil losses were observed in the jammer area. After the logging operation, soil losses did not increase in either the high-head or jammer areas. In 1964 (3 years following road construction and 2 years after the logging operation) soil losses in the two areas appear to be of the same magnitude.

Further analysis of sediment yield from the 1/100-acre plots corroborates the results of another study. These plots are on both the southwest and northwest exposures; plots on hot, southwest exposures yield significantly larger amounts of sediment than those on northwest exposures as a result of high-intensity rainfall.


WATERSHED PROTECTION REQUIREMENTS AND REHABILITATION MEASURES FOR THE REDUCTION OF FLOOD RUNOFF, EROSION, AND SEDIMENT FROM DESERTIFIED FOREST AND RANGELANDS.

Laboratory project.

Experimental and field investigations; basic applied research.

To relate soil and vegetation characteristics to infiltration, overland and subsurface flow, and soil erosion; to develop flood and erosion hazard criteria and protection requirements for deteriorated rangeland; and to determine effects of watershed rehabilitation on erosion hazard and flood potential.

The effects of sediment, grazing and grass and litter infiltration capacity and soil stability were studied by WATERSHED, years harvest. After 1962, the central Utah on 168 infiltrometer plots sediment flow over a wide range of soil, topographic, and plant-cover conditions. Data obtained were subjected to a stepwise multiple-regression analyses to determine which combinations of site factors exert the greatest influence on infiltration and soil erosion processes. Equations were developed that provide good estimates of infiltration and soil erosion values from several readily measured site factors.

The single site factor most closely correlated with total infiltration was bulk density of the surface inch of the soil mantle. This factor accounted for 35 percent of the variance in total infiltration infiltration. Infiltration was combined with other site factors in multiple-regression analyses, bulk density remained the most important factor affecting total infiltration. These are: clay content of the surface inch of soil, air-dry weight of soil, and dry weight of litter, for 1- to 2-inch depth, soil organic matter content at the 4- to 6-inch depth, plot slope gradient, and aspect. This combination of factors accounted for 65.3 percent of the variance of total infiltration and had a standard error of regression of 0.375 inch of infiltrated water in the smallest standard error obtained in the analyses. The amount of soil eroded from the plots during the 30-minute simulation of simulated rain was related exponentially to the surface inch of soil, the main factors were not significantly correlated linearly to the site factors. Consequently, it was necessary to transform the dependent variable to obtain a good fit by regression analysis. After several transformation were tried, the following regression model was accepted and used:

$$\log (E + 1/2) = b_0 + b_1 X_1 + b_2 X_2 + \ldots$$

in which $E$ is soil eroded in tons per acre, $b_i$ are regression coefficients, and the $X_i$s are site factors.

The proportion of the ground surface exposed as bare soil on the infiltrometer plots was the single site factor most closely correlated with the amount of soil eroded. The percent of exposed bare soil, in the main factors accounted for 66 percent of the variance in the dependent variable ($\log (E + 1/2)$). Plot slope gradient accounted for an additional 10 percent of the variance, and bulk density of the surface 2 inches of the soil mantle accounted for another 4 percent. Together, these three factors explained 86 percent of the variance in soil erosion. Only 1 percent additional variance was accounted for by the next three ranking factors: soil organic matter content, soil aggregates and particles larger than 0.05 mm in diameter, and the percent of organic cover provided by plants and litter.

A study of infiltration characteristics of
ponded water in contour trenches and their change with time, was begun in 1964 in northern Utah.

First-year measurements show that the average infiltration rates in these trenches during the time required for them to completely drain (several hours) were 15.8 inches per hour on coarse-textured soil material, 15.4 inches per hour on medium-textured material, and 9.2 inches per hour on fine-textured material. Laboratory measurements of the saturated permeability of the surface 2 inches of soil material from trenches and sections were 13.9, 11.3, and 9.1 inches per hour, respectively, for the coarse-, medium-, and fine-textured soils. Differences in permeability between cut slopes and fill slopes in the trenches were not significant.

Differences in the infiltration characteristics between trenches in coarse- and fine-textured soils are reflected more sharply by comparisons of infiltration rates with time. Initial infiltration rates, during the first 5 to 10 minutes after the plastic liners were removed, ranged from 150.0 inches per hour on a site where 61 percent of the soil material exceeded 19 mm. in diameter to 25.8 inches per hour on a site where 60 percent of the soil material was smaller than 2 mm. After the trenches were more than three-fourths drained (several hours) the infiltration rates on these same sites had decreased, respectively, to 12.1 and 0.6 inches per hour. Although data from the 1965 tests have not been analyzed, the long periods of time (from 12 to more than 30 hours) required for equivalent amounts of ponded water to infiltrate indicate that infiltration capacities of these trenches 1 year after construction have decreased to perhaps 1/6 to 1/10 of their 1964 capacities. These reductions in infiltration appear to be due to scaling of the soil surface by silt and clay-size soil fractions. A major source of these fine fractions is believed to be wind-blown soil carried from the trench fill slopes during periods of strong upslope winds.

Inquiries concerning the following projects should be addressed to the Director, Lake States Forest Experiment Station, St. Paul Campus, University of Minnesota, St. Paul, Minn., 55101, unless indicated otherwise for a specific project.

(3887) WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA.

(a) Laboratory project.
(b) Experimental and field investigations; basic and applied research.
(c) Tests the influence of forested bogs on streamflow and ground water behavior. Present studies are concentrating on: (1) Hydrology of 6 small bogs instrumented by a total of 5 flumes and 1 weir and by 6 recording and 5 nonrecording wells; (2) Laboratory and field studies to evaluate the hydrological and physical properties of peat soils. Laboratory tests have been made of rate of water movement through 62 peat cores, and 72 in situ hydraulic conductivity tests have been run using the piezometer and tube methods; (3) Evapotranspiration studies have been conducted on thirteen 10-foot-diameter bottomless steel lysimeters and four with surface areas of 1 square meter, which have been driven to impermeable peat material in forested and nonforested bogs. Results to date of a study of water table relation to a northern bog indicate that the water table in the nonforested bog is continuous with the regional ground water flow system and is partially controlled by it. Different peat materials with different physical properties were found in each bog because of the influence of topography and the variation of mineral- and organic-enriched water. Waters in the perched bog were more saline.

Evapotranspiration in bottomless 10-foot-diameter lysimeters compared with other methods of measuring transpiration and evaporation showed the following correlations: With open pans, \( r = 0.907 \); with Thornthwaite ET values, \( r = 0.883 \); and with Hamon ET values, \( r = 0.898 \).

(h) WATERSHED MANAGEMENT RESEARCH IN THE DRIPLESS AREA OF SOUTHWESTERN WISCONSIN.

(a) Laboratory project, with some aspects in cooperation with Wisconsin Conservation Dept.
(b) Field investigations; basic and applied research.
(c) Evapotranspiration

Major emphasis is given to the influence of the forests on runoff and erosion. Studies are also underway on gullies in forested land, particularly the evaluation of small structures and the reduction of gully-forming by water spreading into the forest. A total of 37 water-measuring devices, including 3 weir and 34 flumes, were in operation on 12 separate watersheds and in 3 springflow areas. In addition, 32 wells are under observation, with 2 equipped with recording instruments; 30 are of the non-recording type.

(g) Preliminary results indicate that runoff water from small fields of ridgetop agricultural lands can be directed and spread safely into forest land by means of (1) log barriers placed across the direction of flow in the forest or (2) small detention ponds in tandem. Of 20 runoff events observed through the outlet flumes in the plot with 3 detention ponds. Four storms out of 20 resulted in runoff from the contour log treatment. On the plot, when water was diverted into untreated woods, 16 of the 20 storms produced outflow.


WATERSHED MANAGEMENT RESEARCH IN LOWER MICHIGAN.

(a) Laboratory project.
(b) Field investigation; basic and applied research.
(c) The major projects involved here deal with (1) ground water recharge and evapotranspiration of various cover types in deep sandy soils and (2) streambank stabilization on trout streams, and (3) sedimentation in trout streams. Measurements of ground water recharge are based on the behavior of 112 wells and 10 stream gauges. A cooperative study on sedimentation has been initiated with the Biology Dept. of Central Michigan University, with measurements of sedimentation in terms of trout habitat, and especially in terms of aquatic insect popu-
Measurements of eroding streambanks which received chemical mulch treatments 2 years previously have shown no significant improvement in vegetation density due to mulching when compared to seed and fertilizer treatments. These tests apply only to sandy streambanks where survival of the herbaceous cover is affected more by the availability of soil moisture than by surface erosion of seeds.

Studies of evapotranspiration losses from shallow water table sands showed that diurnal water level fluctuations produced by such losses effectively ceased when the water table was more than 4.5 feet below mean ground level in March and April and below 3.5 feet beneath a jack pine plantation. Since the water table levels have dropped below these levels each year over a 4-year period, it is possible that forests on poorly drained sand soils do not act as phreatophytes through the entire growing season. A low capillary fringe in the sand subsoils is evident from these results.


U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Northeastern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. Ralph W. Marquis, Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania 19082.

WATERSHED MANAGEMENT RESEARCH, PERNOW EXPERIMENTAL FOREST, WEST VIRGINIA

Laboratory project.
Field investigation; basic and applied research.
Studies were started in 1951 on the Pernow Experimental Forest, Tucker County, W. Va., to determine the effect of different logging methods, and different forest types, upon water quantity and quality. Nine watersheds have been equipped with streamgage stations and rain-gages.

Streamflow data from control and clearcut watersheds at the Pernow Experimental Forest were analyzed to determine if measurements taken once a day, twice a week, once a week, twice a month, or once a month could be used instead of continuous records. The results suggest that, under some situations, much might be learned from relatively few measurements.
Errors in streamflow measurement from stage-discharge relations, manual checks of stage, and methods used in compilation of data were evaluated, and estimated to total not more than 3 to 5 percent of annual streamflow values.

Dew deposition was measured at the Pernow Experimental Forest in a recording rain gage modified to accommodate a section of live turf. The total for August, the month of maximum deposition, was 0.055 inch.

The amount was not large enough to warrant consideration as a factor in watershed management research.
Before clearingcutting a portion of an experimental watershed on the Pernow Experimental Forest during the winter of 1963, all trees above 1-inch dbh were basal sprayed with 2,4,5-T in No. 2 diesel oil. After clearingcutting, sawlogs and streamflow measurements were made. During these treatments, numerous water samples were obtained from the stream immediately below the treated area and sniff-tested. There was no evidence of contamination by the herbicide.

The watershed treatment increased water yield from the treated area by almost 200,000 gallons per acre during May-October 1964.


WATERSHED MANAGEMENT RESEARCH, HUBBARD BROOK EXPERIMENTAL FOREST, NEW HAMPSHIRE

Laboratory project.
Field investigation; basic and applied research.
The objective is to determine the effect of forest type, condition, and stand treatment on quantity and quality of streamflow. Studies are conducted in plots and experimental watersheds on the 7500-acre experimental forest in the White Mountains at West Thornton, New Hampshire. Seven weirs have been built and climatic stations established.

WATERSHED MANAGEMENT RESEARCH, SYRACUSE UNIVERSITY, NEW YORK

Laboratory project, in cooperation with the State University College of Forestry at Syracuse University, Syracuse, New York.
Field investigation; basic and applied research.
This cooperative project was started in 1961 to determine quantitative relationships of forest types and conditions to the amount, timing, and quality of streamflow in the Adirondacks, the glaciated Appalachian Plateau, and the Catskills.

On the basis of experiments for turbulent heat and vapor transfer, and reasoned application of knowledge about intercepted snow, great differences are predicted in the energy and water balance of treated "snowfield" and one on level open ground. The differences, resulting from the complex surface geometry of a closed conifer forest, are sufficient to account for considerably greater losses of intercepted snow.


WATERSHED MANAGEMENT RESEARCH, UPPER DARBY, PA.

Laboratory project in cooperation with: (1) the School of Forestry, Pennsylvania State University and the Pennsylvania Dept. of Forests and Waters; (2) Baltimore (Md.) Bureau of Water Supply; and (3) Woodland and Water Supply of the City of Newark, N. J.
Field investigation; basic and applied research.
At Pennsylvania State University a cooperative study was started in 1957 to determine the effect of forest cover and treatment on quantity and quality of interception in the oak-hickory type in Pennsylvania, and to study
associated and basic soil-water relationships. Six experimental watersheds have been selected, were have been constructed, and climatic stations established. At Baltimore, Md., a cooperative study started in 1958 to determine effect of growth of logically and water-plants in plantations on streamflow, and to compare streamflow from watersheds in conifer plantations with streamflow from a hardwood forest watershed. Streamflow of three experimental watersheds is being measured and a climatic station has been established.

At Newark, N. J., a cooperative study to determine the influence of selected treatments of forested municipal watersheds on water supply. Waters on 3 experimental watersheds were built in the fall of 1956 and stream gauging and climatic measurements were started in the spring of 1958.

In a cooperative study with the School of Forestry of the Pennsylvania State University, an analysis was made to determine the amount of annual and seasonal water yield, flow duration, and peak flow frequency for seven major physiographic units in the northeast. All watersheds (137) in the Northeast that were less than 100 square miles in area, that had continuous records from 1930 to 1957, and that were not appreciably affected by regulation and diversions were included in the analysis. In addition, streamflows of four small forested experimental watersheds were correlated with average streamflow values of the physiographic units in which they were located. The longest simultaneous record available was for a 5-year period from 1952 to 1956. Results indicate significant differences in water yield between physiographic units as well as between watersheds within units. Water yields from the small experimental watersheds, although based on a shorter and different period of time, were found to correspond closely with average water yields of their respective physiographic units. The relationship of physiographic units In the Northeast, by William E. Sopper and Howard V. Lull. Water Resources Res.: 1: 115-124.


Inquiries concerning the following projects should be addressed to Mr. Michael A. Breg, Director, Pacific Northwest Forest and Range Exp. Sta., P. O. Box 3141, Portland, Oregon, 97208.

(475) WATER YIELD AND EROSION, WENATCHEE, WASH.

(b) Laboratory project.

(d) Field investigations; basic and applied research.

(e) Field studies in ponderosa pine and mixed-conifer forests and forest ranges on the east slopes of the Cascade Range in Oregon and Washington. Erosion in forests and ranges: (1) Sediment production from Swauk sandstone-ponderosa pine; (2) sediment production from pnw-nf-larch ranges, Blue Mountains; (3) stream generation of natural and artificial basins, and natural grass cover by fertilization - Swauk sandstone soils; (4) relation of parent material and vegetation cover to runoff, evapotranspiration, infiltration, soil moisture, and bulk density of forest-range soils - eastern Washington. (5) effect of climate on development of soils from identical parent rock. Evapotranspiration: includes studies with the overall objective of measuring factors which affect distribution and use of water in forest ecosystems and forest ranges: (1) Measurement of solar energy in a conifer forest; (2) seasonal changes in soil moisture under a lodgepole pine forest; (3) measurement of moisture use by plants; (4) effect of removing brush and tree growth in three experimental watersheds on water yield (Entiat watershed study, in calibration stage - no treatment yet applied); (5) water-holding capacity and drying rates for humus types characteristic of ponderosa pine-Douglas fir forests - east side of the Cascade Range.

(g) Early results of a study of soil moisture depletion dramatically illustrate the manner in which soil depth and potential water yield increases due to timber harvest. Measurements made during the past year confirmed those made the previous year. The shallow soil (2-3 ft.) lost 2.5 inches while the deeper soil lost 6.4 inches during the drying season. A vegetation inventory was completed and half of all stands still had a small tree growth during late October. These data indicate that removal of lodgepole pine from the soil will not only increase the storage of more soil water than would be gained in shallow soils. Thus, it can be presumed that on deeper soils, more water can be made available for streamflow by timber management practices.

WATERSHED LOGGING METHODS AND STREAMFLOW.

Laboratory project with some phases in cooperation with City of Portland, Bureau of Water作品 and Oregon State University. Field investigations; basic and applied research. Research is conducted at three field locations in the Cascade Range of western Oregon; Bull Run watershed (domestic supply area for Portland), H. J. Andrews Experimental Forest, and South Unit Experimental Forest. Studies are confined to two forest types representing major segments of the remaining old-growth forests of the Pacific Northwest: (1) Douglas-fir, western hemlock, western redcedar, and (2) Douglas-fir, sugar pine. Investigations represent an initial effort to study precipitation runoff, erosion, and soil moisture in undisturbed stands, and to follow changes caused by several methods of logging. Included are studies in two categories: (1) Soil movement on logged land and an evaluation of effectiveness of grass seeding on roadsides; (2) changes in water quality resulting from roadbuilding, two methods of cable logging, two degrees of forest removal -- 25 percent and 100 percent -- and slash burning; (3) changes in streamflow caused by clear cutting and partial cutting in groups of varying size on matched watersheds in old-growth Douglas-fir and sugar pine-fern. Pretreatment measurements are still being made to provide statistical basis for treatment evaluation; (4) soil moisture movement and disposition and the role of vegetation in moisture recycling, including measure of seasonal changes in soil moisture under a Douglas-fir stand, vertical movement of water in Douglas-fir soils, rainfall interception by crowns of old-growth Douglas-fir soils, rainfall interception by crowns of old-growth Douglas-fir, and changes in plant succession following logging and slash burning.

Second year measurements after logging showed a storage capacity at the end of the summer of 3.5 inches of water in the top 4 feet of soil. Had the timber not been logged, storage capacity would have been an estimated 6.7 inches. With some recovery of vegetation following logging and burning, water removal from the top 4 feet of soil was about half what it would have been under undisturbed conditions. First measurements of suspended sediments from tractors crossing small streams during road construction show that during low summer flow there is a ten-fold reduction in sediment concentration after the stream flows through 1,000 feet of natural channel. Suspended sediment was reduced from 1,000 to 100 parts per million. Particle size analysis showed the following concentrations.

Distance downstream from road crossing | Suspended sediment concentrations per million
--- | ---
150 | 80, 618, 358, 1,055
300 | 3, 226, 440, 681
600 | 6, 40, 410, 450
1,200 | 0.8, 3, 104, 108

Water samples collected in spring, summer, and winter of 1965 were analyzed. Form and concentration of nitrogen was erratic. Nitrate form in spring changed to ammonia form in summer and nitrate form in winter. Phosphorus levels were generally higher in the spring and summer than in winter. Phosphate levels were higher from burned and unburned watersheds, returned to same levels in both burned and unburned watersheds summer and winter. Phosphate levels were greater from logged and burned watersheds except during summer low flows. Sodium was consistently slightly greater from logged and burned watersheds. K, Fe, and Mn showed no difference. Total dissolved solids were 80 percent HCO$_3$ plus hardness; the other 12 percent included Cl, PO$_4$, Mn, K, Na. pH remained near neutral except during sampling periods. First year results from snow measurements in 2-chain-wide, east-west, clearcut strips show greater accumulation but more rapid melt of snow in the slash. At the time of maximum accumulation in March, water content of snow on the clearcut strip was 35 percent greater than that under undisturbed forests. By June 15, only 3 of 36 plots in the open were snow-covered in contrast to 26 of 36 plots snow-covered under the undisturbed forest.


U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Southwest Forest and Range Experiment Station.

WATERSHED MANAGEMENT RESEARCH IN CALIFORNIA'S SNOW ZONE (SNOW MANAGEMENT RESEARCH). Laboratory and the following cooperators: State of California, Dept. of Water Resources, Atomic Energy Commission, and Pacific Gas & Electric Company. Dr. James L. Smith, Project Leader, Snow Management Research, Pacific Southwest Forest & Range Experiment Station, 1960 Addison Street, Berkeley, California. Experimental; field investigations; basic and applied research. The objective of this project is to determine methodology for increasing water yield and changing timing of water delivery by vegetation manipulation, by evaporation suppression, etc. Its area of interest is confined to the snowpack zone of the Sierra Nevada of California. Present studies emphasize development of methods for management of high elevation snowpacks for yields and snow accumulation and melt; and the evapotranspiration from various sites -- species combinations. Project scientists are located in Berkeley with field personnel and studies located at the Central Sierra Snow Laboratory, Soda Springs, California. Two sites only located at Teakettle Experimental Forest in the headwaters of the north fork of the Kings River, above Fresno, California. Both sites lie at 7000-8000 ft. water elevation. At the north fork of the Kings River was installed 9000' long and a timber harvest to determine their
effects upon water yield. At the Central Sierra Snow Laboratory five small watersheds are gaged to study the hydrologic effects upon water yield. In the headwaters or the Feather River a practical sized logging is being tested for more accurate and prediciton of delivery of snowmelt water has been possible using gamma and neutron probes. Commercially available probes with gamma source (Troxler Laboratories, 50-10 and 50-20 probes) were tested for the ability to measure snow density of the individual layers in the snowpack. Useable regressions of snow density (D) measured gravimetrically and gamma counts (Cg) in CPM in the snowpack were obtained. Only one calibration curve is needed regardless of how close to the snow-air interface one takes measurements. A snow gage has been tested with which one may accurately measure snow density in a 2- inch vertical increments to 1 percent of actual density. With this system a 10-foot snowpack may be profiled in 10 minutes before the detector and source was moved through the snowpack at a constant rate. Output was recorded on an analog chart. The system operates on the theory of gamma transmission. Gamma energy is emitted through the snowpack to the crystal detector, thence through a pulse-height analyzer set to pass photo-peak energy only and from there to the meter-scaler. Output can be fed to a chart. Problems of temperature effects upon the crystal are controllable. "Cold-up" and "euthanization" problems are negligible with use of proper access tubing. Effect of crystalline structure of snow, ice, and water upon gamma attenuation are shown to be negligible if present at all. Count was shown to be wholly dependent upon density of material between the source and detector. Soil samples were obtained for analysis in a study designed to identify the hydrologic and topographic characteristics of the major soils in the Sierra Nevada of California. Snowmelt was increased by 45 percent in clean-cut strips 132 feet wide. These strips were cut in virgin red fir at an elevation of 7,000 feet. However, approximately a 50 percent snow was almost equal to the increase was "stolen" from the bordering forest "downwind" from the cut strips. Snowmelt in east-west cut strips was shown to be drastically affected by the heating up of the tree trunks to the north of the cut strips. These in turn heated radiated to the snowpack and melted the pack rapidly from the north edge progressively to the south edge. Winter surface evaporation from snowpack at high elevation sites was greatly reduced by the addition of the suppressant hexadecanol. It was shown that hexadecanol did not materially increase snowmelt.


WATER SOURCE HYDROLOGY.

Laboratory project. Cooperators are: State of California, Department of Water Resources; University of California; State of Hawaii, Division of Forestry; and Oregon State University, College of Forestry. Mr. Henry H. Anderson, Project Leader, Pacific Southwest Forest and Range Experiment Station, F. C. Box 245, Berkeley, California.

Experimental and theoretical; basic and applied research.

The objective of the study through analytical modeling to advance the state of knowledge of watershed hydrology and sedimentation, and particularly, knowledge of the relationship of watershed management and other hydrologic processes at the water sources to water yield, floods, sedimentation, and water quality delivered to wildlands.

The relation of snow accmulation and melt to terrain and forest conditions measured at 153 snow courses in central California were determined using principal component analysis. Snow data included wet years and dry, 1956, 1959 and 1960.

Terrain was expressed in two parts: first, meso terrain the snowmelt processes were within a few hundreds or thousands of feet around the snow course, and second, the local terrain at the course. Meso terrain variables were shade from surrounding mountains, forest or lack of it at distances up to one mile to the windward, and position on the mountain slope, ridge vs. valley, etc. Interactions of these with the local terrain were also investigated. Local terrain variables included topographic and forest variables; topographic variables were expressed in terms of the triangle and aspect; measured variables were expressed in energy terms and included interactions with meso terrain and the forest. The effects of topography were further investigated by variables affecting the amount of snowfall, and the heat--both the solar energy and the exposure to winds affecting advecive heating at the course. Forest variables were found to be significant, and some forest variables were density of forest canopy, vegetative species, tree heights, sizes of openings and position of the snow course within the forest or opening. Under conditions when average snow (at all sites) was greater than 20 inches, the largest contrasts in annual amounts of snowmelt and south slopes occurred in the forest; openings were next; and forests near openings showed very little contrast between slopes. Under all three worst conditions, moisture differences occurred at about 35 inches of snow storage. The principal components analysis also indicated the possible magnitude of meso-effects of forests for distances one-half mile to the windward (SW) of snow courses. For a snow course with a dense forest (66 percent canopy) to windward, and a comparable forest area (55 percent canopy) of 33 percent, the analysis indicated 4-8 inches more snow at the course with the less dense forest to the windward.

Effects of the application of multivariate techniques in appraisals the adequacy of current sediment networks, some interesting relations of sediment discharge to past land use and condition have been indicated. For a selected group of 23 watersheds in northern California the relation of suspended sediment discharge (SED) to watershed fires in the last ten years (PINEO), to unimproved roads (URCADS), to "poor" logging (LOG1), to steep grassland (IGS) and to mean annual streamflow (Q), the following regression gave the following equation: log(SED) = 0.568 + 0.346 log(URCADS) + 0.248 log(PINEO) + 0.959 log(IGS) + 0.378 log(Q).

By solving the equation one can obtain estimates of the effects of a change in a particular land use or change in streamflow. For example, one can determine the overall sediment activities (as characterized by PINEO, URCADS, and LOG1) have increased average sediment loads for some northern California streams by seventeen times.


(4998) WATER YIELD IMPROVEMENT, AND FLOOD AND SEDIMENT REDUCTION IN THE LOWER CONIFER ZONE OF CALIFORNIA.

(b) Laboratory project. Cooperators are: California Department of Water Resources, California Division of Forestry, East Bay Municipal Utility District, and California Department of Fish and Game.

(c) Mr. Robert P. Crouse, Project Leader, Lower Conifer Zone, Pacific Southwest Forest & Range Experiment Station, 1500 Addison Street, Berkeley, California.

(d) Experimental: field investigations; basic and applied research.

This project conducts basic studies of forest hydrology which will suggest methods of land management for improving water yield, preventing floods and controlling sediment in the commercial timber zones of California below the snowpack. A study of soil moisture depletion in the Sierra zone of the Lower Conifer Zone concerns the magnitude of soil moisture storage and depletion under different stand and timber cutting intensities.

Because soil creep and landslides are prevalent in the zone, a study of gravitational mass movement will form an effort to develop the means of estimating the consequences of mass movement, with emphasis on initiation of landslides. Soil moisture data has been collected at 2-hour intervals for an additional summer's depletion period from 64 neutron moisture meter access tubes planted to a depth of 20 feet in a wide range of forest vegetation densities. Distance and bearing to all vegetation within 84 feet (1/2 acre) of each access tube has been collected. Soil texture has been determined for each plot to a depth of 50 feet. An additional 20 access tubes have been installed to a depth of 17 feet around a single isolated sugar pine. Recording water table stage recorders have been installed at 3 locations. The initial base survey of natural soil creep rates has been completed at the Moraga and Northern Coast Range sites. A preliminary standard penetration test survey has also been completed on the slopes adjacent to all inclinometer holes. A refraction seismograph survey of soil thickness is at present being carried out at these sites. The watershed calibration period at Casper Creek is continuing with measurements of streamflow, sediment discharge, and precipitation.

(4999) FLOOD AND SEDIMENT REDUCTION FROM STEEP UNSTABLE BRUSHLANDS OF THE SOUTHWEST.

(b) Laboratory project. Cooperators: California Division of Forestry, Los Angeles County Flood Control District, University of California, Berkeley, Los Angeles, and Riverside, Angeles National Forest.

(c) Mr. Raymond M. Rice, Project Leader, Pacific Southwest Forest and Range Experiment Station, 110 North Wabash Avenue, Glendora, Calif.

(d) Experimental: field investigations; basic and applied research.

(e) Purposes are (1) to determine how watersheds function; what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography; and (2) to develop methods of watershed management, including treatment of areas denuded by fire, to insure maximum yield of usable water and satisfactory flood runoff and soil erosion control. Principal work center is the 17,000-acre San Dimas Experimental Forest located in the San Gabriel Mountains. A fire started by lightning in July 1960 consumed the vegetation, mostly brush, on 50 percent of the area and destroyed many of the research installations. Immediately after the fire a major emergency research program was started to test the effectiveness of various measures used to reduce flood runoff and erosion on the denuded watersheds. These rehabilitation measures include installing brush control singly and in combination with physical treatments such as wattling, channel barriers and contour terraces. The tests are being made on 39 watersheds of 2 to 30 acres each, equipped to measure rainfall intensity, peak discharge and suspended sediment. Twenty-five have basins to measure bedload. Studies of the erosion processes and tests of applied management methods to decrease the erosion potential are being continued.

(g) Plots installed in the fall of 1965 to evaluate two methods of applying a wetting agent for post-fire erosion control yielded negative results. There were no significant differences between the surface runoff and erosion from treated and controlled plots. The lack of effectiveness is attributed to wind blowing the treated surface soil from the plots. Most of the erosion occurred immediately after fire and during the first 24 hours after burning.


(5000) WATER YIELD IMPROVEMENT FROM THE BRUSHLANDS OF THE SOUTHWEST.

(b) Laboratory project. Cooperators: California Division of Forestry, Los Angeles County Flood Control District, University of California, Berkeley, Los Angeles, and Riverside, Angeles National Forest.
Division of Forestry, Los Angeles County Flood Control District, and University of California at Berkeley, Riverside, and Los Angeles.

Mr. Leonard F. DeBano, Project Leader, Pacific Southwest Forest and Range Experiment Station, 110 North Wabash Avenue, Glendora, Calif.

Experimental; field investigations; basic and applied research.

The work center is the 17,000-acre Sen Dimas Experimental Forest in the San Gabriel Mountains of Southern California. Field investigations included studies concerned with the hydrologic factors of chaparral watersheds, riparian zone hydrology, and evaporation from water bodies. Laboratory studies on the movement (saturated and unsaturated), loss and storage of water in brushland soils supplement field studies on chaparral and riparian hydrology. Purpose of the work is (1) to establish fundamental plant, soil, water relationships so they influence water losses and water yields; and (2) to develop and test cultural practices aimed at improving water yield.


A naturally occurring water resistant soil was exposed to different burn regimes and temperatures after which the soil samples were tested for non-wettability. The less intense treatments produced an extremely non-wettable condition. Temperatures of 800 and 900 degrees applied for 20 minutes completely destroyed the non-wettable property. Heat treatments within the realm of soil temperatures existing during wildfires were capable of producing the extreme non-wettable condition. The increase in surface runoff and erosion from burned southern California watersheds could be the result of this relationship.

"Effects of Hydrophobic Substances on Moisture Movement During Infiltration," by Leonard F. DeBano (presented to Division S-1, Soil Science Society of America, National Meetings of the American Society of Agronomy, Nov. 3, 1965). The effects of a hydrophobic substance on moisture movement was studied during infiltration into soil columns. Physically similar wettable and non-wettable soils were used for the experiments. Data on infiltration rates and soil moisture distributions obtained during horizontal infiltration were used to calculate soil moisture diffusivities for the two soils. Horizontal infiltration rates were reduced 25 fold by the presence of a hydrophobic substance. Also, soil moisture distributions developed in a non-wettable soil during infiltration were different than in the wettable soil. In a non-wettable soil there was a decrease in moisture content between the water source and the wetting front while the wettable soil the decrease over this interval was smaller. The ratios of soil moisture diffusivities of wettable to those of non-wettable soil decreased as the relative moisture content decreased. This indicates that the hydrophobic substance has a greater effect on measurements of soil moisture movement at low moisture contents. Results of this study taken as a whole suggests a non-wettable soil property may be a significant factor in moisture movement in southwestern brushlands.

"Longevity of a Wetting Agent Treatment for Water Resistant Soils," by J. S. Krammes and L. F. DeBano (presented to Division S-1, Soil Science Society of America, National Meetings of the American Society of Agronomy, Columbus, Ohio, November 3, 1965). Field sampling in burned chaparral watersheds showed that non-wettable property to be widespread in southern California. Restricted moisture movement and penetration in this soil condition results in high surface runoff and erosion rates during store periods. A wetting agent treatment has been used to modify the wetting characteristics of these soils on burned watersheds. The longevity of such remedial treatment was evaluated in the laboratory leaching study. Both surface tension measurements of the wettable soils and capillary rise data shows that wetting agent treatment to have a residual effect. It persisted in the soil until an amount of water equivalent to more than 1 inch of natural precipitation was applied.

Other experiments.

Preliminary laboratory infiltration experiments were conducted on soil columns containing a layer of non-wettable soil located below the soil surface. The non-wettable layer was 2 inches thick and was placed 2 inches below the top of the column.

The results of these experiments indicated that a non-wettable layer located in this position reduced total infiltration into columns. Infiltration rates decreased when the wetting front entered the non-wettable layer. Infiltration rates into the wettable soil overlying the non-wettable layer was similar to those in columns packed with wettable soil. As the wetting front entered the non-wettable layer, infiltration rates dropped below those for columns packed only with non-wettable soil. When the wetting front left the non-wettable layer and entered the wettable soil, infiltration rates increased slightly and maintained a rate similar to those of the non-wettable soil which appeared to influence not only infiltration when the wetting front was located in the non-wettable layer, but also has a residual effect at lower depths in wettable soil.


WATER YIELDS IN HAWAII.

Laboratory project. Cooperator: State of Hawaii, Department of Land and Natural Resources, Div. of Forestry.

Mr. Robert E. Neumann, Chief, Hawaii Research Center, Pacific Southwest Forest and Range Experiment Station, 400 South Beretania St., Honolulu, Hawaii.

Experimental; field investigations; basic and applied research.

The objective is to develop a hydrological and meteorological baseline in Hawaii's wildland watersheds. This will also suggest the potential for management of improving or maintaining water yield and water quality and minimizing soil erosion and sedimentation; to obtain adequate understanding of the processes of rainwater infiltration and discharging water and being able to predict the effects of a wide span of forest land management practices upon water yield and water control; such studies are to suggest ways to manage watersheds that will (1) assure the continued protection of watersheds; (2) improve the distribution of the water yield by modifying the base flow between the ground-water recharge and surface waterflow; (3) increase water yields by decreasing evapotranspiration losses; and (4) minimize flood runoff and sedimentation.

Major work center is in Honolulu. The principal studies under way are the determination of soil erosion rates and sedimentation indices for forest soils in Hawaii, the measurement of evapotranspiration from several selected wildland vegetation types, and a study of rainfall-runoff relations on two small forest watersheds.

Studies of soil erodibility indices, their predictability from recognizable site characteristics and parent material, vegetation and precipitation, and their relation to measured splash under artificial rain conditions are now in progress. A report of these results is expected this year (1968).

Measurements of soil moisture depletion under-
a grass cover and under an aluminum-roofed plot were made. This study complements earlier measurements of soil moisture depletion under several tree and brush plots in adjacent areas in the summer projects. A study of rainfall interception and fog-drip was begun in several forest plantations on Maupin and Garfield where the studies will be expanded to include the effects of size, shape and other characteristics of natural and artificial leaves on water storage and drip under laboratory conditions.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Rocky Mountain Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Raymond Price, Director, Rocky Mountain Forest and Range Experiment Station, Room 221 Forestry Building, Fort Collins, Colorado 80521.

(377) WATERSHED MANAGEMENT RESEARCH, FRASER HYDROLOGIC LABORATORY.

(b) Laboratory project.

d) Field investigations; applied research.

(e) To determine influence of lodgepole pine and spruce-fir forests and of the management of these forests on two wood products: factors associated with the yield of water, largely from stored snow. The purpose is to solve problems in the management of forested watersheds of the high altitude zone of the Rocky Mountains for maximum yields of usable water.

(g) The energy budget for a snowpack is evaluated to determine energy available for evaporation. The effect of turbulence is considered. Results were checked by determining sensible heat flux with known gradients of specific humidity and temperature. Agreement was close. In February and March 1965 evaporation from 0500 to 1600 on clear days was ranged from 0.17 to 0.59 inches. Night-time condensation was 0.008 to 0.012 inch. From opaque aerial photographs, significant relationships between areal snow cover and seasonal water yield have been derived for watersheds at Fraser Experimental Forest. The characteristic rate of snow-cover depletion on a given basin can be indirectly determined from image analysis of such factors such as aspect and elevation. Near-identical relationships were obtained when two adjacent watersheds having similar image characteristics were compared with respect to: (1) the distribution of area with elevation and (2) areal extent of snow cover. Watersheds are highly correlated with respect to residual volumes. This indicates that small index watersheds may provide a reliable basis for making accurate short-term residual volume forecasts for larger drainage basins.

An automatic system has been devised to record heat pulse velocities at preselected intervals. Heat pulse velocities in tree stems are an index to velocity and direction of sap movement. Most rapid rates have been observed in both spruce and lodgepole pine during snowmelt when soils are throughly wet. Rates later in the season are reduced. Apparently, even with old, well-established trees soil moisture controls moisture loss from the tree more than do other environmental factors.

Seismic determination on Pool Creek watershed at Fraser revealed that depth of soil and watershed is about 14 feet on slopes. Concentration of run off in the period during and shortly after snowmelt indicates high permeability of these regolith materials.


(657) WATERSHED MANAGEMENT RESEARCH, TEMPE, ARIZONA.

Laboratory project.

d) Experimental; basic and applied research.

(e) To study the disposition of rainfall as influenced by watered vegetation; to determine the influence of various types of forest and grassland vegetation as well as vegetation modified by cultural treatment such as grazing and timber harvest, on sheetflow, water use, water loss, and erosion and sediment yields; and to determine for phreatophytic vegetation (water-loving plants) the amount of water used, methods for reducing water use by phreatophytes or for replacing them with more useful plants. At Sierra Ancha Experimental Watersheds in central Arizona, rainfall, runoff, and erosion are measured on three watersheds in the pine-fir vegetation type at high elevations, on two watersheds in the ponderosa-chaparral type, and from four watersheds in the grassland-chaparral type at lower elevations, and on nine small watersheds in the semidesert-chaparral type at low elevations. Water use by different types of plants in various soils is studied on eleven large lysimeters. Three watersheds have been established on the ponderosa pine type, three in the mixed-spruce type and two in the mixed-forests (high foot elevation) grassland type. Current plans are to treat one ponderosa pine watershed in 1965, testing current Forest Service methods of harvesting mature timber, but adjusting cutting methods to lead to eventual even-aged management. Soils from each plot are identified to allow determining regional composition of species. Seedling dip logs are being laboratory treated for hydrologic characteristics. Soil moisture is followed with a neutron probe. Gaging stations for four watersheds in the pure chaparral type are also available to evaluate watersheds-game interrelations. One cluster of two watersheds and another cluster of three watersheds are available for testing the effect of manipulating chaparral cover. Supplemental studies are determining the coppering of chemicals, fire, and mechanical treatment for manipulating shrub in the type. Ecology of Tamarix pentandra and other phreatophytes is under investigation. Germination, seedling survival, sprouting ability, and rate of spread studies were continued. Salt glands in T. pentandra are distinctive structures composed of eight glands. The glands excrete salt solutions through a single pore during relatively high humidity conditions. More herbaceous plants emerged after complete litter removal than after burning, scarifying, or no treatment. Burning appeared to favor morning-glory and yerba-santa. Required germination conditions for some species were not met in these laboratory tests.

Five years after converting one-third of the 248-acre North Fork Watershed from moist-site forest vegetation (White and Douglas fir) to perennial grass, the increase in water yield is statistically highly significant. The slope of the pretreatment regression is also significantly different from the pretreatment regression. The significant difference in slope of the pretreatment and the posttreatment regressions indicates the water yield increase was significant because of the increase in water yield due to the change in vegetation. The increase in water yield due to the change in vegetation will be expressed by the slope of the posttreatment regression. The significant difference in slope of the pretreatment and the posttreatment regressions indicates the water yield increase was significant because of the change in vegetation. The increase in water yield due to the change in vegetation will be expressed by the slope of the posttreatment regression.
increased water yield on North Fork has varied from 44 percent in 1960 to 65 percent in 1965, and has averaged 55 percent for the 5 posttreatment years. After 12 years, 1954-1965, the data from South Fork indicates that streamflow has not been increased significantly. The changes in water yields following treatment have shown increased 9 out of 10 years, but the average increase was only 2.7 percent. Future increases may be expected from an individual trees selection timber harvest which leaves a heavy stand of timber in the watershed.

In contrast to the two previous years, no frozen soils have been observed in the White Mountain area (elevation 0,900 feet) during the 1964-65 period. This appears to be related to early snow that has remained to protect both forest and grassland soils. This lack of snow frost will be related to runoff during the spring runoff period.

High water savings from "control" of sprouting shrubs on the burned Three-Bar experimental watersheds continue into the fourth posttreatment year. Sediment movement has declined on all watersheds after the very high yield of the first year. The three watersheds left in shrubs are still releasing significant amounts of sediment, but watershed C converted to grass, has yielded no sediment in the past 2 years even though this period included the largest high-intensity summer storm since the watersheds were established in 1956. In Whitespar A and B, the previously noted strong correlation with respect to timing of peaks and lengths of spring recessions continues. No particular change has occurred in the sporadic flows from the three Kings watersheds.

A water vapor adsorption apparatus is being developed for measuring the transpiration water losses from plants. Water vapor in air is absorbed by a desiccant, and the amount adsorbed is determined gravimetrically. Initially the method is being developed for potted plants.

The control of transpiration water losses from plants by means of chemical treatments is being explored. The objective of a recent study is to determine the influence of foliage sprays of 4 amino, 5,6-trichloropicolinic acid (picloram) on the transpiration water losses from potted shrub live oak plants. Picloram is a phytotoxic chemical which shows promise for the control of brush. Soil-applied treatments of picloram are lethal to potted shrub live oak plants and the transpiration water losses from plants are not. In the present study low-volume foliage sprays of picloram were applied to potted shrub live oak plants and the transpiration water losses for the treated plants were compared with those of untreated control plants. A low-volume foliage spray of picloram at a sublethal rate (1/2 lb/A) reduced transpiration of shrub live oak temporarily only. Removed applications were necessary to maintain or reduce the transpiration rate to levels achieved by the initial treatment.

A field reconnaissance survey has been developed by a relatively fast and accurate sampling technique for measuring the riparian vegetation. The survey was designed to test the value of aerial photography in mapping inaccessible riparian vegetation. The majority of the riparian plant species can be identified from the large-scale aerial photographs. "Salt Gland Anatomy in Tamarix Pentandra (Tamariscaceae)," C. J. Campbell and J. E. Strong, Southwest. Naturalist 9(4): 232-238, illus.


1965 WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

Laboratory project. Some work in cooperation with Bureau of Land Management and Geological Survey.

Applied research.

Evaluation of range-watershed conditions on small watersheds in the San Luis drainage of the Rio Puerco. Three controllable watersheds, ranging from 338 to 555 acres located about 8 miles north of the San Luis community area west of New Mexico Highway 35, provide the study area. Water and sediment inflow are measured in small reservoirs formed by earthen dams. Precipitation rates and amounts of vegetation changes are periodically measured over the watersheds. Ten years of data have been collected under cattle grazing during a 5 1/2-6 month overwinter period (November 1 to April 30). Evaluation of soil ripping on surface runoff, erosion, and vegetation. Surface runoff plots (64), 10' x 31', are installed on a north and south aspect upper and lower slope representing different soil conditions in the Rio Puerco drainage. Precipitation, runoff, and sediment are measured.

To obtain inventory information on the hydrologic variables of the pinyon-Juniper type, six small watersheds with ephemeral streams are being grazed by means of a prefabricated, fiberglassed version of the Beaver Creek flume.

Ripping killed 28 percent of the perennial grass ground cover on the experimental watersheds, caused a 50 percent loss of litter, and a 24 percent increase in bare soil. Beneficial effects of ripping were: an increase in forage production from 2.2 to 5.5 tons per acre to 476 pounds per acre; the first year after treatment no runoff was produced, and the second year runoff was about half as much as expected. Plot studies indicate ripping effectiveness in stopping runoff will decline in about 3 years.

Protection from grazing has given some interesting results. Grazing animals are hardy enough to forecast what will ultimately occur but trends are evident. Ground cover has declined by 32 percent, but litter increased 253 percent and no litter was observed. Forage production has declined about 11 percent. Forage production measurements separate growth from last year's litter, thus total plant material is greater than reflected in the production measurements. Fiberglassed plywood sheets are undergoing strength and durability tests for use in fully control check dams near Albuquerque, New Mexico. A low cost, rapidly installed, durable gully check dam is needed for use in rehabilitating waterways. The check dams were begun this year on the use of prefabricated dams made of 4 foot by 8 foot fiberglass plywood sheets and plywood sheets treated with formaldehyde. Plywood is used as the apron and dam wall.

Field construction is simple. After sites are selected, keyways are dug, the support frames
installed and the plywood is placed and screwed to the frame. As with any gully check dam, success is dependent primarily on proper location, installation, and design for accommodating peak flows. Since these initial dams are restricted to small-size, they are presently used only on a limited basis. Currently, work is being done to design dams that can lap plywood pieces to extend effective dam widths.

Those installed today in the summer of 1965 were given a severe test when between 1.25 and 1.5 inches of precipitation fell in an hour on the watersheds. The dams caught and held sediment without downstream or side seepage. "Ground Cover Changes in Relation to Runoff and Erosion in West-central New Mexico," Earl F. Aldon, Res. Note RM-34, 4 pp.


WATERSHED MANAGEMENT RESEARCH, RAPID CITY, SOUTH DAKOTA.

Laboratory project.

(1) Experimental; basic and applied research.

(2) To evaluate water yield and sediment production in small watersheds to determine current management practices in ponderosa pine. (3) To determine surface runoff and rates of reduction from soil compaction on various types of grasses and fescue. Results indicated a probable curvilinear relationship, throughfall increasing with increase in canopy density from 40 percent to saturation in the center and then a drop in percent throughfall with increase in canopy density to 70 percent, the limit of the data. Possible explanation for such a relationship lies in the dependence on wind velocity and turbulence factors.

An impact penetrometer with cone point for measuring depth of soil freezing was developed. Use of a cone point (45°) with the base of the cone slightly larger than the rod diameter virtually eliminated frictional resistance compared to a straight rod, making breakthrough from frozen into unfrozen soil much more distinct.

A diversion slot for sampling through the flow and suspended sediment off the end of a supercritical velocity flume was designed and tested. Laboratory tests indicated a tapered slot necessary for constant proportional sampling. Hypothetical consideration of the relationship of mean cross section flow velocity to mean velocity in center vertical of flume flow supports the hypothesis. From laboratory tests a proportionate constant of taper was calculated. There remains the practical problem of preventing debris from lodging on the slot in field operation.

WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING.

Laboratory project.

(1) Field investigation; applied research.

(2) To determine the effects of big sagebrush on total runoff from snowmelt, snow accumulation and storage pattern. Three high elevation sagebrush watersheds, 60 to 106 acres, in western Wyoming provide the study area. Precipitation, snowpack and runoff, and suspended sediment samples are taken periodically. Snowpack is sampled along permanent transects. Sediment is sampled at random points. Precipitation is sampled by a network of recording and non-recording gages. (3) To determine the soil moisture withdrawal pattern under natural stands of big sagebrush, the effect of sagebrush eradication on moisture withdrawal. Four 0.1 acre plots on an east and west slope have been established within high elevation sagebrush type in western Wyoming. Sagebrush on two of the plots has been eradicated by spraying. Soil moisture samples are taken periodically to trace moisture through the underlying condition. (4) To evaluate the comparative efficiencies in terms of water stored in accumulated snow, or tandem 4-foot slatted snow fences erected at different spacing intervals on windward slopes in southeast Wyoming. (4) To evaluate the effectiveness of inducing snow accumulation on a watershed through use of artificial barriers. Three experimental grassland-type drainages, 80 to 144 acres, have been selected for this study. These are in southeastern Wyoming where snow transport by wind commonly occurs. V-notch weirs are installed to measure water yield. Snowpack is sampled in areas of natural snow cover and on experimental plots. Summer precipitation is sampled by a network of recording and non-recording gages.

(5) To determine the basic hydrology of mountain bogs in Wyoming. The prevalence of small bogs along many perennial streams in the mountains of Wyoming has stimulated the posing of various questions concerning the hydrologic significance of these areas in relation to management techniques for water yield improvement. To provide information basic to advanced studies oriented toward this problem, hydrologic characteristics of a 3-acre bog were studied intensively during the summer of 1963 and will be continued for another field season. Various hydraulic, physical and chemical conditions on the bog indicate possible relationships between various species and environmental conditions such as peat depth and surface-water depth.

The chemical control of big sagebrush has become an important method of range improvement. To provide information basic to understanding results of a sagebrush watershed study presently underway, a plot study of the effect of sagebrush eradication by spraying on soil moisture withdrawal has been in progress since 1962. The third year following spraying of the treated plots, indicate that soil moisture content as measured by neutron probe equipment at depths of 0-8 feet on 0.1 acre treated and untreated plots were significantly different (at the 0.05 confidence level) on one date near the commencement of snowmelt. Moisture levels were not significantly different between treatments on seven other sampling dates. There were significant differences between treatments when changes in volumetric moisture content between consecutive sampling dates were analyzed, particularly in late spring and late summer. Soil moisture accumulation and drainage rates generally were greater on the untreated plots than on sprayed plots.


"Snow Accumulation and Disappearance in

**WATERSHED MANAGEMENT RESEARCH, ALPINE HYDROLOGIC LABORATORY.**

(b) Laboratory project.

d) Field investigations; basic research.

e) To determine methods for increasing the amount of snow storage in alpine snowfields, and to develop control of evaporation and melting to insure maximum effective contribution to summer streamflow. To reduce snow avalanche danger by improved forecasting of hazard, and methods of stabilizing snowpacks on mountain slopes.

(g) A joint study with the SCS was initiated in October 1964 at Berthoud Pass, Colorado, to test a pressure pillow designed to record the weight of the circular area in pillow is made of rubber 12 feet in diameter and is filled with 300 gallons of methyl alcohol. The pressure of the snowpack on the pillow is continuously recorded on an F-35 water level recorder. Weekly increments on the pillow compared closely to snow board readings. However, short-term increments do not compare with snow board readings because of the diurnal effects of temperature on the alcohol in the standpipe.


**WATERSHED MANAGEMENT RESEARCH, FORT COLLINS, COLORADO.**

(b) Laboratory project.

d) Field investigations; applied research.

e) Field plot to observe the adaptability and growth characteristics of twenty-three tree shrub and twenty-six grass and forb species for further testing on critical soil sites.

Research to find the influences of mechanical watershed rehabilitation measures on the microclimate and other site factors in the southern Rocky Mountains. To determine the effect of range conditions and related factors on sediment production and runoff on three mountain grassland watersheds in western Colorado. Range condition is being measured by means of 20 or more 3-step transects on each watershed. Ninety degree V-notch weirs are used to gage the watersheds which vary in size from 86 to 272 acres. Water samples are taken several times daily during snowmelt, and periods of storm runoff for determination of suspended sediment; bedload is measured in the weir ponds.

(g) Costs of loose rock, wire bound, single fence and double fence rock check dams were determined for heights of dams of 2 and 6 feet and for gully bottom slopes of 5 to 15 percent. (a) The double fence type is being used at other installations because it is more stable and less complicated to install. (b) Costs per cubic yard of structure decreased with increasing height or dam for all types. (c) Costs of gully control increased with increasing gradient. (d) Cost of gully control with double fence design was less when 6-foot-high dams were used except on gradients of 5 percent. One prefabricated concrete check dam successfully passed a severe test when heavy runoff from snowmelt filled the catch basin to spillway crest with 4,000 cubic feet of sediment.

On three Black Mesa watersheds spring snowmelt averaged 1.95 inches on a lightly grazed watershed, 4.73 inches on a heavily grazed watershed, and 7.09 inches on a moderately grazed watershed. Correlating precipitation received (peak snowpack plus incoming precipitation in snowmelt); runoff volume for the spring snowmelt period with spring runoff yield highly significant correlation coefficients. From 94 to 96 percent of the variation in runoff is explained by the precipitation variable and the standard errors are about 1 inch. Using spring and fall soil moisture measurements to compute water available for runoff does not yield improved regression coefficients. In addition to multiple linear regressions relating peak snowpack, soil moisture recharge index and runoff the soil moisture variable contributes significantly to the regression.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southeastern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. T. F. McLintock, Director, Southeastern Forest Experiment Station, P. O. Box 2570, Asheville, North Carolina 28802.

**WATER RESOURCE AND WATERSHED MANAGEMENT RESEARCH.**

(b) Laboratory project. For general public use and information.

d) Experimental; basic and applied research.

e) Basic research into forest hydrologic processes governing the disposition of precipitation on forest lands of the southeastern United States. Demonstrations of several cover types and land management practices and their effect on soil moisture and water yield. Development of watershed management methods pertinent to the region including pilot testing, cooperative trials, and demonstrations of these methods.

The work is centered at the 5,600-acre Coweeta Hydrologic Laboratory in the mountainous western North Carolina near Franklin. Located in the zone of maximum precipitation in the eastern United States, the research area receives an average of 80 inches of precipitation of which nearly coming as rain in about 100 separate climatic events. The basic hydrologic gaging network at Coweeta includes 3 multiple, 12 unit, and 16 standby watersheds ranging from 4 acres to 8 square miles with continuous streamflow records up to 31 years in length; 12 recording and 11 standard rain gages; 1 evaporation pan; 1 metering anemometer; 2 recording pyranometers; and 1 hygrothermograph. A small laboratory provides facilities for routine soil and water quality and yield studies for turbidity measurement of streamflow. Soil moisture is measured in the field by 3 neutron scattering devices. Now largely inactive, a unit located near Unton, North Carolina has been the site of considerable work on erosion control, comparative water use by different forest cover types, and soil moisture recharge in the piedmont.
Research studies include: (1) forest treatment effects on water yield; (2) the hydrology of mountain unit watersheds under several cover types; (3) movement and storage of soil water on steep slopes; (4) predicting the effects of steep terrain for hydrologic purposes; (5) morphology of the soil mantle related to water storage and runoff; (6) rainfall interception by white pine; (7) mechanizing hydrologic data collection and processing; (10) stream diversion to deep soiled slopes to stabilize the water regimen; and (11) pilot testing multiple use of forest for water, timber, recreation, and wildlife on a 30-acre watershed.

Active; as individual studies are completed they are reported via technical reports and publications.

A 22-acre catchment converted from hardwood to grass in 1959-1960 has continued to yield more water each year as the original grass cover declined in vigor. Water yield increases for the past 5 years have been 0.3, 1.5, 4.6, and 6.9 inches as dry matter production of grass declined from about 3.5 to 1.5 tons per acre per year. Grass vigor was restored to near preproductive levels by regrowth in April 1965; the effect on water yield is not yet known. A computer method of separating a continuous streamflow hydrograph into quick flow and delayed flow components has been developed to facilitate study of streamflow behavior from small catchments. This technique employs a straight line of separation placed at the beginning of hydrograph rise until it intercepts the recession side of the storm hydrograph. All flow above the separation line is quick flow, all below it is delayed flow. Using this technique, 15 forested watersheds in eastern United States were separated into quick and delayed flow ranked according to mean precipitation, quick flow, and response factors quick flow/prefcipitation and quick flow/total water yield. The over riding prevalence of subsurface flow was indicated and other important relationships determined by this technique. Use of computer separated components of the hydrograph is continuing with delayed flow prediction methods and for analysis of forest treatment effects based on the climatic years of clearcutting.

A 40-acre watershed was repeated after 23 years of regrowth since the first cut in 1940. The water yield increases during the first year after cutting continued but dieted with results after the first cut, 14.7 and 14.6 inches respectively. A review of worldwide forest cutting experiments reveals that 100 percent reduction of forest vegetation may give water yield increases as large as 18 inches during the first year following treatment, but that most treatments give considerably smaller responses on climate and distribution of preci

Laboratory project. For general public use and information.

Experimental; applied and basic research.

Project objective is to develop effective and reliable water control and soil management techniques which increase knowledge of the hydrology, soil properties, and water-plant relations of wetland forests. Research is conducted in wetland forests of various types throughout the United States; in the eastern control plain from Virginia through Florida. Accordingly, much of the program consists of water control and soil studies in cooperation with wood-using industries, and other forest management who have made or plan capital investments to manage the water on their land. In addition, research is also can be conducted on the Santee Experimental Forest, located 32 miles north of Charleston, which has a small soils laboratory and two stream gaging stations on watersheds of 400-500 acres. Active studies include: (1) response of wet, slash pine flats to drainage; (2) relationships between soil and water conditions and their effect on tree growth on drained wetlands; (3) study of the water balance of selected wetland units; (4) precipitation-runoff relations on small forested watersheds in the coastal plain; (5) effects of understory control on soil moisture; and (6) moisture characteristics of representative wetland forest types.

Active; as individual studies are completed they are reported via technical reports and publications.

Study of water tupelo, a valuable timber species, in a swamp along the Santee River in South Carolina, showed maximum diameter and height growth occurred where soil and site were poorly drained and subject to


Factors affecting the response of small watersheds to precipitation in subhumid areas, by J. D. Hewlett and A. R. Hibbert, presented at the International Symposium on Forest Hydrology, Penn. State University, August 30 - September 10, 1965.

Research in forest hydrology at the Coweeta Hydrologic Laboratory, by J. E. Douglass, presented at the Clemson University Council on Hydrology, Clemson, South Carolina, 1965.

HYDROLOGY AND MANAGEMENT OF WETLAND SOILS.


157
long periods of wetness. It also appeared that seepage into the swamp from adjacent upland areas provided important supplemental moisture for this water-loving species. With increasing intensive management of water levels in lowland swamps, close attention must be paid to their control if water tupelo is to be perpetuated on these sites. On the other hand, large-scale drainage programs underway in other wetland forests are being evaluated to aid forest managers in determining the desirability of drainage to favor other species. Changes in soil productivity were assessed by measuring growth rates of pines before and after drainage on wet, sandy pinelands in northwest Florida. Comparison of observed increments with expected showed soil drainage has resulted in increased site productivity. Surveys have shown that, under certain conditions, increased site productivity for some southern pines by controlled drainage could almost double pulpwood yields from certain wet pinelands in the southeastern coastal plain. (h) "A Method for Sealing Soil Moisture Access Dikes," by Cortland E. Young, Jr. and James E. Henderson, Soil Science, Vol. 99 (3) : 213-214, 1965. "Forest Drainage in the Southeast," Ralph A. Klawitter, Jour. Soil and Water Cons, Vol. 20(4) : 181-182, 1965. "Forest Drainage Research in the Coastal Plain," Ralph A. Klawitter and Cortland E. Young, Jr., Jour. Irr. and Drain. Div., Amer. Soc. Civil Engineers, Vol. 91 (IR3), Proc. Paper 4456, Sept. 1965, pp 1-7.  

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southern Forest Experiment Station. 

Inquiries concerning the following projects should be addressed to Mr. W. W. Gillis, Director, Southern Forest Experiment Station, T-10210 Federal Bldg., 701 Loyola Avenue, New Orleans, Louisiana 70113:

(2914) WATERSHED MANAGEMENT RESEARCH, OXFORD, MISSISSIPPI: 

(b) Laboratory project, in cooperation with Soil Conservation, Agricultural Research Service, and University of Mississippi. 

(d) Field investigation of runoff and erosion from small experimental watersheds on Forest and potential Forest lands; basic and applied research. 

(e) Twelve small natural headwater catchments, two to four acres each, were installed in watersheds of three to determine runoff and erosion from old fields, depleted upland hardwoods, pine plantations, and mature upland pine-hardwoods. Four of the six old field and depleted hardwood watersheds were planted to pine in 1964, after site preparation which included burning. Treatments on the pine and pine-hardwoods are deferred until after a suitable calibration period. Five additional watersheds in pine plantations are being calibrating prior to testing effects of timber harvesting on runoff, erosion, and sediment flows. Related studies include restoration of depleted watersheds and plant-soil-water relationships. 

(f) Data collection on all watersheds is continuing. 


(2225) WATERSHED MANAGEMENT RESEARCH, HARRISON, ARKANSAS. 

(b) Laboratory project. 

(d) Field investigations on effects of forest type and condition on timing of flows in streams of the Ozark-Osagea uplands; basic and applied research. 

(e) Runoff and sediment from three small mountain watersheds are measured currently. H-blumes and surge recorders were installed on eight additional watersheds ranging from 2 to 40 acres. Cover conditions will be changed after an adequate calibration period. Related studies of soil moisture and erosion are continuing. 

(f) Records of runoff and sediment collected currently. 

CORPS OF ENGINEERS, U. S. ARMY, Coastal Engineering Research Center. 

Inquiries concerning the following projects should be addressed to James S. Young, Director, Coastal Engineering Research Center, 5201 Little Falls Road, N.W., Washington, D. C. 20016. 

(181) EQUILIBRIUM PROFILE OF BEACHES AND STUDY OF MODEL SCALE EFFECTS. 

(b) Laboratory project. 

(e) Equilibrium beach profiles will be determined experimentally for waves up to 6 feet in height in a prototype tank; the waves will be modeled at small scale in the laboratory tank (to determine scale effects) for various median diameter and specific gravity sediments. 

(g) Analysis is underway. 

(660) OBSERVED WAVE CHARACTERISTICS. 

(b) Laboratory and field project. 

(d) Field investigation; basic research. 

(e) To secure a more thorough knowledge of the characteristics of ocean waves, wave gages have been installed in a number of locations in coastal waters. These wave gages provide a pen and ink strip chart recording and also magnetic tape recordings. The records from the paper chart records are analyzed for significant wave height and wave period. The records from the magnetic tape recorders are analyzed to provide a spectral analysis of wave frequency (or period) versus: (1) Linear average wave height; (2) squared average wave height; and (3) peak wave height. 

(g) Additional wave recording stations were installed at the U. S. Coast Guard Light Tower, Prying, Ocracoke Island, Pleasure Pier, Galveston, Texas. The previously planned installation of 3 wave sensors at the Buzzards Bay Light Tower (Coast Guard) has been re-scheduled for installation on a new Coast Guard Light Tower at the entrance to Chesapeake Bay. These gages will used to obtain pressure records at different water depths. This data will be compared to surface waves as recorded by a surface wave gage. Additional wave recording stations are planned to be installed at: (a) Lake Worth, Florida (b) Galveston, Texas (16 miles offshore on oil production platform) (c) U. S. Coast Guard Light Tower at entrance to Chesapeake Bay. Two wave gages are to be installed in Chesapeake Bay (Chesapeake Beach, Md. and Tiltgham Island) for observation of wave characteristics relative to erosion processes.
METHODS OF BY-PASSING SAND FROM PAST INLETS.

Laboratory project.  
(d) Field Investigation; applied research. 
(e) To study methods and requirements for pumping sand from past inlets and to determine the applicability of the methods in stabilization of beaches adjacent to inlets. 

Data are being processed on the effect of the shoreline of sand bypassing operations at Fort Ruenneke, California and Lake Worth Inlet, Fla. and on the effect of the shoreline of a new harbor constructed at Ventura, California. This latter harbor involves an offshore detached breakwater along with entrance jetty's to the new harbor. Data at the three locations include periodic hydrographic surveys south and north of the inlet, wave data, sand samples, detailed records of pumping operations, and detailed records of entrance channel maintenance. A general study is being made of the possibility of adapting commercial instruments utilizing a radioactive source to the discharge line to measure quantity of material pumped in by-passing operations.

ESTABLISHMENT OF CRITERIA FOR CONSTRUCTION OF ARTIFICIAL BEACHES.

Theoretical; applied research.  
To develop criteria for construction of beaches by artificial means. The present continuing phase of this general study involves the measurement of a natural beach slope and attempts to determine its response to the forces normally incident upon the shore such as wave action, angle of wave approach, tide, and direction and magnitude of littoral current. By statistical methods the relative importance of the forces or combinations of forces may be evaluated.

Computer machine techniques have been applied to a statistical evaluation of the importance of the forces and of the parameters.

DEVELOPMENT OF WAVE HEIGHT AND WAVE DIRECTION DATA.

Laboratory project.  
(d) Experimental; development. 
An ultrasonic Wave meter was checked in the laboratory large wave tank as a wave direction gage. Data show good promise of adapting the flowmeter to function as a wave direction gage. Tests of the flowmeter were conducted at Atlantic City, N. J. in March of 1965. Results of these tests were somewhat encouraging. Results of the tests to date were presented in a paper at the ISA Oceanographic Instrumentation Conference, Miami, Florida, held 21 April 1965. Further tests in both laboratory and field are planned. "An Ocean Wave Direction Gage," Lee C. Williams, Marine Sciences Instrumentation, Volume 5, 16 pp., January 1965.

STUDY OF EFFECT OF A GROIN ON THE RATE OF LITTORAL MOVEMENT.

Laboratory project.  
(d) Experimental; basic research. 
To study the effect of groins on the rate of littoral drift passing a groin system. Initial tests consist of waves generated at a 30-degree angle to the sand beach with measurement of material movement being made at the downstream end. The analysis for the immediate future, as have the current season tests, will continue to emphasize the task of collecting and establishing reliable calibration data in the relationship between the littoral transport rate and the wave characteristics. These generalized (not to specific model scale) studies are being made in the Shore Processes Test Basin of the Coastal Engineering Research Center. Littoral transport tests in the Shore Processes Test Basin continue. Training and splitter walls have been removed and a rubble absorber beach has been installed. The new setup is arranged to permit generation of a wave crest approximately 60 feet long which approaches the toe of the test slope at a 30 degree angle, shoals and refractions and finally impinges along the test shoreline 92 feet long. The downdrift part of the test beach is a concrete slab (10 on 30 slope) about 30 feet long and 5 feet wide. An initial test of this new sand beach setup was made with waves at T = 5.72 sec, for a duration of 40 hours. At the end of 24 hours a large cut had eroded just upslope of the sand trap. Wave diffraction analysis of the test setup showed that waves diffracting from both the updrift and downdrift on the wave generator blades concentrated wave energy in the area of the eroded cut. At the end of 40 hours the downdrift generator was turned off so that during the remaining 15 hours of the test a wave crest 60 feet in length was generated in contrast to an 80-foot crest length up to that time. As the tests continued beyond 24 hours the eroded cut filled in so that at the end of 35 hours the shoreline was essentially straight from trap to feeder. The shoreline remained essentially straight throughout the remainder of the test, ending at 40 hours total test time. Turning off the downdrift wave generator after 24 hours testing had the effect of shifting the K' line (attributable to the downdrift wave diffraction) a distance of approximately 25 feet upslope along the shoreline. The main result of this updrift shift of wave diffraction was a redistribution of the wave energy reaching the shore. This redistribution resulted in less energy reaching the previously eroded area immediately updrift of the trap and more energy reaching the shore in the area of the feeder, with the generation of uniform, distributed energy along the shore from trap to feeder. This result from the test is based on a preliminary analysis of the data. A more comprehensive analysis of the data is in progress but it is not expected to change the general results and conclusion given here.

REGIONAL STUDIES OF THE ATLANTIC COAST OF NEW JERSEY; AND THE DELAWARE-MARYLAND-VIRGINIA SHORELINE FROM CAPE HENlopen TO CAPE CHARLES.

Laboratory project.  
(d) Field investigations; basic research. 
To compile all existing data pertinent to shore processes on a regional scale. Reports to consist of three chapters: geomorphology and shoreline histories, littoral forces, and littoral materials. Subject matter to include physiography, geological development of the shore region, sources of littoral material, wave conditions and water level fluctuations, current physical characteristics of the littoral materials, inter-connection of submarine properties, relation of properties of littoral materials and position in the littoral zone, and changes in shoreline configuration. The Delaware-Maryland-Virginia shoreline from Cape Henlopen to Cape Charles currently under study. Data compilation for this reach is essentially completed and the report is under preparation.

SHORE PROTECTION PLANNING AND DESIGN.

Laboratory project.
(d) Design.
(e) To supplement and revise the Coastal Engineering Research Center's (formerly Beach Erosion Board) technical report no. 4, "Shore Protection Planning and Design," as new data and techniques are developed for use in the solution of coastal engineering problems.

(g) The supply of the 1961 edition of the report has been depleted. It is anticipated that the new edition will be available in the Spring of 1966.

(2195) RE-EXAMINATION OF ARTIFICIALLY NOURISHED AND CONSTRUCTED BEACHES.

(b) Laboratory project.
(c) Field investigation; applied research.
(d) To study the behavior of beach fills placed to restore or nourish a beach sector and the effect of the fill on adjacent shores. A selection of number of beach fills are being re-examined.

(g) Follow-up reports prepared but not yet published on beach fill projects at Sherwood Island State Park, Conn., and Presque Isle Peninsula, Pa. Other reports are in preparation for beach fill projects at Hammansett Beach State Park, Conn., and Key West, Fl., and a bypassing and beach nourishment operation at Channel Islands Harbor - Port Hueneme, Calif. Arrangements were made to collect follow-up data at an inlet bypassing and beach nourishment project on Long Island, N. Y., groin construction on Long Island, N. Y., and protective beach and dune fill projects in North Carolina.

(h) "Behavior of Beach Fill and Borrow Area of Seaside Park, Bridgeport, Conn.," H. N. Vesper, Tech. Mono., No. 11 of CERC, 14 pp., Feb. 1965. Limited number of copies available for free distribution upon request to Director, CERC, 5201 Little Falls Rd., N. W., Washington, D. C. 20016.

(2660) STUDY OF QUANTITY OF SEDIMENT IN SUSPENSION IN THE SURF ZONE (INCLUDING TEMPERATURE EFFECTS).

(b) Laboratory project.
(c) Experimental; basic research.
(d) To determine the relationship between wave, water, and sand characteristics, and the amount of material maintained in suspension and, hence, available for longshore transport by currents.
(e) Analysis of suspended sand samples collected at Nags Head, N. C. continues. An additional 415 suspended samples were collected in May 1965 at Ventnor, N. J. Analysis of these samples and related data and observations of the shore processes are in progress. Moment parameters from the samples at each location are being digitized for analysis through a computer program which is now operational. In addition to the suspended sand samples, data at Ventnor, N. J. included wave height, wave breaker angles, bottom soundings along the pier, and a few observations of littoral current velocity. When the analysis of these samples is completed the results will be published in the CERC Technical Memoranda series.


(2661) WAVE RUN-UP ON SHORE STRUCTURES.

(b) Laboratory project.
(c) Experimental design.
(d) Wave run-up is determined experimentally for various waves for different types of shore structures. Effect of both structure roughness and permeability is being investigated.
(e) Analysis of some field measurements of run-up on a beach obtained in an attempt to delineate the run-up distribution function is underway.

(3228) MODEL TESTS OF WAVE SETUP ON BEACHES.

(b) Laboratory project.
(c) Experimental; basic research.
(d) Measurement of the mean water level of shoaling waves on beaches using damped piezometers buried in the beach. Study is being made in order to (1) Check existing theory for setup offshore of breaking; (2) estimate rate of energy supplied required to maintain setup in"surf" zone; and (3) provide engineering criteria for design of coastal structures. Setup measurements on concrete beaches with slopes of 0.20 indicate that the mean water level is depressed below the still water level in the shoaling zone offshore of the breaking point. The mean water level rises above the still water level at, or slightly shoreward of the breaking point.

(5897) RADIOACTIVE TRACERS FOR BEACH STUDIES.

(b) Laboratory project.
(c) Experimental; research.
(d) (1) Studies of possible field sites for the application of radioactive and/or fluorescent tracers are being continued. (2) Further tests using fluorescent tracers were made recently to test the possibility of using they for probalistic motion of tracer particles was made, and a model developed.


(4760) EXPERIMENTAL STUDY OF DUNE BUILDING WITH SAND FRINGES.

(b) Laboratory project.
(c) Experimental; design.
(d) The experimental study consists of the construction of various types and arrangements of sand fences to determine the fence type and arrangement most effective in building a dune by trapping and holding wind-blown sand. Dist-type snow fencing and locally constructed brush fencing have been used in straight, straight-with-side spars, and zigzag configurations. The study is being conducted on the Outer Banks of North Carolina between Cape Hatteras and Cape Lookout.

Multiple sand fences have been used to construct a dune 8 feet high and 30 feet in base width in 3 years. Vegetation (American Beach Grass) has been planted in an attempt to grow a grass stabilized dune.

(4762) CORRELATION OF STORM WAVE ATTACK AND BEACH EROSION.

(b) Laboratory project.
(c) Field and office investigation to develop quantitative correlation between storm violence and shore erosion.
(d) Repetitive profiles are taken at selected beach areas. The storm wave action between surveys is analyzed and correlations between the wave action and observed profile changes are established. Repetitive profiles were established in September 1962 at nine locations between Delaware Bay and Cape Cod. These profiles were re-surveyed at weekly and bi-weekly intervals. The resurvey interval now is 4 to 6 weeks. Storm wave action is measured by the Coastal Engineering Research Center ocean wave gauges and storm surges by U.S.C. & G.G. gage at
d

(h) An article entitled "The Study of Pilot Beaches in the New England Area for the Improvement of Coastal Storm Warnings," John M.
Daring is being prepared for publication in a forthcoming CENG Bulletin.

(4753) OFFSHORE SAND SOURCES.

Laboratory project. Field investigation; applied research.

(e) Exploration along the Atlantic Coast of Fla. by geophysical (sonic) methods and by shallow borings is scheduled for completion by Dec. 31, 1965. Further testing of the pump-ashore system is planned for 1966.

(5079) WAVE HEIGHT PREDICTION FOR WAVE MAKERS IN SHALLOW WATER.

Laboratory project. Theoretical and experimental; basic research.

(e) By equating the volume of water displaced in half a period by a displacement-type wave maker to the volume of water raised above mean water level in a sine-shaped wave, a simple relation results for shallow water waves which gives wave height as a function of wave length, wave maker stroke, and wave maker geometry. For shallow water, this relation agrees with hydrodynamic theory for piston-type and flap-type wave makers, and with published and unpublished data for waves generated by displacement-type wave makers in absolute water depths ranging from 0.5 feet to 15 feet.

(f) Suspended.

(g) Data from a flap-type wave generator support the approximate and the complete theories for wave height prediction.

(5325) FIELD MEASUREMENT OF LONGSHORE CURRENT VELOCITY.

Laboratory project. Field investigation.

(e) Longshore current velocity was measured by timing the travel of water filled balloons in the surf on the beach near Nags Head, N. C.; breaker angles were measured with a Brunton compass, by triangulation and by measuring the speeds of the current and plunge point of the breaking wave; beach slope was obtained from profiles through the surf zone; and wave height and periods were measured from wave gage records.

(f) Suspended.

(g) For the five sets of data obtained, longshore current velocity is roughly predicted by two of the several equations available to predict longshore current velocity.


(5326) RESONANT EDGE WAVES ON LABORATORY BEACHES.

Laboratory project. Experimental.

(e) An unusual standing wave in the runup on laboratory beaches is under study. The combination of slope, period, breaker type, standing wave length, and resonant amplification are being measured in order to describe the phenomena and to understand its affect on laboratory and natural beaches.

(g) The run-up from lightly plunging or surging waves occasionally resonates between the sidewalls of a wave tank 1.5 ft. wide. The resonant period is twice the period of the waves reaching the beach. Whenever the resonance is present on the plane beach, it always has a resonant period, beach slope, and tank width (1.5') which fits the equation for resonant edge waves. When this resonance occurs on a sand beach 40 feet wide, it occasionally produces cusps whose spacing is one-half the edge wave length. The width of the sand patch is not necessarily an integral multiple of the cusp spacing.

(h) "Resonant Edge Waves on Laboratory Beaches" (Abstract), C. J. Galvin, Trans. A. G. U., March 1966.

(5327) THE EFFECT OF SECONDARY WAVES ON WAVE RUN-UP.

Laboratory project. Experimental; basic research.

(e) This project was begun to learn the cause of certain peculiarities in the variability of wave run-up with wave period and height on steep slopes. Run-up tests were made in a 21 x 1-1/2' X 30' wave tank on smooth slopes installed at various locations along the tank. Slopes varied from 1:15 to 1:6. Each slope was tested in three water depths (0.65, 0.90, and 1.25 feet) in an attempt to determine the effect of water depth on the wave run-up.

(g) It was learned from an analysis of the tests that a strong correlation exists relating the phase shift between the primary and secondary waves and the height of wave run-up. The run-up for a given wave condition is a maximum if the primary and secondary waves are 180° out of phase (i.e. the secondary wave is in the trough of the primary wave) and a minimum when the two waves are in phase. This variable phase relationship of primary and secondary waves causes the run-up to vary up to a factor of 3 for steep slopes. For flatter slopes (about 1:6) this effect had essentially disappeared. Parameters useful in correlating run-up to wave characteristics are currently under study.

(5328) CHARACTERISTICS OF A PLUNGING BREAKER.

Laboratory project. Experimental and theoretical; basic research.

(e) The wave height, mean water depth, and distance traveled in the breaking process are being measured for waves which break by plunging on a concrete beach in a wave tank 96 feet long and 1.5 feet wide. Parallel wire resistance wave gages measure the wave heights, damped piezometers are flush with the beach surface to measure the mean water level and photographs record the distances traveled in breaking. This study is undertaken to increase the knowledge of the breaking process, to relate the energy flux of the incoming waves to the resulting wave setup, and to provide engineering criteria for the design of coastal structures.

(g) The horizontal distance between the observed breaking point and the point where the wave crest touches down in the trough before it breaks was measured from run-up records by two of the several equations available to predict longshore current velocity.


(5834) LONGSHORE CURRENT VELOCITY REVIEW.

Laboratory project. Review of experimental, theoretical and field investigations.

(e) A search of the literature was made to collect all available data on longshore currents and to publish relations for predicting longshore current velocity, for comparison purposes.

(g) Eight equations and 902 sets of data were obtained from the literature. All data were used in all applicable equations and the predicted and measured velocities compared. No single equation predicted well for more than a limited part of the data.

(5835) ORIGIN AND TRANSMISSION OF SECONDARY WAVES.

Laboratory project. Experimental; basic research.

(e) This project has as its purpose the study of the origin and transmission of secondary waves. Tests have been conducted to determine the effect of scale with a length ratio of 1:10 and 1:20. Tests were made of the effect of the type of generator on the
formation of these waves and of the ability of energy absorbers to damp-out the secondary waves. Current study is directed toward the breakdown of the unstable wave train into a sum of stable wave records which have been collected in the CERC 635 ft tank for this purpose. In these tests wave records were taken one foot for each wave along the tank, and a generator driven timing mechanism was used so that the water surface is known as a function of both time and distance along the tank. A water depth of 2 ft was used so that a relatively large length to depth ratio could be obtained. The results of the scale tests indicated that a Proudian Scale ratio is appropriate.

5856 FEASIBILITY STUDY OF A MODEL WAVE-POWERED SAND DREDGE.

(b) Laboratory project.
(d) Experimental investigation.
(e) The model of a wave-powered sand dredge consisted of a float-supported vertical array of check valves. The purpose of these tests was to determine if this device could use the wave energy present to bring sand through the nearshore and surf zones in sufficient quantities to be useful in beach replenishment operations. The tests were conducted on a 1:15 scale in a 65 foot long tank using waves having prototype periods of 5, 9, and 15 seconds. The dredge was floated in the flume (with the valve array parallel to the impinging wave crest) over an equilibrium profile having an average 1:10 slope, with the bottom material composed of crushed anthracite having an average specific gravity of 1.52 and a median diameter of .25 mm. The dredge was placed at various locations along the length of the profile and its valve array was set so that either 1, 2, 5, or 14 valves were operated, with the nearest valve being close to the bottom surface. Tests were made in which the dredge remained in a single location for the duration of each run, lasting about 13 minutes, as well as where the dredge was moved, by means of a winch and cable system, some distance along the length of the flume at a rate of .2 feet per minute of wave action. A total of 27 runs was completed.

(f) Completed.
(g) The results of the test series indicate that the device is not suitable as a float-supported sand dredge in its present form and actually increased the erosion rate by flushing far greater volumes of coal downslope on the seaward side of the dredge than were flushed through the valve array on the up-slope side of the dredge.

5857 NEW BEHN STONE STABILITY TESTS.

(b) Laboratory project.
(d) Experimental; applied research.
(e) A rubble breakwater with an armor layer of clayey limestone on a 1 in 1/2 slope is being tested for stability with non-breaking waves. Slope weights for the armor layer vary from 230 to 650 pounds and tests are being made with wave periods of 3.75, 5.60, and 7.87 seconds. Wave heights used vary from 2 to 4 feet. The tests are conducted in a wave tank 635 feet long, 20 feet deep, and 15 feet wide.

5858 RAYLEIGH DISC-WAVE DIRECTION GAGE.

(b) Laboratory project.
(d) Experimental; development.
(e) This project is being undertaken in an attempt to evaluate the feasibility of utilizing a Rayleigh Disc as a wave direction gage. A damping mechanism with two fixed and two moving vanes, mounted on the shaft with the disc, is employed to reduce the instantaneous response of the disc to changes in the flow field and thereby to cause the disc to respond only to changes in the mean of the directional velocity field. The gage has been tested in unidirectional and bidirectional wave fields. Indications are that the Rayleigh Disc wave direction gage will indicate the direction of simple wave trains and the mean of the directions of mixed wave trains - the accuracy of the indication being a function of the torques involved. The Rayleigh Disc gage is subject to errors, for example: a primary moment induced by the velocity field, a periodic torque induced by secondary flows, a damping torque, which is a function of the wave configuration, and a frictional torque, caused by the shaft bearings. When the potential friction torque exceeds the primary moment, the gage does not respond to the waves and it indicates direction; hence there are sufficiently small waves whose direction is not to be indicated by the gage. As the wave energy increases and the periodic torque increases, the damping mechanism has been found to be relatively effective in reducing the motion resulting from the periodic torque, but for sufficiently large waves, the motion of the disc becomes quite erratic and the direction of the wave train is only poorly indicated.

Memorandum for Record, Subject: The Rayleigh Disc as a Wave Direction Gage.

U. S. ARMY ENGINEER DIVISION, NORTH PACIFIC, Division Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to the Director, Division Hydraulic Laboratory, U. S. Army Engineer Division, North Pacific, Corps of Engineers, Bonneville, Oregon 97008.

1462 GENERAL MODEL STUDY OF THE DALLES DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) Department of the Army, Corps of Engineers, Portland District, Portland Oregon.
(d) Experimental; for design.
(e) A 1:80-scale, multidirectional, fixed bed model reproduces 2.7 miles of the Columbia River at the dam site. The original layout consisted of a circular-arc, 50-bay spillway, a 22-unit powerhouse, an 86- by 675-foot navigation lock, a rock-fill non-overflow section, and facilities for passing fish over the dam. Maximum head is 90 feet. Revised layout has a straight 23-bay spillway. Purposes are to study the structures alignment and flow conditions affecting navigation, power generation, cofferdam placement, rock-fill dam construction, and fish passage.

(f) Completed.
(g) Five major layout plans were tested and the most economical plan that effects satisfactory hydraulic conditions is selected. Tests indicated ability to reduce length of spillway and to reduce forebay excavation by 30 feet. Data relative to water-surface elevations and velocities in the tailrace, and the effects of excess fill placed in the forebay have been obtained. Flow conditions during various stages of construction and with the project completed have been observed with special attention given to navigation and fish migration problems.

(h) "The Dalles Dam, Columbia River, Oregon and Washington," U. S. Army Engineer Division Hydraulic Laboratory, Bonneville, Oregon. Tech. Report No. 59-1, June 1965. (Available on loan). Final report covering tests in general (1462), and powerhouse intake models (1789, respectively).

MODEL STUDY OF ROCK FILL, THE DALLES DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer Division, Portland, Corps of Engineers, Portland, Ore.
(d) Experimental; for design.
(e) The 1:40-scale model of the 500-foot-wide closure section of the rockfill portion of the powerhouse service gallery of the Dalles Dam included portions of the river channel upstream and downstream
therefrom and the eight partially completed units at the upstream end of the powerhouse through which the river flow was diverted as the closure fill was constructed. A study of the rock sizes and placement procedure required to construct the fill at a river flow of 200,000 cfs and for stability of 300,000 cfs was made.

The fill has been constructed by placing quarry-run (1000 lb and less) in 12-foot lifts or by end-dumping from the Oregon shore at river discharges of 200,000 cfs and less. Owing to the faster placing program possible with end-dumping, studies were concentrated on this method of closure. The 1000 lb and smaller material was placed without ladders on the bottom very close to the surface velocities of 24 fps. The higher velocities caused some movement of material but owing to the 250-foot width of fill the material did not move beyond the confines of the fill. Flow data were obtained during the prototype closure for correlation with model data. A model check of three stages of the process showed good agreement of flow conditions.


MODEL STUDY OF THE DALLES DAM NAVIGATION LOCK, COLUMBIA RIVER, OREGON AND WASHINGTON.

U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.

Experimental; for design.

A 1:25-scale model reproduced the 66- by 575-ft lock chamber, its culvert systems, and portions of the upstream approach channels. Studies were made of various types of filling and emptying systems to determine the most advantageous design from the standpoint of rate of operation during a maximum lift of 90 ft, degree of turbulence, and economy. The proposed portals included lateral culverts within the lock chamber combined with several locations of intake ports, longitudinal culverts, and outlet ports.

Completed.

Designs were selected for all features of the lock. A valve-opening schedule of 4 min resulted in a filling time of 12.5 min and a maximum water force, without supplemental use of the upstream lock tainter gate. The lock emptied in 16 min. Studies have shown that staggered valve operation will reduce maximum water forces. Operational tests of the final design were made with several heads and barge positions using a 4-min valve-opening schedule. One combination of head and barge position corresponded to conditions existing during prototype tests performed in December 1957.


MODEL STUDY OF THE DALLES DAM FISH LADDERS, COLUMBIA RIVER, OREGON AND WASHINGTON.

U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.

Experimental; for design.

Experiences with fish facilities at existing large dams, together with results of tests on hydraulic laboratory test apparatus, were used to solve the complex problems associated with passing migrant fish upstream at this huge project.

Completed.

The possible effects of the following on flow conditions affecting upstream passage of salmonids were investigated: length of spillway training walls adjacent to fishway entrances, attraction flow rates and for stability of flow through fishway entrances, fish ladder operating characteristics for alternative weir crest designs, distribution of auxiliary attraction water from diffusion chambers in powerhouse fish collection system, scheduled sequences of project construction, and different maintenance and operation. Pressure tests with live fingerling salmon showed that few young fish would be killed by proper fishway design even as they pass under the spillway gates.


MODEL STUDY OF ICE HARBOR POWERHOUSE INTAKE GATES, SNAKE RIVER, WASHINGTON.

U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.

Experimental; for design.

A 1:25-scale model included a typical powerhouse unit with intake, scroll case, emergency closure gates, and gate slots. The middle of the powerhouse was reproduced in plastic and was operated at simulated prototype speeds by means of a synchronous electric motor. Correlation of model-prototype downstream forces on Choke Point powerhouse intake gates was made as a basis for evaluating tests of intake gates for Ice Harbor powerhouse. Hydraulic dropdown forces on a moving gate were measured electronically. Forces on a stationary gate were computed from pressures at piezometers on the lip, bottom beam, and top seal.

Completed.

Model-prototype correlation of dropdown forces on Chief Joseph powerhouse intake was satisfactory. Maximum hydraulic dropdown on the lip and bottom beam was about 94 per cent of the total dropdown on each gate design that was tested for Ice Harbor. Maximum dropdown on the lip gate was reduced by increasing the lip. 12 to 20 in. and by increasing the bottom taper (no lip) from 30 to 45 degrees.


GENERAL MODEL STUDY OF LITTLE GOOSE LOCK AND DAM, SNAKE RIVER, WASHINGTON.


Experimental; for design.

A fixed-bed model constructed to an undistorted scale ratio of 1:300 reproduces the Snake River bed and pertinent overbank topography between river miles 66.3 and 71.6. The dam axis is at mile 70. The original layout consists of a straight, gravity-type spillway controlled by 50- by 59-ftainter gates, a powerhouse for six Kaplan turbines (two units and other three units), an 66- by 675-ft navigation lock having a maximum lift of 101 ft, concrete nonoverflow sections, rockfill abutments,
and facilities for passing migratory fish over the dam. The initial power installation will produce 405,000 kilowatts. Purposes of the model are to check the structures layout and flow conditions affecting cofferdam placement, power generation, navigation, and fish passage.

Following verification and tests of various cofferdam plans, alternative structures, arrangements and excavation amounts adjacent to the structures were studied. Operational tests of the final design structures and excavation plans are in progress.

MODEL STUDY OF SPILLWAY FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON.

(a) U.S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(b) Experimental; for design.
(c) The 1:42.41-scale model includes a 3-bay section of the 6-bay spillway and stilling basin. Tests are being made to evaluate hydraulic performance of the proposed spillway and to develop revisions in design that would increase performance or reduce construction and maintenance costs. Completed.
(d) Pressures, head-discharge relationships, and pier contraction coefficients were determined for free flow over the crest and for unequal openings of adjacent crest gates. Although an acceptable design for a horizontal stilling basin was derived in the model, protection against unusual amounts of artesian water underpinning the cofferdam will greatly increase construction costs if a conventional stilling basin is adopted. Attempts to eliminate the stilling basin paving through use of a conventional roller-type bucket were not satisfactory. Satisfactory hydraulic conditions and minimum downstream erosion were obtained with a denoted roller-type bucket.

MODEL STUDY OF LITTLE GOOSE NAVIGATION LOCK, SNAKE RIVER, WASHINGTON.

(a) U.S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(b) Experimental; for design.
(c) A 1:25-scale model reproducing the intake manifolds, the 35-ft-long lock chamber, split lateral filling and emptying system, outlet culverts, and portions of adjacent approach and outlet areas is being used to check the accuracy of the original design and to develop improvements if needed. An alternative method for distributing flow to the lateral culverts through a central junction chamber is being studied in a separate 1:25-scale model.
(d) Completed.
(e) Satisfactory designs for all elements of the structure were developed. The lock chamber can be filled in 11.5 minutes and emptied in 12.8 minutes under an initial head of 101 feet through a split lateral hydraulic system. Maximum gage forces on an 8-barge tow completely filling the lock will average about 8.5 tons. After numerous flow adjustments, good flow distribution was obtained in the junction chamber model. This hydraulic system was not tested in the comprehensive model.

MODEL STUDY OF SPILLWAY FOR DWORSKI DAM, NORTH PORK CLEARWATER RIVER, IDAHO.

(a) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(b) Experimental; for design.
(c) An undistorted, 1:300-scale, fixed-bed model reproduces the river bed and pertinent overbank topography for about 3600 feet upstream and downstream from the project area under the stilling basin and diversion tunnel, tunnel outlet channel, and temporary fishway entrance. The 675-ft-high dam, spillway, stilling basin, regulating outlets, and exit channel are being reproduced for tests of these elements.
(d) Verification of the model and diversion studies were completed, tests indicated that relocation of the tunnel entrance and realignment of tunnel and downstream approach were required.

MODEL STUDY OF LOWER GRANITE LOCK AND DAM, SNAKE RIVER, WASHINGTON.

(a) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(b) Experimental; for design.
(c) An undistorted, 1:100-scale, fixed-bed model will reproduce the Snake River bed and pertinent overbank topography for about 3.1 miles. Tests were made to determine flow conditions during successive construction stages and after proposed structures have been installed.
(d) Verification tests and studies of successive cofferdam and first-step diversion plans were completed.

MODEL STUDY OF REGULATING OUTLETS FOR DWORSKI DAM, NORTH PORK CLEARWATER RIVER, IDAHO.

(a) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(b) Experimental; for design.
(c) With the spillway gates closed, or with pool level below the spillway crest, reservoir outflows will be controlled by three 9- by 12.5-ft tainter gates located near the upstream end of separate conduits at elevation 1550. Heed on the conduits will vary from 55 feet at minimum pool elevation 1445 to slightly more than 250 feet at maximum pool elevation 1501. The outlet conduits will discharge onto the spillway chutes at about elevation 1150. Total outlet capacity will vary from 28,300 cfs at minimum pool to approximately 40,000 cfs at maximum pool. Pressures, flow conditions, and discharge relationships will be checked in a 1:20-scale sectional model that reproduces a portion of the forebay, an outside conduit (with streamlined entrance and centerline angle 5 - 58' to headwall), and a section of spillway downstream from the conduit.
(d) Bellmouth conduit entrances having simple and elliptical curves (plans A and B) were investigated with two 15-in. and one 60-in.-diam air vents in the valve housing and with one or two 20-in. Vents in the bellmouth.
(e) Pressures within the cavitation range existed in both bellmouths when the tainter valve was fully opened (12.5 ft). Pressures were satisfactory for openings less than 15.0 ft. Pressure conditions were not improved when the horizontal skew (5°-58'-0" in plan) was eliminated but the vertical skew (10° in elevation) was retained (see Figure C). Revision of the model for tests of plan D bellmouth, which will eliminate skew in both plan and elevation, is in progress.

MODEL STUDY OF COLUMBIA RIVER, OAK POINT TO VANCOUVER, WASHINGTON.

(a) U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(b) District Engineer, U. S. Army Engineer District, Portland, Oreg. Pittock Block, Portland, Oregon 97205.
(c) Experimental; for design.
(d) A 60-ft-deep by 600-ft-wide navigation channel between Columbia River, Miles 82 and 100 and from the Willamette River mouth to Portland, Oregon was authorized recently. Five separate movable-bed models, with 1:300 horizontal and 1:100 vertical scales, will...
be required to cover improvements in the Columbia River. The models will be used initially to check plans for constructing and maintaining the 90-ft channel. During these studies the location of pile dikes, channel alignment and location of spill areas will be investigated. Later the models will be useful on a continuing basis to check operation and maintenance activities and new construction.

(g) Verification tests on the first model, of Columbia River, at 1/25 scale, were continued. Construction of the second model (miles 52 to 65) was completed and verification tests were begun.

(5318) MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.

d) Owing to an accelerated schedule for completing construction of the John Day powerhouse, it is proposed to place as much of the draft tube concrete as diversion requirements will allow. The proposed skeleton bay interior will be much different from the present contract plans and from that at The Dalles Dam, which is the only unit that has been model tested. Tests of the contract plan and proposed skeleton unit were made in a 1:25-scale model.

(c) Completed.

d) Discharge capacity of the contract plan draft tube was inadequate to meet design requirements. Improved designs were developed for units 11 to 19 (with drainage tunnel over draft tube) and for special unit 20 (without drainage tunnel).

(h) Final report is in preparation.

(5614) MODEL STUDY OF SPILLWAY FOR LIBBY DAM, KOOTENAI RIVER, MONTANA.

(b) U. S. Army Engineer District, Seattle, Corps of Engineers, Seattle, Washington.

d) Experimental; for design.

e) The project, located at mile 218 on Kootenai River, 17 miles upstream from Libby, Montana, will include a spillway with two 40-ft wide bays (design discharge 145,000 cfs under maximum head of 4 ft), three regulating outlets with total capacity of 41,000 cfs at maximum pool elev 2455 and 35,000 cfs at minimum pool elev 2267, and a powerhouse for eight Francis units (ultimate installation, 840,000 kw). Three powerhouse units having a total rated capacity of 315,000 kw will be installed initially. The powerhouse and spillway, with approach and exit channels, are installed in a 1:50-scale model to determine hydraulic characteristics of spillway crest, pier, abutments, chute, regulating outlets, and stilling basin and to check flow conditions and without powerhouse discharge.

(g) Design and construction of the model were completed during 1965. Test results indicated that revisions of original designs for the stilling basin and spillway outlet abutments were needed. Development of improved designs for these elements is in progress.

(5815) TESTS OF CONDUIT VALVE SEALS, DWORSNIK DAM, NORTH FORK CLEARWATER RIVER, IDAHO.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.

d) Experimental; for design.

e) Threeainter valves with eccentric trunnions are proposed for use in the outlet works. Rubber seals mounted in the valve shaft upstream from each valve must be compressed by horizontal valve motion to prevent blow-by from hydrostatic heads up to 250 ft.

(g) Sealing tests on a 3-ft-long section of prototype rubber seal were made in a pressure chamber under heads up to 300 ft. Owing to residual "set" of the rubber under pressure, satisfactory sealing was obtained under slightly different amounts of nominal compression in successive pressure tests. The need for actual compression amounts greater than 3/8 in. was not indicated. Mechanical tests showed that a force of 3500 lb per lineal ft of seal was required to compress the seal 9/16 in., when the rate of valve motion was 1-1/2 in. per min. Maximum forces needed to compress two modifications of the original seal 5/8 in. were 7/00 and 6270 lb per lineal ft, respectively, under the same test conditions. With the modified seal designs, adequate sealing should occur with no more than 1/4 in. of seal compression.

U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, St. Paul.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OP SEDIMENT LOADS IN STREAMS.

U. S. Army Engineer District, St. Paul and U. S. Geological Survey, in cooperation with St. Anthony Falls Hydraulic Laboratory. See St. Anthony Falls Hydraulic Laboratory, page 73.

U. S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS.

(856) HYDROLOGY OF STORM DRAINAGE SYSTEMS IN URBAN AREAS.

Cooperative with the Johns Hopkins Univ. See page 42.

(3806) INVESTIGATION OF SUPERCRITICAL FLOW CHANNEL JUNCTIONS.

Cooperative with Oregon State Univ., Dept. of Civil Engrg. See page 61.

(2435) HYDRAULICS OF PIPE CULVERTS.

Cooperative with the National Bureau of Standards. See page 166.

(1011) UNSTEADY FREE SURFACE FLOW IN A LARGE STORM DRAIN.

Cooperative with Colorado State Univ., Civil Engrg. Section. See page 16.

(5597) CORUGATED PIPE ROUGHNESS STUDY.

Cooperative with U. S. Army Engineer Waterways Experiment Station. See page 195.

(4617) MECHANICS OF LOCAL SCOUR.

Cooperative with Colorado State Univ., Civil Engrg. Section. See page 18.

(5457) A NEW TYPE ENERGY DISSIPATOR FOR CULVERT OUTLETS.

Cooperative with Univ. of Texas, Dept. of Civil Engrg. See page 84.

(5533) USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION.

Cooperative with Virginia Polytechnic Inst., Dept. of Civil Engrg. See page 94.

U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, Fluid Meters Section.

(6012) CALIBRATION AND PERFORMANCE OF TURBINE FLOWMETERS, SIZE 2-INCH AND SMALLER.
(b) Bureau of Weapons, Dept. of the Navy.
(c) Mr. W. R. Shafer, Research Engineer, NBS, Washington, D. C. 20234.
(d) Experimental; applied research.
(e) To develop calibration procedures for and investigate the performance of typical turbine-type flowmeters, flow rates ranging from 0.5 to 250 gallons per minute, while metering liquid hydrocarbons. Purpose: to improve the accuracy of typical fuel and hydraulic oil metering applications in the aircraft industry.

(g) Recent investigations have been concerned with applications in which the turbine meters are operating at pressure levels up to 1500 psig. The meters may be calibrated conveniently while operating at high pressure levels by throttling meter discharge and measuring with conventional gravimetric or volumetric calibration systems. Influence of pressure on the density (0.5 to 1.0% per 1000 psi) and kinematic viscosity (10 to 20% per 1000 psi) of liquid hydrocarbons must be considered.


(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. G. Kulin, Hydraulic Engineer.
(d) Experimental; basic research.
(e) Investigation of effect of a following wind on a mechanically produced wave, with emphasis on changes in wave damping and on hydrodynamic roughness of the resulting surface. Completed.

(f) Wind shear forces were deduced for a variety of wind speeds and wave configurations.


(5613) RESPONSE OF A DENSITY-STRATIFIED LIQUID TO A SOURCE OR SINK IMPULSE.
(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. Karl Lofquist, Physicist, National Bureau of Standards, Washington, D. C. 20234.
(d) Theoretical and experimental; basic research.
(e) Investigation of the change of form of the shorter waves, and of the effect, if any, on damping of the longer waves.
(g) Experiments in progress.

(5615) INTERCOMPARISON OF TOWING TANK AND WATER TUNNEL CALIBRATIONS OF CURRENT METERS.
(b) Laboratory project.
(c) Mr. John L. French, Hydraulic Engineer, National Bureau of Standards, Washington, D. C. 20234.
(d) Experimental; basic and applied research.
(e) Investigation of wall interference and turbulence effects on current meter calibrations in water tunnels.
(g) Apparatus under construction.

(6015) DAMPING OF SHALLOW-WAVES: SUMMARY OF AVAILABLE INFORMATION.
(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. G. Kulin, Hydraulic Engineer, National Bureau of Standards, Washington, D. C. 20234.
(d) Analytical; basic research.
(e) A state-of-the-art review of viscous damping of waves, with analysis of available theoretical and experimental results.
(g) Literature review in progress.

(5664) STREAMFLOW FORECASTING RESEARCH.
(b) Laboratory project.
(c) Mr. William E. Hirst, Associate Director of Weather Bureau (Hydrology), Wash. D. C. 20235.
(d) Theoretical and field; applied research.
(e) In Wash., D. C., and at River Forecast Centers throughout the U. S., phenomena are being investigated for improved objective forecasts of streamflows. This work includes study of storage and movement of rain and snowmelt through the soil, including the influence of evapotranspiration, and routing of flow.
in natural channels.

Major results are adaptation of field procedures to digital computer operation at several River Forecast Centers, using a more sophisticated model than was possible earlier.


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U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY.

(2948) ANALOG MODEL ANALYZER FOR STOSS-STATE GROUND-WATER FLOW PROBLEMS.

(b) Laboratory project.
(c) Mr. R. W. Stallman, U.S. Geol. Surv., Denver, Colo.
(d) Theoretical study and instrument development.
(e) Use of a variable-resistance grid analyzer in analyzing steady-state ground-water flow problems in which the transmissivity varies in space.
(f) Completed.
(g) "From Geologic Data to Aquifer Models," R. W. Stallman, Geotimes, v. 5, no. 9, p. 8-11, 37, 1961.

(2950) SEDIMENT TRANSPORT AND CHANNEL ROUGHNESS IN NATURAL AND ARTIFICIAL CHANNELS.

(b) Laboratory project.
(c) Mr. Thomas Maddock, Jr., U.S. Geological Survey, Tucson, Arizona
(d) Basic research.
(e) Field and laboratory studies, original and other inverse analyses will be analyzed in terms of sediment movement, channel roughness, shear distribution in channel prism and other effects on shape of natural channels.
(f) Relations between velocity and sediment load have been developed. Relations involving slope are shown to be indeterminate within certain limits.
(g) "The Behavior of Straight Alluvial Channels," U.S. Geol. Survey Prof. Paper now in stage of final review.

(3264) SUBSURFACE EXPLORATION EQUIPMENT AND TECHNIQUES.

(b) Laboratory project.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo.
(d) Laboratory and field investigation; applied research.
(e) Evaluate and adapt subsurface sampling and coring equipment and techniques to ground-water investigations.
(g) Core samplers designed, and some commercial models procured and compared under field conditions. Library research in progress.

(3265) INVESTIGATION OF VAUDE FLOW THROUGH POROUS MEDIA.

(b) Laboratory project.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo.
(d) Experimental; basic and applied research.
(e) Laboratory model study of infiltration of fluids from surface pits into a thick unsaturated zone above the water table.
(f) Completed. Model tank designed and constructed; several test runs with beads of different particle size completed; library research; test runs photographed by slide and lapse-time movies.

(4/87) MECHANICS OF FLUID FLOW IN POROUS MEDIA.

(b) Laboratory project.
(c) Dr. Akio Ogasata, U.S. Geological Survey, F. O. Box 657, Honolulu, Hawaii.
(d) Experimental and theoretical study; basic research.
(e) Theoretical and laboratory study of microscopic and macroscopic aspects of flow through porous media.

(5075) DOPPLER VELOCITY METER.
Laboratory project.


Experimental; Instrumentation and development.

The objective is to measure the instantaneous local velocity by means of the Doppler frequency shift of an ultrasonic signal reflected by minute particles of suspended sediment. Models undergoing laboratory and field tests.

RESEARCH ON PERMEABILITY.

Cooperative with the State of California.


Laboratory and field investigation; basic and applied research.

Theoretical, library, laboratory, and field study of permeability, mainly as related to water movement through rock and soil materials, both as saturated and unsaturated flow.

Evaluation of existing laboratory and field methods and development of new or improved methods.

MOVING BOAT TECHNIQUE FOR MEASUREMENT OF OPEN-CHANNEL DISCHARGE.

Laboratory project.


Experimental; Instrument and technique development.

The purpose of this research is to provide the instrumentation and to develop the technique needed to rapidly, accurately and inexpensively measure flows especially unsteady flow, in rivers and tidal estuaries.

A Doppler navigator, Doppler velocity meter, and a sonic sounder are being coupled together to provide the required data. The Doppler navigator provides the transverse distance traveled across the channel, the sonic sounder provides the cross-section depth, and the velocity meter provides the flow vector from which the discharge may be electronically integrated.

ALLUVIAL CHANNEL HYDRAULICS.

Laboratory project.


Experimental; basic research.

A laboratory study of resistance to flow, sediment transport and related problems in alluvial channels.

Completed.

Five different bed materials ranging in size from 0.15 millimeters to 0.53 millimeters have been studied in forms of bed roughness which occur and their relation to sediment transport and resistance to flow have been studied and described. The effect of large concentrations of suspended fine sediment (clay), the viscosity of the water and the specific weight and gradation of the bed material on the mechanics of flow and on sediment transport in alluvial channels have also been investigated.


"Discussion of Hyperconcentrations of Suspended Sediment," E. V. Richardson and T. F. Hanly; Am. Soc. Civil Engineers Jour., v. 91, no. HY5, 1965.

MECHANICS OF FLUID RESISTANCE.

Laboratory project.

Dr. H. J. Comer, U. S. Geological Survey, WRD, Room 164 Peachtree Seventh Building, Atlanta, Georgia 30323.
Theoretical and laboratory investigation; basic research.

The objective of this study is to attempt to describe the effects of the boundary on fluid resistance by determining the dimensionless ratios characterizing the physical size and shape of the roughness.

The experimental aspect of the work is being conducted in an artificially roughened, closed circular, air tunnel using hot-wire anemometer equipment to determine velocity profiles, turbulence and energy spectra. The work consists of tests in which roughness element size, density of spacing, and shape are systematically varied. The resulting turbulence spectra are being analyzed in order to correlate the physical dimensions of the roughness with the energy and momentum transfer mechanisms in turbulent flow.

MULTIPLE CHANNEL DIGITAL RECORDING SYSTEM.

Laboratory project.


Institute development.

The objective of this project is to develop a reliable, battery-powered, sensing instrument for field operation which is capable of positioning a punched paper-tape digital recorder. The instrument would be used to provide a variety of hydrologic parameters in rapid sequence for recording on tape.

TRANSPORT SYSTEM INCORPORATING AN A-C WAVE-TRICKLE BRIIDGE BALANCED BY A B-C SERVO SYSTEM OF MINIMUM POWER REQUIREMENTS AND HAS BEEN DEVELOPED AND IS UNDERGOING FIELD TESTING.


EVALUATION OF DEPENDENT AND INDEPENDENT VARIABLES IN OPEN CHANNEL FLOW.

Laboratory project.


Experimental; basic research.

The objective of this study is to identify and evaluate the dependency characteristics of flow and sediment measures of alluvial channel flow. The experiments are designed to (1) determine the mean flow and channel adjustments when bed material is an independent variable; (2) determine the importance of depth as a scale parameter and as a driving force; (3) determine the effect when an independent variable is changed; (4) determine the variance of slope, depth, velocity, sediment transport, and bed conditions in time and space.

DISTRIBUTION AND CONCENTRATION OF RADIOACTIVE WASTE IN STREAMS BY FLUVIAL SEDIMENT.

Laboratory project.


Experimental and theoretical; basic and applied research.

A significant fraction of the low level liquid radioactive wastes which are discharged into surface streams is often sorbed by bed material and fine sediment particles. Consequently the manner in which these sediments are transported is a significant factor in determining the distribution of radioactive wastes in the stream environment. The project is devoted to investigating the dispersion and transport of both fine and bed material radioactive particles. Experiments are conducted in natural streams and in laboratory flumes.

Radioactive tracer techniques, fluorometry and nephelometry are among the experimental techniques being employed. Analytically and experimentally the phenomenon of sediment transport is being treated from a Lagrangian point of view. Completed.

The degree of mixing and the behavior of the longitudinal dispersion coefficient during the initial phases of the dispersion process in turbulent open channel flow has been related analytically to the dimensions of the channel, the resistance coefficient, and the von Karman turbulence coefficient.


STEP LENGTHS AND REST PERIODS OF SEDIMENT PARTICLES IN ALLUVIAL CHANNELS.

Laboratory project.


Experimental and theoretical; basic research.

The object is to study the individual and collective motions of bed-material sediment with a view to obtaining better understanding of the fundamental transport processes. Radioactive tracer and other techniques will be used to determine (1) distribution functions for the step lengths and rest periods of sediment particles and (2) how the parameters describing the distribution functions are related to sediment and flow characteristics.

Preliminary work performed with lightweight plastic particles indicate that the step lengths of particles are gamma distributed and that mean step lengths are on the order of one-half to two-thirds of a ripple or dune length. Experiments with the same particles indicated that the rest period durations are exponentially distributed. It remains to be determined from single particle experiments with radioactive tracer particles whether or not the same conclusions apply to natural sand particles.

MECHANICS OF FLOW STRUCTURE AND FLUID RESISTANCE--MOVABLE BOUNDARY.

Laboratory project.


Experimental and theoretical; field investigation; basic research.

The objective is to measure the internal flow field of turbulent flow in an open channel in order to obtain a fundamental understanding of the mechanics of fluid resistance. Further knowledge of the mechanics of flow structure will give a better understanding of the phenomena of energy dissipation, velocity distribution, shear distribution and the transport and dispersion of radio-active and other materials.

The velocity distribution for flow over a plain sand bed with appreciable bed material transport has an inner and outer zone. The distribution is logarithmic in both zones. In the inner zone the parameters for the distribution vary with the size, density, and
concentration of the bed material, whereas in the outer zone they are constant. The coefficients of the general resistance to flow equation for equilibrium flow in a sand channel vary widely because (1) the flow may be steady or unsteady, uniform or nonuniform depending on the bed configuration; (2) there are four types of energy dissipation; (3) there is a range of shear stress where the bed configuration may range from dunes to plain bed or antidunes.


5611 FALL VELOCITY OF GRAVEL-SIZED PARTICLES.

(b) Laboratory project.


(d) Experimental and theoretical; basic and applied research.

(e) The objective is to evaluate the effects of size, shape, density, and fluid characteristic on the fall velocity of gravel-sized sediment particles and to make exploratory studies on the physical significance of the Reynolds number and the effect of turbulence on fall velocity.

(g) Studies of the behavior of spheres, disks, oblate spheroids, cylinders, and prolate spheroids falling in quiescent liquids show that (1) the fall pattern of disks changes from stable to oscillating to glide-tumble to tumble as the Reynolds number increases, (2) the stability number and the frequency number can be correlated with stability, and (3) particles with small values of the Corey shape factor are less stable than those with large values.


5612 STATISTICAL ANALYSIS OF RIPPLES, DUNES AND ANTIDUNES.

(b) Laboratory and field.

(c) Messers. C. F. Nordin and J. H. Algert.

(d) Experimental; basic and applied research.

(e) The objective is to statistically analyze the frequency distribution of length, amplitude, and shape of bed forms and their sequential dependence on parameters of flow and sediment transport. Data are obtained from sonic records of the movement of these forms under conditions of equilibrium flow in laboratory flumes.

(f) Suspended.

(g) Techniques of correlation and spectral density analysis were applied to describe dune profiles for data from a 0.4-ft flume, an 8-ft flume and a conveyance channel near Bernardo, New Mexico. The first three values of the covariance functions were found to be sufficient for computing approximate models. Two parameters describe the bed elevation as a function of distance by a second order autoregression scheme. The first value of covariance also relates well with unit discharge.


5840 AREAL GROUND-WATER CONTROL.

(b) Laboratory project.


(d) Field investigation; applied research.

(e) Objective is to test, in the field, methods of measuring the hydraulic conductivity of the unsaturated zone, and to find the relation between evapotranspiration and depth to the water table.

(g) Measurements of liquid head and liquid content, as functions of time and depth, will be used for computing hydraulic conductivity and evapotranspiration. Data from several sites will be plotted for relating evapotranspiration and depth to the water table. Tensiometers, moisture measurement access tubes, and piezometers were installed at four field locations; and a column of thermistor rods measuring the temperature profile was installed at one site. Weekly measurements of head were made at all operable sites. Moisture measurements were made sporadically until February 1965, monthly thereafter. Preliminary data analysis was made in May 1965.

5841 DENVER MULTIPHASE FLOW.

(b) Laboratory project.


(d) Theoretical and field investigation.

(e) Devising and testing methods of measuring flow in and hydraulic characteristics of the saturated zone in the field. Measure velocities of fluids underground by analysis of temperature profiles. Develop and test methods of predicting the nature of flow in the unsaturated zone. Improve, and develop new techniques for field measurement of evapotranspiration. Measurement of the time lag and attenuation of fluctuations in gas pressure due to barometric changes as functions of depth below the land surface were made in the unsaturated zone near Cuba, New Mexico, for determining the transition of the saturated zone. Although the field tests were successful, improvement in the instrumentation adopted is indicated.

(g) Type curves for analyzing drawdowns observed in well fields having variable discharges at scattered locations were developed for the New Mexico ground-water data. The Geological Survey Computation Unit. The computer program evolved is available for calculating the hydraulic properties of aquifers in areas where intensity of ground-water is monitored at observation wells. Underground temperature profiles were observed in the field near Globe, Arizona, and Roswell, New Mexico. The possibility of using the temperature profile for indicating vertical velocities of ground water.

5853 MECHANICS OF GROUND-WATER FLOW.

(b) Laboratory project.

(c) Mr. H. H. Cooper, Jr., U. S. Geological Survey, Washington, D. C.

(d) Theoretical investigations with field applications; basic and applied research.

(e) Analysis of ground-water flow problems for which practical need has developed out of observations on field investigations. Possibility of using the temperature profile for indicating vertical velocities of ground water.
through beds having low permeability. Indica-
tions are that vertical velocities as small as
0.1 ft per year can be identified by analysis
of the steady-state temperature profile ob-
erved in beds about 100 feet or more in thick-
ness.

The relation between losses from ground water
and evapotranspiration is being studied with
the aid of the field offices of the Water
Resources Division, U. S. Geological Survey,
in Colorado. Measurements of ground-water
levels, soil moisture tension and content, and
temperature are being made at four 25-acre
sites in the Arkansas River Valley. Lateral
contribution to ground-water loss, due to
spatial changes in flow through the aquifer,
is monitored by finite-difference analysis
of the steady state of the water table. Project
interest lies in testing of field techniques of
measuring the hydraulic properties of the un-
saturated zone, and in the relation between
evapotranspiration and depth to the
water table. Field installations were com-
pleted in May 1965, and rebuilt by October
1965 after destruction by floods.

Discussion of "Analysis of Data from Non-equ-
librium Pumping Tests Allowing for Delayed
Yield from Storage," by N. S. Boult,
Robert W. Shimmin, Inst. Civil Engineers
"Multiphase Fluids in Porous Media--A Review
of Theories Pertinent to Hydrodynamic Studies,"
Robert W. Shimmin, J. Geophysical Survey
"Effects of Water Table Conditions on Water
Level Changes in New Pumping," R. W.
Stallman, Water Resources Research, v. 1, no.
"Steady One-dimensional Fluid Flow in a Semi-
infinite Porous Medium with Sinusoidal Surf
Face Temperature," R. W. Stallman, Journal of
Geophysical Research, v. 70, no. 12, p. 2821-
2827, 1965.

(5843)

THE MOVEMENT OF RADIONUCLIDES IN THE COLUMBIA
RIVER ESTUARY.

(b) U. S. Atomic Energy Commission.
(c) Mr. D. W. Hubbell, Project Chief, U. S. Geo-
logical Survey, P.O. Box 3202, Portland,
Oregon.

e) Experimental and theoretical; applied research.

Certain radionuclides enter the Columbia
River from the Hanford installation of the
U. S. Atomic Energy Commission. Part of the
radionuclides remain in solution, part are
sorbed by fluvial sediments, and part are
sorbed by biota. In order to insure that
no dangerous radionuclide prevails or develops
in the Columbia River estuary, it is impor-
tant to know the distribution of radionuclides
in time and space, and the processes by
which the distribution is altered. The purpose
of this investigation is to study the movement
of radionuclides in the Columbia River
estuary as it is affected by flow, sediment
transport, and chemical processes; to assess
the distribution of radioactivity in the
estuary; to develop measurement methods and
techniques; and to contribute knowledge of estuarine
processes.

(g) Measurement equipment and techniques have
been developed for collecting necessary data in
the estuary. The equipment includes
systems for measuring water discharge rapid-
ly, for collecting large-volume water and
suspended-sediment samples, for filtering
large-volume samples rapidly, for collecting
6-foot long bed-material cores, and for
monitoring radioactivity in situ. The areal
distribution of radioactivity in the estuary
varies markedly, however, high
activities are associated with fine sediments.

"A Sampler for Coring in Rivers and Estuaries,
E. A. Prych and D. W. Hubbell," submitted for
publication as a short note in the Geological
Society of America Bulletin.

"Measurement Equipment and Techniques Used in
Studying Radionuclide Movement in the Columbia
River Estuary," E. A. Prych, D. W. Hubbell
and J. L. Glenn; submitted to the American
Society of Civil Engineers for publication
in a Special Proceedings Volume for the
Coastal Engineering Conference, Santa
Barbara, California, October 11-13, 1965.

THE OCCURRENCE, TRANSPORT, AND DISPOSITION
OF RADIONUCLIDES AS SOLUTES AND ASSOCIATED
FLUVIAL SEDIMENTS IN THE LOWER COLUMBIA
RIVER.

(b) U. S. Atomic Energy Commission.
(c) W. L. Hazel, Project Chief, U. S.
Geological Survey, P. O. Box 3202, Portland,
Oregon 97208.

d) Field investigation; applied research.

Small amounts of radionuclides are being
used for cooling the reactors at the Hanford
installation near Richland, Wash. are acti-
vated and subsequently discharged into the
Columbia River in the controlled release of
the cooling water. The purpose of the pro-
ject is to determine the disposition of
these radionuclides in and along the channel
and the mechanics of transport of the radio-
uclides by the water and sediment in the
river. The investigation is intended to
supplement information on the release
of the Columbia River between Hanford
and the head of the estuary.

(g) The transport and retention of radionuclides
associated with the fluvial sediments of the
river system, and (2) the influence of
the chemical and physical composition of the
environmental settings. The radionuclides
affixed to the sediments varies for specific
radionuclides and correlates with the physi-
ical and mineral characteristics of the sed-
iments. There is a differential transport of
these affixed radionuclides because of the
differences in the fall velocity of the sedi-
ments, and this difference in transport
affects the retention of radionuclides in the
study reach. The digital computer solu-
tions of a mathematical model for transient
flow have been successfully applied to
the production of continuous discharge data
for tidal-affected flows of the Columbia
River at Vancouver, Wash.

(h) "An Electrically-Powered Vehicle for Large River
Measurements," H. H. Stevens, Jr., and G. R.
Dempster, Jr., Civil Engineering, v. 34, no.
6, p. 74, June 1964.
A discussion of "Tidal Control of Stream Temperatures,"
J. C. Ward; by W. L.
Haushild and G. R. Dempster, Jr., Am.
Soc. Civil Engineers Proc., v. 90, no. 3A4, p.
3060-92, August 1964.
"Concurrent Collection of Hydraulic and
Sediment Data in Rivers," G. R. Dempster,
Jr., and H. H. Stevens, Jr., Jour. Am.
Water Works Assoc., v. 57, no. 9, p. 1135-1138,
September 1965.

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U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF MINES,
Morgantown Research Center.

(4436)
FLOW PROPERTIES OF COAL-WATER SLURRIES.

(b) U. S. Bureau of Mines, Morgantown Coal
Research Center.
(c) Mr. J. P. McColl, Research Director, Morgan-
town Research Center, Morgantown,
West Virginia.

d) Experimental; applied research.
(e) The object of the project is to establish
friction factor-Reynolds number relationships
for coal-water slurries of various concen-
trations with data collected in 6-foot
size analyses. Work is being done with 1/2
inch, 3/4 inch, and 1 inch pipes. Data are
processed on an IBM-1620 computer.

(f) Inactive for the present.

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Laboratory project.
(d) Experimental; for design.
(e) A model was constructed to generalize stilling basin dimensions, using either one or two slide gates.
(f) Data were taken for two types of stilling basins for high-head slide gates. Preliminary design curves were developed for the usual hydraulic jump basin and for a single plunge-type basin.

(2874) CONSTANT HEAD ORIFICE TURNOUT.
(b) Laboratory project.
(d) Experimental; applied research for design.
(e) A 24-inch slide gate turnout was calibrated by means of a 1:2 scale model. Design changes resulting from use of the turnout have necessitated an analysis and calibration of the variables affecting the discharge capacity.
(f) Suspended.
(g) Results show that submergence of the orifice or of the upstream gate at the two-gate turnout has a major effect on the discharge coefficient. A calibration curve for a 9 cf standard turnout and several comparative calibrations of modified turnouts have been obtained.

(2878) CAVITATION OF CONCRETE SURFACE IRREGULARITIES.
(b) Laboratory project.
(d) Experimental; applied research and design.
(e) Into-the-field Tests with abrupt edges, chamfered edges, and rounded edges were tested to determine the velocity-head relationships for incipient cavitation.
(g) Data analysis not completed.
(h) Progress report to be prepared.

(3611) ADJUSTABLE WEIR.
(b) Laboratory project.
(d) Combined laboratory and field research.
(e) Weirs having adjustable crest height are used for checking water surface elevations for upstream water delivery and for water measurement beyond the weir. An investigation of the head discharge capacity of a single 2-foot crest-length weir was completed.
(f) Single weir investigation completed.
(g) Capacities of weir for crest heights greater than 0.1 foot above fixed blade compare very favorably with standard 2-footcipolleti weir.

(3612) DISCHARGE COEFFICIENTS FOR RADIAL GATES.
(b) Laboratory project.
(d) Experimental, laboratory and field investigations; applied research.
(e) Radial gates are used extensively in irrigation systems for discharge and water surface level control. Intelligent operation of the systems requires that the rate of flow passing the gated structure be known. Literature research resulted in an analytical approach and adjusted equation for the gate capacity with unsubmerged flow.
(g) Extensive model and prototype radial gate data were obtained from the TVA Hydraulic Laboratory. The data are being analyzed to verify the proposed discharge formula and to extend the scope of presently available information.

(3965) DISCHARGE CAPACITY OF LARGE CONCRETE-LINED CANALS.
(b) Laboratory project.
(d) Experimental, laboratory and field investigations; applied research and design.
(e) This study is for the purpose of exploring the effects on the hydraulic gradient of the relationship of boundary surface resistance to the cumulative resistance of crossings, inlets, turnouts, checks, and other local items in concrete-lined canals of different sizes, shapes, and grades. This study is part of a program to explain why design procedures used successfully for small and medium size canals may not be adequate for large concrete-lined canals on flat slopes.
(f) Completed.
(g) Between 1957 and 1965, tests were made on 170 miles of nine large (700 to 13,200 cfs) and small (0.013 to 0.016 for the smaller, and from 0.015 to 0.019 for the larger) canals having ages ranging from 7 to 23 years. Resistance coefficients varied with the amount growth, canal alignment, and canal size and ranged from 0.013 to 0.016 for the smaller channels, and from 0.015 to 0.019 for the larger channels.

(3994) HYDRAULIC JUMP CHUTE BLOCK AND Baffle BLOCK PRESSURES.
(b) Laboratory project.
(d) Experimental; applied research.
(e) A spillway stilling basin model has been constructed to study chute block and baffle block pressures and to relate these pressures to the Froude number of the entrance flow and to tailwater depth.

HIGH-VELOCITY JET ON PROTECTIVE COATINGS.
(b) Laboratory project.
(d) Experimental; operation and maintenance.
(e) A 100-fps, 1-inch-diameter jet was impinged at 45 degrees on protective coverings proposed for application on concrete surfaces to be subjected to high-velocity flow.
(f) Completed.
(g) All protective coatings tested, in which the surface was unbroken, withstood the jet for 4 hours. All coatings were ripped from the concrete test blocks in less than 5 minutes.
(h) Report in preparation.

(4792) CANADIAN RIVER AQUEDUCT CHECK TOWERS.
(b) Laboratory project.
(d) Experimental; for design.
(e) Laboratory tests are being made to determine the hydraulic losses and air-entrapment potential of check towers to be installed in the 125-mile-long Canadian River Aqueduct. The aqueduct consists of 54-, 60-, and 66-inch-diameter concrete conduits. The check towers are so designed that the top of each is slightly below the hydraulic grade line when the aqueduct is flowing full. Each check tower consists of a 90 degree vertical bend to direct the conduit upward, a 180-degree return bend at the top of the tower, and a 90-degree bend at the bottom of the downstream leg to return the conduit to the original alignment. There is a 22-inch air vent at the top of each tower.
(f) Completed.
(g) Head loss was determined for each size check tower. During filling or evacuating the tower, air was entrained in the downstream leg and carried into the horizontal conduit. A 36-inch-diameter vent was installed 120 feet downstream from each tower to release the entrained air.
(h) Report in preparation.
(4794) VERTICAL STIRRING WELL.
(b) Laboratory project.
(d) Applied research.
(e) The purpose is to obtain the optimum size, depth, and internal configuration of vertical stirring wells for high-head discharges. The test installation has a 4-foot by 4-foot-square, 20-foot deep, followed by a canal with a 4-foot bottom width and 1-1/2:1 side slopes. An adjustable downspout is symmetrically located in the well and discharges against the flat floor. Piezometers are located in the floor and lower sidewalls of the well. Adjustable corner fillets provide a means for determining optimum fillet angle, size, and height.

(f) Continuing.
(g) The addition of corner fillets to the well results in smoother water surface. The fillets direct the flow from the corners back to the center of the well inducing roller action. Optimum fillet configuration has been determined for one ratio of downspout area to well area. Additional studies will determine optimum fillet configurations for larger downspouts.

(4802) STUDIES ON ORIFICES FOR AUTOMATIC RADIAL GATE CONTROLS.
(b) Laboratory project.
(d) Experimental; for design.
(e) The studies are for the purpose of determining flow characteristics and discharge coefficients for various size orifices in floatwell intakes of automatic radial gate controls. A 1:1 scale model of a floatwell intake structure was constructed to determine discharge coefficients of the irregular orifice configuration in the regulating exit.

(f) Although the test arrangements differed substantially from arrangements for which data are presently available, measured coefficients compared closely with existing data.

(4807) MORROW POINT DAM SPILLWAY AND OUTLET WORKS.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:24 scale model was constructed to aid in the development of the unusual design of the spillway and outlet works for the thin-arch concrete dam. The original design, consisting of a free overfall spillway and an outlet wall located near the bottom of the dam, was abandoned because of undesirable flow conditions in the artificially formed falling pool at the base of the dam. The present design includes four fixed-wheel gate controlled conduits near the top of the dam which discharge 34,400 cfs, allowing it to fell approximately 400 feet to the stilling pool. The small slide-gate-controlled outlet works in the lower portion of the dam and the underground powerhouse tailrace channels are also included.

(f) Completed.
(g) Model studies have proven the acceptability of the powerhouse design. Design of the control weir which forms the stilling pool was modified and the two inside spillway conduits were tipped downward to provide more even distribution of impact of the free-falling jets. Revisions were made to the topography of the downstream river channels to improve flow conditions in those areas.

(h) Report in preparation.

(4947) OROVILLE DAM INCLINED POWERPLANT INTAKE TOWERS.
(b) California Department of Water Resources.
(c) California Dept. of Water Resources, State of California, Sacramento 2, California.
(d) Experimental; for design.
(e) Hydraulic phenomena of the unique inclined intake towers were studied in a 1:24 scale model. Temperature control shutters were arranged on three towers so the water could be drawn from selected levels in the reservoir to maintain desired river temperatures for irrigation and for fish propagation. Differential pressures were read at very large gates, and any tendencies for hydraulic instability during operation were studied.

(f) Completed.
(g) (l) The uppermost temperature control shutters must be a minimum of 40 feet below the reservoir water surface to prevent air entrapment by vortices. (2) A head loss of 2.6 feet for maximum discharge (8,600 cfs) with water flowing through the trashracks, past the temperature control shutters and emergency closure gate and into the 150-foot-diameter penstock. (3) A head differential of 3 feet will exist across the 40- by 42-foot temperature control shutters during normal power plant operation.


(4950) OROVILLE DAM FLOOD CONTROL OUTLET AND SPILLWAY.
(b) California Department of Water Resources.
(c) California Department of Water Resources, State of California, Sacramento 2, Calif.
(d) Experimental; for design.
(e) Models built to 1:48 and 1:78 scale are being used to study the hydraulic features of a revised design of the flood control outlet. The general flow conditions, discharge coefficients, water surface profiles, flow velocities and energy dissipation as the flow reaches the Feather River are being tested on the 1:48 scale model of the entire outlet structure. The 1:78 scale sectional model of four of the eight outlet bays is being used to obtain discharge capacities for uncontrolled releases. Pressures along the pier walls and bellmouth roof of the bays were recorded from this model. A 1,470-foot-long uncontrolled overfall spillway which will operate only during extreme flood conditions was not modeled.

(f) Completed.
(g) Flow through the outlet approach area, bays and channel was good except for slight vortex action at the outlet entrances. Modifications at the left abutment virtually eliminated the vortex. The outfall propped, the pier sides and bellmouth roof were all at or slightly below atmospheric. The discharge capacity was 3,400 cfs higher than design capacity. Spillway chute and bucket were developed for discharge of 230,000 cfs.


(4965) NAVAJO MAIN CANAL HEADWORKS.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:16 scale model containing two 9- by 12-foot top seal radial gates, a divided underground stilling basin, and a horseshoe-shaped downstream tunnel was constructed to aid in evaluating and improving the stilling basin performance, and to test the unusual application of radial gates. Discharges ranged up to 1,800 cfs, and heads ranged from 15 to 126.5 feet.

(f) Completed.
(g) Abasin was developed that provided good energy dissipation and smooth water surface conditions in the downstream tunnel. Back-flow, which struck the downstream faces of the radial gates for a wide range of heads and discharges, was prevented by placing...
(4952) SURGE STUDIES IN LONG, LOW-HEAD PIPELINE SYSTEMS.

(b) Laboratory project.

(d) Experimental; applied research and design.

(e) Laboratory studies will be made to verify an electronic computer program for analyzing low frequency surge characteristics of long pipeline systems. The test facility consists of 1,400 feet of 4-inch pipe, a constant head water supply, a constant head terminal reservoir, and a slow closing and opening valve for producing controlled changes in rate of flow. The pipeline is interrupted at 160-foot intervals with open check stands that divide the line into individual reaches with pressure heads not greater than 2.8 feet. Total drop of the line is 24 feet.

(f) Continuing.

(g) A series of test runs with varying control valve closure times have been made. The results, listing head versus discharge for various stations and time intervals have been furnished for debugging and modifying an ADF program which will be used to predict prototype results.

(4954) SAN LUIS FOREBAY PUMPING PLANT INTAKE TRANSITIONS.

(b) Laboratory project.

(d) Experimental; for design.

(e) A 1:15 scale model was used to compare head loss, velocity distribution, and flow patterns in various configurations of canal transitions to pumping plant intakes.

(f) Completed.

(g) On the basis of velocity distribution and surface flow patterns in the transition and pump intake, it was found that a symmetrical transition was more desirable than an angled transition. Head losses were too small to justify this transition. The angled transition was chosen for the final design after consideration of economic factors. Numerical methods and a digital computer were used to analyze the large volume of velocity data.


(4955) SAN LUIS FOREBAY CANAL SURGE STUDIES.

(b) Laboratory project.

(d) Experimental; for design.

(e) A 1:40 scale model was tested to determine the magnitude and velocity of surge in a pumping plant supply canal after power failure and rejection of flow. Efforts of bifurcations, curves, and canal structures and methods of relieving surges were investigated.

(f) Completed.

(g) Comparative data were obtained on the size, form, and velocity of surge waves following rejection of the canal flow and drainage from the pump discharge lines. A longitudinal side weir was developed to attenuate the surge to an allowable height.


(4956) YELLOWTAIL AFTERBAY DAM SLUICEWAY AND OVERFALL WEIR.

(b) Laboratory project.

(d) Experimental; for design.

(e) One to twenty-four scale models were used to determine the hydraulic operating characteristics of the afterbay dam sluiceway and overfall weir, and to develop satisfactory stilling basins for both structures. The basins were judged on appearance of flow conditions and downstream bed erosion.

(f) Completed.

(g) The model study resulted in hydraulic jump type stilling basins containing chute blocks, baffle piers, and an end sill (Type III) being recommended for the sluiceway and overfall weir. Both recommended structures provided smooth approach-, chute-, stilling basin-, and downstream channel flow, and produced no erosion or movement of downstream riverbed or riprap. Discharge capacity and efficiency curves were prepared for both structures.


(4957) BAFFLED PIPE OUTLET ENERGY DISSIPATORS.

(b) Laboratory project.

(d) Applied research.

(e) Hydraulic models are being made to extend present information concerning this type of impact energy dissipator. Prototype data from existing operating structures will be compared with model data. Investigation of erosion around the structures and in the downstream bed will be studied.

(f) Suspended.

(4958) AIR DEMAND TESTS ON 34-INCH JET FLOW GATE--TRINITY DAM, CALIFORNIA.

(b) Laboratory project.

(d) Field investigations.

(e) Field measurements were obtained to compare model and prototype air demand for the complete range of gate openings at maximum operating head (560 feet) on the gate. A laboratory model study was made to obtain centerline velocity coefficients for the prototype air duct to provide for a quantitative analysis of field measurements.

(f) Completed.

(g) Maximum velocity in the air supply conduit was within design limits.

(h) Report in preparation.

(4959) FLAT BOTTOMED TRAPEZOIDAL VENT FLUMES.

(b) Laboratory project.

(d) Experimental; for design.

(e) A pilot study of a single flume is being conducted to determine the best approach to a comprehensive program to generalize the design and calibration of this type of water measuring device.

(f) The model study has demonstrated that the particular pilot flume tested is an adequate measuring device.

(h) Report in preparation.

(4960) PROTOTYPE PIEZOMETRIC AND AIR DEMAND MEASUREMENTS OF 4-FOOT TANDEM GATE--NAVAJO DAM, NEW MEXICO.

(b) Laboratory project.

(d) Field investigations.

(e) To compare the model and prototype, piezometric measurements were obtained for the complete range of gate openings with a head of 164.5 feet. Prototype air demand measurements were made simultaneously with piezometric valves to evaluate adequacy of the air supply system. Further tests are planned at heads of about 250 feet and 300 feet to more fully evaluate the hydraulic characteristics of this gate and to check the model scaling.
LABORATORY INVESTIGATION OF THE REMOVAL OF SALT WATER FROM A TWO-PART AGUJerUS USING TILE DRAINS INSTALLED IN THE UPPER MEMBER, AND PUMP WELLS INSTALLED IN THE LOWER AGUJerUS.

Laboratory project.

Applied research.

Tests were performed on a 16-foot-long 1:40 scale model containing two-part and single-part aguJers to determine the hydraulic action of simulated tile ground-water drains placed 0.2 foot below the model surface. The lower aguJer was composed of coarse sand 50 times more permeable than the fine sand in the upper aguJer. For initial conditions the model was charged with salt water, concentration 6,000 ppm NaCl, dyed blue for visual identification. Tests are continuing using vertical pump wells in the lower aguJer as drains.

For the given prototype conditions, tile ground-water drains will not intercept and discharge fresh water if the lower aguJer contains salt water. The fresh water tends to drive the salt water ahead of it to the drain.

Progress Report No. 2 in preparation.

INVESTIGATION OF THE EFFECT OF TURNOUT GEOMETRY ON THE ACCURACY OF A PROPELLER-TYPE OPEN FLOW METER.

Laboratory project.

Experimental; for design.

The purpose of the investigation was to determine whether a change in the design of outlet structures for open flow meters from a relatively unconfined outlet to a confined outlet changed the registration accuracy of the meter.

Completed.

Results indicate that a confinement just large enough for discharge of the turnout did not significantly change the meter registration accuracy.


HIGH PRESSURE SLIDE GATE STUDIES FOR PIERD AND MORROW POINT DAM OUTLET WORKS.

Laboratory project.

Experimental; for design.

A 1:9 scale model is being used to determine operating characteristics and pressure conditions on slide gates to be used for regulation at heads up to 335 feet. The flow passages of the gates slope downward 30° in the direction of flow, and the gate leaves and booms are vertical. Effects of flaring the sidewalls immediately downstream from the leaf are being studied.

Preliminary studies show that a gate slot design used very successfully on gates with horizontal flow passages and vertical leaves is not satisfactory for gates with 30° sloping passages and vertical leaves. Also, flaring the downstream walls in the normal fashion just downstream from the leaf leads to extremely subatmospheric pressure conditions and cavitation. By offsetting the walls abruptly 3 or 4 inches outward a very short distance downstream from the leaf, an excellent design with either parallel or diverging downstream walls is apparently obtained.

BUTTERFLY VALVE STUDIES WITH CAVITATION OCCURRING.

Laboratory project.

Experimental; for design.

A commercial 8-inch, 125 psi butterfly valve is being tested under prototype head to determine the effects on cavitation characteristics, air demand, and discharge coefficients that result from discharging the valve di-

rectly into sudden enlargements, or through short conduits into the enlargements. Tests are made with and without the admission of air, and quantities of air needed to just quiet the cavitation are being obtained. Effects of air admission on the discharge coefficient are also being obtained.

Preliminary results show the satisfactory pressure reducing stations for high differential heads and low back pressures can be obtained with butterfly valves in the valves discharge directly into a 2.0 dia enlargement. Air in sufficient quantities to relieve cavitation when the discharge enters the enlargement, or through short sections of pipe, has little effect upon the discharge coefficient.

PRESSURE RELIEF PANELS FOR OROVILLE DAM POWER PLANT INTAKE TOWERS.

California Dept. of Water Resources.

California Dept. of Water Resources, Sacramento, Calif.

Experimental; for design.

The 40- by 42-foot temperature control shutters for the inclined intake towers are designed to withstand a maximum head differential of 5 feet of water. Under maximum discharge through the power plant the head differential across the shutters will be 3 feet. Surges caused by power plant demand fluctuations, or removal or replacement of temperature control shutters, could cause pressures across the shutters in excess of the design maximum allowable.

Completed.

Relief panels have been designed which will open under a head differential of 3 1/2 feet. The recommended panel was calibrated to determine the number of panels required to furnish the discharge demanded by the power plant for a maximum head differential of 5 feet of water.


LABORATORY TESTS OF GATE SEALS UNDER PROTOTYPE HEADS.

Laboratory project.

Experimental; for design.

A facility for testing gate seals under heads of up to 200 feet was used on two similar double stem rubber gate seals. One seal bulb was capped with teflon and the other was uncapped. The program consisted of extrusion tests under sustained load, and tests with relative motion to determine the seal action as it approached, touched, and moved on the seat. A new facility is being built to test seals at heads of approximately 600 feet.

The teflon cap added to the rigidity of the seal and prevented much of the distortion noted with the uncapped seal. Also, when the seal was moved relative to the seat, the teflon cap prevented the seal from being pinched between the clamp bar and seal seat.

MODEL-PROTOTYPE CORRELATION OF AIR DEMAND.

Field tests and laboratory project.

Theoretical and experimental; applied research.

Basic parameters are being developed to correlate model results with prototype measurements for the flow of air in a closed conduit partially filled with moving water. Prototype measurements are essentially complete. Laboratory tests are beginning in a variable slope, enclosed, rectangular channel. The mean air velocity and turbulence intensity of the air stream will be measured for various water velocities, various water depths and various pressure gradients.

GRANBY DAM SPILLWAY.
(b) Laboratory project.  
(d) Experimental; for design.  
(e) A 1:36 scale model was used to study the modification to the spillway chute and the proposed flip bucket and plunge basin for flows up to 12,000 cfs at velocities in the flip bucket ranging up to approximately 10 feet per second.  
(f) Completed.  
(g) A deflecter and transition in the curved super elevated, horizontal portion of the chute was developed to provide good flow distribution in the flip bucket. The flip bucket and plunge basin were developed to provide effective energy dissipation for flows up to 3,000 cfs and to prevent erosion in the area adjacent to the flip bucket for flows up to 12,000 cfs.  

(5342) SWIFT DAM SPILLWAY.  
(b) Laboratory project.  
(d) Experimental; for design.  
(e) A 1:42 scale model was constructed to determine necessary modifications to rehabilitate a 46-year-old chute spillway.  
(f) Completed.  

(5343) STRATIFIED FLOW.  
(b) Laboratory project.  
(d) Library study.  
(e) Library research is being made to determine the extent of work that is being done and has been done in this field. An abstract will be prepared and a proposal made for laboratory research. Particular interest is being given to regulation of reservoir releases and the design of outlet works to maintain desirable oxygen balance in streams.

(5345) YELLOWTAIL AMERYBEY DAM SPANNING CHANNEL.  
(b) Laboratory project.  
(d) Experimental; for design.  
(e) A 1:13 scale model was constructed to study the stilling basin and diffuser chamber in the intake to the resting pool of the spillway channel.  
(f) Completed.  
(g) A slotted baffle for the stilling basin was developed to dissipate the energy of the incoming flow and to provide good flow distribution from the diffuser chamber into the resting pool.  

(5346) GLEN ELDER DAM SPILLWAY.  
(b) Laboratory project.  
(d) Experimental; for design.  
(e) A 1:72 scale model is being used to study the hydraulic features of the spillway. The model contains 12 radial gate controlled spillway bays, the approach channel, surrounding topography, the hydraulic jump stilling basin and concrete lined apron, and a portion of the downstream channel.  
(f) Completed.  
(g) The flow in the approach area, through the bays, and in the downstream channel is smooth. The operation of the stilling basin is efficient. There is no excessive erosion of the downstream channel. No major changes to the initial design were recommended as a result of the model study.  
(h) Report in preparation.

(5347) LITTLE PANOCHE CREEK DETENTION DAM SPILLWAY INVADE STRUCTURE.  
(b) Laboratory project.  
(d) Experimental; for design.  
(e) A 1:15 scale model was built to study the flow conditions in a square, submerged vertical inlet and bend when stop logs are used to control the flow into the inlet.  
(f) Completed.  
(g) Report in preparation.

(5843) FORTINE MOUNTAIN DAM LOW LEVEL OUTLET WORKS.  
(b) British Columbia Hydro and Power Authority, W. F. Miles, General Manager.  
(c) International Rivers and Engineering Consultants, Ltd., 370 Dunsmuir Street, Vancouver 2, Canada.  
(d) Experimental; for design.  
(e) The outlet works will utilize two of the three 48-foot-diameter horseshoe-shaped diversion tunnels and will consist of two conduits through each of the two diversion tunnel plugs. An 84-inch Howell-Burger valve at the downstream end of each conduit is used to control the flow. Each conduit is designed to discharge 2,500 cfs at an approximate head of 450 feet but may discharge twice this amount in emergencies. A 1:14 scale model of the valves and the horseshoe-shaped tunnel has been constructed to develop the design of the air supply system to the valve, the optimum location of the valve, and the energy dissipating devices required in the diversion tunnel.

(5845) PATILLAS DAM SPILLWAY.  
(b) Puerto Rico Water Resources Authority.  
(c) Rafael V. Urrutia, Executive Director, Puerto Rico Water Resources Authority, San Juan, Puerto Rico.  
(d) Experimental; design.  
(e) The existing spillway has operated over the years and a considerable amount of erosion has occurred in the natural channel at the downstream end of the spillway. Numerous modifications to the original spillway have been ineffective in reducing the erosion. A 1:36 scale model is being constructed to develop the required modifications to eliminate this adverse operating condition.

(5846) CRYSTAL DAM SPILLWAY.  
(b) Laboratory project.  
(d) Experimental; design.  
(e) A 1:40 scale model of the spillway will be tested to investigate overall flow conditions. In addition, a structure at the end of the spillway tunnel will be developed which will function as a stilling basin for flows up to 11,000 cfs and as a flip bucket for higher discharges. Determination of discharge coefficients for a tangent gate on the spillway crest and the development of an atmospheric pressure spillway crest will be accomplished through the use of a 1:24 sectional model.

(5847) CRYSTAL DAM OUTLET WORKS.  
(b) Laboratory project.  
(d) Experimental; design.  
(e) A 1:12 scale model will be tested to evaluate the operation of the outlet works stilling basin. Two 3-foot 3-inch-square high-pressure slide gates discharge a maximum of about 2,000 cfs into the stilling basin under a head of approximately 200 feet. The energy dissipating efficiency of the basin and the downstream flow conditions will be investigated. Special attention will be given to the measurement and evaluation of hydrodynamic forces acting on various parts of the structure, particularly the cantilevered vertical concrete wall which separates the flow from the two gates.
(5848) EL VADO DAM OUTLET WORKS.

(b) Laboratory project.

(2) Experimental design.

(a) A 1:50 scale model was used to develop a flip bucket to minimize river channel erosion by dispersing sizable releases, and would allow small releases to be bypassed through an offset opening in the right wall. The model consisted of the dual gate controlled outlet works tunnel, the flip bucket, a section of the existing spillway, and a section of river channel.

(g) The recommended flip bucket contained two vertical confining walls and two sloping plane surfaces to intercept and direct the flow to the lip of the bucket. The best flow dispersion occurred for normal releases of from 2,000 to 4,000 cfs. Small releases are passed through an offset opening in the right wall.

(h) Report in preparation.

U. S. DEPARTMENT OF THE NAVY, DAVID TAYLOR MODEL BASIN.

Inquiries concerning the following projects should be addressed to the Comming Officer and Director, David Taylor Model Basin, Washington, D. C. 20007.

(1778) HYDRODYNAMIC NOISE.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Hydrodynamic research.

(i) Investigations of the characteristics of underwater noise associated with various hydrodynamic phenomena such as cavitation, bubble oscillations, surface disturbances, turbulence, and unsteady flow. Attention is now being given to measurement of spectra and space-time correlations of pressure fluctuations on walls adjacent to turbulent flows, such as curved plate boundary layer flows, turbulent boundary layers on buoyancy propelled bodies, and fully turbulent pipe flows.

(g) The effect of flush microphone size on measurements of boundary layer pressure fluctuations has been determined. The pressure distribution on the noses of various bodies of revolution have been examined. The pressure fields below multiple sources near free surface have been studied.


(1763) MATHEMATICAL SHIP LINES.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Theoretical research.

(e) Development of a suitable method for the mathematical determination of ship lines which can be applied to a wide variety of ship forms especially to those of modern design.

(f) Inactive.

(g) A method has been developed for the mathematical fairing of graphical lines. This is a first step toward the development of a flexible system of mathematical ship lines. Future work is directed toward the development of a system of mathematical lines which will permit the fairing of a hull form for a given set of parameters.

(1766) STUDIES OF THE SLAMMING OF SHIPS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental and theoretical basic research.

(e) Phase 1: Study of slamming phenomenon experienced by a ship in rough seas and to develop a method for predicting the frequency of occurrence of slamming as well as its severity.

Phase 2: Computations and measurements of the pressure distribution and impact forces on the bottom of slamming ship for the purpose of developing criteria to effect their reduction.

(f) Phase 1: Partially completed. Phase 2: Partially completed.

(g) Phase 1: Basic nature of ship slamming phenomenon has been clarified by conducting tests on a MARINER model. For MARINER model, initial step is to determine the slamming impact force and pressures on ship's bottom during slamming. A two-dimensional drop test to evaluate the effect of sectional form on impact pressure was conducted for three different ship forms ranging from extreme U to extreme V form. A comparison between theoretical and experimental results was made on impact pressure.


(2229) NEAR SURFACE EFFECTS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Hydrodynamic research.

(e) A mathematical study of the forces and moments acting on bodies due to the proximity of a free surface. The studies include both the case in which the surface is initially undisturbed and the case in which there are disturbances propagating at a distance. Experiments are being conducted to verify the theoretical developments.

(g) Methods were developed for computing the forces and moments acting on bodies of revolution, both due to waves generated by the body itself and to regular trains of waves. Experiments with spheric moving under waves largely confirmed the theory except in following seas. The damping forces for a submerged translating ellipsoid which is oscillating in any of its six degrees of freedom have been developed theoretically. The effect of tank walls has been evaluated theoretically as well.

Theoretical methods have been developed for the determination of wave resistance of floating bodies in steady motion from wave measurements along a parallel cut. The first and second order diffraction and radiation forces on a submerged two-dimensional circular cylinder have been developed and computations have been made. Analytic expressions have been obtained for arbitrary bodies relating the radiation and diffraction forces to each other.

For a submerged, translating, two-dimensional cylinder, it has been shown that second-order forces due to nonlinearity of the free surface boundary conditions are comparable to second order forces resulting from exact satisfaction of the body boundary conditions. Formulas have been derived for the sinkage and trim of ships moving in shallow water. These agree well with experiments except for speeds near to the shallow water critical speed. Formulas have been derived for the force and moment on a ship sliding parallel to a plane infinite rigid wall.

(2230) THEORY OF SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) A theoretical study, with experimental confirmation, of the factors affecting the seaworthiness of ships, for the purpose of developing procedures for predicting their motions.
(f) Theoretical results for ship motions based on the "thin-ship" idealization have generally proved to be either inaccurate or incomplete. Recent results from application of slender body theory have shown good agreement with experiments at zero speed of advance. The corresponding theory has been developed for non-zero speeds, but calculations have not yet been made, and it is not known whether the success at zero speed can be extended to the more general situation. Improved methods of testing ship models have been developed, and a study of frequency-response of a ship at a single speed can be determined from one test run. The form of the equations of motion have been obtained by any general variational approach. These equations are characterized by the appearance of convolution integrals involving the entire past history of the motion; they are free of the usual frequency-dependent coefficients. Tests have been conducted to characterize the dynamics of a ship relating the kernels of these convolution integrals to the common added mass and damping coefficients. A survey of ship-motion theory has been prepared, and corrections have been derived for the drift force and moment on slender ships in regular waves, at zero forward speed.

(2237) LIFTING SURFACE THEORY OF PROPellers.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical; applied research.
(e) Studies of the corrections on lifting line theory which arise from the finite extent of the blades.

(2971) FULL SCALE TRIALS AND MODEL PREDICTION CORRELATION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental testing and re-evaluation of existing test data.
(e) The accuracy of full scale power predictions from model test results depends upon the proper selection of the correlation allowance (Cp) to be used in model tests. The results of about 54 correlations of surface ship have been completed and published. The present target is the analysis of correlations submines, considering all trials conducted, and selecting those most acceptable to this program.
(g) Same analysis has been done in connection with submarines. Further analysis of the data derived from the surface ship trials is continuing.

(3204) UNSTEADY HYDROFOILS.

(d) The Bureau of Ships uses results of this work to design high speed, sea-going hydrofoil craft. Two experiments are being run to determine: (1) The unsteady forces on two-dimensional hydrofoils due to hydrofoil motions, surface waves, and cavitation. (2) The forces on surface-piercing struts as functions of profile, angle of yaw and ventilation.

computations are done, based on existing theories, to determine cavitation inception speeds of hydrofoils as functions of surface roughness.

(f) Tests were completed with a subcavitating, NACA 16-209 profile hydrofoil model in smooth water. For the surface-piercing strut study, profiles were determined and equipment is being designed and assembled. For the surface roughness study, computations are being made on the IBM 7030 computer.
(g) Reports will be written on the smooth water tests. Tests will be continued under waves. The surface-piercing struts will be tested. A report will be written on the surface roughness study.

(3285) HYDROELASTICITY PROBLEMS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and Theoretical Applied Research.
(e) Investigations to determine the flutter parameters of two-dimensional, two-degree of freedom hydrofoils. The effects of speed, frequencies, load distribution, surface, ventilation and waves are being studied. This work is related to Unsteady Hydrofoils (Reference No. 3284).
(g) Flutter tests have been conducted in the 36" Variable Pressure Water Tunnel and in the High Speed Towing Basin at various submergence depths. All tests have been performed with a NACA 16-209 hydrofoil. There was good flutter speed correlation between the tests carried out in the Water Tunnel and in the Towing Basin at a submergence of one chord length. The flutter speeds were noticed at submergences less than one chord length beneath the free surface.

(3286) SUPERCAVITATING PROPELLER DEVELOPMENT.
(5292) EXPLORATORY STUDIES AND PLANS AT DTMB FOR MODEL TESTS IN 3-DIMENSIONS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental; basic research.

(e) New seakeeping test facility is now in operation. Techniques for generating irregular short-crested seas and measuring the response of ship models at oblique headings is under development.

(g) Segmented wave generators provide the ability to produce oblique waves. Programming to individual wavemakers results in generation of confused seas of almost any nature. The rectangular basin offers opportunity to test in any relative heading to the waves and even in closed seas. Problems in analysis of results involve determination of the seaway (in the tank) as a function of frequency and direction. Ship motions in confused seas will be random in nature and will be analyzed by spectrum methods.

(5617) VENTILATED PROPELLER DEVELOPMENT.

(b) David Taylor Model Basin.

(d) Theoretical and experimental; applied research.

(e) Studies and design of ventilated propellers for operation at intermediate speeds.

(g) New instrumentation is being assembled for tests scheduled for this winter during which cavity pressures on an operating ventilated propeller will be measured. Some work showing the feasibility of low-speed ventilation on foils has been completed. This work will be reported this fiscal year (1966).

(5619) VERTICAL AXIS PROPELLER.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental and theoretical; applied research.

(e) Theoretical and experimental studies of performance characteristics of various types of vertical axis propellers.

(4426) DEVELOPMENT OF A LOW WAVE DRAG HULL FORM.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Basic research.

(e) To establish a series of basic hull forms which can be used as a guide to evaluate the merit of future high speed ship designs.

(g) Results of computations of 29 models of conventional hull form up to speed-length ratio of 5-0 has been reported.

(4427) A METHOD OF CALCULATING SPINDLE TORQUE OF CONTROLLABLE PITCH PROPELLERS.

(b) David Taylor Model Basin.

(d) Theoretical; applied research.

(e) A method of calculating the spindle torque of a controllable pitch propeller over the complete range of operating conditions and a theoretical investigation of the effect of various design parameters upon spindle torque. In order to calculate spindle torque at off design conditions, the off design performance of the controllable pitch propeller must first be determined.

(f) Inactive.

(g) A method of calculating the spindle torque at design conditions has been completed. The geometric problem of determining the effective distortion of blade sections at off design pitch settings has been solved. The solution has been programmed for the 7090 Computer.

(4428) COMPUTER SOLUTIONS OF FREE SURFACE FORCES.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Hydrodynamic research.

(e) The linearized potential problem of a body oscillating on the free surface will be solved directly on a digital computer by distributing pulsating sources over the surface of the body and calculating the required source density. The individual source potentials are chosen to satisfy the free surface boundary condition.

(g) The integral equations for the case of two dimensional bodies have been approximated by algebraic equations. Solutions have been obtained for heavy sway and roll motions of several bodies. Forces and moments have been calculated.

An extension to 3-dimensional solutions has been made for zero and infinite frequencies, and computations of added masses performed for actual ship hulls.

(4429) LATERAL FORCES.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Hydrodynamic research.

(e) The lateral force on a translating body which vertically cuts the free surface is being formulated theoretically. Two special cases are included: (a) If the draft is large compared to the length, the body is a strut with angle of attack. (b) If the draft is very small, the body corresponds to a yawed main ship.

(f) Suspended.

(g) An integral equation has been derived for the density of a surface distribution of dipoles, such that the boundary conditions are satisfied.

(4508) TURBULENT BOUNDARY LAYERS IN PRESSURE GRADIENTS ON ROUGH SURFACES.

(b) Laboratory project, David Taylor Model Basin.

(d) Theoretical and experimental; basic and applied research.

(e) Research in the behavior of rough surface turbulent boundary layer in pressure gradients leading to separation. Roughnesses are screens of various gages fastened to wall of wind tunnel. Pressure gradients are obtained by deforming the opposite wall. Velocity surveys and turbulence measurement will be made.

(g) Data have been obtained, with one wall roughness in three pressure conditions. Measurements are in progress to obtain smooth wall data under similar pressure conditions. Boundary layer velocity profiles are measured with a pitot tube and hot wire. Longitudinal turbulent intensities are measured with a hot wire. Measurements are made at numerous longitudinal points along the wall. Two reports on this work will be published in the near future.


(4610) SHIP WAKE SIMULATION STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental and theoretical; applied research.

(e) To produce ship wake distributions in a variable pressure water tunnel in order to determine the performance of propellers in non-uniform wake flows.

(f) Completed.

(g) A theoretical method has been obtained for determining the wire grid geometry necessary to produce arbitrary, steady, three-dimensional flows. Simple experimental confirmation of the method has been obtained.


(4611) STEADY-STATE FORCES ON SUPERNAVITATING AND VENTILATED HYDROFOILS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Theoretical and experimental; applied research.

(e) The linearized potential problem of a body oscillating on the free surface will be solved directly on a digital computer by distributing pulsating sources over the surface of the body and calculating the required source density. The individual source potentials are chosen to satisfy the free surface boundary condition.

(g) The integral equations for the case of two dimensional bodies have been approximated by algebraic equations. Solutions have been obtained for heavy sway and roll motions of several bodies. Forces and moments have been calculated.
To study the steady-state lift and drag characteristics of supercavitating hydrofoil configurations for application to hydrofoil craft and supercavitating propeller design.

Experimental determination of the lift and drag of various three-dimensional supercavitating hydrofoils is in progress. These include foils with 2-term, 5-term and flat-faced sections. The effects of aspect-ratio and taper are being investigated. Ventilation by blowing air through holes in the suction surface of the foil is used to extend the range of cavitation number. Future research includes the determination of two-dimensional lift and drag, studies of flap configurations and measurement of the force of tandem and cascade foil.*


PROPELLER AND BODY INTERACTION.

Bureau of Ships; David Taylor Model Basin.

Theoretical and experimental; applied research.

Study and development of design criteria for determining propulsion characteristics of submerged bodies and hydrofoil-supported craft.

Axial clearance between a submerged body of revolution and a stern propeller has been optimized on the basis of propulsive coefficient. A method has been developed for computing thrust deduction for submerged hydrofoil-propeller arrangements.

INVESTIGATION OF DUCTED PROPELLERS.

Bureau of Ships; David Taylor Model Basin.

Theoretical and experimental; applied research.

To develop a design method for ducted propellers and to conduct a parametric study of ducted propeller performance.

A theory of the ducted propeller with finite number of blades has been developed. From this theory, design methods will be developed and then a parametric study of ducted propeller performance will be conducted.


FUNDAMENTAL PROPERTIES OF SHIP ROLLING.

Bureau of Ships; David Taylor Model Basin.

Experimental and theoretical.

Though extensive studies of rolling have been made in recent years, a great deal remains to be learned concerning the fundamental properties of rolling for both surface ships and submarines. Areas which require additional research are (1) applicability of superposition principle for rolling motion especially in short crested waves, (2) unstable rolling motion in oblique regular and in irregular waves, (3) nonlinear roll behavior in rough seas, etc. In order to clarify the fundamental nature of rolling, forced oscillation tests as well as model tests in regular and irregular waves will be conducted. Parameters significant for roll will be investigated.

The effect of blade keels on roll magnitude and damping characteristics has been clarified through forced and free roll tests at various speeds of advance.

SERIES 60 - PROPELLER INDUCED VIBRATION.

David Taylor Model Basin.

Experimental; basic research.

Measurement of propeller induced vibratory forces to study the effect of fore and aft clearance in the propeller and the propeller-surface clearance of the clearwater type. The effect of number of blades and the tip clearance will also be determined. In addition, the pressure transmitted and shaft transmitted forces will be measured independently to determine the significance of each.

Technique and instrumentation capable of measuring the hydrodynamically transmitted propeller forces on ship models has been developed in the past few years. Using these measurements, obtained on various types of ship models, the optimal parameters for horizontal and vertical propeller clearances (position) will be established to minimize the effect of propeller forces on the ship structure. Improved stern and appendages designs to reduce these forces will be developed.

FLOW VISUALIZATION STUDIES.

Bureau of Ships; David Taylor Model Basin.

Experimental; applied research.

To visually determine in water the effect of boundary-layer growth and trailing edge geometry on separation, and the mechanism of vortex shedding, from stationary and oscillating hydrofoil shapes.

The hydrogen bubble visualization technique has been adopted to the 12-INCH water tunnel and preliminary flow studies have been made on a number of two-dimensional bodies. The experiments are being extended to study vortex shedding from stationary and oscillating bodies of different trailing edge geometries.

A report has been written and is under review titled "The Hydrogen-Bubble Flow Visualization Technique" G. E. Metalling TMB Report, Sept. 1965.

THE EFFECT OF GAS NUCLEI ON CAVITATION.

Bureau of Ships; David Taylor Model Basin.

Experimental; applied research.

To determine the effect of gas nuclei on the inception of cavitation.

Acoustic techniques to measure the distribution and size of nuclei are being studied, and one will be added to the water tunnel at DMD. Cavitation inception studies will be made for a simple body and propellers and the results correlated with gas nuclei content of the water.

PROPELLER OSCILLATING PRESSURE FIELD.

Bureau of Ships; David Taylor Model Basin.

Experimental; applied research.

To experimentally determine the oscillating pressure field about marine propellers and correlate these measurements with theoretical predictions.

Pressures have been measured on a flat plate parallel to the axis of two propellers, one a propeller of conventional design and the other of double blade thickness, in both uniform and non-uniform flow.

HYDRODYNAMICALLY EXCITED PROPELLER SINGING.

Bureau of Ships; David Taylor Model Basin.

Experimental; applied research.

To determine the characteristics of flow induced propeller singing and investigate methods to suppress singing.

Tests on a model propeller have demonstrated the feasibility of studying singing at model scale by suitable trailing edge modification. The investigation will be extended to determine the applicability of two-dimensional flow-excited vibration data to propeller blades and to study the influence of variations in trailing edge geometry and other design parameters, including the use of high damping alloys, on propeller singing.


CAVITATION INCEPTION ON A ROUGH SURFACE.

Bureau of Ships; David Taylor Model Basin.

Experimental and theoretical; applied research.

An investigation to determine the effect of surface roughness on cavitation inception.
The incipient cavitation number of various types of surface roughnesses mounted in boundary layers will be determined as a function of boundary layer parameters. Theoretical studies will attempt to establish scaling laws for cavitation.

The incipient cavitation number has been obtained for idealized three-dimensional roughnesses: cones, semi-spheres, and semi-cylinders. These roughnesses were mounted in a flat plate boundary layer. The cavitation number was determined as a function of the ratio of roughness height to boundary layer thickness. This work will soon be published as TMB Report 2104. Similar tests will be conducted on roughness that more closely simulate roughnesses found on ship hulls.

INTERACTION FORCES BETWEEN LIFTING SURFACES.

- Bureau of Ships; David Taylor Model Basin. Theoretical; applied research.
- A two-dimensional theory for determining the forces and moments acting on two lifting surfaces as one passes through the wake of the other will be developed. This theory will be applied to the prediction of hydrofoil appendage interaction forces on a ship.

RESEARCH ON CAVITY FLOW IN COMPLEX FLOWS. USE OF CAVITATION IN INDUSTRY.

- Bureau of Ships; David Taylor Model Basin. Theoretical and experimental research.
- A systematic series investigation will be carried out in order to determine the effect of basic hull form parameters on seakeeping qualities and speed loss at sea. Design criteria for ships with minimum motions, dry decks and high speed will be established.

SHIELD HULL FORM RESEARCH.

- Bureau of Ships; David Taylor Model Basin. Theoretical and experimental research.
- The wavemaking resistance theory is used in the design of practical ships forms with low resistance characteristics. Model experiments are conducted to supplement the theoretical analysis.

WAVE TUNNEL CAVITATION STUDIES.

- Bureau of Ships; David Taylor Model Basin. Theoretical and experimental research.
- Experiments are being performed to evaluate the differences between open and closed-jet tunnels, to evaluate the effect of a seaborne on cavitation inception on bodies and conventional propellers, and to evaluate propeller size and loading effects on supercavitating propellers. These tests are being performed in the TMB 24-inch open-jet water tunnel, and in the TMB 36-inch water tunnel with both open and closed-jet sections.

No results are available at this time since the first phase of testing has not been completed.

CAVITATION INCEPTION ON HYDROFOILS.

- Bureau of Ships; David Taylor Model Basin. Theoretical and experimental research.
- Project objective is to predict inception on practical hydrofoils from macroscopic principles.

Methods of pressure predictions on two-
dimensional hydrofoils have been examined and refined to secure the predicted minimal is obtained. Inception tests are being performed on two-dimensional foils by varying significant parameters.


SELF-EXCITED PLANNING VIBRATION.

BuShips, David Taylor Model Basin.
Experimental and theoretical basic research.
A study of the self-excited vibration of lifting shapes planing on a water surface. The purpose of the work is to define the conditions of incipient vibration and explain the mechanism involved.
Completed.

The effects of beam, sweepback, trim, load, speed, natural frequency and vibrational direction on the incipience of vibration of planing surfaces with large wetted aspect ratio were investigated. Experimental results are presented in non-dimensional form and correlated with results from a semi-empirical analysis. These results lead to the conclusion that the vibration under study was a dynamic instability involving an induced rise of the water surface ahead of the planing surface. Based on the results of this study, means of alleviation of the vibration are suggested.


ELECTRIC ANALOG TECHNIQUE FOR HYDROFOIL INDUCED DRAG.

BuShips, David Taylor Model Basin.
Basic research.
Modification and refinement of an electric analog technique for determining load distribution of non-planar lifting lines having minimum induced drag.

Analog results have been obtained for some simple configurations. Comparison with analytical computations indicate that good accuracy is possible.

HIGH SPEED TESTS OF BuShips "PARENT HYDROFOIL."

BuShips, David Taylor Model Basin.
Experimental research.
Tests in the NASA High Speed Hydrodynamics Facility to determine the lift and drag of the BuShips "Parent Hydrofoil" at high speed.
Tests in the 45-70 knot range are complete. Agreement with lower speed results is acceptable where the cavity is similar; however, there is considerable variation of cavity ventilation with speed.

For sponsored projects see the following:

Sound Radiated From a Turbulent Boundary Layer.
Interaction of Distributed Surface Vibrations with an Adjacent Boundary Layer Flow.
Ship Resistance in Irregular Waves.
Hydrodynamics of Ship Slamming.
Wake Characteristics for Bodies of Revolution with Momentum Addition.
Theoretical Study of Hydrofoil Flutter Characteristics.
A Study of Viscous Flow Past a Ship.
Theoretical and Experimental Running Under Sinusoidal Surface Waves.
Turbulent Flow Transition Near Solid and Flexible Boundaries.
Research on Hybrid Theory.
Turbulence Characteristics of the Wake of a Body of Revolution.
A Photomicroscopic Investigation of Non-Newtonian Flow at Low Reynolds Numbers.

A Theoretical and Experimental Study of the Fluid Motion About a Flat Plate Rotated Impulsively From Rest to a Uniform Angular Velocity.
Influence of Micro Bubbles on Flow Noise.
A Study of Impact Cavitation Damage.
Structure of Turbulence of Non-Newtonian Flows.
A Study of Flow Noise in a Non-Newtonian Fluid.
A Study of Surface Sealants to Reduce Cavitation Damage.
Hydrodynamic Flutter on Supercavitating Hydrofoils.
TPC Headform Study.
Jet Flap Studies.
Non-Newtonian Boundary Layer.
Impact Cavitation Damage II.
Dumel Flow Test with Cavitating Bubbles (5770).
Hydrodynamics of Ship Anti-Roll Tanks.
Vibration of Hydrofoil Structure.
Monograph of Hydroelastic Problems of Foils.
Supercavitating Hydrofoil Theory.
Estimation of Stability Derivatives and Induces Variation in Ship Forms, and Comparison with Experimental Results.
Acoustic Properties of Bubbles in Pressure Fields.
Structure of Turbulent Waves with Asymmetries.

ROUGH WATER TAKE-OFF RESISTANCE OF HYDROFOIL SHIP HULLS.

Unsteady Loads on Ducted Propellers and Nozzles.
Propeller-Singing Phenomenon as a Self-Excited Vibration System.
Propeller-Suction Interaction.
Unsteady Loads on a Marine Propeller.
Dimension Effects on Hydrophone Output in the Near Field.
Acoustic Excitation of Flat Plates by Turbulent Flow.

DRAG FORCES IN VELOCITY GRADIENT FIELDS.

Low-Aspect-Ratio Jet-Flap Control Surfaces.
Prediction of Ship Slamming Loads.
The Effect of Flow Separation From the Hull on the Stability of a High Speed Submarine.
Determination of Ship Wave Resistance.
Effect of Polymer Coating on Drag Reduction.
Effect of Molecular Weight and Segmental Constitution on Drag Reduction.

TURBULENCE MEASUREMENTS IN LIQUIDS.

PHILADELPHIA NAVAL SHIPYARD, Naval Boiler and Turbine Laboratory.

HIGH PRESSURE-TEMPERATURE WATER FLOW METER CALIBRATION.

Bureau of Ships; Philadelphia Naval Shipyard (Naval Boiler and Turbine Laboratory).
Mr. J. W. Harlock, Head, Applied Physics Division, Naval Boiler and Turbine Laboratory, Phila. Naval Shipyard, Phila. 12, Penna.
Experimental; applied research.
A facility is available for calibrating with water at pressures and temperatures up to 1500 psi and 600 F respectively. Capacity is 100 gpm at maximum pressure and temperature and greater at lower pressures and temperatures. After flowing through the metering section, the water is cooled and weighed. The facility is also used to investigate and verify orifice meter coefficients at pressures and temperatures above those at which the coefficients in use were

PHILOMAT.
established. A number of flow meters which measure the flow in nuclear reactor loops have been calibrated.

(f) Inactive.

(g) A limited amount of test data indicate good agreement between orifice flow rates obtained by calibration to high pressures and temperatures and those obtained by extrapolating from cold water calibrations. Other meter tests show the need to include suitable corrections for change in shape, size, density, etc.

4001 HIGH PRESSURE STEAM AND WATER FLOW TESTS.

(b) American Society of Mechanical Engineers.

(c) Mr. J. W. Murdock, Head, Applied Physics Division, Naval Boiler and Turbine Laboratory, Philadelphia Naval Shipyard, Philadelphia, Pa.

(d) Experimental; applied research.

(e) Although the ASME Research Committee on Fluid Meters has sponsored many fundamental research programs dealing with the development of basic constants used with primary elements, hardly any of this work has been done on steam flow at high pressures and temperatures. Neither has research been done on high temperature water flow. Analysis of many tests indicates that the basic calibrations obtained with low temperature water (air and gas) could be extrapolated with high accuracy to the measurement of high pressure and high temperature steam and water flow provided suitable corrections were made for the shape in the size and shape of the primary element, the pipe, and the fluid. This procedure has been experimentally verified for steam up to 2000 psi and 1050 F and for water to 2500 psi and 500 F.

(f) Completed.

(g) Nozzles and orifices were calibrated with water at 240 °F, 2200 psia, and with steam at 1050 °F, 2000 psia. Pipe Reynolds numbers averaged 500,000 for the water and 4,000,000 for the steam were generally in agreement with ASME predicted coefficients. Two and a quarter percent (1/2/%) chromolybdenum steel proved unsatisfactory for the steam nozzles showing rusting and pitting after less than 10 hours. Type 430 stainless steel was substituted and was satisfactory.


5286 MEASUREMENT OF ACOUSTIC VELOCITY OF STEAM.

(b) Joint research project, Naval Boiler and Turbine Laboratory and Office of Naval Research.

(c) Mr. J. W. Murdock, Head, Applied Physics Division, Naval Boiler and Turbine Laboratory, Philadelphia, Pa.

(d) Experimental; basic research.

(e) Objective is to obtain precise knowledge of acoustic velocity values in liquid-vapor and vapor phase. Data will be obtained with steam pressures and temperatures up to 5000 psia and 800°F respectively.

U. S. NAVAL ORDNANCE LABORATORY.

4657 THE HYDROBALLISTICS OF WATER ENTRY.

(b) Bureau of Naval Weapons, Department of the Navy.

(c) Commander, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland.

(d) Experimental, theoretical, basic and applied research.

(e) The purpose is to study high velocity water entry as related directly or indirectly to the behavior of missiles. The study includes the stability and forces during the entry, velocity development and pressure, and the missile trajectory. A wide range of developmental and research configurations and of environmental conditions are investigated. The missiles are launched from gas or powder guns.

A large tank facility, under construction, is scheduled for completion in early 1966. This facility, which was designed for use with large, high-speed missiles, will be supplemented by the smaller, lower-speed tank now in operation. Both tanks are suited to experimental projects such as water-entry, water exit, and trajectory studies, and both permit atmospheric pressure reduction for water entry and hydrodynamic scaling for model studies.

(g) Data have been obtained on the water-entry whip of missiles with cone noses. These include preliminary experimental results and calculations using an unsophisticated mathematical model.


U. S. NAVAL ORDNANCE TEST STATION.

4002 MISSILE BEHAVIOR DURING WATER EXIT.

(b) Bureau of Naval Weapons, Navy Department.

(c) Commander, U. S. Naval Ordnance Test Station, Attn: John Q. Waugh, Code P0874, 3202 E. Foothill Blvd., Pasadena, California.

(d) Experimental; basic research.

(e) The objectives of this project are as follows: (1) To study missile water-exit behavior and associated phenomena under different conditions to determine if problems exist in missile water-exit technology and to establish scaling techniques for modeling missile water-exit behavior. (2) To evaluate qualitatively the inherent value of slender-body theory in predicting the underwater and water-exit behavior of an underwater launched missile in the presence of various sea states. The following facilities were made available to the California Institute of Technology, Pasadena, California: (1) A series of tests was made to determine the added mass of a 1-inch-diameter steel sphere accelerated vertically upward from rest along the axis of Lucite cylinders filled with water and the results correlated with ideal fluid theory. No free surface effects were involved. The sphere was accelerated electromagnetically and the acceleration was sufficiently high so that essentially potential frictionless flow obtained. Eight cylinders were used whose inside diameters ranged from 1.11 to 4.45 inches. The agreement between experiment and theory was very good. (2) Further tests were made to determine the effect of water surface proximity on the added mass of a 1-inch-diameter steel sphere accelerated vertically upward.
from rest in open water and the results correlated with ideal fluid theory. Again, essentially frictionless potential flow obtained during the acceleration regime. The agreement between experiment and theory was very good and the results indicate that surface proximity has practically no effect on the added mass until the sphere center is about two diameters from the surface. For lesser depths, the added mass decreases with depth. Several techniques for retrieving photography were developed and used in the studies described above. In the first, missile position-time data are obtained from measurements of photographs of the virtual image produced in a precision-ground sphere by a timed stroboscopic point-source lamp. In the second, a rotating circular film disk is covered with sector-shaped exposures, using a timed stroboscopic lamp. In the third, the previously described techniques are combined to obtain data simultaneously.


(4434) SHROUDED PROPELLER DESIGN.

(b) Bureau of Naval Weapons, Navy Department. Commander, U. S. Naval Ordnance Test Station, Attn: Mr. F. J. Reynolds, Code P8074, 3202 East Foothill Blvd., Pasadena, Calif.

d) Theoretical; applied research.

e) This study is useful in the design of flow fields induced by shrouded propeller models. This will lead to a pump-jet configuration which includes boundary layer, central body and wide blade effects. The analysis will also allow for a pump-jet design at any level of complexity based on calculations of the induced fluid. This analysis is considered a summary estimate of the particle velocity profile.

(1) Computer programs are available which compute the average radial velocities induced by a finite bladed propeller operating in a uniform or non-uniform flow field. (2) A computer program is available which determines the axial velocities at the propeller plane induced by an average shroud load distribution. These velocities can be computed at locations both on and off the cylindrical vortex surface representing the shroud. The above computer programs will give a preliminary design procedure for an open water or wake adapted shrouded propeller model, neglecting central body effects.

(h) "Summary of Shrouded Propeller Theory," to be published.

(4668) NON-NEWTONIAN FLUIDS.

(b) Bureau of Naval Weapons, Department of the Navy. Commander, U. S. Naval Ordnance Test Station, Pasadena, Calif.

d) Experimental; basic research.

e) The turbulent flow characteristics of dilute solutions of various high polymers are being studied to understand why they often display anomalous flow behavior.

(f) Pipe flow tests and chemistry studies are being made of high polymers which seem to produce the turbulence.


(4682) A METHOD FOR COMPUTING TURBULENT BOUNDARY LAYERS BASED ON THE LAW OF THE WALL AND THE LAW OF THE WAKE.

(b) Bureau of Naval Weapons, Navy Department. Commander, U. S. Naval Ordnance Test Station, Attn: Mr. David M. Nelson, Code P8074, 3202 E. Foothill Boulevard, Pasadena 6, California.

d) Theoretical; applied research.

e) A method for computing turbulent boundary layers based on the law of the wall and Coles' law of wake is under development. This method is applied to two dimensional bodies and to bodies of revolution in axill-symmetric flow where the boundary layer thickness is not necessarily small compared to the body radius. A simultaneous solution of the momentum integral equation and the energy integral equation is carried out assuming the mean velocity profiles are given by a universal, two-parameter representation as suggested by Coles. The computational procedure will be programmed for an IBM computer. All theoretical work, computer programming, and comparisons with experimental data have been completed. A final report is in preparation.

(4900) UNDERWATER GAS-JET PROPULSION STUDY.

(b) Bureau of Naval Weapons, Dept. of the Navy. Commander, U. S. Naval Ordnance Test Station, 3202 East Foothill Blvd., Pasadena 6, Calif., Attn: H. V. L. Patrick or T. G. Lang, Code P5006.

d) Experimental; applied research.

ej) The thrust and efficiency of a submerged supersonic gas-jet propulsion system will be studied with a solid propellant grain generating hot gas at 4,000 psig exhausted through four nozzles along its afterbody. The efficiency of the momentum to gas flow will be measured in a wind tunnel. The surrounding water will be studied in an effort to increase the normally low propulsion efficiency of high speed jets.

(g) Propulsion tests at speeds to 45 knots in a ring channel have been successfully completed.

(5381) BASE-VENTED TORPEDO STUDY.

(b) Bureau of Naval Weapons, Dept. of the Navy. Commander, U. S. Naval Ordnance Test Station, Attn: H. V. L. Patrick or T. G. Lang, Code P5006, 3202 E. Foothill Boulevard, Pasadena 6, California.

d) Experimental; applied research.

ej) The drag of several truncated torpedo models with air exhausted through their bases is measured as a function of gas flow rate, water tunnel speed, and angle of attack. Cavitation pressure is also measured.

(f) The drag of all models remained the same as that of a streamlined profile truncations up to 40% of the maximum diameter, one of the models was fully base vented.

Bureau of Naval Weapons, Dept. of the Navy.
Commander, U. S. Naval Ordnance Test Station, Attn: Mr. David M. Nelson, Code P8074, 3202 E. Foothill Blvd., Pasadena 8, Calif.

Theoretical; applied research.
The Douglas Aircraft Company computer programs for the solution of the potential flow about bodies of revolution, where the bodies are represented by a surface source density, are being used to theoretically determine hydrodynamic coefficients for bodies of revolution. A comparison between the theoretical values and the experimental values for blunt base bodies will be made first. Depending on the success of the method for these blunt base bodies, the method will then be applied to streamlined bodies having thick boundary layers on the aft half of the body. This will be done by a combination of boundary layer calculations and potential flow calculations to obtain, if possible, a reasonable theoretical model of the flow about such bodies.

Inclusion of the hub boundary condition in lifting surface propeller design.
Bureau of Naval Weapons, Dept. of the Navy.
Commander, U. S. Naval Ordnance Test Station, Attn: Mr. David M. Nelson, Code P8074, 3202 E. Foothill Blvd., Pasadena 8, Calif.

Theoretical; applied research.

Inclusion of the hub boundary condition in lifting surface propeller design is under development. The hub is represented by a surface source distribution by utilizing a recently developed Douglas potential flow computer program for three-dimensional bodies in an arbitrary onset flow. The onset flow to the hub is computed from the singularity distributions representing the blade surfaces. This onset flow and the hub geometry is then input to the Douglas program which yields the hub induced flow at the propeller blades. The camber lines and angles of attack of the added sections are all computed including the hub induced flow.

EFFECT OF POLYMER ADDITIVES ON SEPARATED FLOW.
Bureau of Naval Weapons, Dept. of the Navy.
Commander, U. S. Naval Ordnance Test Station, Attn: Mr. David M. Nelson, Code P8074, 3202 E. Foothill Blvd., Pasadena 8, Calif.

Theoretical; applied research.
The diffuser efficiency is evaluated on non-conical diffusers exhibiting transitory and fully established separated flow using high molecular weight polymer solutions. The purpose is to evaluate what effect polymer additives will have in separated flow regimes as a function of Reynolds number and solution concentration.
The diffuser efficiency of a conical diffuser with a transitory separated flow regime is improved by approximately 11%. These results were obtained when using J2-FF guar gum solutions at concentrations of 1/64 to 1/0% and Reynolds numbers greater than fifty thousand but less than eighty thousand.

U. S. DEPT. OF THE NAVY, OFFICE OF NAVAL RESEARCH.
For sponsored projects see the following:

Project  Page
Problems in Hydrodynamics.  4
Hydrodynamics of Turbomachines.  6
Experimental Studies of Unsteady

DETERMINATION OF THE HYDRODYNAMIC COEFFICIENTS OF BODIES OF REVOLUTION USING THE DOUGLAS POTENTIAL FLOW PROGRAMS.
<table>
<thead>
<tr>
<th>Project</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity Flow. Research on Cavitation Ring Wings.</td>
<td>6</td>
</tr>
<tr>
<td>Annular Nozzle Cavitation Effect.</td>
<td>7</td>
</tr>
<tr>
<td>Turbulent Machine. Dynamic Interaction Between Ships.</td>
<td>11</td>
</tr>
<tr>
<td>1094: Ships of Minimum Resistance.</td>
<td>13</td>
</tr>
<tr>
<td>1047: Pressure Distribution on Semi-Submerged Oscillating Bodies.</td>
<td>15</td>
</tr>
<tr>
<td>4112: The Discharge of Major Western Rivers in Relation to the General Circulation of the Atmosphere.</td>
<td>17</td>
</tr>
<tr>
<td>5412: Hydrometeorology of Western River Basins.</td>
<td>21</td>
</tr>
<tr>
<td>5163: Theoretical Study of Hydrofoil Flutter Characteristics.</td>
<td>24</td>
</tr>
<tr>
<td>5564: Radar Investigation of Dynamics of Turbulent Water Motion in Waves.</td>
<td>25</td>
</tr>
<tr>
<td>5776: Theoretical Investigation of Hydrofoils Running Under Sinusoidal Surface Waves.</td>
<td>25</td>
</tr>
<tr>
<td>5685: Study of Long Wave Penetration in Deep Narrow Fjords (Iceland).</td>
<td>28</td>
</tr>
<tr>
<td>Measurement of Turbulence in Flowing Water.</td>
<td>28</td>
</tr>
<tr>
<td>79: Cavitation.</td>
<td>37</td>
</tr>
<tr>
<td>1875: Characteristics of Stable Eddies.</td>
<td>38</td>
</tr>
<tr>
<td>2091: Research of Ship Theory.</td>
<td>38</td>
</tr>
<tr>
<td>2528: Investigation of Surface Roughness.</td>
<td>38</td>
</tr>
<tr>
<td>2541: Development of Instruments for Use in Analyzing Aperiodic Signals.</td>
<td>38</td>
</tr>
<tr>
<td>5074: Wake of Zero Momentum Flux.</td>
<td>38</td>
</tr>
<tr>
<td>1419: Superimposing Bodies of Revolution.</td>
<td>39</td>
</tr>
<tr>
<td>5907: Self-Preservation Tendency in Turbulent Shear Flows.</td>
<td>40</td>
</tr>
<tr>
<td>2801: Interaction of Waves with Submerged and Placing Bodies.</td>
<td>46</td>
</tr>
<tr>
<td>3444: Effects of Basin Geometry and Viscous Damping of the Amplitude of Resonant Oscillations in Harbors.</td>
<td>47</td>
</tr>
<tr>
<td>4160: Motion of Submerged Bodies Below a Free Surface.</td>
<td>47</td>
</tr>
<tr>
<td>4983: Determination of the State of the Art in Two-Phase Gas-Liquid Flow Phenomena.</td>
<td>48</td>
</tr>
<tr>
<td>5780: Analytical and Experimental Investigation of Flow Oscillations in a Closed Loop with Transparent, Parallel, Vertical, Heated Channels.</td>
<td>49</td>
</tr>
<tr>
<td>5864: Separated Flow About Lifting Bodies.</td>
<td>52</td>
</tr>
<tr>
<td>5120: Office of Naval Research ATMOSPH:Inter-Action and Wave Project.</td>
<td>57</td>
</tr>
<tr>
<td>5593: Investigation of Laminar Boundary Layer and Transition in the Vicinity and Between Sectioned Cells.</td>
<td>64</td>
</tr>
<tr>
<td>5594: Grid Turbulence in Dilute Polymer Solutions.</td>
<td>65</td>
</tr>
<tr>
<td>5595: Turbulence Measurements in the Viscous Sublayer.</td>
<td>65</td>
</tr>
<tr>
<td>5596: Theoretical Investigation of Turbulence Flow of Non-Newtonian Media.</td>
<td>65</td>
</tr>
<tr>
<td>2144: Experimental and Analytical Studies of Hydrofoils.</td>
<td>69</td>
</tr>
<tr>
<td>3513: Flow About Bodies at Small Cavitation Numbers.</td>
<td>70</td>
</tr>
<tr>
<td>4700: Oscillating Lift and Drag Forces on Ventilated Hydrofoils in Regular Waves.</td>
<td>70</td>
</tr>
<tr>
<td>4595: A Study of Impact Cavitation Damage.</td>
<td>71</td>
</tr>
<tr>
<td>5690: Influence of Micro Bubbles on Flow Noise.</td>
<td>71</td>
</tr>
<tr>
<td>5796: Impact Cavitation Damage II.</td>
<td>72</td>
</tr>
<tr>
<td>5922: Mechanic of Sediment Transport by Waves and Currents.</td>
<td>74</td>
</tr>
<tr>
<td>5923: The Circulation of Water on Beaches.</td>
<td>74</td>
</tr>
<tr>
<td>5925: Wave Attenuation.</td>
<td>74</td>
</tr>
<tr>
<td>5926: Deep Sea Tides.</td>
<td>74</td>
</tr>
<tr>
<td>4256: Investigation of Surface-Piercing Fully Ventilated Dihedral Hydrofoils.</td>
<td>76</td>
</tr>
<tr>
<td>4917: Mechanisms Involved in Wind-Generated Waves.</td>
<td>76</td>
</tr>
<tr>
<td>5453: Studies of Large Waves.</td>
<td>76</td>
</tr>
<tr>
<td>4227: Smooth Water Behavior of Surface-Piercing Hydrofoil Vessel.</td>
<td>77</td>
</tr>
<tr>
<td>The Boundary Layer Under Progressive and Standing Waves.</td>
<td>77</td>
</tr>
<tr>
<td>Investigate Gain in Water Speed Obtained by Coupling Amphibious Craft.</td>
<td>78</td>
</tr>
<tr>
<td>Hydrodynamic Track Propulsion.</td>
<td>78</td>
</tr>
<tr>
<td>Publication of Amphibian Research Studies.</td>
<td>79</td>
</tr>
<tr>
<td>Effect of Natural Roughness on the Pressure Fluctuations in a Turbulent Boundary Layer.</td>
<td>81</td>
</tr>
<tr>
<td>Special Problems in Fluid Dynamics.</td>
<td>85</td>
</tr>
<tr>
<td>The Effect of Flow Separation From the Hull on the Stability of a High Speed Submarine.</td>
<td>93</td>
</tr>
<tr>
<td>Hydrodynamics of Rotating Liquids.</td>
<td>101</td>
</tr>
<tr>
<td>Measurement of Acoustic Velocity of Steam.</td>
<td>156</td>
</tr>
<tr>
<td>Flow Over Hydropropic Materials.</td>
<td>156</td>
</tr>
<tr>
<td>Motion Around a Body In a Stratified Fluid.</td>
<td>166</td>
</tr>
<tr>
<td>Wave Propagation In a Turbulent Liquid.</td>
<td>166</td>
</tr>
<tr>
<td>Turbulent Shear Flow through Compliant Walled Tubes.</td>
<td>166</td>
</tr>
<tr>
<td>Wind Action On Pre-Existing Waves.</td>
<td>166</td>
</tr>
<tr>
<td>Response of a Density-Stratified Liquid to a Source or Sink Impulse.</td>
<td>166</td>
</tr>
<tr>
<td>Interaction Between Long Waves and Superposed Short Waves.</td>
<td>166</td>
</tr>
<tr>
<td>Damping of Shallow Waves: Summary of Available Information.</td>
<td>166</td>
</tr>
<tr>
<td>TENNESSEE VALLEY AUTHORITY, Engineering Laboratory.</td>
<td></td>
</tr>
<tr>
<td>Inquiries concerning the following projects should be addressed to Mr. Rex A. Elder, Director, TVA Engineering laboratory, P. O. Box 37, Norris, Tenn. 37828.</td>
<td></td>
</tr>
<tr>
<td>LOW POWER VHF RADIO GAGES FOR REPORTING RAINFALL AND STREAM LEVEL DATA.</td>
<td></td>
</tr>
<tr>
<td>Development.</td>
<td></td>
</tr>
<tr>
<td>Transistorized radio components powered from nickel cadmium batteries, which will be charged by thermoelectric generators and/or solar cells, will be used. Data in gray code will be transmitted by audio tone pulses. Untainted operation of long duration is a primary objective in the design of these stations.</td>
<td></td>
</tr>
<tr>
<td>Construction of station components is under way.</td>
<td></td>
</tr>
<tr>
<td>MEASUREMENT OF KAPLAN TURBINE DISCHARGES USING OTT COMPONENT CURRENT METERS.</td>
<td></td>
</tr>
<tr>
<td>Turbine discharge rating equipment, using the Ott component type current meters, has been developed to measure the discharge of turbine units. Twenty-seven current meters mounted on three frames are used to simultaneously measure velocities in the three interse of each unit by either the step or integration method. Measurements made at several fixed loads are employed to calibrate the Winter-Kennedy scroll case pressure taps. The Winter-Kennedy taps are used with suitable measuring equipment to determine the discharge for any turbine loading.</td>
<td></td>
</tr>
<tr>
<td>Measurements have been taken at four main river hydro dams, Wilson, Kentucky, Guntersville and Wheeler. Forty-one turbine units at these facilities have been measured.</td>
<td></td>
</tr>
<tr>
<td>BASIC STREAM AND RESERVOIR HEAT BUDGET STUDIES.</td>
<td></td>
</tr>
<tr>
<td>Experimental; for basic and applied research.</td>
<td></td>
</tr>
</tbody>
</table>
| This is a study to develop the basic tem-
perature prediction equations for a stream or reservoir into which a volume of water at a different temperature is injected. All known variables such as stream flow characteristics, meteorological conditions and thermal characteristics will be included. Theoretical studies, field tests, and possible laboratory studies will be combined to produce verified equations.

Additional data were collected during the year and the measured water temperatures are being compared to the predictions produced by the basic heat budget equation. Several particular solutions, involving the equilibrium temperature concept, have been obtained from the basic differential equation relating hydraulic, meteorologic, and thermal parameters, and an intensive study of individual heat budget terms has been made to determine the most reliable means of evaluating each term. Five sets of field data have been collected for evaluating the accuracy of the prediction equations.

NICKAJACK PROJECT.

Studies using the 1:150 horizontal by 1:90 vertical scale distorted model of the Nickajack Project were completed and a 1:100 scale undistorted model was constructed for study. The 1:100 scale model represents an area of approximately 2 miles in length by 1 mile in width of the river site. In addition to the apron studies, the 1:100 scale undistorted model was used to develop information on the terminal wave dimensions, bank protection designs and the design of various other features in the river areas immediately upstream and downstream from the dam structures.

Thirteen internal reports have been issued to date.

NICKAJACK PROJECT—LOCK MODEL.

A 1:25 scale model of the NICKAJACK Project was used to adapt the multipurpose filling and emptying system to this size chamber. The proposed intake and outlet structures for both the main and 600' x 110' auxiliary locks are being tested by incorporating them with the main chamber model and a simplified model of the auxiliary chamber. The report issued on the results of look chamber studies, lock intake systems studies and the development of the 600-foot-lock outlet system.

NICKAJACK PROJECT—VALVE-CULVERT MODEL.

A 1:10 model of an existing lock filling valve, with related culvert appurtenances, is being used to determine the nature and origin of the hydrodynamic forces which act on reversed tainter lock filling valves. The model was specifically designed to reproduce the transient conditions existing while the valve is operating, and designs are being compared with respect to their reaction to hydrodynamic forces.

NICKAJACK PROJECT—SPILLWAY MODEL.

Studies were conducted on a 1:35 scale model of three of the ten spillway bays of the Nickajack project. Tests were for the purposes of determining the spillway capacity under the maximum design head, developing the optimum upstream pier shape, and finding a relatively simple yet effective apron design. Such factors as water surface profiles through a bay and pressures on the piers under adverse gate openings were also investigated.

An upstream pier shape with a relatively sharp nose was found to decrease vortex action upstream from the gate for gated discharges. A simple horizontal spillway apron with a dented end sill minimized scour and produced acceptable wave action.

MODEL FLUME TO BE USED TO STUDY THERMAL DENSITY RECIRCULATION PROBLEMS.

A model flume was constructed of transparent material and equipped with circulating pumps to simulate a typical steam power plant's condenser intake and outlet system. The flume is approximately 100 feet in length and 9 inches deep by 12 inches wide. The basic intent is to develop and prove the analytical equations for flows in the vicinity of a steam plant or in similar areas.

Data on lengths and depths of warm wedges near the intake and outlet, for various river and intake flows and for various initial density differences have been obtained, but have not been analyzed.

WALL-PRESSURE FLUCTUATIONS IN A CAVITATING TURBULENT SHEAR FLOW.

See Project 5709, University of Kansas, page 45.

NICKAJACK PROJECT—TURBINE INTAKE GATE STUDIES.

Tests on multi-leaf gates have indicated an interdependence of the design of the lifting beam and gate when the gates are to be positioned in flowing water. A 1:36 scale model of a complete turbine intake and a 1:15 scale model of one bay were used in tests conducted to develop an operable lifting beam and gate design for the Nickajack Project. Double leaf gates 18' x 18' are to be used.

A lifting beam and gate design was developed which solved the basic problems of successfully lowering and raising the gate and beam in flowing water.

An internal report of these results was issued.

WATER QUALITY STUDY; MEASUREMENTS OF THE STRUCTURE OF STRATIFIED RESERVOIRS.

Effective and optimum water resource development requires knowledge of the yearly cyclic changes of the various properties of the water in deep, stratified reservoirs. This study will measure current velocities, dissolved oxygen content, temperature, conductivity, and density as a function of depth at various stations in Fontana Reservoir during the stratinification season. All measurements are performed from a barge securely moored to each bank of the lake. Currents are measured with a deep water isotopic current analyzer which utilizes a radioactive tracer material and which is capable of measuring horizontal currents from 0.005 to 1 fps. Oxygen content is measured from water samples with a simplified Winkler method. Temperatures are measured continuously in situ with a resistance-type thermometer. Conductivity and water densities are measured in water samples with a capacitance instrument and precision hydrometer, respectively. Depth is measured continuously with a pressure transducer.

A thermal stratification causes selective withdrawal from the reservoir. The thickness and speed of the flowing layer are being established. The equipment will be used in other reservoirs which have different outlet structures.

TIMS FORD PROJECT.

Experimental; applied research.
(e) A 1:100 scale model will be used to determine the characteristics of the proposed flip bucket spillway. Particular attention will be given to erosion patterns and means of limiting scour.

TENNESSEE VALLEY AUTHORITY, Hydraulic Data Branch.

Inquiries concerning projects should be addressed to Mr. James W. Beveridge, Chief, Hydraulic Data Branch, Tennessee Valley Authority, Knoxville, Tenn. 37902.

(756) EVAPORATION IN THE TENNESSEE BASIN.

(d) Field investigation; applied research.
(e) To provide data for estimating reservoir losses and derive a general rule, applicable to the basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.
(h) Results published in monthly and annual bulletins, "Evaporation in Tennessee River Basin" (Project 768).

(768) PRECIPITATION IN TENNESSEE RIVER BASIN.

(d) Field investigation; basic research.
(a) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.

(797) RESERVOIR AND STREAM TEMPERATURES.

(d) Field investigation; basic research.
(e) Study of water utilization and water movement as concerns industrial and storm plant locations and stream pollution. Variations in temperature from surface to bottom in selected reservoirs are determined by sounding, and by continuous recording gages in selected natural streams. Periodic observations are made at gaging stations.

(771) GALLERY DRAINAGE IN LARGE DAMS.

(d) Field investigations; design.
(e) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

(779) MAXIMUM POSSIBLE PRECIPITATION IN TENNESSEE VALLEY.

(b) Cooperative with U. S. Weather Bureau.
(d) Theoretical; applied research.
(e) Hydrometeorological analysis of large storms with upward adjustments of controlling factors to maximum limits as applied to the Tennessee Valley and sub-basins.
(g) Results to be published as one of current series of hydrometeorological reports by the U.S.W.S. and cooperating agencies.

(780) PERIODIC EVALUATION OF GROUND-WATER STORAGE.

(d) Theoretical; operation.
(e) By analysis of current records of stream discharge, the volumes of runoff in ground-water and channel storage are determined for use in operation of multi-purpose reservoirs.
(h) Results reported weekly within the organization.

(785) SEDIMENTATION OF EXISTING RESERVOIRS.

(d) Field investigation; basic research.
(e) Selected ranges in reservoirs are probed and sounded, vegetative and bottom samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.
(r) Selective cutting delayed, now scheduled for 1965-66.

(g) During the 20-year period 1941-1960, the cover improvement and erosion control in the watershed resulted in a decrease in surface runoff volumes and an increase in groundwater discharges, marked reductions in summer and winter rainfall discharges, a reduction in overland surface velocities, a prolongation of the period of draining of surface runoff from the channel system, an appreciable decrease in water yield, and a 96 percent reduction in sediment load.

(4011) NORTH FORK CITICO CREEK RESEARCH WATERSHED.

(b) Project conducted in cooperation with U. S. Forest Service.

(d) Field investigation; basic research.

(e) To determine the effects of normal, high-standard National Forest Multiple-use management upon the hydrology of the area. Observations include rainfall, runoff, air and water temperature, and humidity, timber inventories, soil surveys, wildlife inventories, and evaluations of soil disturbances will be made. Project activities are divided into calibration, development, and evaluation phases.

(f) Calibration period completed. "Action" phase started with mock peak flow run into watershed to site of first timber sale.

(g) Results are published in annual reports distributed to cooperating agencies.


(4884) UPPER BEAR CREEK EXPERIMENTAL PROJECT.

(b) TWA Tributary Area Development project cooperative with U. S. Forest Service and Auburn University.

(d) Quantitative determination of the effectiveness of soil type, slope, and vegetative cover upon runoff, peak discharge, and erosion on small watersheds progressing to large watersheds. Development of procedures to make data usable in projecting effects from small watersheds to larger drainage areas and to transfer results of the study to ungauged areas.

(e) The general types of land cover and use will be considered in the study of the watersheds that progress downstream from areas of several hundred acres through intermediate-sized watersheds to a drainage area of 143 square miles.

(f) Hydrologic condition surveys made in March and August, 1964.

(g) Results are published in quarterly and special reports on the project.


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U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.

Inquiries concerning the following projects should be addressed to the Director, U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, P. O. Box 61, Vicksburg, Miss. 39181.

(236) MISSISSIPPI BASIN MODEL.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.

(d) Experimental; for design.

(e) The project provides for design and construction and operation of a model of the Mississippi River watershed including the Missouri, Ohio, White, Arkansas, and Red Rivers and their principal tributaries. All existing and proposed flood-control reservoirs as well as levees, dikes, floodwalls, and other pertinent works are represented.

The model area comprises 200 acres, and measures 4500 ft east and west, and 3800 ft north and south. Completed construction consists of the following.

Mississippi River from Hannibal, Mo., to Baton Rouge, La.; the Missouri River from Sioux City, Iowa to the mouth; the Arkansas River from Blackburn Dam site, Okla., to the mouth; the Ohio River from Louisville, Ky., to the mouth; the Cumberland River from Old Hickory Dam, Tenn., to the mouth; the Tennessee River from Pickwick Dam to the mouth; and the Mobile-Alabama River to the Gulf of Mexico.

The topography of the streams and floodplains is being reproduced to a horizontal scale of 1:2000 and a vertical scale of 1:100. Water-surface elevations are measured by electrically operated stage devices with the recorders located in central control buildings. Streamflow is introduced and controlled by automatic instruments called inflow controllers.

The purpose is to study the coordination of releases from reservoirs, investigate the effectiveness of reservoir operation on flood stages, check the routing of project and other floods, and establish and check levee grades, predict flood stages, and determine the effect of floodways on stage reduction.

(g) The extent of model operation each year is determined by the testing programs directed by the Mississippi Basin Model Board of Engineers and requested by Divisions and Districts that have operable sections on the model. The model was operated as an integrated unit to Memphis, Tenn., for comprehensive (basinwide) tests. Tests were completed of the four historical floods—1857, 1943, 1945 and 1950—using three reservoirs (EN) scheduled for completion in the near future (approximately 1970), and with ultimate reservoirs (ENR) operated to full capacity to store inflows and to affect operation of the Lower Mississippi River, and of the three hypothetical floods—M 52-A, M 56 and M 58-AON—using inflows unmodified by reservoirs and modified by En and EDR reservoirs for local and Lower Mississippi River benefits for the basinwide testing program. Tests were completed also for the St. S. Army Engineer Division, Ohio River, to obtain effect of proposed Interstate highway fill on Wabash River in vicinity of Grayville, Ill. Tests were conducted for several years at the Corps of Engineers, Inc., St. Louis, Mo., on the portion of the MEH model that is in the Lower Mississippi Valley Division. These tests were concerned with the size and effects of annual and periodic openings for the proposed Mississippi River Bridge to be constructed near Caruthersville, Mo., on Interstate Route 155.

(425) COMPREHENSIVE MODEL STUDY, DELAWARE RIVER, PENNSYLVANIA.

(b) District Engineer, U. S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pa.

(d) Experimental; for design.

(e) The project provides for a navigation channel about 96 miles long from Trenton, N. J., to Delaware Bay. As modified in 1954, the project provides a 40-ft-deep by 400-ft-wide channel between Philadelphia and the upper end of Bombay Island, thence a 35-ft-deep by 300-ft-wide channel to Trenton. Included in the project are provisions for constructing dikes and training walls for regulation of tidal flows, and dredging to provide turning basins and adequate anchorage at several points.

The purpose is to improve and develop plans for reduction of shoaling in several ranges of the navigation channel; and to determine the probable effect on the hydraulic and salinity
regimen in the estuary that would result from modifications of channel depth and alignment and flow regulation.

The model is of the fixed-bed, slit-injection type with a 1:4000 scale ratio of 1:1000 horizontally and 1:100 vertically, and reproduces the entire tidal portion of Delaware River and Bay from the Capes to Trenton, including tidal portions of tributaries.

Tides and tidal currents are reproduced by automatic tide control mechanisms, and fresh-water discharges of the Delaware River and significant tributaries are introduced by means of Van Leer weirs. Observed prototype salinities are reproduced in the Delaware Bay portion of the model, and provisions have been made for the injection of slit into the model, and for measuring slit deposits on the bed of the model. Studies of the dispersion of various contaminants are made by releasing permanent dyes and tracing their movement and concentrations with time after release and distance from the release points.

A preliminary report, Delaware River Model Study: Results of Hydraulic and Shosling Studies in the Marcus Hook - Shoyulkill River Reach, was furnished the Philadelphia District in October for review and comment. The tests were conducted in the existing model to determine the effects on tides, currents, and shoaling of filling several large back-channel areas with dredge spoil.

Several proposed sediment traps, conveniently adjacent to spoil disposal areas, were tested to determine whether or not depositing of sediments would occur in the traps and if such depositing would cause significant reductions in channel shoaling. Special tests to determine the effects of the current (1955) drought on sand in the Delaware estuary were undertaken and completed.

Tests on the existing Delaware River model to determine the effects of flank off several back-channel areas to provide disposal areas for dredge spoil and the dredging of adjacent sediment traps indicated that closure of both the Tincicum and Chester Island back channels would have no detrimental effects on the main navigation channel. A small-boat channel should be provided through Tincicum Island. Overdredging in Kantsu Creek anchorage and in Tincicum range to create sediment traps would cause no significant increase in deposition and is not considered justified.

Sediment trapping in Marcus Hook anchorage and adjacent to Chester Island would be beneficial to channel shoaling.

CAVITATION RESEARCH.

(a) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(b) Experimental; applied research.
(c) This is a general study, be means of model tests, of the cavitation characteristics of various elements of hydraulic structures, and of the resistance of construction materials to cavitation damage. Further, the investigations include a review of literature to evaluate the many variables that affect cavitation results.
(d) The purpose is to study cavitation characteristics of such elements as baffle pliers, steps in stilling basins, spillway and conduit gate slots, and offset joints. This program will include tests to determine the conditions for dynamic stability of the cavitation phenomena. (b) To determine the resistance to cavitation damage of construction materials with particular emphasis on materials suitable for passive concrete.
(e) The cavitation characteristics of the various elements are investigated in a variable pressure water tunnel with a 12-by 12-in. test section. Velocity is adjustable and can be varied from 8 to 35 fps. Resistance-to-damage tests are conducted in apparatus in which cavitation is induced in velocities of 90 fps by an alignment change.

EFFECTS OF MODEL DISTORTION ON HYDRAULIC ELEMENTS.

(a) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(b) Experimental; applied research.
(c) This is a general study of similitude relations in distorted models. The purpose is to determine the hydraulic effects of various types and degrees of model scale distortion on velocity distribution and other hydraulic conditions, with the ultimate aim of establishing limits of permissible distortion for the various types of models.
(d) Tests have been conducted in a 5-ft-wide masonry flume having a 90-degree bend of 10-ft radius, with straight approaches 20 ft long and exit channel 60 ft long, in which can be reproduced a hypothetical stream to a horizontal scale of 1:200 and variable vertical scales to produce distortions up to 1:10. The flume was provided with three venturi meters of different sizes for the control of discharge and a tailgate for the control of tailwater elevation.
(e) Suspended.
tribars, quadripods, modified cubes, and other specially molded armor units.

Tests will be conducted in 50-ft, 5.5- by 250-ft, L-shaped wave flumes designed to allow the testing of breakwater sections using various angles of wave incidence. Initial tests will be conducted on breakwater trunks constructed of quarrystone, tetrapods, quardripods, modified cubes, hexapods, and tritbars using nonbreaking waves in deep water was initiated.

Preparation of the 50- by 5.5- by 250-ft wave flumes for the testing of breakwater sections using various angles of wave incidence was initiated. A technical report describing the results of tests conducted on breakwater sections using nonbreaking waves in deep water was initiated.

EFFECTS OF SCALE AND OPERATING TECHNIQUES ON HARBOR WAVE ACTION AND BREAKWATER MODELS.

Office of the Chief of Engineers, Department of the Army, Washington, D.C., Experimental; applied research.

A general study is being conducted to determine effects of various model scales and distortion on wave characteristics in harbor and breakwater stability models. The effects on test results of various model-testing techniques are also being investigated. The purpose is to obtain information which will allow a more accurate determination of optimum scales for wave models, and the effects of different scales and operating techniques on the accuracy of model results. A 2- by 4.5- by 8.0-ft, rocking, rectangular steel basin will be used for studying the wave-damping effect of expanded metal screens.

Preparation of the rectangular steel basin for studying the wave-damping effect of expanded metal screens was initiated.

INSTRUMENTATION.

Office of the Chief of Engineers, Department of the Army, Washington, D.C.

Development of instruments for use in hydraulic models and in field measurements.

The development of improvements for a current direction indicator was completed. Development of a revolution-sensing and remote-indicating device for velocity meters, development of a spherical-head turbulence meter, and development of a level indicator for tests of prototype locks were continued.

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA.

Office of the Chief of Engineers, Dept. of the Army, Washington, D.C.

Analytical (model and prototype); design.

Hydraulic design criteria relating to the design of spillways, outlet works, gates, valves, navigation structures, flood-control channels, and natural waterways are developed from laboratory research, model studies, and prototype observations. Results are prepared in the form of design charts and distributed to design offices.

To analyze hydraulic data, theories, and procedures, to develop design criteria therefrom, and to disseminate this information in the form of Hydraulic Design Criteria to insure adequate capacity, economy of design and construction, and safe and satisfactory operation of the large structures being designed, built, and operated by the Corps of Engineers.

Preparation of the reproduction copy of the thirteenth issue of Hydraulic Design Criteria was in progress.

This issue provides design criteria on energy loss for high overflow spillways and discharge coefficients for low wave crests on 5- by 5-ft or 4.5- by 250-ft straightsloping faces, for flows over low monoliths in concrete spillway gates. Charts are also included on

crest shapes for overhanging spillways, low wave crest overflow pressure, hydraulic jumps on sloping aprons, and stilling basin end-sill heights. Fourteenth issue studies undertaken included minimum pressure in pipe bends, loss in outlet work, control structures with one or more gate passages closed, and discharge coefficients from spillway withainter-stage gates operating under submerged conditions. The final contract report from the University of Missouri was received and published as WES Contract Report 7-116, Analytical Study of Flow Characteristics for Flow Over a Curved Spillway Bucket, by J. J. Cassiday, May 1965. An electronic computer analysis of flow patterns in an open channel flow was based on a contract study on this report was undertaken. Extensive studies pertinent to the hydraulic design of riprap were in progress. A draft of a miscellaneous paper on hydraulic design of riprap was prepared.

The study of experimental data on minimum pressures in pipe bends showed that two-dimensional flow analyses was applicable to pipe bends as well as to circular bends in rectangular conduits. The study of loss coefficients for multiple-gate passage control works control structures with one or more passages inoperative indicated that loss coefficients for abrupt expansion are not applicable to control structure problems.

Studies on hydraulic design of riprap indicate the need for field and laboratory investigations to provide firm criteria for design purposes.

INVESTIGATION OF SALINITY INTRUSION AND RELATED PHENOMENA.

Office of the Chief of Engineers, Corps of Engineers (correspondence should be addressed to Mr. J. B. Mill Committee on Tidal Hydraulics, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.).

Experimental; applied research.

The project consists of the following three broad phases: (a) analysis of prototype data to define the range of conditions for which investigations appear desirable; (b) flow tests to study factors which influence the phenomena involved, and (c) analytical studies aimed at establishment of fundamental laws describing the phenomena involved, and preparation of data for use in connection to specific prototype problems. Dr. Donald Harleman, consultant, has been engaged to assist in phase (c) above.

To determine the effects of the physical and hydraulic features of estuaries such as tidal prism, tidal range, freshwater discharge, channel depth, channel width, etc., on the extent of salinity intrusion, the nature of salinity intrusion, the magnitudes and durations of current velocities, and other factors considered essential to proper solution of estuarine problems encountered by the Corps of Engineers.

The flow studies under phase (b) above are being carried out in a transparent flume 27 ft long, 1.5 ft deep, and 0.75 ft wide. One end of the flume is connected to a tidal basin 25 ft square and 3 ft deep, which is equipped with a tide generator capable of producing tides of any desired range, period, or other characteristic. The opposite end of the flume is connected to a large header channel equipped with weirs for measuring and introducing freshwater inflows. Salt water to fill the tidal basin and flume is supplied from an adjacent underground equipment house which is equipped with the necessary appurtenances to mix salt and fresh water and control the salinity of the mixture. The tidal basin is equipped with skimmer to maintain constant basin salinity during tests. Current velocities are measured in the flume by timing the travel of indicators over measured ranges, and salinity measurements are made either by
withdrawing samples for chemical titration or by means of a recording salinity meter which operates on the electrical conductivity principle.

No flume tests were required during the year; however, prototype and model physical, hydraulic, and salinity data from Savannah Harbor were furnished to Dr. Harlman in checking the validity of equations developed from flume test data. Analysis of flume data, and checking of results obtained against prototype and model data from Savannah Harbor are in progress by Dr. Harlman and his staff. Additional flume tests will be conducted as necessary to supplement available data.

(1987) **RIPRAP PROTECTION AT HYDRAULIC STRUCTURES.**

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

c) Experimental; applied research.

e) The erosion characteristics of various sizes of riprap and gravel material are being studied with a view to securing adequate protection at minimum cost. Measurements of velocity and turbulence at which movement of material begins are being made. The purpose is to develop design criteria for riprap at hydraulic structures.

(1988) **WATER TEMPERATURE EFFECTS ON BED FORMS AND ROUGHNESS.**

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

c) Experimental; applied research.

e) It has long been known that water temperature variations cause marked variations in the nature and rate of bed movement, which are of major significance in movable-bed model studies. The onset of cold weather produces excessive rifting of bed surfaces, resulting in sharp increases in roughness values and changes in volumes of material transported. Investigation of this phenomenon is being conducted in existing laboratory flumes, in which water temperatures can be varied to simulate normally experienced summer and winter temperatures. The purpose is to determine the effects of water temperature on streamed forms and bed roughness of various types of bed material, and to recommend changes in design criteria for such conditions.

(f) Review of the work accomplished to date and literature available on the subject was completed, and a new comprehensive testing program was developed.

(2428) **MODEL STUDY OF SAVANNAH HARBOR, GEORGIA.**

(b) District Engineer, U. S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Georgia.

c) Experimental; for design.

e) The purpose is to determine if the present rate of shoaling can be reduced by proposed plans of channel realignment, freshwater diversion, and other remedial measures; to develop criteria for the critical spillway closure problem; and to test ultimate harbor developments. Studies were also made to determine effects of proposed improvement plans on dispersion and dilution of contaminants discharged into the harbor. The investigation was conducted in a model which reproduced the following: (a) that portion of the Atlantic Ocean, adjacent to the harbor entrance, from Calibogue Sound on the north to Wassaw Sound on the south; (b) the Savannah River and its floodplain to the head of tide at Ebenezer Landing; and (c) that portion of the Intra-coastal Waterway which crosses the area included in the model. The model was of fixed-bed construction with scale ratios, model to prototype, of 1:600 horizontally and 1:50 vertically. Automatic tide generators were used to reproduce tides and tidal currents throughout the harbor, and salt water was used in the model ocean to reproduce the effects of density difference on current velocities and distributions. Shoaling studies were made by injecting finitely ground sand into the model to reproduce the patterns of shoaling as observed in the prototype, following which the effects of proposed improvement plans on shoaling patterns could be observed and evaluated.

(g) Completed.

(h) Measurements were made of sediment load, suspended and colloidal, moving in Savannah River above the tidal prism. In Savannah Harbor, periodic surveys and sampling of the discharge were performed to determine the consolidation rates and the locations of the shoaling. A separate report of prototype investigations is not required.

The results of model tests indicated that the effectiveness of the previously recommended plan for reducing shoaling in the Savannah Harbor would not be materially changed by construction of the authorized deeper and wider channel. Model tests indicated that pollution of Wilmington River by the city of Savannah municipal and industrial wastes could be reduced by closure of the South Channel and/or St. Augustine Creek. Model tests indicated that bank erosion in the North Channel would probably be reduced by construction of the authorized deeper and wider channel.

(h) Section 4, "Horn Inlet Artificial Channel Dimensions," Section 5, "Wilmington River Pollution Studies," and Section 6, "Results of Tests of Bank Erosion in North Channel," of TR 5-66, Volume III, were published in March, April and October 1965, respectively.

(2673) **MODEL STUDIES OF BARCLAY LOCK AND DAM, CUNEO REAL RIVER, TENNESSEE.**

(b) District Engineer, U. S. Army Engineer District, Nashville, Corps of Engineers, Nashville, Tennessee.

c) Experimental; for design.

e) A 1:120-scale comprehensive model of the fixed-bed type reproduced the Cumberland River from mile 29.4 to mile 32.2 and the lock, dam, and powerhouse. A 1:56-scale section model reproduced the riverward, downstream lock and spillway of the Hartwell manifold which discharges into the spillway stilling basin, five spillway bays, the lock, and powerhouse. The model reproduced the flow through the floor of the spillway apron, 326 ft of approach and 596 ft of exit channel. The emergency lock gate was studied in a large-scale model reproducing the lock chamber, gate sill, and portions of the upstream lock approach and the lock chamber downstream from the gate.

To determine the arrangement of lock and appurtenant walls and to study approach conditions under various flows; to develop a satisfactory stilling basin and determine the feasibility of emptying the lock into the spillway stilling basin; and to determine (a) hydraulic forces on and stability of the emergency lock gate under various flows including flow over the top sill, (b) hydrostatic forces on the gate in various positions, (c) gate wheel reactions and sill roller reaction in several positions, and (d) head loss through the bridge deck.

(f) Completed.

g) Adequacy of the spillway stilling basin was verified, and the necessary realignment of the right bank downstream from the powerhouse were accomplished. The original design of the emergency lock gate was unsatisfactory for an uplift greater than 200 kips the dry weight of gate. This was corrected by the use of a 45-degree lip on the apex of the gate. For this design the gate was stable throughout its operational range and hydraulic forces were in the range of 107 kips downpull and 207 kips uplift. No rotation of
the gate in a downstream direction was noted. TR 2-599, "Tests of Structure Orientation, Spillway, and Lock Emergency Gate, Berkely Lock and Dam Rehabilitation," Hydraulic Model Investigation, August 1965.

MODEL STUDY OF NAVIGATION CONDITIONS, McALPINE LOCKS AND DAM, OHIO RIVER.

District Engineer, U. S. Army Engineer District, Louisville, Kentucky.

Experimental; for design.

A 1:120-scale, fixed-bed model was used for the investigation. The model reproduced the reach of the Ohio River from about mile 602 to about mile 608 below Pittsburgh, Pa., including adjacent overbank areas to an elevation of approximately 445 ft, the locks and dam structures, and all bridges and other structures that might affect flow conditions.

To determine the effects of location, size, and alignment of the dam on stages and currents within the upper pool; study the effects of location, size, and alignment of a new approach channel on navigation and surge conditions; determine the best location for a new navigable span on the Pennsylvania Railroad bridge; determine a method of operating the dam for optimum navigation conditions; study navigation conditions in the lower approach as affected by flow through dam, powerhouse, and lock emptying system; and provide a means for navigation interests to satisfy themselves as to the acceptability of the proposed plan by observing the model in operation.

Satisfactory plans were developed covering composition and location of the dam, upper and lower approach channels, and lock filling and emptying. Tests of various gated sections of the dam provided data for use by the District office in developing discharge rating and stage structure curves. Data were also obtained on the effects of various dam alignments on head at the hydroplant, and on velocities along the Indians shore.

Preparation of final report is in progress.

SCALE-EFFECT TESTS OF RUBBLE-MOUND BREAKWATERS.

Office of the Chief of Engineers, Department of the Army, Washington, D.C.

Experimental; applied research.

To investigate the effects of model scale on the results of experimentally determined criteria for design of rubble-mound breakwater bars.

Stability tests were made of a breakwater slope of 1 on 1:1/2 using wave periods of 2.61, 3.75, 7.67, and 11.33 sec. Tests in the GERC wave flume (18 by 20 by 635 ft) were conducted using a linear scale of 1:7.5 to 1 based on the tests conducted in the WES 5- by 4- by 119-ft wave flume. Additional stability tests will be conducted on 1:4- by 119-ft wave flumes using linear scales of 0.5 to 1, and 1 to 1, and following the same testing procedure used in the tests conducted in the GERC wave flume. Therefore, data on the stability of rubble-mound breakwaters will be available for three different linear scales, 0.5 to 1, 1 to 1, and 1:1.15. Test data from the GERC wave flume will be correlated with data from the WES flume.

Revisions were made to a 5- by 4- by 119-ft concrete wave flume to be used for the test on the stability of rubble-mound breakwaters conducted using linear scales of 0.5 to 1 and 1 to 1.

MODEL STUDY OF SOUTHWEST PASS, MISSISSIPPI RIVER.

District Engineer, U. S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.

Experimental; for design.

To determine the effectiveness of proposed improvement works (jetty extensions, channel realignments, and construction works) in the elimination or reduction of maintenance dredging in the jetty and bar channels. The investigation was made for a model constructed to linear scale ratios, model to prototype, of 1:500 horizontally and 1:100 vertically, and reproduced the lower 12 miles of Southwest Pass adjacent to the Pass. The entire bed of the model was molded in concrete to the latest hydrographic survey available at the time of construction. Models were made for reproducing prototype tides, tidal currents, littoral currents, and wave action in the simulated Gulf of Mexico and saltwater and freshwater flows, including those of the Pass and the bar channel. Shoaling studies were made by introducing various mixtures of plastic materials, simulating prototype shoaling materials, into the model and reproducing the shoaling patterns and distribution that occur in the prototype.

Tests of proposed plans for reducing shoaling in the jetty and bar channels indicated that plans involving a curved realignment to the jetty channels would greatly reduce shoaling by creating bar prosperity upstream from ends of the jetties. The tests also indicated that reducing the prototype jetty channel from 600 to 600 ft would also be beneficial in reducing shoaling in the bar channel.


MODEL STUDY OF SHOALING, HUDSON RIVER, N. Y.

District Engineer, U. S. Army Engineer District, New York, Corps of Engineers, New York, N. Y.

Experimental; for design.

To determine the source of material shoaling the Hudson River in the vicinity of Edgewater and Weehawken piers and the most effective means of reducing or eliminating this shoaling; to determine the causes of shoaling in the pier slips in New York Harbor and develop plans for alleviating this shoaling.

Two models were used in this study. Shoaling in the river channel was studied using a fixed-bed model, built to scales of 1:100 vertically and 1:1000 horizontally. The model reproduced Upper and Lower Raritan Bay, Hudson River to Hyde Park, East River to Throg's Neck, and tributaries flowing into the model bodies of water. Observations were included for reproducing tides, freshwater discharge, salinity intrusion, and shoaling. The study of pier-slip shoaling was conducted in a section model reproducing that portion of the Hudson River between piers 21 (Duane St.) and West 156th St., Manhattan, constructed to scales of 1:100 vertically and 1:500 horizontally, in which the tides, river current, and shoaling in the navigation slips was reproduced.

Test results indicated that the best plan involving increasing the river cross section at the George Washington Bridge would increase shoaling in the navigation channels by about 25 percent, and would decrease shoaling of the slips by about 15 percent. Field and office studies indicated that a control structure in the Harlem River would significantly reduce shoaling both in the navigation channels and in the slips. Models showed that decreasing the channel width from Haverstraw Bay would not reduce shoaling of channels or slips. A sediment trap in the
upstream end of the 30-ft project channel would reduce scouring in this channel, although similar reduction can be attained by overdredging the area involved at frequent intervals. Test in the pier-slip model indicated that approximately 25% of any dredge spoil free-dumped in the navigation channel would return to and deposit in the slips. These tests also showed that free-
dumping, if permitted, should not be done within 500 ft of the pierhead line.


Model Study of Navigation Conditions of Locks and Dam No. 4 (Reconstructed), Monongahela River.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

d) Experimental; for design.

e) Reconstruction of dam 4 will involve replacement of the existing fixed dam with a non-


Non-navigable-type gated dam in order to raise the pool 2 ft as required in the Knox 1 project upstream. The reconstructed dam will have five 84-ft crest gates. A raised fixed weir 2 ft wide and the dam to the existing locks, which are 56 ft wide, and 720 and 360 ft long. Provision is being made in the dam structure for ultimate replacement of the existing locks by two locks each 760 ft long, with one lock to be 84 ft wide and the other 110 ft wide.

The purpose is to determine the effects of modifications of the existing locks and dam on navigation conditions, and to develop modifications required to overcome any undesirable conditions.

A 1:120-scale, fixed-bed, comprehensive model reproduced about 2.5 miles of the Monongahela River and the locks and dam structures.

(g) The last series of tests showed that additions of concrete cells at the end of the upper guard wall would tend to improve navigation conditions with the existing locks and reconstructed dam.

(h) Preparation of final report is in progress.

Model Study of Stilling Basin and Conduit Outlet Portal, Red Rock Dam, Des Moines River, Iowa.

(b) District Engineer, U.S. Army Engineer District, Rock Island, Corps of Engineers, Rock Island, Illinois.

d) Experimental; for design.

e) Red Rock Dam, a flood-control structure to be located at mile 143 on the Des Moines River, 10 miles east of Knoxville, Iowa, will be an earth fill 6280 ft long, rising about 112 ft above the river floor. The ogee-type spillway will be 24 ft wide, surrounded by five 41- by 45-ft tainter gates, and will contain fourteen 5- by 9-ft controlled conduits. A hydraulic jump-type stilling basin with two rows of baffle piers and an end sill will return flow to the Des Moines River.

The investigation was conducted on a 1:50-
scale model reproducing 300 ft of the approach channel above the spillway, an 825-ft-wide section along the dam, the spillway, conduits, stilling basin, and 575 ft of the outlet channel. The model reproduced on the entire spillway and stilling basin, sufficient approach area to assure natural flow conditions over the spillway and at the submats, and sufficient exit area to permit formation of the natural flow pattern in the exit channel. A 1:16-scale model of the intersection of the spillway face and conduit outlet portal was used for the completed requirements tests. To verify stilling basin and training wall design; to calibrate the spillway; to study flow conditions in the upper approach, particularly at the submats; to determine armor-

plate requirements at the outlet portal; to determine operation in conduit flow during combined operation; and to study the effects of deflectors above the conduit outlet portals.

(f) Completed.

g) Tests on the 1:16-scale model indicated that during combined operation, simulating spillway and conduit flow at maximum reservoir elevation, pressures in the conduits and in the outlet portal were positive. "Eye-
brows" or deflectors above the portal increased conducted the 1:16 scale conduit line within the conduit. The Polson Dam, high-level conduit, reproduced in the model, verified prototype cavitation-damage areas and furnished cavitation-free evaluation of Red Rock conduit test results. The general model provided information on spillway capacity as affected by abutment changes; velocities in the approach, particularly against the dam; optimum basin elevation consistent with safety and economy; basin elements of minimum size; and bottom velocities in the exit conduit.


Model Study of Draghead for Hopper Dredge.

(b) District Engineer, U.S. Army Engineer Division, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania.

d) Experimental; for design.

e) This study was a component of a comprehensive "Program for the Improvement of Hopper Dredges and Hopper Dredging." It involves comparison of the effectiveness of hopper dredge dragheads of different designs in various types of materials. The investigation was conducted in a 60-by 10-ft flume containing various types of bed material. The draghead, constructed to a scale of 1:16, was connected to a suction pump mounted on a double car-
riage that provided travel, both longitudi-


nally and transversely, along the top of the flume. The carriage traveled on rails extending the length of the flume. To develop ideal dragheads designed to attain a greater rate of intake of solids when dredging mud and silt mixtures (soft materials) and dredging densely packed, fine sand (hard materials).

The results demonstrated how the performance of dragheads can be affected by variations in design and operating procedures. The factors affecting the performance of draghead were indicated to be shape and dimen-
sions of the draghead, position of draghead with respect to the bottom, vacuum, and orientation of draghead relative to the current.

(h) Preparation of final report in progress.

Model Study of Effects of Hurricane Barrier on Navigation Conditions in East Passage, Narragansett Bay, Rhode Island.

(b) Division Engineer, U.S. Army Engineer Division, New England, Corps of Engineers, Waltham, Massachusetts.

d) Experimental; for design.

e) Hedge Barrier in East Passage, Narragansett Bay, has been proposed to limit the quantity of water entering the bay from hurricane surges.

To examine ship navigation conditions with respect to barrier location and its naviga-
tion opening under current, wave, and wind conditions created by astronomical tides and hurricane conditions. A study of the discharge characteristics of the navigation opening.

A 1:150-scale model of East Passage was used in the study of navigation conditions. Currents, waves, and wind effects were simulated. A self-propelled, radio-controlled, model aircraft carrier, constructed dynamically similar to its prototype, was used in the
tests. In the study of the discharge characteristics of the navigation opening, two section models, reproducing the barrier to scales of 1:50 and 1:150, were used to determine the effects of roughness of the barrier, model scale, and weir design on the discharge characteristics. In addition, the 1:150-scale, three-dimensional model was used to study the discharge characteristics of two weir plans.

Tests showed that a velocity of 3.5 knots through the roughened barrier is produced by a head differential of 0.3 ft across the barrier. This is equivalent to the maximum differential caused by a 2.8-ft tide range.

Preparation of final report is in progress.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

(c) Office of the Chief of Engineers, Department of the Army, and Bureau of Public Roads, Department of Commerce, Washington, D.C.

(d) Experimental; applied research.

(e) This was a general investigation to determine a resistance coefficient and the law of velocity distribution for flow in structural-plate corrugated pipe. A fiber-glass test section reproducing a 5-foot-diameter corrugated pipe at a scale of 1:4 was tested in order to obtain additional data on the resistance coefficient and velocity distribution and to correlate model work with full-scale tests. Fiber-glass test sections reproducing a 5-foot-, 10-foot-, and 20-foot-diameter structural-plate pipe of 1:2.2, 1:8, and 1:16, respectively, were tested to determine the effect of relative roughness upon the resistance coefficient and velocity distribution. The hydraulic gradient and the energy loss through 20- to 80-diameter lengths of test section were established by piezometers located at 5-foot intervals. These piezometers were 1/8 inch in diameter, on center of the crests of the corrugations, and four in number around the perimeter of the pipe. Velocity traverses were made by means of calibrated pitot tubes at several locations along the test section for determination of the velocity distribution.

(f) Completed.

(g) Hydraulic gradients, velocity distributions, and static pressure measurements across a diameter for a range of Reynolds numbers were used to develop a mean flow equation with which the resistance coefficients due to the corrugations for all sizes of structural plate pipe were computed. A method for determining the increment of resistance attributable to the assembly bolts of structural plate pipe is presented (Appendix A).


(3502) RADIOACTIVE TRACER TESTS OF SEDIMENT, GALVESTON BAY (HARBOUR), TEXAS.

(c) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

(d) Experimental; field investigation.

(e) To study the movement of sediment in the vicinity of the Galveston Bay Jetties by use of radioactive gold-impregnated glass.

(f) A radioactive sediment tracer labeled with gold 198 was used to follow sediment movement in the vicinity of the north and south jet-}

(g) Wylen and Galveston model and to aid in design of corrective measures to prevent silting of the Galveston ship channel.

(h) The glass tracer was ground to the particle size of the native sediment and deposited on the gulfside of the jetty. It was expected that the tidal action, littoral current, and wind waves would move the material around the jetty and deposit it in the ship channel or through the jetty. The path of the activity gold-impregnated glass particles was traced by instruments from a small boat.

(g) Completed.

(h) The results of the north jetty tests indicated that, while small amounts of tracer moved through the small boat pass in the jetty and permeated through the jetty proper, much larger amounts of tracer moved around the seaward end of the jetty and into the navigation channel. In the one south jetty test, the movement of the tracer was generally seaward for the duration of the test, and there was no indication of tracer movement around the end of the jetty into the entrance.

Personnel monitoring was performed during all high-activity handling operations including transportation and release. In addition, adjacent beaches were monitored for possible contamination. Maximum dosage to personnel was less than 15 percent of maximum permissible weekly dosage; no beach contamination was observed during the period of testing.

(i) Equipment and procedures used during the tests were satisfactory and will be used again in the event of future tests. Should be noted for future programs of this type that periods of time up to 6 months or more may be required to obtain approval by all agencies involved and to secure the necessary license for such tests.

Radioactive Sediment Tracer Tests near the North and South Jetty, Galveston Harbor Entrance, MP 2-472, November 1965.

MODEL STUDY OF TSUNAMIS AND NAVIGATION IMPROVEMENTS AT Hilo HARBOR, HAWAI.

(b) District Engineer, U.S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.

(c) Experimental; for design.

Field study: To measure wave and surge action at piers 1 and 2 in the harbor to provide data for use in engineering the surge problem. Model study: To determine the optimum breakwater plan to decrease wave and surge action in the harbor so that troublesome and damaging ship motions at piers 1, 2, and 3 will be alleviated, and to investigate effects of different plans of construction on reduction of damage to the city of Hilo from tsunamis.

The model, about 62 ft wide and 92 ft long, is constructed to a vertical scale of 1:500 and a horizontal scale of 1:1600 and is contoured from 220 ft above mean lower low water. The model area of 2286 sq ft is comprised of 12- by 12-ft sections with jacked supports to accommodate the different settlement of the foundation, and includes a 1809-sq-ft concrete slab in the wave generator pit. The wave generator is comprised of eight pumps, each being 6 by 8 by 10 ft. A programmer operates the generator to simulate tsunami waves. Tests are complete.

The Honolulu District completed its test program except for the analysis and final report of test data. Five basic plans, with several variations to each plan, were tested during the year with a total of approximately 1500 test runs being completed. The Hilo Harbor model consultants held a conference in Honolulu in March. The test program was restructured as a result of the recommendations of the consultants. The Hilo Tsunami Technical Advisory Council (consultants to local interests) met in Honolulu to discuss the results of the model tests. They concluded that the test results were valid.

195
Analysis of test data is incomplete. The model is being transferred to the University of Hawaii in accordance with the Memorandum of Understanding. However, it will be available for use by the Corps of Engineers, if needed, until construction is under way.

Preparation of final report is in progress.

POWER-PLANT TRANSIENTS TESTS, GARRISON AND OHARE DAMS, MISSOURI RIVER, N. DAK. AND S. DAK.

Division Engineer, U. S. Army Engineer District, Missouri River, and District Engineer, U. S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.

Field investigations; applied research and design.

Hydraulic prototype measurements of power-plant transients for different plant loadings, and instantaneous pressure values at a number of locations in the power tunnel, the surge tank system, turbine scroll case, and draft tube were obtained simultaneously with instantaneous values of tunnel flow velocity, reservoir and tailwater elevations, turbine speed and gate opening, power output, and other elements (including control system). Pressure and water-level measurements were made with electrical pressure transducers, velocities were measured with pressure transducers mounted inverting into the flow and connected to pitot-static tubes on cross struts in the penstock, and mechanical and electrical values were transmitted with appropriate transducers. Measurements were recorded on about 90 channels of oscillograph and magnetic tape recorders, and digitized for use in the digital computer analyses by Massachusetts Institute of Technology.

To evaluate results of a comprehensive digital computer study made by the Missouri River Division, Omaha District, Massachusetts Institute of Technology and to determine extent operation corresponds to design, in order to develop a solution of the entire problem of plant transients with primary emphasis on governing stability.

Data are being digitized for the Omaha District for computer analyses. The final report on the test operations is being prepared.

Preparation of final report is in progress.

SHOALING PROCESSES.

Office of the Chief of Engineers, Department of the Army, Washington, D.C.

Experimental; for design.

The annual cost to the Federal Government of maintaining navigable channels in tidal waterways is estimated to be of the order of $60,000,000. The Committee on Tidal Hydraulics has concluded that a thorough study of shoaling processes in tidal waterways would lead to improvements in channel design, dredging, and spacing practices, and other maintenance techniques which would reduce this large expenditure. The Committee concludes that the following program of research is essential in arriving at the objective of reducing maintenance cost: (a) flume studies to determine the basic laws involved in the movement and deposition of muddy sediments; (b) flume studies to determine effects of repetitive scour and deposition on sedimentation; (c) the development of techniques for using radioactive tracers for observing the movement and deposition of sediments in nature; (d) the development of a simple and accurate instrument for in-place measurement of turbidity; (e) study of no. Effect of biological, chemical, and hydraulic factors involved in the stabilization of deposits in navigable channels; (f) determination of the effects of flocculation on shoaling; (g) testing of portable, easy-to-install, and compact instruments for determining of sedimentation phenomena in tidal waterways with physical, chemical, hydraulic, salinity, and other significant factors; and (h) classification of the sediments which constitute all major repetitive shoals in tidal waterways.

Item (a) above has been completed under terms of a contract between the University of California, and the San Francisco District, and all pertinent reports have been published; item (b) is presently inactive; item (c) is presently inactive; item (d) is presently inactive; item (e) was completed by the University of California, under terms of a contract with AES, and a report entitled A Study of Sediment Properties of Estuarial Sediments was published as Technical Bulletin No. 7 of the Committee on Tidal Hydraulics; item (f) is under study by the Committee on Tidal Hydraulics and AES; and item (g) is in progress at AES.

MODEL STUDY OF NAVIGATION ENTRANCE TO ARKANSAS RIVER.

District Engineer, U. S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

Experimental; for design.

Tests were conducted on a fixed-bed model reproducing to scales of 1:600 horizontally and 1:100 vertically about 35 miles of the Mississippi River near the mouths of the White and Arkansas Rivers, 37 miles of the lower Arkansas River, 12 miles of the lower White River, and the major portion of the White-Arkansas River system.

The model was used to demonstrate alternate routes for the entrance to the Arkansas-White Cutoff, and problems related to the location and alignment of the navigation entrance to the Arkansas River from the Mississippi River.

Data on stages for various combinations of flow from the three streams, velocity measurements at critical points, and current directions were obtained under various test conditions for use of design engineers in determining the most feasible plan from both a navigation and economical standpoint.

Preparation of final report is in progress.

HANNIBAL (FORMERLY OPOSSUM CREEK) LOCKS AND DAM, OHIO RIVER.

District Engineer, U. S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Penna.

Experimental; for design.

Tests were conducted on a 1:120, fixed-bed, comprehensive model reproducing about 4 miles of the Ohio River and the lock and dam structures.

The purpose is to study navigation conditions in the approaches to the locks, determine suitability of the selected site, and develop modifications required to overcome any undesirable conditions found.

Suspended.

MODEL STUDY OF MATAGORDA SHIP CHANNEL, TEXAS.

District Engineer, U. S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

Experimental; for design.

The fixed-bed model, constructed to scale ratios of 1:1,000 horizontally and 1:100 vertically, reproduced about 800 square miles of prototype area, including all of Matagorda Bay, part of the connecting bay system, and a portion of the Gulf of Mexico adjacent to Port Cavell. The model was reproduced by one primary and one secondary tide generator, and fresh-water discharges of tributaries, together with the rainfall over the channel, was reproduced by means of weirs and flowmeters. Salt water was used in the model Gulf to reproduce the prototype salinity regime, and provisions were made for the injection of silt in the model for measurements of deposits on
the bed of the model. Studies were made to determine: (1) The best location for the entrance channel; (2) the best route for the channel from the entrance to Point Comfort; (3) such protective works as may be required in the entrance and maintenance of the channel; and (4) the effects of the deep-nutrition channel on the salinity regimen of the bay system.

Test results indicate the proposed channel Route C is superior to any of the other channel routes tested. Model tests also indicate an arrangement of spoil disposal areas for use with this channel route which will have the least adverse effects on tidal currents, circulation, and salinity.

Preparation of final report is in progress.

(3912) MODEL STUDY OF GALVESTON BAY (HARBOR), TEXAS.

(b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

d) Experimental; for design.

(e) A 1:25 model which reproduced the filling and emptying systems used with the channel and determined the best port arrangement and valve schedule for filling the locks. Tests indicated that the best port arrangements still will not permit filling in 16 min if requirement for a maximum hawser stress of 5 tons is satisfied. A filling time of 1 min with approximately equal hawser stresses can be obtained, either by use of the type 2 intake and a 12-min valve schedule or the type 1 intake and a 4-min valve schedule. If maximum hawser stresses greater than 5 tons are allowed, advantages can be gained by use of the type 2 intake.

(h) Preparation of final report is in progress.

(3915) MODEL STUDY OF DROP STRUCTURE, GERING VALLEY PROJECT, GERING VALLEY, NEBRASKA.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.

d) Experimental; for design.

e) The Gering Valley project in western Nebr. will consist of low rectangular drop structures designed for alluvial channels, a series of which would be located on the main Gering drain as well as in the tributaries. Structure widths will vary from 6 to 33 ft and lengths from 16 to 47 ft, with drop heights of 5 and 10 ft. A 1:12-scale model and a 1:33-scale model were used in the investigation. Each model reproduced a typical drop structure, adjacent overbank areas, and channel characteristics at approach and exit areas. The smaller scale model permitted more rapid modifications of the structure.

(g) Families of curves were developed that permitted drop structure design based on drop height and discharge conditions. Design criteria based on investigation of structures having a 5-ft drop height were applicable to structures with drop heights up to 10 ft. A satisfactory plan for placement of riprap material in the vicinity of the structure was developed.

(h) Preparation of final report is in progress.

(3917) GENERAL SPILLWAY MODEL TESTS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

d) A general study, by means of model tests, of variables elements of spillways was developed and more nearly defined values of coefficients used in design formulas. A flume 70 ft long by 3 ft wide and 4 ft high comprises the test facility. Section models designed for study of particular elements of spillways are installed in the test flume.

To study hydraulic characteristics of spillway crest shapes with heads greater than the design head, including the effects of approach depth, crest plain, elevation of downstream floor of spillway, and of downstream slope of spillway, and to establish general rules for design of roller-type energy dissipators.

(4382) HYDRAULIC PROTOTYPE TESTS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

d) Field investigations for applied research and design.
(e) The purpose of the investigation is to coordinate the hydraulic prototype testing program of the Corps in order to ensure complete coverage of needed testing, prevent unnecessary duplication of testing facilities and tests, recommend instrument installations at prototype size where physical and hydraulic conditions will be suitable for obtaining data, and investigate hydraulic performance.

(g) Assistance in planning prototype instrumentation and testing was furnished to 15 Districts for 22 projects. Other hydraulic prototype tests related to and conducted partly under this study are described in detail under: (a) Power-Plant Prototype Tests, Garrison and Oahe Dams, Missouri River, N. Dak. and S. Dak.; (b) Barren River Dam, Barren River, Ky.; Stilling Basin Prototype Flow Tests; (c) Prototype Hawser-Force Measurements, Jackson Lock, Tombigbee River, Ala.; (d) Prototype Spillway Tests, Analysis and Report, Fort Randall Dam, Missouri River, S. Dak.; (e) Prototype Culvert Pressure Tests, Greenup Locks and Dam, Ohio River, Ky. and Ohio; (f) Prototype Tests, Gated Intake and Tunnel, Nolin Dam, Nolin River, Ky.; (g) Acoustic Flowmeter Installation and Prototype Tests, Summersville Dam, Geuly River, W. Va.; and (h) Old River Control Structure, La., Prototype Tests.

(h) Prototype Hawser - Force Measurements, Jackson Lock, Tombigbee River, Ala., TR 2-656, August 1965.

(4.385) MODEL STUDY OF TURTLE CREEK CHANNEL IMPROVEMENT.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

(d) Experimental; for design.

(e) To evaluate proposed channel improvements and determine the necessity for raising bridges and modifying piers and abutments in the lower 7700 ft of the Turtle Creek channel to a scale of 1:50. Provisions were made to test the lower 1500 ft of the creek in existing and improved conditions.

(g) Tests indicated that the proposed channel was adequate to carry the design discharge, although low-level railroad bridges in the reach would project into the flow. Additional reduction in stages and improvement in flow conditions could be obtained by realignment of the lower 2000 ft of channel projecting piers and abutments, and by removing projections and obstructions remaining in the channel upstream.

(h) Preparation of final report is in progress.

(4.385) GENERAL MODEL STUDY BELLEVILLE LOCKS AND DAM, OHIO RIVER, OHIO AND W. VA.

(b) District Engineer, U.S. Army Engineer District, Huntington, Corps of Engineers, Huntington, West Virginia.

(d) Experimental; for design.

(e) The project involves construction of a non-navigable-type dam with parallel locks about 204 miles below Pittsburgh, Pa.; the existing lock will be 1200 by 110 ft and the auxiliary lock 600 by 110 ft. The dam will consist of eight gate bays, each 110 ft wide, and a 265-ft-long fixed-crest weir. The locks and dam will have a lift of 22 ft and will replace four of the existing low-lift locks and dams. A 1:1200-scale fixed-bed model, reproducing about 3 miles of the river adjacent overbank area, and the locks and dam structures, was used for the investigation. The model included sufficient piezometer-type gages to permit an accurate study of the effects of the installation on stages at the dam, at the ends of the lock walls, and upstream and downstream over the ends of the walls.

To study navigation conditions in the lock approaches and the effects of the structures on flood stages under various flow conditions; to develop modifications required to overcome any undesirable conditions; and to demonstrate navigability and overall acceptance of the proposed design from a navigation standpoint.

(h) Preparations of final report is in progress.

(4.386) GENERAL MODEL STUDIES OF HOLT LOCK AND DAM, WARRIOR RIVER, ALA.

(b) District Engineer, U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama.

(d) Experimental; for design.

(e) To study flow conditions in the lock approaches and in the approach and exit channels for all arrangements of the structures; to determine the adequacy of the weir and stilling basin design; to design the model type of filling and emptying system from the standpoints of rate of operation, degree of turbulence, economy; and to study proposed valve designs.

Four models were used in this study: a 1:80-scale model reproducing the structures, 4800 ft of the approach channel, and 4800 ft of the exit channel; a 1:35-scale section model reproducing one full bay and two adjacent half bays of the spillway and stilling basin; a 1:25-scale model reproducing 800 ft of the lock approach channel, intake manifolds, the 670-ft lock chamber culverts, bottom laterals, outlet stilling basin, and 750 ft of the downstream exit channel; and a 1:40-scale model of a culvert valve.

(g) The 1:80 general model indicated that the overall arrangement and location of the structures were generally satisfactory. Installation of a 300-ft-long dike in the downstream river channel afforded improved flow conditions in the lower approach to the lock. Tests on the 1:35 section model indicated that the 60-ft-long, apron-type basin can be replaced with a small, 20-ft-radius bucket. In the 1:25 lock model the design laterals were revised for better flow distribution between the 12 ports. The bottom, middle-third lateral system was found to be feasible. Increasing the spacing between the laterals in this system improved its performance. The final design middle-third system consisted of 12 laterals spaced on 17-ft centers with the first 127 ft below the upstream gate pate. A satisfactory split-lateral filling system was also developed, consisting of 12 laterals divided into groups of six each in 17-ft centers. The land-wall group began 177 ft from the upstream gate pate and the river-wall group began 401 ft from the upper gate pate. With either filling or emptying system installed the lock could be filled in 3.3 min with a 4-min valve or emptied in 11 min with a 2-min valve. New stresses of 5 tons or less obtained. A vertically framed culvert valve was developed in the 1:15 valve model.


(4.388) SECTION MODEL STUDY OF SPILLWAY, TYPICAL LOW HEAD NAVIGATION DAM, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

(d) Experimental; for design.

(e) Stability of the stone blanket was investigated on a model reproducing a 5-ft depth of approach channel, one 60-ft gate bay and two adjacent half bays, the spillway, stilling basin, and channel. Observation of gate sill performance and stilling basin action were made on a 1:50-scale section model installed in a 1-ft-wide, glass-sided Plume Tank. Supplementary tests were conducted to investigate (a) flow conditions and maximum bottom velocities downstream of a trapezoidal gate
sill without stilling basin; (b) relative merits of a parabolic gate sill with a roller bucket energy dissipator and same sill with a horizontal apron stilling basin terminated by a sloping wall with flow-reducing energy at low-head navigation dams, specifically, proposed Locks and Dams 5 and 7; and (c) stability of a horizontal protective stone blanket downstream of the most practical energy dissipator.

Completed.

The trapezoidal gate sill permitted separation of the rapids from the gate sill and formation of an undesirable flow condition termed an undulating jet which created high bottom velocities and surface waves in the exit channel. Therefore, use of such a sill and the possibility of eliminating stilling basins at certain low-head dams on the Ark. River were studied from a preliminary investigation. Tests revealed the relatively short apron and end sill to be the most practical design for use with the parabolic gate sill and the conditions expected at the proposed Locks and Dams 5 and 7. The model also indicated that horizontal protective stone blankets consisting of stone up to 36 and 48 in. in diameter were stable over horizontal apron and end sill for all possible flow conditions other than spray action. The additional flow modifications to the elimination of stilling basins was not practical for the conditions investigated. However, a 40-ft-long, horizontal apron terminated by a 4-ft-high sloping and sill provided satisfactory performance and was found to be more effective in dissipating energy than were various roller buckets.

"Gate Sills and Stillings Basins for Locks and Dams Nos. 5 and 7," Appendix A to the final report on the principal study, TR 2-655, Spillway for Typical Low-Head Navigation Dam, Arkansas River, Arkansas Hydraulic Model Investigation, October 1965.

GENERAL MODEL STUDY OF CANNELTON LOCKS AND DAM, OHIO RIVER, IND. AND KY.

(a) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
(b) Experimental; for design.
(c) The project involves the construction of a nonnavigable reservoir approximately 12 miles below Pittsburgh, Pa., with parallel locks, the main lock to have clear dimensions of 1200 by 110 ft and the auxiliary lock to be 600 by 110 ft.
(d) Two models were used in this study. A 1:120-scale model reproduces about 9 miles of the river and sufficient overbank areas to permit the reproduction and flow up to the maximum of record (1967 flood). The model includes the locks and dam structures with provisions for the installation of powerhouse facilities. Also, 20 piezometer-type gages are provided to permit study of seepage as affected by the locks and dam and the powerhouse structures. A 1:25-scale model reproduced 500 ft of the lock approach channel, intake manifolds, the 1200-ft lock chamber, culvert, sidewalk, water manifolds, outlets, and 200 ft of the overbank area which will obtain at the Cannelton Lock and other locks on the Ohio River.
(e) Based on the 1:120-scale model indicated that the powerhouse should be placed on an angle of 70°45' with the axis of the dam, and that satisfactory navigation conditions could be obtained during flood stages by division of the left overbank upstream of the powerhouse entrance channel. Lock model tests indicated that satisfactory performance should be obtained with a sidewall port arrangement for a 110-by-1200-ft lock based on the following recommendations: (a) Port areas ratios should be about 0.85. (b) Ports should be spaced 28 ft on centers. (c) The port group should extend over about 50 percent of the lock chamber, the longer portion in the chamber. (d) Triangular deflectors or recesses are desirable at the upstream one-third of the ports.

MODEL STUDY OF NAVIGATION CONDITIONS OF LOCK AND DAM NO. 3, ARKANSAS RIVER, ARKANSAS.

(a) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(b) Experimental; for design.
(c) A movable-bed powerhouse, producing about 13 miles of the Arkansas River and adjacent overbank area, constructed to a scale of 1:120 horizontally and 1:80 vertically, was used. The purpose is to determine the suitability of the proposed site for the lock and dam structure, the effects of proposed regulating works in the vicinity including a cutoff and modifications which might be required to provide adequate channel depths in the lock approaches and safe navigation conditions with minimum maintenance.
(d) Tests to determine the effects of various combinations of training dikes and gate operation were completed.
(e) Results indicated that shoaling in the lower lock approach can be reduced by selected operation of the lock gates and the installation of training dikes in the channel upstream of the dam.

MODEL STUDY OF COLUMBIA RIVER ESTUARY, ENTRANCE TO OAK POINT, OREGON AND WASHINGTON.

(a) District Engineer, U.S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(b) Experimental; for design.
(c) The model reproduces the lower 52 miles of the Columbia River and pertinent offshore areas to linear scales of 1:500 horizontally and 1:100 vertically. The model depth, currents, density currents, waves, and other phenomena significant to the movement and deposition of sediments are reproduced and studied. Some portions of the model are of the fixed-bed type, while some portions are to be converted to the movable-bed type at a later date. The purpose is to determine the need for and to develop optimum plans for rehabilitation of existing jetties and proposed additional improvements; to investigate future shoaling developments in the entrance channel and in the reach between the entrance and Oak Point, and means of alleviating such shoaling; and to investigate existing and proposed spoil disposal areas to establish locations that will not permit movement of material back to the channel.
(d) Fixed-end shoaling tests indicated that construction of two proposed cutoffs in the channel will increase channel shoaling by the following amounts: Miller Sands Bar, 41.0 percent; Tongue Point Bar, 124.4 percent; Vauna-Lower Westport Bar, 75.6 percent; and Pillar Rock Bar, 60.2 percent. An improvement plan at Miller Sands Bar, consisting of a combination of 4 pile dikes and a 6000-ft-long dredge spoil fill, was developed which reduced the 40- by 6000-ft channel shoaling rate by 47.0 percent. Dredge spoil areas at Tongue Point Bar were developed which will not affect the shoaling rate at this bar. An improvement plan at Vauna-Lower Westport Bar, consisting of a combination of 4 pile dikes and 3 dikes and spoil fill, reduced the 40- by 600-ft channel shoaling rate by 29.6 percent.
(4593)  **GENERAL MODEL STUDIES OF MILLERS FERRY LOCK AND DAM, ALABAMA RIVER, ALABAMA.**

(b) District Engineer, U. S. Army Engineer Dist., Mobile, Corps of Engineers, Mobile, Ala.

d) Experimental; for design.

The project is located 142.2 miles above the mouth of the Alabama River and is part of the development program of the Alabama River waterway. It will include a nonnavigable dam with a gated and an overflow section, a lock on the left bank having clear dimensions of 600 ft by 84 ft and a powerhouse.

To investigate navigation conditions through an existing bridge and in the lock approaches, the effects of the structures on flood stages, and the effect of operations on navigation conditions. A separate model study investigated the suitability of a longitudinal floor culvert system for filling and emptying the lock under existing and submerged conditions which will obtain at the Millers Ferry Lock site.

A 1:100-scale general model reproducing about 5.1 miles of river was used to study navigation conditions, and a 1:125-scale model reproducing 700 ft of the lock approach channel, the 600-ft by 84-ft lock chamber, the entire culvert system, and 800 ft of the downstream exit channel was used to study filling and emptying of the lock.

Results in the general model indicated the need for modification of the left bank to facilitate the movement of downstream towa leaving the lock. In the lock studies, two satisfactory floor culvert arrangements were developed. The arrangement was adapted to the particular foundation conditions existing at the Millers Ferry Lock site which confined the culvert system to the middle third of the lock chamber. The second arrangement was developed for locations with less restrictive foundation conditions.

Preparation of final reports on general and lock model studies is in progress.

(4594)  **MODEL STUDY OF SPILLWAY, SHELBYVILLE DAM, KASKASKIA RIVER, ILLINOIS.**

(b) District Engineer, U. S. Army Engineer Dist., St. Louis, Corps of Engineers, St. Louis, Missouri.

d) Experimental; for design.

The investigation was conducted on a 1:40-scale model that reproduced the spillway and the approach channel. The embankment on each side of the spillway, 1500 ft of the approach channel, and 1150 ft of the exit channel.

The purpose of the investigation is to study the overall hydraulic performance of the spillway and outlet of the sluices, verify the chute and stilling basin designs, and develop an exit channel protection plan.

Achieve spillway capacity and flow conditions at the abutments were obtained by placing rock dikes at the abutment to guide flow into the weir. The model was found to be adequate and satisfactory for the release of the expected diversion flows. Exit channel protection, with and without berms behind the stilling walls, consisting of riprap and concrete paving was developed.

Preparation of final report is in progress.

(4595)  **GENERAL MODEL STUDY OF COLUMBIA LOCK AND DAM, OUCHITA RIVER, IA.**

(b) District Engineer, U. S. Army Engineer Dist., Vicksburg, Corps of Engineers, Vicksburg, Mississippi.

d) Experimental; for design.

The project involves construction of a cutoff channel about 5,600 feet long with a bottom width of 322 feet, a gated structure (consisting of fourainter gates each 50 feet wide and 26 feet high) located about midway of the cutoff, a 200-foot-wide navigable pass on the right of the dam, and a 220- by 84-foot lock on the left. A 1:100 model, reproducing about 2.6 miles of the river, was used to investigate navigation conditions in the approaches to the lock and navigable pass, and the effects of the structures on flood stages.

Final report in preparation.

(4598)  **MODEL STUDY OF DROP STRUCTURE, CAYUGA INLET, ITHACA, NEW YORK.**

(b) District Engineer, U. S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.

d) Experimental; for design.

The investigation was conducted on a 1:20-scale model which reproduced 300 ft of the approach channel, the drop structure, and about 400 ft of the exit channel.

The purpose of the study was to confirm the suitability of the drop structure, and if indicated, to develop modifications thereto. Of particular concern is the magnitude of channel velocities below the structure.

Completed.

Tests demonstrated that the original design structure was unsatisfactory as little or no energy dissipation occurred at low and intermediate flows. The length of the structure was reduced and baffle piers were eliminated from the basin. A 5-ft-high sill was added to the weir crest to fill the channel upstream from the structure. Use of a 12-ft-radius abutment wall improved conditions at the entrance to the structure and reduced construction cost. A "Drop Structure, Cayuga Inlet Cayuga Lake, New York Hydraulic Model Investigation," TR 2-709, Dec., 1965.

(4599)  **MODEL STUDY OF CONTROL STRUCTURES, LITTLE SIOUX RIVER PROJECT, LITTLE SIOUX, IOWA.**

(b) District Engineer, U. S. Army Engineer Dist., Omaha, Corps of Engineers, Omaha, Nebraska.

d) Experimental; for design.

The 1:30-scale model reproduced about 700 ft of the channel and berms upstream of the structure, the drop structure, and about 1300 ft of the channel and berms below the structure.

Portions of the levees containing the structure were reproduced adjacent to the berms. The approach channel and berms were initially molded in sand; subsequent tests were conducted with this area molded in cement mortar to sheet-metal templates.

Prototype roughness was simulated by installing expanded metal mesh (7/8-in.) on the upstream berms. The approach structure was fabricated of plastic-coated plywood.

Studies were made of the placement of riprap materials in the vicinity of the structure and the discharge capacity of the structure.

As the design of the drop structure for Little Sioux was based on the successful design of the Gering Valley structure, and as initial observations revealed unsatisfactory performance of the structure from a hydraulic standpoint no changes were made to the drop structure during the model study. Model tests were mainly concerned with the determination of an adequate riprap plan to protect the structure and to obtain the most economical use of the rock. Calibration data for submerged and unsubmerged flows were obtained. It was determined from the model study that while the overall performance of the structure was excellent, and the dimensions of the drop structure based on the Gering Valley tests were satisfactory, certain modifications of the structure would improve hydraulic performance and effect economies in construction.

Tests indicated that stone sizes in the original riprap plan were larger than necessary and smaller sizes could be used with a resulting saving in construction costs. Tests also indicated that approximately 150 ft of riprap protection on the channel banks upstream from the structure could be eliminated.
(h) Preparation of final report is in progress.

LOCK FILLING AND EMPTYING SYSTEMS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

d) Experimental; research.

e) The following models were used in this study during the past year: the 1:25-scale model of the 67C- by 11C-ft low-lift locks on the Arkansas River west of the Jones Bluff Lock, Arkansas, and a 1:36-scale model of the culvert system for a longitudinal floor-culvert system in a 1:250-scale model. The purpose of the studies is to provide new or improved design information and procedures to assist in the design of navigation lock filling and emptying systems.

Tests were conducted in the low-lift lock test facility to provide additional information on the desirable culvert and port sizes for use in the installation of lock filling and emptying systems. The longitudinal floor-culvert filling and emptying system developed for the Jones Bluff Lock was tested at a head of 60 ft to provide data on the performance of this type system at high heads. Development tests of a floor-culvert system for use in high-lift locks were conducted in the 1:25-scale model. Tests to date have been directed toward improving the design of the transitions, bifurcations, and bends required in the culvert system. Several designs have been tested in an effort to minimize head losses while maintaining the desired distribution of flow in the culvert system.

Correlation of results from the low-lift lock tests with other data resulted in design recommendations for low-lift lock systems. Results of the tests on the Jones Bluff Lock model indicated that the longitudinal floor-culvert system has potential for adaptation to larger locks with intermediate and high lifts.

(h) Preliminary report is in preparation.

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR LOW-LIFT LOCKS, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U. S. Army Engineer Dist., Little Rock, Corps of Engineers, Little Rock, Arkansas, and other interested Corps of Engineers offices.

d) Experimental; for design.

The investigation was conducted on a 1:25-scale model which reproduced 700 ft of lock approach channel, intake manifolds, a 670-ft-long lock chamber, culvert, and sideval port systems on a 700-ft-long downstream channel. It is being used to determine an optimum port arrangement for the filling and emptying system for low-lift locks.

(d) Experimental; for design.

The investigation was conducted on a 1:25-scale model that reproduced the intake tower and a portion of the reservoir, the 29-ft-diam diversion tunnel, stilling basin, and 240 ft of the exit channel. At the conclusion of the diversion tests, the flood-control gate was installed at the end of the 29-ft-diam conduit for additional flow studies.

The purpose is to develop a conventional hydraulic model of a cylindrical intake tower with reduced head loss and surging. A model of the slide-gate intake tower will provide the performance characteristics and no zones of separation were evidenced. Pressure fluctuations in the flood-control transitions indicated a gradient that approximated that of the area curve. The stilling basin developed for the large diversion releases was found to be adequate for dissipation of the high-energy flood-control releases.

CRITERIA FOR THE DESIGN OF SMALL-BOAT HARBOURS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

d) Experimental; applied research.

e) To develop criteria and experimental coefficients for use in predicting the motion of small boats moored to floating docks under the action of progressive- and standing-wave systems; determine the optimum shape of harbors and types of perimeter walls with respect to the response characteristics of small-craft harbors and the surge of moored craft in the harbors; and provide design criteria for protective structures at the entrance to small-craft harbors.

(h) Wave Basin of Various Sizes will be used in the laboratory tests.


GENERAL COASTAL INLET STUDIES.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

d) Experimental; for design.

This is a general study to develop means for computing discharge and velocity distribution through tidal inlets, leading to determination of tidal profiles, and water-surface elevations in inner bay systems; and to determine the factors involved in both inner and outer bar formation, the shoaling of inlet channels, and the stability of inlet shape and location.

The project will consist of the following three phases: (1) Tests in four generalized test facilities, three of which are the hydraulic models at the Waterways Experiment Station and the fourth at the Naval Construction Research Center; (2) analysis of results of these tests by the Waterways Experiment Station, the Coastal Engineering Research Center, and the Committee on Tidal Hydraulics; and (3) field observations and field observations under sponsorship of the Committee for Tidal Hydraulics to confirm the principles developed. Construction of Tidal Hydraulics, including the control system design, and final design for the water supply and control systems have been obtained. Design of Facility C, located at WES, has been completed and design of the initial inlets to be used in this facility has been completed. The basic structure of Facility D, located at WES, has been designed and construction in progress for the water supply and control systems have been obtained. Design of Facility B to be located at WES has been completed. Fabrication of the shelter for the water supply and control systems has been prepared. Design of Facility C has been completed and the design of the initial inlets to be used in this facility has been completed. The basic structure of Facility D, located at WES, has been designed and construction in progress for the water supply and control systems have been obtained. Design of Facility B to be located at WES has been completed. Fabrication of the shelter for the water supply and control systems has been prepared. Design of Facility C has been completed and the design of the initial inlets to be used in this facility has been completed. The basic structure of Facility D, located at WES, has been designed and construction in progress for the water supply and control systems have been obtained. Design of Facility B to be located at WES has been completed. Fabrication of the shelter for the water supply and control systems has been prepared. Design of Facility C has been completed and the design of the initial inlets to be used in this facility has been completed. The basic structure of Facility D, located at WES, has been designed and construction in progress for the water supply and control systems have been obtained. Design of Facility B to be located at WES has been completed. Fabrication of the shelter for the water supply and control systems has been prepared.
MODEL STUDY OF NAVIGATION CONDITIONS, LOCK AND DAM NO. 4, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U. S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

d) Experimental; for design.

e) The investigation was conducted on a 1:120-scale, fixed-bed, comprehensive model, reproducing about 5 miles of the Arkansas River and adjacent overbank areas, the lock and dam structures, and all bridges and other structures that might affect flow conditions. The purpose is to determine the suitability of the lock and dam structure, and the effects of regulating works in the lower approach, and to develop modifications which might be required to overcome any undesirable navigation conditions.

(g) The location and arrangement of the lock, dam, and overbank sections were satisfactory. The upper guard wall should be on the riverside rather than landside. Modification of the Bob Roy Bridge and alignment of the right bank near the bridge would be desirable to improve navigation. The mooring area would have less effect on navigation through the lock if moved upstream. Shunting in the lower approach will depend on amount of sediment moving through the dam.

Preparation of final report is in progress.

MODEL STUDY OF NAVIGATION CONDITIONS, OZARK LOCK AND DAM, ARKANSAS RIVER.

(b) District Engineer, U. S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

d) Experimental; for design.

e) A 1:120, fixed-bed model, reproducing about 3 miles of the Arkansas River, adjacent overbank areas to an elevation of approximately 385 ft msl, the lock and dam structures, and all bridges and other structures that might affect flow conditions, is being used to determine the suitability of the proposed site for the lock and dam structures, and to develop modifications which might be required to overcome any undesirable navigation conditions.

Tests have resulted in modifications in the lock approaches and in the excava-

tion in the approach to the powerhouse, and in the development of a suitable plan for the dam.

Preparation of final report is in progress.

MODEL STUDY OF SUBMERGED SILLS, ST. CLAIR RIVER.

(b) District Engineer, U. S. Army Engineer District, Detroit, Corps of Engineers, Detroit, Michigan.

d) Experimental; for design.

(e) To study effects of one or more submerged sills at different locations on downstream effect, to study sedimentation characteristics and velocities and current directions, and to verify the adequacy of the submerged sills to withstand propeller wash with an initial velocity of 25 fps.

The comprehensive model reproduced the St. Clair River from Lake Huron to a point about 31 miles downstream to a scale of 1:120; this model was of the fixed-bed type with provisions for the study of sediment movement and for the study of shunting in the critical area. A 1:20-scale section model installed in an existing, 2.5-ft-wide flume was used to investigate the stability of the submerged sills and the ability of 15-ton barge units and various sizes of stone to withstand propeller wash with an initial velocity of 25 fps.

Tests on the comprehensive model to determine the effects of various submerged sill combinations were conducted. Construction of the section model and tests to determine the stability and discharge coefficients of various submerged sills (selected as a result of the section model tests) and the effects of sediment deposition were accomplished.

The results indicated that: the new type sill would be slightly less effective than the vertical-faced sills; sediment deposition between sills would tend to reduce the effectiveness of the sills; and sills would have no appreciable effect on navigation conditions in the reach.

MODEL STUDY OF SEAWALL, TEXAS CITY, TEXAS.

(b) District Engineer, U. S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

d) Experimental; for design.

(e) A levee and seawall system has been proposed to protect Texas City and adjacent areas of the sheet of Galveston Bay against overflow caused by hurricanes. To develop designs for (1) vertical-faced seawalls, (2) rubble-mound structures to protect the natural ground at the base of a vertical wall on its bayside, and (3) rubble-mound armor layers to protect the bayside slope and crown of an earth levee, 1:35 section models of the structures are being tested in a concrete flume 110 feet long, 5 feet wide, and 4 feet deep. Model waves are generated by a plunging-type wave machine, and measured and recorded electrically on a recording board on the dam.

(g) To stabilize the type 1 design, when attacked by 6-second, 15-foot waves, 6-ton stones instead of 3.3-ton stones were required at the bayside toe. The landside slope was made stable by using 3.3-ton stones instead of riprap. The type 2 and type 3 designs were made stable under the attack of 1.5-second, 15-foot waves by using a mound of 1- to 1-1/2-ton stones to scotch the toe of the 6-ton cover layers. The results of the pressure distribution tests showed that the forces acting on the vertical-wall sections were greater than those obtained from Sainflou's theory for nonbreaking waves, and less than those obtained from Minkkin's formula for breaking waves.

Final report in preparation.

MODEL STUDY OF BESSEY CUTOFF, MISSISSIPPI RIVER.

(b) District Engineer, U. S. Army Engineer District, Memphis, Corps of Engineers, Memphis, Tennessee.

d) Experimental; for design.

(e) The proposed Bessey Cutoff would eliminate the river bend at New Madrid, Mo., and shorten the river about 21 miles. A model, reproducing 85 miles of the river to a horizontal scale of 1:1,000 and vertical scale of 1:100, is being used to obtain indications of the probable effects of various degrees of cutoff development on velocities, current directions, water-surface profiles, navigation depths, channel meandering tendencies, and general navigability of the affected reach. The model is of a type with the vision for converting to a movable bed the reaches expected to be affected appreciably by the cutoff.

Test results indicated no serious navigation difficulties during the time of the intermediate or final development stages of the cutoff, except for locally high velocities. The low-water slopes upstream of the cutoff would be increased by about 50 percent, with stages lowering from 1.5 ft at a.5 ft at the head of the cutoff, to 6.5 ft at the head of the cutoff with a flow of about 200,000 cfs. Flood stages would be lowered by about 0.5 ft at the cutoff, to 11.0 ft at the head of the cutoff, depending on the magnitude of the flood and whether or not the Birds Point-New Madrid Floodway is in operation. The tests indicated the general effects of the cutoff on channel development and stabilization, the effects of
the flood-free roadway connecting the severed area with the mainland, and the movement of sediment at the head of the cutoff during the initial development.

(b) "Model Study of Lomita Cutoff, Mississippi River; Hydraulic Model Investigation," Report No. TR 2-592, September 1965.

(S238) MODEL STUDY OF SPILLWAY, STOCKTON DAM, SAC RIVER, MISSOURI.

(b) District Engineer, U. S. Army Engineer District, Kansas City, Corps of Engineers, Kansas City, Kansas.

(d) Experimental; for design.

(e) A 4-gated, ogive spillway and one 45,000-kilowatt powerhouse unit located in a concrete nonoverflow section adjacent to the spillway are proposed for Stockton Dam. A 1:60 model extending 700 feet of the approach area, the entire spillway and powerhouse, the stilling basin, and 1,100 feet of the exit channel was used to investigate the hydraulics adequacy of the spillway, stilling basin, and appurtenances, and to determine any desirable modifications for various operating conditions.

(f) Tests completed.

(g) The overall performance of the original design structure was satisfactory. Flow conditions in the approach, at the shuttoms, over the spillway, and on the chute were adequate. The capacity of the spillway as determined on the model was greater than that computed. No alterations to the original spillway section were made during the course of the model study. However, in several tests the discharge per foot of crest width was adjusted upward to simulate flow over a slightly reduced crest width. The performance of the original design stilling basin was satisfactory in the dissipation of all spillway discharge. However, three alternate designs were investigated in an attempt to effect economies in construction costs. A stilling basin (type 5) was developed which permitted a reduction in the size of basin elements and permitted the basin elevation to be raised 5 ft. The model tests also indicated that the height of the stilling basin divider wall could be reduced 3 ft without affecting the efficiency of the basin.


(S241) MODEL STUDY OF WAVE ACTION AND SHIP MOORING, POINT LOMA, CALIFORNIA.

(b) Department of the Navy.

(d) Experimental; for design.

(e) The Navy Engineering Laboratory desires to use an aircraft carrier, moored behind a protective breakwater about 4,000 feet offshore, in the design and development of electronic equipment. A 1:100 model reproducing about 4.5 square miles of the locality and a 1:100 model of an Essex class aircraft carrier were used to:

(1) Determine wave-action conditions that will obtain within the mooring area; (2) study variations in design and location of the breakwater on the results of wave data on actual movement of the ship due to wave action; (3) investigate the feasibility of proposed floating causeway shoreward from the ship; and (4) study alternate designs of a proposed small-craft landing area in the immediate vicinity. Waves were generated by a 60-foot-long wave machine, and are measured, recorded and recorded electrically. The model of the aircraft carrier was dynamically balanced to reproduce the physical characteristics of the prototype ship.

(f) Completed.

(g) (1) Breakwater length was reduced from 3,500 to 2,100 feet, resulting from original design. (2) It was determined that wave heights behind the breakwater, and the resulting ship motion, would not be excessive insofar as waves from average severe storms are concerned. (3) The optimum crown elevation for a rubble-mound causeway and small boat landing area (l) was determined that a nearby sewer outfall pier would be unsafe for fishermen during periods when wave heights approached 13 to 18 feet because of overtopping of the structure.


(P242) PROTOTYPE CULVERT PRESSURE TESTS, GREENUP LOCKS AND DAM, OHIO RIVER, KENTUCKY AND OHIO.

(b) District Engineer, U. S. Army Engineer District, Huntington, Corps of Engineers, Huntington, West Virginia.

(d) Experimental; for design.

(e) The project, located on the Ohio River 341 miles downstream from Pittsburgh, Pa., consists of a 110- by 600-ft auxiliary lock, a 110- by 1200-ft main lock, and a nine-bay, 1227-ft-long spillway dam. The lift of the locks is 32 ft at present, but will be 30 ft when additional downstream development is completed. The spillway and outfall were designed for the height of the main lock consists of two culverts and a split-lateral system. To measure prototype pressures in the filling and emptying systems of the main lock and water-surface elevations in the lock chamber for comparison with model results and for further development of lock design criteria. Electrical transducers connected to piezometers by air-purged lines were used to measure pressures in the lock culverts and water-surface elevations in the lock chamber of the main lock. The data analysis and model-prototype comparison in report form were furnished by the St. Paul District. These were combined with remainder of the report. Final editing is in progress. Analysis of prototype pressures in the filling and emptying systems of the main lock for two-culvert operation, single-culvert operation, and steady-flow conditions indicates reasonable confirmation of the model results. Discrepancies between model and prototype simulation, however, caused the dissimilarity in the data.

gate hydraulic cylinder pressures were made with pressure gages. (g) Tests were conducted in December 1964. Preliminary analysis of the data has been completed and a report prepared. Additional tests are planned when water becomes available. (5245) MODEL STUDY OF HOUSTON SHIP CHANNEL, TEXAS. (b) District Engineer, U. S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas. (d) Experimental; for design. (e) Houston Ship Channel is a 52-mile reach extending from the Gulf of Mexico across Galveston Bay; to the Turning Basin at Houston. A model study is being conducted to determine if the present cost of maintenance dredging in the channel can be reduced by proceeding with channel realignment, partial or complete diking of connecting bays, sediment traps, dikes in Galveston Bay, local contractions, enlargements, and other remedial measures. The model reproduces a portion of the Gulf of Mexico outside the entrance to Galveston Bay; all of Galveston and Trinity Bays; Dickinson Bay and Clear Creek to the head of project; the tidal portion of Trinity River; the Houston Ship Channel in its entirety; and Buffalo Bayou from the Turning Basin to the confluence of White Oak Bayou. The model is of fixed-bed construction with scale ratios, model to prototype, of 1:60 horizontally and 1:60 vertically. Tides and tidal currents are reproduced by a tide generator located in the Gulf of Mexico portion of the model, and the salinity of the model Gulf is reproduced to scale so that the effects of salinity differences on the vertical distribution of current velocities, as well as salinity concentrations throughout the model, accurately represent those of the prototype. The model will be used to establish the effects of all proposed improvement plans on tidal current velocities, current patterns, and salinities in all critical areas. All hydraulic and salinity data obtained from the model will be quantitative and will be used directly to the prototype. Shoaling studies will be made by injecting finely ground gilsonite into the model to reproduce the patterns of shoaling as observed in the prototype, following which the effects of proposed improvement plans on shoaling patterns may be observed and evaluated from a qualitative viewpoint. (g) Operation of the model with salt water for verification of salinities, tidal elevations, and current velocities for conditions of low and medium freshwater discharges was in progress; model verification is about 90 percent complete. (5246) MODEL STUDY OF NAVIGATION CONDITIONS, UNIONTOWN LOCK AND DAM, OHIO RIVER. (b) District Engineer, U. S. Army Engineer Dist., Louisville, Corps of Engineers, Louisville, Kentucky. (d) Experimental; for design. (e) The project involves construction of a dam consisting of a gated section with sill elevation at 317, a fixed overflow section with crest at elevation of 344, and two parallel locks. The main lock chamber will have clear dimensions of 110 by 1200 ft. The auxiliary lock, 110 by 600 ft, will be located on the right bank. To investigate navigation conditions with the proposed structures, to determine the effects of modifications in the composition and arrangement of the structures, and to develop any modifications considered desirable, the investigation is being conducted on a 1:120 model reproducing about 8.6 miles of the Ohio River and adjacent overbank area near Uniontown, Ky., the lock and dam structures, and the lower reach of the Vabash River. (5247) MODEL STUDY OF FILLING AND EMPTYING SYSTEM, JONESVILLE LOCK AND DAM, CHICKASAW-BLACK RIVER, LOUISIANA. (b) District Engineer, U. S. Army Engineer District, Vicksburg, Corps of Engineers, Vicksburg, Mississippi. (d) Experimental; for design. (e) A 1:25 model, reproducing 750 feet of the lock approach channel, intake manifold, the 84-by-500-foot lock chamber, culvert, sidewall and outlets and exit channel, is being used to develop the optimum side port filling and emptying system for the lock. Completed. (g) The original design intake and outlet manifold performed satisfactorily. Tests of 31 sidewall port configurations were conducted. In the adoption of 17 ports per culvert spaced 20 ft on centers with 8-by-8-ft-deep recesses in the lock chamber floor in front of each port. With the adopted hydraulic system installed in the model, hawser stresses on 4- and 6-barge tows were well within the limits that can be obtained at normal and probable maximum heads and submergences. Flow conditions in the upstream lock approach indicated that rectangular guide wall piers were not required. For the flexible nature of the approach, the use of circular guide wall piers is recommended. Flow conditions in the downstream lock approach were satisfactory during emptying operations. (5248) PROTOTYPE HAWSER-FORCE MEASUREMENTS, JACKSON LOCK, TOSHOES RIVER, ALABAMA. (b) District Engineer, U. S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama, Chief of Engineers, Washington, D. C. (d) Experimental; for design. (e) The Jackson lock chamber is 110 feet wide by 670 feet long and has a 34-foot maximum lift. Reverse tailwater control flow in two 12.5-foot-square culverts, each of which has 6 intake ports in the upper approach walls, 14 side ports to the lock chamber, and an outlet discharging outside the lower lock approach. To measure prototype hawser loads resulting from hydraulic forces acting on a tow of loaded barges, data obtained with rigid and flexible-type connections between the tow and floating mooring bitts were compared with model results and used in developing lock design criteria. The rigid connections, containing calibrated dynamometers in various forces, were measured in the lock on the portside of the tow and connected to floating mooring bitts in the lock land wall. One connection measured longitudinal hawser forces, and the other measured transversal forces. Potentiometers were mounted on the culvert-valve operating arm to measure valve opening. Differential-type pressure transducers were used for measuring the slope of the water surface in the lock chamber, and absolute pressure transducers were used for measuring pressures in the valve port and the approach channel. Potentiometers also were installed on the land-wall floating bitts to measure tow movement during the rigid connection tests. For the flexible connection tests, the rigid connections were replaced by flexible hawser 1-inch-diameter wire rope at all four corners of the tow, and calibrated dynamometers were mounted in the hawser and connected to floating bitts in both lock walls. Other instrumentation was identical with that of the rigid connection tests. Completed. (g) Good agreement was found between the prototype cable hawser measurements and the model results with maximum longitudinal forces of
about 4 tons and maximum transverse forces of about 1-1/2 tons. Unscheduled overfilling of the lock chamber, resulting from the momentum of the flow in the filling system, forced the upstream walls against the powerhouse and the 4-min valves, causing longitudinal forces of 8 tons. Prototype hawser loads in the rigid-connection tests were much higher than with the flexible connection, allowing clearances between the floating mooring bitt rollers and guides permitted the tow to move freely about 2 ft, resulting in impact-type loads.


**Prototype Spillway Tests, Analysis and Report**, FORT RANDALL DAM, MISSOURI RIVER, SOUTH DAKOTA.

1. District Engineer, U. S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
2. Experimental; for design.
3. Fort Randall Dam, in southeastern South Dakota, is one of a system of multiple-purpose reservoirs. The dam consists of a rolled-earthfill embankment almost 2 miles long with a maximum height of 160 ft. Four 22-ft-diam conduits discharging into a common stilling basin provide for flood-control releases.
4. Eight 22-ft-diam conduits supply water for power generation. A 1000-ft-wide, concrete-chute spillway with a design capacity of 600,000 cfs is located in the reservoir. Spillway discharge is controlled by 21ainter gates, each 29 ft high and 40 ft wide. To obtain vertical velocity distribution and water-surface depths on the spillway chutes for use in checking design resistance coefficient assumptions and computing discharge over the spillway. These data will assist in eliminating the uncertainty of calculations on full-scale chute spillway flows used in design of such structures.
5. Two pitot flumes were fabricated and installed on the spillway chutes. The pitot flume instrumentation consisted of eight total-head tubes to measure vertical velocity distributions. Water-surface measurements along the spillway length were made with wire-weight gages. Visual observations and photographic records of flow conditions were also made.
6. Water-surface measurements on the spillway appeared to be close to the normal depth at the downstream end of the chute. Vertical velocity distributions on the spillway slab were obtained by the logarithmic equation for the supercritical flow conditions of the tests. Flow resistance was relatively high, possibly due to the concrete spillway slab or wave effects in the super-critical flow. Equivalent sand roughness values and the slope of the velocity distribution curve agree with results of previous investigations.
7. Preparation of final report is in progress.

**Model Study of Navigation Conditions, ROBERT S. KERR Lock and DAM, ARKANSAS RIVER.**

1. District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.
2. Experimental; for design.
3. The Robert S. Kerr Lock and Dam, to be located at about 1 mile downstream on the Arkansas River, will involve construction of a nonnavigable-type dam, a 110- by 600-ft lock, and a powerhouse. The lock will provide a maximum lift of about 40 ft. To study navigation conditions in the approaches to the lock, determine suitability of the selected site, and develop modifications required under undesirable conditions. The model reproduces about 3.2 miles of the Arkansas River and the lock and dam structures to a scale of 1:1150. It is a 5-ft-wide model with provision for a movable-bed section below the dam for use in the development of channel configurations in the reach.
4. Tests have indicated the need for modification of the alignment of the right bank downstream of the powerhouse and the extension to the lower guard wall to improve navigation in the lower approach with existing and ultimate channel, and a fill along the left side of the approach to eliminate objectionable crosscurrents.
5. **Model Study of Breakwaters, Dana Point Harbor, California.**
6. District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers, Los Angeles, California.
7. Experimental; for design.
8. Dana Point Harbor is a proposed small-craft harbor to be located on the southern California coast in Orange County, about 46 miles southeast of Los Angeles. This harbor is to be constructed at a site which is exposed to ocean waves. The harbor will be protected by rubble-mound breakwaters which are permeable and allow some of the wave energy to pass through the structures into the calm area. To determine the effectiveness of the proposed breakwater sections in reducing transmitted wave energy, and the stability of the breakwaters to provide a basis for the design of the proposed harbor; and to test available basic data on the transmission of wave energy into artificial harbors.
9. Tests were conducted in a 10-ft-wide, 119-ft-long, 5 ft wide, and 4 ft deep section model of the proposed structures constructed to linear scales of 1:50 and 1:100. Model waves were generated by a plungertype wave machine and measured and recorded electrically.
10. Stability tests, wave-transmission tests, and wave runup and wave-breaking tests were conducted on breakwater sections with crown elevations of +14 and +18 ft mllw. Tests were also conducted on wave absorbers on the face slope of the mole with a view to reducing the wave runup on the mole and wave heights in the fairway between the mole and the breakwater.
11. Stability tests showed that the proposed breakwater section would be adequate to withstand the attack of the 12-sec, 16-ft design waves. The maximum transmitted wave height measured on the waveguide was found to be about 45 percent of the incident wave height. The average value of the wave transmission coefficient (Ht/Hs) is about 15 percent of the incident wave height. Throughout the wave period, the more wave energy is transmitted through a rubble-mound breakwater. Appreciable scale effect in wave transmission was found between the results of tests conducted on model-developed breakwater at crown elevation of +18 ft mllw which would provide a mole revetment and breakwater combination that would satisfy the selected wave-height criterion in the fairway between the mole and the breakwater.
12. Preparation of final report is in progress.

**Investigation of Wave Reflecting and transmitting Characteristics of Rubble-Mound Breakwaters, Rubble-Wave Absorbers, Sand Beaches, Wave Traps, and Resonators.**

1. Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
2. Experimental; for research.
3. A theoretical study of the phenomena of wave transmission through rubble breakwaters in the light of turbulent flow through porous media has been made. The study also includes the study of the effects of breakwater permeability and wave characteristics on wave transmission through rubble-protected areas which are being conducted in a 1- by 1.5- by 65-ft wave flume.
water sections, having different crown width, side slopes, and rock characteristics (size, shape, and hardness) were built and were subjected to waves having different heights and periods. Both the incident and transmitted waves are measured and recorded electrically. Similar tests will also be done in 2- by 5.5- by 140-ft wave flume. Laboratory investigations of the wave reflecting-absorbing characteristics of different types of wave absorbers will be conducted. Several factors relating to wave absorbers will be investigated.

To establish design criteria (a) for rubble breakwaters with respect to their wave reflecting-transmission characteristics, and (b) for the different types of wave absorbers (natural seagrass, wave traps, resonators, and rubble mound).

A 1 by 1.5- by 85-ft steel wave flume is used in which waves are generated by a hinged-plate type wave generator. The wave transmission through rubble breakwaters is being conducted.


(a) Experimental; for design.

(b) Model study, Waterways Experiment Station, for Galveston District.

(c) Experimental; for design.

(d) The Gulf Intracoastal Waterway, Channel to Victoria, Tex., is located along the Gulf coast in south-central Texas. The navigation channel extends northward from the Gulf Intracoastal Waterway in San Antonio Bay about 35 channel miles to a turning basin about 7 miles south of Victoria, Tex. The channel, when completed, will have a controlling depth of 10 ft below mean sea level over a bottom width of 100 ft and 1-on-3 slopes. The proposed turning basin and flushing system will be located at the end of the navigation channel. The flushing system is to consist of a freshwater intake ditch, flushing canal, gate control, underground conduit, and stilling basin. It is anticipated that the navigation channel will require two flushings per year to eliminate objectionable surface debris, oil, and foul water and that the average annual inflow of 14,400 acre-ft can be expected to flow from the channel to local runoff, the unpredictable magnitude of storms and the distribution of the inflow throughout the year. The flushing system may not be used for the flushing of the navigation channel only and may be used for the flushing of the channel itself.

Tests revealed that flow conditions were satisfactory for all partial gate openings with the original design gated sill shape. The original design stilling basin resulted in high bottom velocities in the exit channel, which were decreased by the introduction of the sill apron. The stability of the store protection blanket placed on a 1-on-5 slope downstream from the sill was determined. "Spillway for Belleveille Locks and Dam, Ohio River, Ohio and West Virginia; Hydraulic Model Investigation," Technical Report No. 2-687, August 1965.

(b) Study conducted for the Little Rock project.

(c) The project involves construction of a gated dam and lock. As proposed, the dam will contain 14 gate bays (60-ft span) with sill at elevation 232. The lock will have clear dimensions of 110 by 600 ft. The maximum lift will be 19 ft. To investigate navigation conditions with the proposed structures, to determine the effects of modifications in the composition and arrangement of the structures, and to develop such modifications as might be considered desirable.

The investigation is being conducted on a 1:120 scale model reproducing about 5 miles of the Arkansas River channel near Morrilton, Ark. The model is of the fixed-bed type with provisions for changes in the channel based on the existing bed levels.
proposed regulating structures.

Design and construction of the model were completed, and tests for the development of satisfactory navigation conditions were undertaken.

Results have indicated the need for improvement in navigation conditions in the upper and lower lock approach.

(5639) MODEL STUDY OF NAVIGATION CONDITIONS, LOCK AND DAM NO. 7, ARKANSAS RIVER.

(b) District Engineer, U. S. Army Engineer District, Little Rock, Corps of Engineers, Arkansas.

d) Experimental; for design.

e) A 1:120, fixed-bed, comprehensive model, reproducing about 7 miles of the Arkansas River, adjacent overbank areas, the lock (110 by 600 feet) and dam structures, and other structures that might affect flow conditions, will be used to study navigation conditions in the lock approaches, the design of the upstream guard wall, and location and design of any training works needed to improve navigation conditions and distribution of flow to the spillway.

(g) Design and construction of the model were completed, and tests for the development of channel conditions based on proposed regulating structures were accomplished. Tests for development of satisfactory navigation conditions were undertaken.

Results indicated the need for modification in regulating works upstream of the lock for the improvement of navigation conditions and distribution of flow through the gated spillway.

(5640) POLLUTION MODEL STUDY, CHARLESTON HARBOR, SOUTH CAROLINA.

(b) District Engineer, U. S. Army Engineer District, Charleston, Corps of Engineers, Charleston, South Carolina.

d) Experimental; for design.

e) The Charleston Harbor model reproduces about 17 miles of the South Carolina shoreline, 220 square miles of the Atlantic Ocean, and the entire tidal portions of the Cooper, Ashley, and Wando Rivers and their tributaries. The model is of the fixed-bed type and is constructed to scales of 1:1,000 vertically and 1:2,000 horizontally. Provisions are included for reproducing tides and tidal currents, upland and freshwater flows, ocean salinity, and salinity intrusion. Conservative-type fluorescent dyes will be introduced to simulate industrial and municipal waste effects and variations in the upland flow on the dispersion and flushing characteristics of the dyes will be determined.

To provide data on dispersion and transport of waste in the harbor under various conditions of freshwater inflow along with data on tides, currents, and salinities for all inflow conditions studied.

g) The testing program to provide data on the dispersion and transport of wastes in the harbor was undertaken. Several special series of tests were determined to study the effects of various plans and suggested changes and undertaken and completed. The special studies involved: (a) extension of the navigation channel in the Cooper River to Pinopolis, (b) construction of a sediment trap in lower Wando River, (c) construction of a spoil disposal area in the shallows adjacent to Daniel Island, and (d) diversion of the powerhouse discharge from the Cooper River into the Wando River.

(5641) MODEL STUDY OF PREOMONT DROP STRUCTURE, SANDUSKY RIVER, OHIO.

(b) District Engineer, U. S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.

d) Experimental; for design.

e) The project provides for widening, deepening, and streamlining the main channel of the Sandusky River in the vicinity of Fremont, Ohio. A drop structure will be constructed near the upper end of the project area to dissipate energy created by the difference in elevation of the water surface above and through the improved reaches. The structure will include a concrete weir 10 ft high, concrete paved sloping abutments and stilling basin, and riprap protection above and below the paved sections.

Model tests were conducted on a 1:36-scale model reproducing the drop structure and 800 ft of the channel upstream and downstream. Tests were also conducted on a 1:40-scale rock-lined channel which reproduced about 2000 ft of the proposed channel.

To develop an economical design of the drop structure which will assure the dissipation of the kinetic energy developed when the water-surface profile drops from existing levels upstream of the improvements to levels within the improved channel. Tests were also conducted to investigate the adequacy of a rock-lined friction channel in lieu of the drop structure.

The length of basin below the weir was increased from 22 to 41 ft and the basin depressed 2 ft in elevation (ft test basin arrangement). No riprap protection was required upstream of the structure and the downstream rock protection could replace all but 20 ft of concrete protection (plan 5 riprap). The alternate weir arrangement with its multiarea openings (total area 675 sq ft) provided satisfactory fish passage facilities through the structure.

The channel below the structure could be reduced in width from 450 to 350 ft without materially affecting flow conditions in the exit. A friction channel that will provide a drop in water surface of about 4 ft in a 2000-ft-long reach with minimum size stable slope was developed.

Final report is in preparation.

(5642) MODEL STUDY, DESIGN OF SMALL BOAT HARBOR, DANA POINT HARBOR, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers, Los Angeles, California.

d) Experimental; for design.

e) The inner-harbor berthing area and navigation channels will comprise about 200 acres. The inner-harbor area will be accessible by a mole and will be accessible through 200-foot-wide navigation entrance, one at each end of the 3,500-foot-long inner basin. The inner harbor will be connected to the two arms of rock-bound breakwater having a total length of about 7,700 ft. Tests to study the effects of storm-wave action on the proposed harbor design and to determine what, if any, design modifications are necessary to ensure that wave heights during storms do not exceed (1) 1.5 feet in the inner-basin anchorage, (2) 4 feet in the approaches to the entrance of the inner-harbor berthing areas, (3) 5 feet in the railway channel parallel to the proposed west breakwater, and (4) 2.5 feet in the ramp basin area in the eastern sector of the inner harbor, are being conducted on a 1:100, fixed-bed model. The model reproduces sufficient area of the shoreline and oceanward to ensure that propagation of waves toward the problem area is adequately simulated. Waves are generated by a 60-foot-long, plunger-type wave machine, and are measured and recorded electrically.

Wave-height tests were performed with model conditions simulating (a) basic or existing prototype conditions, (b) the first phase of proposed prototype construction wherein only the proposed rock-bound breakwater system will be installed, and (c) the overall proposed inner-harbor elements in combination.

207
with the protective rubble-mound breakwater system. Modifications in the alignments and lengths of the rubble-mound breakwaters, and also different crown heights and rock distribution, were tested to determine the frequency of the proposed harbor design. Tests were performed simulating storm waves generated from all critical directions reckoned counter-clockwise between west and south-southeast. All tests were performed using a still-water level of 6.0 ft above msl.

Comparison of the two-dimensional flume tests performed to determine the characteristics of the optimum slope and rock composition of the mole-section slope, along the fairway, indicate that the same section along the mole-section slope will ensure reduction of waves reflected from this structure sufficiently to meet the required wave-height criterion.

(5643) ACOUSTIC FLOWMETER INSTALLATION AND PROTOTYPE TESTS WORKS, SUMMERSVILLE DAM, GAULEY RIVER, WEST VIRGINIA.

(b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Huntington, West Virginia.

d) Experimental; field investigation.

e) The outlet works consist of an intake structure, 29-foot-diameter operating tunnel, three 11-foot-diameter conduits, and one 3-foot-diameter low-flow outlet pipe. Tests will be made with an acoustic flowmeter to gage operational discharges, and to measure pressure and gradients in the tunnel and each conduit. The accompanying circuitry to indicate the discharge from the outlet pipe and the flow rates on the acoustic signals. The pressure test facilities consist of six pairs of piezometers along the tunnel and three pairs along each conduit.

The final report is being prepared on evaluation tests made at Oahe Dam in November 1964. The equipment will be installed in Summersville Dam early in 1966. Equipment for measurements in the 3-ft pipe was added to the flowmeter.

(5644) MODEL STUDY OF NAVIGATION CONDITIONS, LITTLE ROCK REACH, ARKANSAS RIVER.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

d) Experimental; for design.

e) A fixed-bed model representing about 3 miles of the Arkansas River and adjacent overflow areas to a scale of 1:100, is being used to study navigation conditions through six bridges at Little Rock, AR., to determine modifications required in the existing bridges, and to develop a plan of regulating structures required to provide satisfactory navigation conditions.

The need for modifications in dimensions of some of the bridge spans with pier protection and training structures has been indicated.

(5645) MODEL STUDY OF OUTLET WORKS, COCHITI DAM, NEW MEXICO.

(b) District Engineer, U.S. Army Engineer District, Albuquerque, Corps of Engineers, Albuquerque, New Mexico.

d) Experimental; for design.

e) The dam will contain a concrete, gravity, uncontrolled spillway with a 460-foot-long ogee crest. A 180-foot-long section of the spillway will be lowered 10.5 feet to provide a service spillway. The outlet works will consist of a triple box conduit. The necessity for providing a reliable water supply for irrigation throughout the range of conduit releases, and the need for a two-level stilling basin 60 feet wide to provide for flows as large as 15,200 cfs made it desirable to test the energy dissipator, and the irrigation and silt sluices in a model. Tests were conducted in the prototype model in the following sections: (a) downstream 150 feet of the triple box conduit, the chute, the primary and secondary stilling basins, the irrigation and the silt sluices; and 670 feet of exit channel.

(e) Completed.

(g) The performance of the energy dissipator was improved by using the appropriate section of the secondary basin 5 ft, and modifying the position of the baffles piers and end sill in the secondary basin. Capacity of the irrigation diversion sluice was from 200 to 300 ft³/s. Realignment of one of the irrigation sluices to eliminate a relatively sharp horizontal bend was proposed in order to reduce wave action at the downstream end of the sluice. Hydraulic performance of the silt sluices was as anticipated, but at low discharges, fine sand was removed from the model only in the immediate vicinity of the sluice intake.


(5646) SECTION MODEL OF SPILLWAY, HANNIBAL DAM, OHIO RIVER.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

d) Experimental; for design.

e) The spillway will consist of a concrete sill surrounded by 8 tainter gates and a conventional, horizontal stilling basin with baffles piers and end sill. A 1:36 section model, reproducing approximately 700 feet of the approach area, one central gate bay and the adjacent half-bays of the spillway, a 216-foot-wide section of the stilling basin, and approximately 800 feet of the exit area, will be used to investigate the adequacy of the proposed stilling basin for a full range of tailwater elevations at that point. The structure will be required to operate.

(g) Tests to determine the optimum elevation and length of the stilling basin and the size and arrangement of its elements were conducted. The spillway rating curves for full and partial gate openings were determined. The original design stilling basin resulted in high bottom velocities in the exit channel with one gate open approximately halfway and minimum tailwater. These velocities were reduced by lowering the elevation of the basin apron.

(5647) GATE VIBRATION TESTS.

See Project No. 5321, Iowa Institute of Hydraulic Research, page 40.

(5648) MODEL STUDY, BRUNSWICK HARBOR, GEORGIA.

(b) District Engineer, U.S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Georgia.

d) Experimental; for design.

e) The investigation is being conducted in a model reproducing the following features: (a) profile from vicinity of Jekyll Island and St. Simons Island on the downstream end to the upper limits of Turtle River and Brunswick River on the upstream end; (b) entire theory; (c) Jekyll Creek from Brunswick River to Highway 84 Bridge; and (d) all marsh areas surrounding the rivers, creeks, and tributaries of the system. The model is of the fixed-bed model of concrete to linear scale ratios, model to prototype, of 1:100 vertically and 1:500 horizontally. Automatic tide generators reproduce tides and tidal currents throughout the harbor. Shoaling studies will be made by injecting finely ground glisnite into the model to reproduce the patterns of shoaling observed in the prototype, and to determine the effects of

208
proposed improvement plans on shoaling patterns. Changes in shoaling patterns as affected by each proposed improvement plan will be determined and evaluated.

(g) Design and construction of the model were completed, and adjustment of the model to reproduce prototype tides and currents was undertaken.

(5649) SECTION MODEL OF SPILLWAY, CANNELTON DAM, OHIO RIVER, INDIANA.

(b) District Engineer, U. S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.

d) Experimental; for design.

e) The spillway will consist of a concrete sill surmounted by 10 tainter gates and a conventional horizontal stilling basin with baffle piers and end sill. A riprap blanket will be provided downstream from the stilling basin to prevent undermining of the structure. A 1:35 scale model, reproducing approximately 70 feet of the approach area, one central gate bay and adjacent half bays of the spillway, a 216-foot-wide section of the stilling basin, and approximately 800 feet of the exit area, is being used to determine the flow characteristics of the spillway, the optimum elevations and conditions of the apron, baffle piers, and end sill, and to develop an adequate protective stone blanket downstream from the stilling basin.

(f) Completed. The conditions at which failure of various protective stone blankets downstream from the stilling basin occurred were determined. The final report, TR 2-710, Spillway for Cannelton Locks and Dam, Ohio River, Kentucky and Indiana; Hydraulic Model Investigation, was published in December. Tests revealed that flow separated from the downstream face of the original gate sill which utilized submergible gates, and a parabolic shoal was added to the weir crest in order to prevent separation and guide flow into the stilling basin. Rating curves were determined for the submergible-gate spillway with both weir crest shapes. Tests to determine effect of gate radius and trunnion location on stilling basin action with the submergible-gate spillway revealed that a 64-ft-radius gate with its trunnion at elevation 388.0 was more effective in preventing undesirable basin actions than was a 50-ft-radius gate with its trunnion at elevation 383.0. Although adequate performance was obtained with the submergible-gate spillway utilizing the parabolic weir crest, tests revealed that the flow conditions, adequate energy dissipation, and effective passage of debris could be obtained with a nonsubmergible-gate spillway which is considered to be the most practicable design. Several stilling basin designs were tested, but the original basin design was recommended for adoption because of structural advantages. Riprap requirements were investigated, and the conditions at which failure occurred were determined.

(h) Spillway for Cannelton Locks and Dam, Ohio River, Kentucky and Indiana; Hydraulic Model Investigation, TR 2-710, December 1965.

(5650) MODEL STUDY OF FILLING AND EMPTYING VALVES, CORDELL HULL LOCK, CUMBERLAND RIVER, TENN.

(b) District Engineer, U. S. Army Engineer District, Nashville, Corps of Engineers, Nashville, Tennessee.

d) Experimental; for design.

e) The lock will be 84 by 400 feet. A 1:25 model, reproducing only the portion of the lock between filling and emptying valves, is being used to evaluate the overall performance of the multipurpose lock, with particular emphasis on determining the optimum number and position of chamber ports, and to investigate methods of controlling pressures below the filling valves.

(g) Multiport arrangements using 14-in.-diam ports were tested. Tests confirmed that acceptable performance could be expected from the original design multiport arrangement for Cordell Hull Lock. Initial tests resulted in the development of satisfactory multiport arrangements using 8-, 10-, and 12-in.-diam ports. A satisfactory arrangement using 14-in.-diam ports was developed. For a lift of 62 ft, these arrangements resulted in a filling time of about 8.9 min with a maximum water stress of about 3.5 tons. Tests indicated that pressure conditions in the critical area just downstream from the filling valve were improved by clamping the concrete downstream end of the valve well. The effect of air venting on culvert pressures was also investigated.

(h) Report in preparation.

(5651) MODEL STUDY OF JAMES RIVER, VIRGINIA.

(b) District Engineer, U. S. Army Engineer District, Norfolk, Corps of Engineers, Norfolk, Virginia, and the State of Virginia.

d) Experimental; for design.

e) The James River, which discharges into Chesapeake Bay, presently has a controlling channel depth from Newport News to Richmond of 25 ft mean low water. Improvement plan has been proposed to increase the channel depth to 35 feet mean low water, and widen the channel at several locations. Because the James River tributaries and tributaries provide ideal locations for oyster beds, an important industry in the area, a model study will be made to determine the effects of the channel improvements on hydraulic and salinity conditions in an adjacent to the oyster beds. The fixed-bed model will reproduce 300 square miles of the Atlantic Ocean, the James River estuary, and all its principal tributaries from Norfolk to Richmond, Va., to scales of 1:1,000 horizontally and 1:100 vertically. Tides and tidal currents will be reproduced by a tide generator located in the ocean portion of the model. The ocean salinity will be reproduced so that the effects of salinity differences on the vertical distribution of current velocities, as well as salinity concentrations throughout the model will accurately simulate those of the prototype.

(g) Design and construction of the model were completed, and the hydraulic and salinity verifications were made. Verification of the model was about 50 percent complete as of December 31, 1965.

(5652) MODEL STUDY OF NAVIGATION CONDITIONS, WEBBER FALLS LOCK AND DAM, ARKANSAS RIVER.

(b) District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.

d) Experimental; for design.

e) The Webber Falls Lock and Dam, to be located about mile 432.2 on the Arkansas River, will involve the construction of a nonnavigable-type dam, a 110- by 600-ft lock, and a powerhouse. The lock will provide a maximum lift of about 30 ft. To study navigation conditions in the approaches to the lock, to determine the adequacy of the design, and develop modifications required to overcome any undesirable conditions.

The model reproduces about 3.1 miles of the Arkansas River and the lock and dam structures to a scale of 1:120. It is of the fixed-bed type with provisions for changes which can be anticipated at this time.

(g) Construction of the model was completed, and tests to develop satisfactory navigation conditions were undertaken. Results indicated the need for modification in the design of the upper lock approach.
channel and that by use of a training dike upstream the elevation of the nonoverflow section could be raised, it was also indicated that the length of the upper guard wall and dredging in the approach channel could be reduced.

(5653) LAKE ERIE-LAKE ONTARIO WATERWAY MODEL STUDIES.

(b) District Engineer, U. S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.

d) Experimental; for design.

c) The project will provide a second navigation passage from Lake Erie to Lake Ontario to supplement the existing Welland Canal. The plan includes a control structure at the head of the Niagara River, another rock Black Rock Lock at Buffalo, and improvements to the existing navigation channel around Great Island to the entrance of the proposed overland canal downstream of Tonawanda Island. The canal (with locks) will connect the Niagara River and Lake Ontario. An existing Niagara River model is being used to investigate control structure and lock arrangements and navigation channel features including compensating excavations or structures required to maintain existing sediment discharge relations. Navigation conditions at the entrance to the overland canal are being studied in a second model.

The initial phase of the study utilized an existing distorted-scale model which reproduces the Niagara River from approximately 100 feet above the Peace Bridge at Buffalo to Rainbow Bridge below the falls. The upper limit extends into Lake Erie. The model was constructed to scale ratios of 1:360 horizontally and 1:60 vertically. It is of the fixed-bed type with all channel and over-bank areas molded in concrete. An undistorted-scale model of a reach of the river at the upper canal entrance was used in studying navigation conditions in this area. The model is of the fixed-bed type, constructed to a scale of 1:120.

d) Four lock plans were investigated in the distorted model and a fifth possible lock plan location is being considered. Each plan was tested with an improved navigation channel. Construction was completed and testing was initiated on the undistorted model of the overland canal entrance and improved navigation channel. A radio-controlled model ship is being used to study navigation conditions in this model. Of the four lock plans tested in the distorted model, look plan 1 appears to be the most feasible. Look plan 1 is the only one of the plans tested which can be used without a control structure at the mouth of the river. This plan also requires less excavation. The fifth lock plan is being considered which positions the lock farther downstream than lock plan 1. Current patterns in the improved channel near the canal entrance, as shown in the undistorted model, indicate the need for widening of the improved channel between Tonawanda Island and the canal entrance. A widened channel would not only tend to reduce the siltation of the river and the adjacent areas. A widened channel would also be designed to provide an anchorage area for use in times of severe weather.

(6011) MODEL STUDY OF HARBOR DESIGN, SANTA BARBARA, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers, Los Angeles, Calif.

d) Experimental; for design.

c) The enlarged harbor, to be enclosed by the protective breakwater system, will have an area of about 188 acres. Of this area, three moles and the perimeter wave absorber will occupy about 48 acres, leaving about 140 acres within the west, center, and east basins and the access channels leading thereto. New breakwater required under the project plan will aggregate about 5700 lin ft, 1600 ft of which would be a detached structure about 1600 ft long protecting the breakwater entrance. To study the effects of storm wave action on the proposed harbor design and to determine in advance of prototype construction whether, if any, design modifications are necessary to ensure that (a) wave heights in the berthing areas do not exceed specified criteria during storms, and (b) these criteria are met while using the minimum amount of protective breakwater positioned to provide minimum requirements for navigation to and from the harbor by pleasure craft and also commercial fishing boats.

The 1:100-scale model is of the fixed-bed type and is made of concrete except for the breakwaters and breakwater entrances. The inner-harbor moles which are constructed of rubble, sized to simulate that required for prototype design. The model reproduces sufficient area along the shoreline east and west of the harbor site and oceanward to ensure that propagation of waves toward the problem area is adequately simulated. The model has an area of about 10,700 sq ft, equivalent to about 3.84 square miles in nature. Waves are generated by a 60-ft-long, plugger-type wave machine. A two-circuit-type wave-measuring rods are used in connection with automatic recording equipment to obtain necessary wave-height data.

d) The model was designed and construction initiated.

(6014) MODEL STUDY OF BREAKWATER STABILITY, SANTA BARBARA HARBOR, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers, Los Angeles, Calif.

d) Experimental; for design.

c) Additional protection of construction of rubble-mound breakwaters is required. These structures are permeable and thus will allow some wave energy to pass through the structure into the protected area. To determine the effectiveness of the proposed breakwater sections in reducing transmitted wave energy and to develop a breakwater section at a 1:100 scale that will transmit the same amount of energy as transmitted at a 1:33 scale.

Wave transmission tests were conducted in a concrete wave channel 119 ft long, 5 ft wide, and 4 ft deep on sections of proposed structures constructed to linear scales of 1:133 and 1:100. Model waves were generated by a plugger-type wave machine and measured and recorded electrically.

d) Wave transmission tests were conducted on a breakwater design proposed by the District Engineer. Tests were conducted using 6-, 12-, and 16-sec waves and wave heights of 6, 10, 14, and 18 ft. These tests were conducted using model scales of 1:133 and 1:100. Wave transmission tests indicated that changing the scale of model test sections from 1:133 to 1:100 reduced the heights of transmitted waves about 25 percent. It was found that for wave heights less than about 14 ft in height, wave transmission characteristics for 1:133- and 1:100-scale breakwaters would be similar if the armor stone size for the 1:100-scale test section was increased about 100 percent. Also, the crown elevation of the core stone in the 1:100-scale model was lowered about 1 ft. For waves greater than 14 ft in height, wave transmission in the 1:100-scale model breakwater section was less than obtained in the 1:133-scale model.

(6015) MODEL STUDY OF HARBOR DESIGN, NOYO HARBOR, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, San Francisco, Corps of Engineers, San Francisco, Calif.

d) Experimental; for design.

c) The plan of harbor improvement will entail...
construction of two arms of rubble-mound-type breakwater. One arm would stem from shore on the south side of Noyo Cove and extend 1100 ft or more in a northwesterly direction while the companion arm would stem from the north side of the cove. A naviga-
tion entrance into the harbor not less than 400 ft in width, measured at +35 ft mllw, would be required. Inside the harbor local interests would construct a berthing-loading pier or wharf about 1050 ft long.

To study the effects of storm wave action and characteristics of the Noyo area on the proposed harbor, a 1:100-scale, streamlined, 400-ft-long, 1:20-scale concrete still-water experimental breakwater would be constructed in the still-water basin. The preparation of a detailed analysis of the wave climate of the area, construction of the prototype structure, and determination of wave actions would be conducted prior to the construction of the breakwater. The breakwater would be 1:100 scale to satisfy simplified criteria for the harbor.

The 1:100-scale model is of the fixed-bed type and is molded of concrete except for the breakwaters which are constructed of rubble, sized to simulate that required for prototype construction. The model reproduces sufficient area along the shoreline north, south, and oceanward of the harbor site to allow the propagation of waves toward the problem area to be adequately simulated. Special emphasis was placed on wave-reflecting and wave-absorbing characteristics of the prototype in all plan elements. A weir to permit simulation of Noyo River floodflow was also an element of the model. The model has an area of 3500 sq ft, equivalent to about 2 square miles in the prototype. Waves are generated in the model by a plunger-type wave machine, and electrical, printed-circuit-type, wave rods in connection with automatic recording equipment are used to obtain necessary wave-height data.

The model was designed, and constructed, and wave-height tests were performed with model conditions simulating (a) basic or existing prototype conditions, and (b) the effects of the "project-document" plan and several alternate variations thereof. In these tests the characteristics of the waves were varied with respect to period, height, and direction of attack. Tests in the tests of the proposed improvement plans were also made. The tests were made from the west, west-northwest, and northwest to southwave directions using waves ranging in period from 10 to 17 sec and in height from 10 to 26 ft adjacent to the harbor approaches. The primary plans tested used the project-document plan consisting of a rubble breakwater 1100 ft in length from the south side of Noyo Cove in combination with a 400-ft-long companion structure stemming from the north side of the cove to form the required naviga-
tion entrance. Modifications of the project-
document plan were tested using alternate lengths for the south breakwater. The alternate lengths for the south breakwater used in combination with the north breakwater were 1300, 1500, 1700, 1900, and 2100 ft. Other variations involving realignment of the north breakwater in combination with 1500-, 1700-, and 2100-ft lengths of south breakwater were also tested. All tests were per-
formed using a still-water level of +6.9 ft mllw. Results obtained to date show that no plan tested met the selected 2-ft wave-height criterion specified for acceptability. How-
ever, the characterized 3500-ft-long south breakwater, and companion 400-ft-long north breakwater would allow waves to average from 2 to 3 ft no more than 50 hours per year as a result of severe wave action. The project document plan would per-
mit the selected criterion to be exceeded about 125 hours per year and would allow waves as high as 10 ft to occur for about 4 hours per year. The SPD is conducting a reanalysis of project-construc-
tion costs on the basis of a revised criter-
ion for plan acceptability. Further testing must await decisions specifying the modified criterion.

MODEL STUDY OF BREAKWATER STABILITY, NOYO HARBOR, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, San Francisco, Corps of Engineers, San Francisco, Calif.

(e) Experimental: for design.

(f) The harbor will be protected by rubble-mound breakwaters which are permeable and allow small amounts of energy to pass through the structure into the harbor. To develop stable rubble-mound breakwaters using quarrystone and molded concrete armor units. Also the effectiveness of crown elevation of a concrete cap will be investigated with respect to overtopping and trans-
mission of wave energy through the break-
water.

Tests will be conducted in a concrete wave flume 119 ft long, 5 ft wide, and 4 ft deep on model sections of the proposed structures to linear scales of 1:61.4 and 1:50. Model wave are generated by a plunger-type wave machine and measured and recorded electrically.

(g) Stability tests were conducted on a section of the south breakwater constructed of two layers of 36-ton tetrapods placed on seaside slopes of 1:3, 1:4, 1:5, and 1:6. Wave-transmission tests were conducted on break-
water sections with crown elevations of +25 and +30 ft mllw. All breakwater sections tested were capped with a concrete cap 2 ft thick and the stone beneath the cap was grouted from the base of the concrete cap down to the base elevation of the tetrapod armor layer. Stability tests showed that a breakwater with a crown elevation of +20 ft mllw (elevation of concrete concrete cap +20 ft mllw and elevation of armor layer crown +30 ft mllw) constructed of two layers of random-placed, 36-ton tetrapods on a slope of 1:4 from crown to +5 ft mllw and 1:1-1/2 from -5 ft mllw to bottom would be stable for the selected prototype design wave 20 ft in height. Wave-
transmission tests showed that for 14-sec waves greater than 25 ft in height, the heights of the transmitted waves were reduced about 67 percent by raising the crown eleva-
tion of the armor layer from +25 to +30 ft mllw.

MODEL STUDY OF EAU GALLE OUTLET STRUCTURE, SPRING VALLEY, WISCONSIN.

(b) District Engineer, U. S. Army Engineer District, St. Paul, Corps of Engineers, St. Paul, Minn.

(d) Experimental: for design.

(e) The project provides for a flood-control reservoir immediately upstream from Spring Valley, Wis.; enlargement of the river channel through the village to improve the flow of water; and changes in structures, and improved channels for the two creeks, Mines and Burghardt, which flow through the village. A 1:20-scale plastic model reproduced the morning glory intake, the elbow below the intake, the horseshoe conduit, a stilling basin, and about 400 ft of the outlet channel. The morning glory intake was housed in a headbay which reproduced appropriate entrance conditions.

Tests demonstrated that the original design structure was unsatisfactory, as negative pressures in the range of one atmosphere (−34 ft of water) were recorded in the intake structure or saturation of several wave action. The project document plan would permit the selected criterion to be exceeded about 125 hours per year and would allow waves as high as 10 ft to occur for about 4 hours per year. The SPD is preparing final report is in progress.
The approved project entails extension of the existing rubble-mound-type breakwater about 1600 ft in an easterly direction to the west side of the wide navigation entrance which would be formed by construction of a companion dogleg-aligned east breakwater about 250 ft long that would extend in a southeasterly direction to shore. This expanded enclosure will provide increased protection for the fishing fleet operating out of this basin and will permit development of greatly expanded recreational facilities associated with boating and other water sports.

To study the effects of storm wave action on the harbor associated both with the surge-type waves having periods ranging from about 23 to 300 sec and short-period waves considered to range from 3 to 20 sec. Determination of the effect of this range of wave conditions on the approved harbor expansion is required in advance of actual construction to ensure that (a) selection of an optimum navigation entrance to the harbor is possible both with respect to width and position; (b) the minimum amount of breakwater is used in satisfying wave-protection requirements for proposed inner-harbor development, and (c) any resonance characteristics an otherwise satisfactory harbor boundary may have have been fully investigated to permit optimum positioning of inner-harbor anchorage areas. The 1:120-scale model is of the fixed-bed type and is molded of concrete except for the breakwaters which are constructed of rubble, sized to simulate that required for prototype construction. The model reproduces sufficient area along the shoreline westerly, easterly, and oceanward to ensure that propagation of waves shoreward is adequately simulated. The model has an area of 7600 sq ft, equivalent to about 4 square miles in nature. Waves are generated by two sections of vertical-bulkhead plunger-type wave machine which can be aligned so as to reproduce the wave curvature of a wave front bent by refraction as it travels through shallow water. The generators, by use of couplings, operate from a single motor-power source. Electrical printed-circuit-type wave measuring rods are used in connection with automatic recording equipment to obtain necessary wave-height data.

Under a contract Dr. Basil W. Wilson, Science Engineering Associates, San Marino, Calif., performed a study of the wave and surge problems characterizing Monterey Bay. In his report, Contract Report 260, Feasibility Study for a Surge-Action Model of Monterey Harbor, Calif., October 1965, sufficient information was made available to permit KES to adequately design the required model. Design and construction of the model are in progress.

(b) District Engineer, U. S. Army Engineer District, San Francisco, Corps of Engineers, San Francisco, Calif.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in Verdigris River reach with lock chambers 110 by 600 ft.

To study navigation conditions at the mouth of the Arkansas River and the two bridges at Fort Smith, Ark., to determine modification required in the existing bridge; and to develop a plan of regulating structures required to provide satisfactory navigation conditions. The investigation is being conducted on a 1:120-scale, fixed-bed model representing about 3.3 miles of the Arkansas River and adjacent overflow areas, the mouth and about 1.4 miles of the Poteau River, one railroad and one highway bridge, and other structures that might affect flow conditions.

(g) Design and construction of the model were accomplished.

(b) District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Okla.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in the Verdigris River reach with lock chambers 110 by 600 ft.

To investigate navigation conditions with the proposed structure and to determine the location and width of a navigation channel, and to develop a plan of regulating structures required to provide satisfactory navigation conditions. The investigation will be conducted on a 1:120-scale, fixed-bed model, reproducing about 4.25 miles of the Arkansas River, the Verdigris River reach and 150 ft in the Verdigris River reach with lock chambers 110 by 600 ft.

(g) Design and construction of the model were accomplished, and adjustment of the model was undertaken.

(b) District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Okla.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in Verdigris River reach with lock chambers 110 by 600 ft.

To determine the adequacy of the proposed channel dredging and realignment, and to develop modifications which might be required to overcome undesirable navigation conditions. The investigation will be conducted on two 1:120-scale, fixed-bed comprehensive models. One model will reproduce about 1.7 miles of the Verdigris River and adjacent overflow area in the vicinity and upstream of Lock and Dam No. 17. The second model will reproduce about 2.1 miles of the Verdigris River and adjacent overflow area downstream of Lock and Dam No. 17.

(b) District Engineer, U. S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Ark.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in Verdigris River reach with lock chambers 110 by 600 ft.

To study navigation conditions at the mouth of the Arkansas River and the two bridges at Fort Smith, Ark., to determine modification required in the existing bridge; and to develop a plan of regulating structures required to provide satisfactory navigation conditions. The investigation is being conducted on a 1:120-scale, fixed-bed model representing about 3.3 miles of the Arkansas River and adjacent overflow areas, the mouth and about 1.4 miles of the Poteau River, one railroad and one highway bridge, and other structures that might affect flow conditions.

(g) Design and construction of the model were accomplished.

(b) District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Okla.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in Verdigris River reach with lock chambers 110 by 600 ft.

To investigate navigation conditions with the proposed structure and to determine the location and width of a navigation channel, and to develop a plan of regulating structures required to provide satisfactory navigation conditions. The investigation will be conducted on a 1:120-scale, fixed-bed model, reproducing about 4.25 miles of the Arkansas River, the Verdigris River reach and 150 ft in the Verdigris River reach with lock chambers 110 by 600 ft.

(g) Design and construction of the model were accomplished, and adjustment of the model was undertaken.

(b) District Engineer, U. S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Okla.
(d) Experimental; for design.
(e) The project involves the improvement of the Arkansas River for navigation from the vicinity of Tulsa, Okla., to the mouth of the Arkansas River. The 9-ft channel will be provided by a system of locks and dams and channel regulating and stabilization works. The channel will have a minimum width of 250 ft in the Arkansas River reach and 150 ft in Verdigris River reach with lock chambers 110 by 600 ft.

To determine the adequacy of the proposed channel dredging and realignment, and to develop modifications which might be required to overcome undesirable navigation conditions. The investigation will be conducted on two 1:120-scale, fixed-bed comprehensive models. One model will reproduce about 1.7 miles of the Verdigris River and adjacent overflow area in the vicinity and upstream of Lock and Dam No. 17. The second model will reproduce about 2.1 miles of the Verdigris River and adjacent overflow area downstream of Lock and Dam No. 17.
of Tulsa, Okla., to its junction with the Mississippi River. The 8-ft channel will be provided by a system of locks and dams and channel regulation and stabilization works. The channel of the Arkansas River will have a minimum width of 250 ft and in the Verdigris River reach, 150 ft. Lock chambers will be 110 by 600 ft.

To investigate the various plans of regulating structures and to develop modifications as required for the development of a channel of adequate dimensions and satisfactory navigation conditions in the approaches to the lock. The investigation is to be conducted on a moveable-bed model reproducing about 10 miles of the Arkansas River and adjacent overbank areas to scale of 1:80 horizontally and 1:80 vertically.

(6023) MODEL STUDY OF LOCK CULVERT DISCHARGE BASINS.

(b) District Engineer, U. S. Army Engineer District, Huntington, Corps of Engineers, Huntington, W. Va.

(d) Experimental; for design.

(e) A review of project plans for several of the Ohio River locks indicated that predominant lock culvert outlet positions used at these projects had the outlet either normal to the lock wall or turned slightly downstream at an angle of approximately 65 degrees to the lock wall. The model tested Ohio River locks with culvert outlet basins located outside the riverward lock wall, difficulty has been experienced in fully emptying these when river discharge conditions were near maximum locking stage. At these projects, the lock emptying operation resulted in a residual head differential across the lower miter gates. Detailed investigation of the various projects was not considered feasible. Consequently, a generalized investigation was recommended to provide information on possible corrective measures. To provide information on possible outlet basin modifications which could be used to alleviate the operating difficulty at completed projects or obviate it at projects proposed or under construction.

A 1:25-scale model of the lock culvert outlet basin was constructed in an existing flume. The model reproduced a 125-ft-wide section of rectangular river channel. A 25-ft-wide by 15-ft-long rectangular box was added as a portion of the lock chamber. The single culvert outlet basin located in the channel section was connected to the tank by a 1-ft by 1-ft culvert. The lock basin and one side of the outlet basin were based on an outlet design used at the Cannelton Locks.

Tests were made to determine the effect of the following variations on head differential between the simulated lock chamber and the adjacent river: (a) position of the basin with respect to direction of flow, (b) height of basin wall, above river floor, (c) vertical extensions on basin walls, and (d) velocity of flow past basin.

The predominant positions of outlets at these projects were normal to the lock wall or turned slightly downstream at 65 degrees to the wall. Results of tests with the outlet at these positions indicated continuation of the basic outlet walls above the river floor or addition of vertical wall extensions will result in a lowering of the lock chamber water-surface elevation with respect to the adjacent river water-surface elevation. Test data also show that no advantage results from turning the basin downstream (parallel to the lock wall).

(6025) MODEL STUDIES OF TEXAS COAST HURRICANE SURGE.

(b) District Engineer, U. S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

(d) Experimental; for design.

(e) The Galveston Bay hurricane surge model reproduces the coast from Freeport on the south to High Island on Bolivar Peninsula on the east. The model includes an average width of the Gulf of Mexico of about 25 miles, measured normal to the Gulf; all of the barrier islands in the bay interior, including its many connecting arms, lakes, and lagoons; and the coastal area of this sector up to a maximum elevation of 20 ft msl. The model is of the fixed-bed type molded of concrete to linear scale ratios, model to prototype, of 1:110 vertically and 1:5000 horizontally. Automatic tide generators reproduce normal tides and tidal currents throughout the model. The hurricane surges will be reproduced by a horizontal-displacement type surge generator.

(g) Design and construction of the model were completed, and adjustment of the model to reproduce prototype tides and current velocities was undertaken. Analysis of prototype tidal and hurricane surge data was undertaken.

(6026) MODEL STUDY OF UMPQUA RIVER ESTUARY, OREGON.

(b) District Engineer, U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Texas.

(d) Experimental; for design.

(e) The existing authorized project in the Umpqua River entrance provides for a channel 25 ft deep at mile with no specified width for about 5000 ft across the bar, and thence 22 ft deep and 200 ft wide to Gardiner and Reedsport. The north and south jetties at the river mouth are about 7800 and 3800 ft long, respectively. A training jetty inside the south jetty is 5500 ft long. To obtain the optimum layout of a jetty system or other structure to reduce entrance maintenance dredging to a minimum, and (b) with the optimum for a guide to adapt the existing jetty system to approach the optimum to the limit allowed by economic considerations. The model will reproduce the lower 14 miles of the Umpqua River and pertinent offshore areas to linear scale of 1:300 horizontally and 1:1000 vertically. An additional 14 miles of the Umpqua River and 20 miles of the Smith River will be reproduced schematically in order to include the upstream tidal reaches. All portions of the model will initially be of the fixed-bed type, with provisions for converting the entrance area to a movable-bed type if movable-bed studies are required. Tides and tidal currents, freshwater inflow, density currents, waves, and other phenomena significant to the movement and deposition of sediments will be reproduced and studied.

(g) Design of the model was completed, and construction was initiated.

(6027) MODEL STUDY OF GASTINEAU CHANNEL, ALASKA.
(b) District Engineer, U. S. Army Engineer District, Alaska, Corps of Engineers.

d) Experimental, for design.

e) The existing authorized project in Gastineau Channel provides for a channel 75 ft wide with a depth of 0.0 mlw from Pritz Cove to naturally deep water near Juneau, Alaska. The navigation channel is flanked by continuous tidal flats having elevations as much as 15 ft above the channel bottom for a distance of about 3 miles. To reduce shoaling in order to maintain a suitable navigation channel, various dike layouts which will isolate the channel cut from the surrounding area will be investigated.

The model reproduces the westernmost 8 miles of Gastineau Channel and Pritz Cove to linear scale of 1:500 horizontally and 1:100 vertically. Tides, tidal currents, and freshwater inflow significant to the movement and deposition of sediments are represented and studied. All portions of the model are of the fixed-bed type.

g) Design and construction of the model were completed, and adjustment of the model was initiated.

(6028) MODEL STUDY OF FIRE ISLAND INLET, LONG ISLAND, NEW YORK.

(b) District Engineer, U. S. Army Engineer District, New York, Corps of Engineers, New York, N. Y.

d) Experimental, for design.

e) Fire Island Inlet, located on the south shore of Long Island, N. Y., connects the Atlantic Ocean with Great South Bay. The inlet is about 3 miles long and approximately 1/2 mile wide, extending generally east and west between Oak Beach on the north and the west end of Fire Island on the south. Great South Bay, the inland waterway to which Fire Island Inlet is the main entrance, is a tidal basin about 25 miles long and 6 miles wide with a general depth of about 6 to 25 ft at mlw. Attempts have been made to stabilize an entrance channel through Fire Island Inlet with little success.

To provide quantitative data on the direction and velocity of tidal currents under existing conditions and with various proposed training structures installed, and by qualitative movable-bed tests to determine probable areas of erosion and deposition. A movable-bed model, with scale ratios of 1:500 horizontally and 1:100 vertically, reproduces all of Fire Island Inlet and a portion of the Atlantic Ocean. Tides, tidal currents, and wave action in the Atlantic Ocean are reproduced.

(6029) MODEL STUDIES OF EFFECTS OF PNEUMATIC BARRIERS ON SALINITY INVASION.

(b) District Engineer, U. S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pa.

d) Experimental, for design.

e) Prolonged drought conditions, plus diversion of water from the Delaware Basin to supply New York City, resulted in reduced upland flows into the Delaware estuary. Upland flow is the controlling factor in preventing the upstream advance of the salinity front in the estuary to the extent that the Philadelphia water supply is contaminated. Other means for retarding the advance of salt water up the Delaware are being sought.

To determine if the additional agitation provided by pneumatic barriers would displace the salinity front in a downstream direction for steady-state conditions, or retard the rate of advance of the salinity front periods of decreasing upland flow.

f) Two tests were conducted in the Delaware model to determine the effects of pneumatic barriers on salinity. The barriers extended completely across the estuary at several locations, and barrier combinations were tested both for steady-state and transient conditions. One test was performed in the existing New York Harbor model, and this test involved four pneumatic barriers located in the lower Hudson River.

The results of tests in the Delaware model indicated that pneumatic barriers would have no significant effects on salinity intrusion for either steady-state or transient conditions. This is attributed to the fact that salt and fresh water in the Delaware are well mixed vertically by existing tidal forces, and additional mixing by supplemental means has little effect on the phenomena. The results of the one test in the New York Harbor model indicate that the pneumatic barriers would be very effective in reducing the extent of salinity intrusion for steady-state conditions. Additional testing to determine such things as the number of barriers required and the best barrier locations is indicated.

(g) Preparation of final report (letter report) is in progress.

(6030) GENERAL MODEL STUDY OF WEST POINT DAM, CHATTahoochee RIVER, GEORGIA.

(b) District Engineer, U. S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Ga.

d) Experimental, for design.

e) The project is a part of the general plan for the development of the Apalachicola, Chattahoochee, and Flint Rivers. The proposed structure is on the Chattahoochee River at miles 4.4 above and 2.0 miles north of West Point, Ga. It is 147 river miles below Buford Dam and 126 miles above Walter P. George Lock and Dam. The project can be described as a gravity-type concrete spillway with crest gates across the main river channel, a penstock intake section and powerhouse, and a concrete nonoverflow section along nonoverflow section and downstream to riverbank. Earth embankments extend to high ground on each side of the structure. The structure will provide hydroelectric power, flood control, and more dependable streamflow for navigation and recreational uses.

To verify the performance of the structure with emphasis on approach conditions to the spillway and the development of a satisfactory energy dissipator below the spillway. The model tests are being conducted on a 1:60-scale general model reproducing about 1700 ft of the approach, the spillway, powerhouse, and 1800 ft of the exit area. Sufficient overbank areas on each side of the structure are provided to reproduce selected flow conditions. Initial study of the energy dissipator was conducted on a 1:60-scale section model of the spillway basin, which was installed in a 1-ft-wide glass-sided flume. This permitted observation of subsurface flow conditions in the basin and facilitated modifications of the basin. Design and construction of the general model were completed and testing was initiated.

The original design bucket-type energy dissipator was found unsatisfactory. Test indicates that an apron-type basin (75 ft long) with a single row of 6-ft-high baffle piers and a 4-ft-high sloped end sill will provide excellent energy dissipation.

(6031) MODEL STUDY OF DROP STRUCTURE, WALNUT CREEK, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, Sacramento, Corps of Engineers, Sacramento, Calif.

d) Experimental, for design.

e) The Walnut Creek project, located 15 miles east of San Francisco Bay, will provide for enlargement of the existing channels of Walnut, Lower San Ramon, and Los Trampas Creeks. The project has a drainage area of 145 square miles and flows northerly to empty into Suisun Bay. Grade control...
structures will be used to reduce velocities and dissipate excessive energy from floodflows. To determine the optimum dimensions for the stilling basin at drop structure 2 that will result in maximum energy dissipation and minimum surface waves downstream in the rock-lined channel, and to determine the stability of the riprap in this channel, a 1:20-scale model was used to reproduce sections of a trapezoidal earth channel, a 50-ft-wide concrete channel, an inlet transition, and drop structure 2. Tests to determine the optimum dimensions of the stilling basin and the stability of riprap downstream were completed. The stilling basin of original design resulted in excessive velocities and wave action in the channel downstream of the drop structure. Several modifications to drop structure 2 were tested. A satisfactory design was developed by flaring the basin walls 1 on 10, adding a trapezoidal drop, placing an 8-ft-high vertical end sill with 10-ft-high baffle blocks, adding quadrant-type wing walls below the basin, and sloping the channel invert up 1 on 6 from the basin floor to the trapezoidal channel invert. Tests of the riprap protection plan in the earth channel indicated the stone to be stable for the design discharge.

Preparation of final report is in progress.

(6032) PROTOTYPE TESTS OF OLD RIVER CONTROL STRUCTURE, LA.

(b) District Engineer, U. S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, La.

d) Experimental; for design.

e) The project, located on the Mississippi River approximately 50 miles downstream from Vidalia, La., consists of an 11-bay, 484-ft-long gated spillway. Flood control is obtained by diverting through the structure approximately one-fourth of the flow in the Mississippi River.

To measure vibration of the structure during periods of high discharge and determine the magnitude of the resulting displacements, utilizing these data, stresses caused by the dynamic response of the structure will then be computed. Accelerometers to measure vibration in the principal directions were located on the piers, gate guides, and crane rail of bays 6 and 10 as the left downstream wing wall and the bridge walkway. Data were recorded on both magnetic tape and oscillograms.

Two test series were conducted at Mississippi River project stages of 40 and 47 ft. The analysis of the oscillograms and a report describing a frequency spectrum analysis of the data from one of the tests have been furnished the New Orleans District. Plans are being made for another test in 1966 at a higher river stage. Due to the very low level of structure acceleration, measurements at more severe flow conditions are needed before a definite conclusion can be made concerning the magnitude of the vibration.

(6933) GENERAL MODEL STUDY OF NASHING NOR RUFF DAM, OSGOE RIVER, NO.

(b) District Engineer, U. S. Army Engineer District, Kansas City, Corps of Engineers, Kansas City, Kansas.

d) Experimental; for design.

e) The multipurpose dam is located on the Osage River near Wichita, Mo. The primary functions of flood control and power generation. Plans call for an earth-fill dam about 5000 ft long with a height of 67 ft above the valley floor. Water will be released to a hydraulic jump-type stilling basin and an adjacent power facility in the right terrace. To study the adequacy of the spillway and the performance of the hydraulic jump-type stilling basin with and without diversion through the powerhouse. A 1:60-scale prototype model that reproduces 1400 ft of the approach and 1900 ft of the exit area, the spillway, powerhouse, nonoverflow sections, and portions of the earth embankment that is being utilized to conduct the study.

The weir was calibrated for uncontrolled flows, pressures on the weir crest along the center of a gate, and basic stilling basin performance data were obtained. A surging occurred at the weir for gated flows. Capacity of the weir was slightly below that anticipated. The stilling basin may be raised 5 ft.

(g) 1:20-Scale Prototype Model Study of Outlet Works, BRANCHED OAK DAM, NEBR.

(b) District Engineer, U. S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Neb.

(d) Experimental; for design.

e) Branched Oak Dam will provide one of several flood-control reservoirs of the Salt Creek project near Lincoln, Neb. The outlet works will consist of a rectangular intake structure with two windows (4 ft wide and 6 ft high), a 6- by 12-ft riser shaft 30 ft high, followed by an elbow and transition, a 6-ft-diam circular conduit 170 ft long, a flared transition with a parabolic invert, an SAP stilling basin, and an exit channel. To verify the performance of the structure, and particularly to ensure satisfactory characteristics such as surging during transition from weir control to pressure flow or excessive vibration under pressure flow. A 1:10-scale plastic model reproduced the outlet works including the intake structure, the elbow, the transition, the circular tunnel, the outlet transition, the stilling basin, and about 150 ft of exit channel. Pressures in the model were determined by piezometers located in appropriate areas of the model. The intake structure was installed in a baffled headway which reproduced the approximate geometry and conditions at entry.

All model tests to verify the adequacy of the design of the outlet structure have been completed; however, tests are under way to determine the effects of other heights of the riser shaft in order to obtain more generalized results.

Discharge characteristics, entrance losses, flow conditions, and pressures throughout the original design outlet works, a Branched Oak Dam were found to be satisfactory. The SAP stilling basin provided adequate energy dissipation, and a practical scheme of riprap protection for the exit channel was determined.

Additional tests will be conducted to investigate the performance of the outlet works with increased heights of the riser shaft.

(6603) STILLING BASIN PROTOTYPE PRESSURE TESTS, BARREN RIVER DAM, BARREN RIVER, KY.

(b) District Engineer, U. S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Ky.

(d) Experimental; for design.

e) Barren River Dam is a 146-ft-high earth dam used for flood control, recreation, and low flow augmentation. The outlet works are a three-gated intake structure and a 17-ft, elliptically shaped tunnel with a 10,000-cfs capacity. An earth-filled saddle-type spillway is located on the right abutment. The Stillin basin is 40 ft wide with a single row of streamlined baffle blocks and an end sill. To measure average and fluctuating pressures against the stilling basin saddle and on a baffle block. The saddle pressure magnitude and area extent will give useful
data for the design of similar stilling basins. Baffle pressures will provide full-
scale data on turbulence pressure fluctuations and possible cavitation.
Prototype test facilities include four slots for pressure transducers and ten
embedded pressure transducer boxes on and near a baffle block. A pressure transducer
will be installed on each carriage and measurements will be made at various
depths. Data will be recorded on oscillographs and magnetic tape for later electronic correlation.

Preliminary single-override measurements were made in April at a discharge of 3600 cfs.
Tests are planned in January 1966 at a flow of 6000 cfs to measure both sidewall and
baffle block pressures. Preliminary data indicated that extreme pressure fluctuations against the stilling basin
sidewall were less than 0.3 times the entering velocity head. Predominant fluctuations were about 3 ft of water.

SECTION MODEL STUDY OF STILLING DAM, BLACK WARRIOR RIVER, ALA.

Experimental; for design.

(a) District Engineer, U. S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Ala.

The existing spillway at John H. Bankhead Lock and Dam, Black Warrior River, which has served its useful life, is to be
modified to provide a structures adequate structure and, under present criteria, extend its
economic life.

To study existing and modified spillway conditions.

A 1:30-scale section model reproduces a 49-ft
wide gate bay and adjacent half bays (non-
spillway length 96 ft) with sufficient length
of approach and exit channels.

Model tests of existing and modified conditions indicated no significant pressures on the weir. Aerating the low-pressure zones failed to raise pressures out of the
cavitation range as the air did not spread
sufficiently in a lateral direction.

MODEL STUDY OF NEW BUFFALO HARBOR, NEW BUFFALO, MICHIGAN.

Experimental; for design.

The proposed small-boat harbor at New Buffalo is located at the mouth of Galien River on the southeastern shore of Lake Michigan. The
project is cosponsored by the Corps of Engineers and local interests. The harbor
will be protected by the north and south breakwaters which converge westward toward the
entrance in the form of an arrowhead to furnish a natural peninsula to
furnish an enclosed area of about 8 acres. The proposed 200-ft navigation opening faces west
and is located about 800 ft northwesterly from the mouth of the Galien River. The
entrance channel is 80 to 180 ft wide by 10 ft deep and 150 ft long. New Buffalo Harbor
is used as a base or port of call for light-
draft recreational and commercial fishing
vessels.

To determine (a) the relative effects of waves of various magnitudes that approach the harbor
site from the predominant storm directions; (b) the optimum length and alignment of the
proposed arrowhead breakwater system; (c) the optimum crown heights or north and south
breakwaters to meet the selected wave-height criteria for the inner-harbor basin area;
and (d) the optimum direction and width of navigation opening with respect to reducing wave action in the protected area.

The harbor model tests were conducted on a 1:75-scale, undistorted, fixed-bed model, con-
structed of concrete except for the breakwater bases which were simulating the stone characteristics of the proposed breakwaters. The model
produced all the inner-harbor area, the breakwater system, and sufficient shoreline and off-shore hydrography to permit simulation of waves propagated toward the harbor from the directions between north-northeast and west. The harbor consists of a 5600 sq ft, approximately 1.1 square miles in
nature. Waves were generated by a 40-ft-long plunger-type wave machine. Wave heights at
selected locations in the harbor were measured with electrical printed-circuit test gages, and were recorded electrically with a multi-
channel oscillograph.

The model was designed and constructed.

Wave-height tests were performed with model conditions simulating (a) basic or existing
prototype conditions; (b) location of breakwaters; (c) wave directions or breakwater lengths, alignments, and harbor entrance widths with a +12 ft lown crown elevation for determination of the optimum
length and alignment of an arrowhead-type breakwater system; and (c) selected
improvement plans with various breakwater crown elevations for determination of the
optimum crown elevations of breakwater systems. Tests were performed simulating storm
waves generated from all critical directions reckoned counterclockwise from north-north-
east through north to west. These tests were performed using a still-water level of +4.5
ft lwd.

Results obtained indicate that 9 of the 15 improvement plans tested met the wave-height
criteria selected for the navigation entrance, navigation channel, and ramp and mooring area of the harbor. This recommendation was delin-
cated from these nine on the basis of economy and direction of littoral transport, pro-
vides a total length of 1305 ft of north breakwater and 861 ft of south breakwater with a crown elevation of +9 ft lwd.

Preparation of final report is in progress.
STABILITY TESTS OF NAVIGATION OPENING STRUCTURES, HILO HARBOR TSUNAMI BARRIER, HAWAII.

(b) District Engineer, U. S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.

d) Experimental; for design.

(e) The project will provide a breakwater of barrier length extending from the Hilo Harbor, Hawaii, to protect the harbor and the city of Hilo against the attack of damaging tsunami waves. A navigation pass will be provided through the barrier. Passage of tsunami waves will result in several minutes of high-velocity flow through the navigation opening. To provide information on the barrier head shape and stone size required to withstand steady flow at a head differential across the barrier of 28 ft. (The effects of wave action on the barrier were investigated in other model studies. Two model arrangements were used during the test program. Tests designed primarily to provide data on the stone size required for stability of the barrier heads were conducted in a 1:160 scale model which reproduced one-half of the navigation opening. Tests conducted to provide information on the navigation opening were made in a scale model in which the full navigation opening was reproduced at a scale of 1:72.)

(g) Eighteen modifications of the basic navigation opening plan were tested to determine the stone sizes required and to evaluate two methods of providing protection for the toe of a barrier constructed of stone. Test results showed that barrier head stone sizes required for stability under the maximum anticipated steady-flow conditions were considerably smaller than those required to withstand the attack of the design waves. Test data also indicated that, if possible, the barrier heads should be constructed on a rock foundation. This was considered the only reliable method of obtaining stable heads. However, if foundation conditions at the site make this method of construction impractical, a protective blanket covering the entire channel bottom through the opening would provide protection for the toe of the barrier heads. The second method of toe protection investigated was the "armoring" technique in which additional stone is placed around the toe of the barrier head and allowed to stabilize the toe and protect it against the waves. Use of this method is not recommended unless the depth of sand is shallow and unless repair and maintenance operations are scheduled after each tsunami, until the currents have removed all sand and the barrier heads rest on rock.

(h) Preparation of final report is in progress.

MODEL STUDY OF HARBOR, CRESCENT CITY, CALIFORNIA.

(b) District Engineer, U. S. Army Engineer District, San Francisco, Corps of Engineers, San Francisco, Calif.

d) Experimental; for design.

(e) The existing recommended project entails dredging to a 20-ft depth an area of about 18 acres adjacent to the Citizens Dock, thus reducing the proposed 10-ft entrance to a 6-ft entrance. The proposed plan is to extend the breakwater from the entrance to a 25-ft depth, and armor the breakwater to a height of 6.5 ft above water. The breakwater is to be a concrete structure.

(f) MODEL STUDY OF BREAKWATER STABILITY, HILO HARBOR, HAWAII.

(b) District Engineer, U. S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.

d) Experimental; for design.

(e) Hilo Harbor, on the northeast coast of the Island of Hawaii, about 195 nautical miles southeast of Honolulu. The proposed plan to protect the harbor against strong waves (tsunamis) and short-period wind waves (sea and swell) consists of extending the existing breakwater westward to a total length of about 10,870 ft. The breakwater was designed to provide protection against breakwaters are to be constructed of concrete and concrete armor units. To develop a breakwater barrier section that will be stable against the attack of tsunami waves (tsunamis) and short-period wind waves (sea and swell), Stability tests of the breakwater trunk when subjected to long-period waves (tsunamis) were conducted at a 1:150 scale in a steel flume 230 ft long, 6 ft wide, and 4 ft deep. Model seismic waves (bores) were generated by a pneumatic-type machine, and measured and recorded electrically. Stability tests of the breakwater trunk when subjected to short-period waves were conducted at a 1:150 scale in a concrete wave flume 115 ft long, 5 ft wide, and 4 ft deep. Model waves were generated by a plunger-type wave machine, and measured and recorded electrically.

The existing facilities were revised for the study. A pneumatic bore generator was designed, constructed, and programmed to generate the required tsunami waves. Tests were conducted on a typical section of the breakwater trunk to study the causes and remedies of failure of breakwater trunks when subjected to tsunami attack. Nonovertopping and nonovertopping sections of the breakwater trunk were designed and tested for stability against tsunamis. Some of the breakwater trunk sections, which were found to be stable against the attack of tsunamis, were checked for stability against the attack of short-period waves. It was found that: (a) Rehabilitation of the existing breakwater will require the addition of one layer of 20-ton stone (placed with tongs) to the existing breaker, and section, grouting 4 ft of the top of the harborside slope of the cover layer of the existing barrier, and addition of a concrete impervious diaphragm on both sides of the breakwater; and (b) construction of a breakwater on the west side of the harbor extending eastward will require the construction of a nonovertopping barrier with 3-ft freeboard, a seaward slope of 1:1 to 1:2, and a harborside slope of 1:6. The nonovertopping barrier consists of approximately 5,000 tons of 6040 Calaveras gravity rock placed to a height of 10 ft above Mean Low Water, and armor cover layers on the seaward slope adequate to withstand the attack of short-period waves.

MODEL STUDY OF HARBOR, CRESCENT CITY, CALIFORNIA.
rubble, sized to simulate that required for prototype construction. The model reproduces sufficient area along the shoreline north, south, and oceanward of the harbor site to ensure that propagation of waves toward the problem area is adequately simulated. The model has an area of about 7800 sq ft, equivalent to about 4.4 square miles in nature. Waves are generated by a 60-ft-long, plunger-type wave machine. Electrical printed-circuit-type wave measuring rods in connection with automatic recording equipment are used to obtain necessary wave-height data.

(6042) LABORATORY RESEARCH ON DIKE DESIGN.

(b) District Engineer, U. S. Army Engineer District, Memphis, Vicksburg and New Orleans District.

d) Experimental; for design.

e) The project involves the construction of dikes for the regulation and improvement of alluvial streams, such as the Mississippi River, to provide for adequate channel depth and alignment for navigation.

To determine the relative effectiveness of various factors, such as alignment, elevation, length, permeability, etc., in stabilizing low-water channels and in providing the required increase in depth. The investigation is being conducted in a flume 230 ft long by 20 ft wide, including two bends and a relatively long, straight reach between bends. The study is of the movable-bed type with a fine, uniform sand used for bed material.

Tests of 15 dike systems were completed. Results have indicated some of the factors affecting the performance of rock dikes, performance characteristics of various types of dike systems, and factors which should be considered in the design of a dike system. The most promising dike designs are being built and tested in the field.
Inquiries concerning the following projects should be addressed to Mr. O. N. Erickson, Head, Hydraulic Department, H. G. Acres & Company Limited, Consulting Engineers, Niagara Falls, Canada.

(S568) MODEL TESTS OF THE ROCKFILL CAUSEWAY CROSS SECTION FOR THE NORTHUMBERLAND STRAIT CROSSING.

(b) Northumberland Consultants Limited, Charlottetown, Prince Edward Island.
(d) Experimental; design.
(e) The rockfill causeway section of the Northumberland Strait Crossing will be approximately three miles in length. The rockfill causeway must be protected against the combined effects of a 20-foot design wave, currents resulting from partial closure of the Strait which at present experiences 2-foot tides, and the movement of extremely large ice floes. Wave studies are being carried out on a 1:20 scale model to determine the most economic combination of dyke freeboard, dyke slope, primary precast concrete armour units and secondary riprap requirements, which will meet the design conditions.

(S569) TIDAL MODEL TESTS FOR THE PROPOSED NORTHUMBERLAND STRAIT CROSSING.

(b) Northumberland Consultants Limited, Charlottetown, Prince Edward Island.
(d) Experimental; design.
(e) To study the effect of partial closure of the Northumberland Strait by the building of a causeway. Model studies are being made of the Strait to scale of 1:6400 horizontal and 1:64 vertical. Tidal movements within the Strait are caused by the tides imposed on the entrances; two tide generators are therefore used. The principal objectives of the study are to confirm conclusions derived from analytical calculations, to determine the velocity distribution through the causeway, the overall velocity pattern, and the maximum tidal difference across the causeway. On completion of the studies for design data, the model will be available for studies required by other interested agencies such as the Department of Fisheries.

(S560) MODEL STUDY OF BRIDGE PIERS SUBJECTED TO PRESSURES FROM LARGE ICE FLOES.

(b) Northumberland Consultants Limited, Charlottetown, Prince Edward Island.
(d) Experimental; design.
(e) Piers for the bridged section of the proposed crossing of the Northumberland Strait will be subjected to ice pressure. Various shapes are being tested on a 1:60 scale model to find the magnitude and direction of the forces, and to observe the mechanism of the splitting and breaking of ice floes against these piers. A special substance has been devised having the appropriate mechanical properties to simulate the ice to the scale of the model. The piers are supported by a specially designed dynamometer and placed in the centre of a raceway. The artificial ice floes, floating in the water, are either carried by the current of water, or forcibly propelled and made to collide with the pier.

(S567) WAVE MEASUREMENTS IN NORTHUMBERLAND STRAIT.

(b) Northumberland Consultants Limited, Charlottetown, Prince Edward Island.
(d) Field; design.
(e) To enable calibration of wave formula for local conditions, a wave recorder consisting of an electronic circuitry cabinet and electrodes mounted on a mast 50 feet in length and anchored to the ocean floor approximately one mile off Borden, P.E.I., was designed and used to obtain wave data. The sending device on the mast was connected by a 7-conductor submarine cable to a power source and chart recorder located on the shore. The wave records obtained are being analyzed for significant wave, wave spectrum and wave period.

(g) Preliminary analysis of wave data indicates good agreement with Bretschneider's technique for wave forecasting, although some adjustment seems justified for use of the technique for an intermediate size body of water. Wave spectrum data was found to be in good agreement with the Longuet-Higgins data.

(S580) INVESTIGATION OF HYDRODYNAMIC FORCES ON BRIDGE PIERS AND TUNNEL ELEMENTS DURING PLACEMENT.

(b) Northumberland Consultants Limited, Charlottetown, Prince Edward Island.
(d) Experimental; design.
(e) To determine the hydrodynamic forces on the bridge piers and tunnel elements of the Northumberland Strait Crossing, 1 to 50 scale models of the piers and tunnel elements are being tested in a flume 11 feet wide, 4 feet deep and 80 feet long. The flume, which is equipped with pneumatic wave generator, is so designed that both current and wave forces can be simulated simultaneously on the models.

(S580) MODEL STUDY OF FORAGE DIVERSION SPILLWAY AND STILLING BASIN.

(b) Water Control and Conservation Branch, Dept. of Agriculture and Conservation, Government of Manitoba, Winnipeg 1, Manitoba.
(d) Experimental; design.
(e) The Portage Diversion spillway which will be located on the Assiniboine River, near Portage la Prairie, has a capacity of 25,000 cfs. The flow will be controlled by means of two 14-foot high by 75-foot long bascule gates located on the crest of the spillway. A 1 to 50 scale model was used to investigate the performance of the stilling basin for discharge over the spillway crest and through an 8-foot by 10-foot low level outlet conduit. Tests were also carried out to determine hydraulic loads for design of the gate operator. Qualitative tests of gate vibration and serton were also undertaken.

(g) A large baffle pier was found to be required at the outlet of the low level conduit to disperse the flow throughout the stilling basin to obtain satisfactory energy dissipation.

(h) A report has been prepared and submitted to the client.

(S590) MODEL STUDY OF MACQUAQUE STILLING BASIN.

(d) Experimental; design.
(e) The main spillway of the Macaquac Development has a capacity of 289,000 cfs and is located adjacent to the powerhouse. Fifty 45-foot wide by 55-foot high spillway crest gates regulate the flow into the stilling basin. The difference between the headwater and the tailwater is about 90 feet. A 1 to 72 scale movable bed model was used to study the performance of the stilling basin and to determine the optimum arrangement of baffle blocks, end still and length of stilling basin. Scour patterns downstream from the stilling basin and adjacent to the powerhouse were also investigated.

(g) Satisfactory design was developed using a stilling basin length equal to approximately 0.3 times the length of the hydraulic jump.

(h) Report prepared and submitted to the client.

(S591) MODEL STUDY OF PROPOSED LOCK 6 WEST INTAKE.
STRUCTURE.

(b) The St. Lawrence Seaway Authority, Montreal, Canada.
(c) Experimental; design.
(d) A new filling system for Lock 6 West of the Welland Canal requires construction of a new intake. The proposed intake structure consists of a funnel shaped entrance transition, symmetrically divided along the curve water to two tunnels. The flow in each tunnel is regulated by a reverse taper gate. A 1 to 40 scale model was used to investigate the possibility of separation, air entrainment and vortex formation at the intake.
(e) Completed.
(f) A tendency for vortex formation was found in the model. Several types of vortex suppressors were tested at 1, 2 and 2.5 times the Proud velocity and a canopy type suppressor recommended as a permanent feature of the intake.
(g) Report completed and submitted to the client.

MODEL STUDY OF LOCK 7 WEST OUTLET STRUCTURE.

(b) The St. Lawrence Seaway Authority, Montreal, Canada.
(c) Experimental; design.
(d) The new emptying system for Lock 7 West of the Welland Canal consists of two concrete tunnels, each 20 feet wide by 20 feet high, and an outlet structure. The outlet structure consists of two conduits curved, in plan, 66.25 degrees on a horizontal radius of 98.5 feet, with two vertical bends having radii varying from 20 to 60 feet. Each conduit of the outlet structure is 20 feet high by 20 feet wide at the entrance, and is expanded and divided by a separation wall along its centraline, into two branch conduits, each with dimensions 14 feet by 29 feet at outfall. A 1 to 40 scale model was used to investigate flow separation along the curve walls, flow distribution at outfall and energy losses.
(e) Completed.
(f) The model showed separation to take place along the inside wall of the horizontal curves of each branch and guide vanes were added to improve the velocity distribution and turbulence at outfall.
(g) Report prepared and submitted to the client.

UNIVERSITY OF ALBERTA (EDMONTON), Dept. of Civil Engineering.

ALBERTAN CO-OPERATIVE STUDIES OF RIVER REGIME.

(b) University, with NRC grant.
(c) Dr. T. Blench, Dept. of Civil Engrg., Univ. of Alberta, Edmonton, Canada.
(d) Laboratory study; Master's thesis.
(e) Literature study and attempt to co-ordinate the maximum scour for a given depth in sand and coal bed material.
(f) A useful formula was obtained containing a power of the buoyant specific gravity of the bed material. Maximum scour was found to be parabolically, less in the light-weight material.

ALBERTAN CO-OPERATIVE STUDIES OF RIVER REGIME.

(b) University and Alberta Research Council.
(c) Dr. T. Blench, Dept. of Civil Engrg., Univ. of Alberta, Edmonton, Canada.
(d) Field study under Co-operative Highway Research Program; Master's thesis and official report.
(e) Fluviological field study and analysis of sand-river regime.
(f) Bed behaviour over 3 miles were observed in detail at three low flood stages using a sonic sounder and careful ground control. Space alternations of scour and deposition were recorded as discharge varied; dune patterns were studied; scour pattern changes with time were noted on a bend. A preliminary quantitative analysis was attempted in terms of regime theory parameters, Manning's n, and a friction factor; the variations of these factors were considered in terms of the qualitative river behaviour.


ALBERTAN CO-OPERATIVE STUDIES OF RIVER REGIME.

(b) University of Alberta, with NRC grant.
(c) Dr. T. Blench, Dept. of Civil Engrg., Univ. of Alberta, Edmonton, Canada.
(d) Laboratory study; Master's thesis.
(e) Study of laminar flow of sand suspension in vertical tubes, and co-ordination of theory. Terminated. An attempt was made to co-ordinate the many formulas offered in Chemical Engineering literature for dilatant behaviour of suspensions. VD was found to be a suitable factor for correlating with boundary shear stress. The Begnold experiments and ideas on dilatancy suggested non-dimensional parameters and the use of a linear separation factor instead of concentration; the resulting formula was a simple power one with an index that changed at high concentration where particles probably interfered with each other. Violently. Investigation of Rheological Characteristic of Sand-Water Suspensions", N. Subramanyam, Univ. of Alberta, M.Sc. Thesis, 1965.

ALBERTAN CO-OPERATIVE STUDIES OF RIVER REGIME.

(b) University of Alberta, with NRC grant.
(c) Dr. T. Blench, Dept. of Civil Engrg., Univ. of Alberta, Edmonton, Canada.
(d) Laboratory study; Ph.D. thesis.
(e) Study of sand suspension in pipes near the drop-out condition. Continuing to other problems. Scattering of Gamma-Rays was used to measure sediment concentration on vertical and horizontal lines. The technique proved satisfactory. Concentration followed an approximately exponential decay law from bottom of pipe to top of observable material. The Begnold's ideas on dilatancy were interfered with each other. Violently. Investigation of the Concentration Gradient in Fluidized Solids Transport", M. P. duPlessis, Ph.D. thesis, Univ. of Alberta, 1965.

SUBMERGED SLICE GATE FLOW AS A WALL JET PROBLEM.

(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton.
(d) Basic problem with practical application; experimental and theoretical in nature. This work is being done to treat the submerged flow below a slice gate as the case of a plane turbulent wall jet under essentially zero pressure gradient and to understand the mechanics of the jet diffusion and energy dissipation.
(e) Completed. The analysis has been successful. The velocity scale factors have been determined and it has been found possible to predict the net diffusion and dissipation of the discharged flow below a slice gate as the case of a plane turbulent wall jet under essentially zero pressure gradient and to understand the mechanics of the jet diffusion and energy dissipation.

SUBMERGED HYDRAULIC JUMP AS A WALL JET.

(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg.,
University of Alberta, Edmonton, Canada.
(d) Basic problem with practical application; theoretical and experimental.
(e) The purpose of this work is to develop a sound method of understanding the diffusion and energy dissipation in the submerged jump.
(f) Completed.
(g) The submerged jump has been treated as a plane turbulent wall jet, with an adverse pressure gradient with backward flow on top. The forward flow has been successfully studied; the friction on the bed has been measured with a Preston tube and a method has been developed to predict the backward flow on top. The effect of the submergence factor has been brought out clearly.

(5587) HYDRAULIC JUMP AS A WALL JET.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Basic problem with practical application; theoretical and experimental.
(e) The purpose of this work is to understand the diffusion and energy dissipation in the jump and also to find out the effect of the adverse pressure gradient on the growth of a wall jet.
(f) Completed.
(g) The velocity distribution in the boundary layer and the free mixing region have been studied and have been found to be similar. The corresponding scale factors have been determined. The boundary friction has been measured with a Preston tube. A more correct form of the momentum equation for the jump has been developed. The surface profile and energy fall in the jump have been predicted.

(5578) PLANE TURBULENT WALL JETS ON ROUGH BOUNDARIES.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Basic problem with applications; theoretical & experimental.
(e) The purpose of this work is to study systematically, the effect of boundary roughness on the growth of the wall jet.
(g) The growth and diffusion of the plane turbulent wall jet on rough boundaries has been studied over a wide range of relative roughness under essentially zero pressure gradient. Further work is in progress to study the effect of adverse pressure gradients.
(h) "Plane Turbulent Wall Jets on Rough Boundaries," by N. Rajaratnam. Submitted for Publication to the ASCE, J. of the Hydraulics Divn.

(5579) PRESTON TUBE - A THEORETICAL CALIBRATION CURVE.
(b) University with NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Basic problem with applications.
(e) The purpose is to develop a refined theoretical calibration curve for Preston tube on smooth boundaries for large Reynolds numbers.
(f) Completed.
(g) The theoretical curve developed agrees very well with the extensive and precise results of Hechenberg and Patel.

(5600) THE STATIC HOLE ERROR PROBLEM.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Basic problem with applications.
(e) The purpose is to study the static hole error problem with a view of using it for the measurement of boundary shear stress.
(f) A method has been developed for predicting the true static pressure using two holes of different diameters. Also Shaw's curve has been found to be applicable for open channel flows.

(5581) PRESTON TUBE WITH A HEMISPHERICAL NOSE.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Basic problem with applications.
(e) The purpose is to develop a method of using the familiar Preston hemi-type pitot-static tube for the measurement of the boundary shear stress.
(f) Completed.
(g) A calibration curve has been developed for the pitot-static tube to predict the boundary shear stress.

(5562) SUBMERGED JUMP IN TRIANGULAR CHANNEL.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Applied research.
(e) To understand the effect of submergence on the jump in a triangular channel.
(f) Completed.
(g) The momentum equation has been found to be satisfactory to predict the overall flow pattern and energy loss.

(5563) HYDRAULIC JUMP IN HORIZONTAL CONDUITS.
(b) University on NRC Grant.
(c) Dr. N. Rajaratnam, Dept. of Civil Engrg., University of Alberta, Edmonton, Canada.
(d) Applied research.
(e) To develop simplified charts to predict the jump characteristics in conduits.
(f) Completed.
(g) Simple charts have been developed for predicting the jump formation in horizontal conduits and are given in exponential cross-section. The effect of air entrainment has also been considered.

(4451) HEAD LOSS IN SPHERICAL AND CONVENTIONAL WYES.
(b) Laboratory project.
(c) Dr. E. Raas, Dept. of Civil Engineering, University of British Columbia.
(d) Applied research. Much of the experimental work is being done by an M.A.Sc. student.
(e) Lucite models of spherical and conventional type of wyes were constructed and the head losses measured. For all wyes the inside diameter of the main pipe and the branch pipes are 1/4 and 3/4 inches respectively. Several modifications such as tapers, tapered outlets, rounded corners and different sphere diameters are being investigated.

(5993) FLOW THROUGH PIPE NETWORKS.
(b) Laboratory project.
(c) Prof. J. F. Muir, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, B. C.
(5994) THE USE OF AIR BUBBLES TO PREVENT SHOALING AT A WHARF IN A NAVIGABLE, ALLUVIAL, TIDAL RIVER.

(b) Laboratory project.
(c) Prof. E. S. Fretious, Dept. of Civil Engrg., Univ. of British Columbia, Vancouver, B. C.
(d) Laboratory experiments and field tests. Applied research to aid operation and development. Project used for master's thesis.
(e) A grain elevator wharf owned and operated by the Fraser River Harbour Commission on the left bank of the Fraser River at New Westminster, B. C., is subject to severe shoaling annually, immediately following a freshet. This shoal is removed by conventional dredging which is inconvenient for shipping using the wharf. If dredges are not immediately available the wharf has to close, resulting in serious financial loss. The shoal is composed of fine sand having a median diameter of about 0.1 m.m. which may be carried in suspension during freshet. By creating a curtain of air bubbles it might be possible to deflect the sediment deposition away from the wharf, in the manner of an underwater deflecting groin, except that it would not constitute a hazard to shipping. Compressed air will be forced through perforations in plastic pipe anchored to the river bed in the vicinity of the wharf, which is 1,122 feet long parallel to the bank. It will be necessary to know the optimum arrangement of the air lines on the river bed and at what stage of the river flow to commence the air bubble operation. Furthermore, the local tidal action may produce shoaling patterns which can best be countered by varying the operation to suit flood, slack, and ebb tides. To be a success, the air-bubble system will have to compete with conventional arrangements as regards cost, apart from the other advantages mentioned.
(f) The findings will be presented in a master's thesis.

(5997) RIVER FLOOD FORECASTING.

(b) British Columbia Disaster Relief Fund.
(c) Dr. R. Singh, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, B. C.
(d) Applied research (mostly theoretical).
(e) To forecast the floods on the Fraser River from snow and temperature data by considering an analogous system.
(f) Under study.

ECOLE POLYTECHNIQUE, Department of Civil Engineering, Hydrodynamics Laboratory.

(4043) STUDY OF THE RELIABILITY AND OPERATION OF BACK-WATER VALVES ON PLUMBING SYSTEMS AGAINST FLOODING BY PUBLIC SEwers.

(b) City of Montreal, City Planning Department, Inspection Division.
(c) Professor Raymond Boucher, Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Avenue, Montreal 26, Quebec, Canada.
(d) Experimental; applied research.
(e) A full scale three-story plumbing system has been erected in the Hydrodynamics Laboratory of Ecole Polytechnique. The diameter of the pluvial column, the soil stack and the drain is 4 inches. The drain has many sections of pyrex glass to permit observations at critical points. A system of valves and of cross-connections on the vents lends to various combinations of tests. The back-water valves have a transparent lucite cover to enable visual observations.
(f) As air entrainment has a great importance on the venting capacity, the rate of air entrained in the vertical columns is measured at the inlet by means of a hot-wire air-meter. Various flooding conditions of the public sewers are simulated by a tank in which the water level can be controlled by gate valves. This research is aimed at determining whether back-water valves can offer home dwellers a reliable protection against flooding due to any overload of combined sewers.
(g) Reactivated.
(h) The mechanism of air entrainment has been studied and tests have revealed the best position for some of the vents. Recent tests have been conducted with new positions of the vents and new arrangements in the piping.


HYDRAULIC MODEL STUDY OF THE INTAKE FOR THE MANICOGUAN 5 HYDRO-ELECTRIC PROJECT.

(b) Quebec Hydro-Electric Commission.
(c) Professor Raymond Boucher, Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Ave., Montreal.
(d) Experimental; for design.

(e) A comprehensive model built to an undistorted scale of 1:50 reproduces the forebay topography, the intake canal and intake structures. This investigation is conducted to examine the overall performance of the structures and to verify the design. A second model of the intake structures of a different design has also been built to the same scale. The first model of the intake structures has been tested. Testing of the second model is being executed at the present time.

(h) Progress reports submitted to sponsor.

(5946) HYDRAULIC MODEL STUDY OF LOG-PASSING DEVICES AT DAMS.

(b) Quebec Hydro-Electric Commission.

(c) Prof. Andre Leclerc, Associate Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Ave., Montreal 26, Quebec, Canada.

(d) Theoretical and experimental for design.

(e) The study is conducted to determine the best geometry of intakes, transitions, flumes and chutes to prevent log jamming and ascertain efficient flow especially in vertical and horizontal bends of chutes. The main purpose of this study is to design an intake that will pass the largest flow of logs of 4, 8, 12 and 16 feet with the minimum of water per log. Consideration must be given to the fact that the water level upstream of the dam may vary with time up to 15 feet at some locations. The elevation of the intake structure must be varied accordingly to control the rate of flow.

(g) Two intakes have been designed which seem to conform to the requirements. Tests are now conducted on a 1:16 scale model to refine the shapes and determine the best slopes. Theoretical design of transitions have been made which will be subjected to experimental verification in the near future.

(h) Progress reports submitted to sponsor.

(5947) HYDRAULIC MODEL STUDY OF HEAD LOSSES THROUGH VARIOUS RESTRICTED ORIFICES FOR THE SURGE TANKS OF MANICOUAN 5 HYDROELECTRIC PROJECT.

(b) Quebec Hydro-Electric Commission.

(c) Prof. Raymond Boucher, Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Ave, Montreal, Canada.

(d) Experimental; applied research (M.S. thesis).

(e) One model has been built to a scale of 1:107.3. Measurements on coefficients of various orifice shapes have been studied for the two flow directions under steady flow conditions. To obtain a given loss coefficient ratio for the two flow directions of the orifice to be installed in the surge tanks has been determined. Fundamental study is planned on four models built to different scales to verify possible scale effects.

(5948) THEORETICAL STUDY ON THE TIDAL MOTION IN THE ST. LAWRENCE ESTUARY.

(b) National Research Council; laboratory project.

(c) Dr. H. Werner Partenskys, Ecole Polytechnique, Hydrodynamics Lab., 2500 Marie-Guyard Ave., Montreal 26, Quebec, Canada.

(d) Theoretical and field investigation; applied research for M.S. thesis.

(e) Investigation of the tidal characteristics of the St. Lawrence Estuary by means of a mathematical model. Empirical determination of geometric and roughness effects on tidal amplitudes and velocities. Calculation of tidal discharges. Study of geostrophic effects. Comparison of computed tidal velocities with field measurements.

(f) Almost completed.

(g) Theoretical results showed good agreement with field measurements for average tidal amplitudes and velocities.


(5949) SALINITY INTRUSION STUDY FOR THE ST. LAWRENCE ESTUARY.

(b) National Research Council; laboratory project.

(c) Dr. H. Werner Partenskys, Ecole Polytechnique, Hydrodynamics Lab., 2500 Marie-Guyard Ave., Montreal 26, Quebec, Canada.

(d) Theoretical and field investigation.

(e) One-dimensional study on the salinity intrusion in the St. Lawrence Estuary based on mean tidal velocities obtained from theoretical investigations and field measurements. Comparison of computed salinity values with prototype data.

(f) Preliminary studies completed. Investigations continuing.

(5950) STUDY ON THE OSCILLATIONS OF FLAP GATES.

(b) National Research Council; laboratory project.

(c) Dr. H. Werner Partenskys, Ecole Polytechnique, Hydrodynamics Lab., 2500 Marie-Guyard Ave., Montreal 26, Quebec, Canada.

(d) Experimental; fundamental study; M.S. thesis.

(e) The oscillations of flap gates to oscillate are being investigated for different gate shapes and operating positions. Measures to prevent the oscillations are being studied. Criteria are to be estabished for the design and operation of flap gates.

(g) Investigation in planning stage.

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THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, Hydraulic Model Laboratory.

Inquiries concerning the following projects should be addressed to Mr. J. B. Bryce, Hydraulic Engineer, Hydraulic Engineering Department, 620 University Avenue, Toronto 2, Ontario, Canada.

(4026) NIAGARA RIVER MODEL.

(b) Ontario Hydro.

(d) Experimental; for design and operation.

(e) An existing 1:250 x 1:50 scale model reproduces the Niagara River from Buckhorn Island to below the Cataracts is being used to determine the operational characteristics of the Niagara River Control Structure under developed conditions. This model was previously used to investigate the remedial works necessary for the Preservation and Enhancement of Niagara Falls and for the location of the intakes and necessary river improvements of both Ontario Hydro and the Power Authority of the State of New York. To fully realize the terms of the 1950 Niagara Treaty, additional remedial works have been designed. These include a five-gate extension to the existing 13-gate control structure as well as a system containing an upstream accelerating wall, a downstream training wall and overflow weir for the safe passage of ice past the various intakes along the Canadian shore of the river above the Falls. The sequence of construction of these works and the conditions during their construction were determined in the model. Rating of the structure under cofferdammed conditions was obtained. An echo-sounding survey with electronic fixing was made in the field in 1962 and portions of the model were also re-contoured. Certain river improvements were designed and executed to assist in the passage of ice flows.

(4455) AARON LAKES DAM - COLUMBIA RIVER.

(b) British Columbia Hydro and Power Authority.
(d) Experimental; for design and operation.
(e) An 1:80 scale model of the Arrow Lakes and dam and environs was built to determine the detailed location and adequacy of the water passages in a concrete structure and the energy-dissipating works necessary to ensure the protection of an associated earth dam. Numerous tests have been made with a movable bed of fine sand to determine erosion characteristics, navigation velocities, and downstream of a lock situated between the concrete structure and the earth dam.

A 1:50 scale model was tested in a flume to determine the hydraulic design of the tunnel ports in the concrete structure and to develop the associated energy-dissipating work. Rating of the tunnel ports was obtained as well as the hydraulic loadings on the port gates. A 1:80 scale model of one of the four sluice-weirs is being tested in the flume to determine the rating of the sluice and the hydraulic loadings on the sluice gate. Piezometers are being used to determine under varying conditions of flow, the run-off pressures as well as the pressures at selected locations in the energy-dissipating bucket and associated tooth-like projections of the dissipator. Design completed, but model still active.

SIR ADAM BECK-NIAGARA GENERATING STATIONS.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:80 scale model was built of the two canals leading to the plants including the crossover, in order to determine the performance with the increased flow of Sir Adam Beck No. 1 canal due to its enlargement.

Work completed and model inactive.

LAMBERTON GENERATING STATION.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1 to 40 scale model reproduces about one mile of the St. Clair River topography. The model will determine the location and size of the intake channels for cooling water and any river excavation for the channel and shipping.

Work completed and model inactive.

SIR ADAM BECK-NIAGARA GENERATING STATIONS.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:50 model of the trapezoidal section of the hydraulic canal leading to Sir Adam Beck No. 1 Generating Station was constructed in order to redesign an enlarged trapezoid in the earth section to accommodate the larger flows of the enlarged rock canal section up and downstream.

Work completed and model inactive.

SIR ADAM BECK-NIAGARA GENERATING STATIONS.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:50 scale model was constructed of the downstream end of the enlarged hydraulic rock canal leading to Sir Adam Beck No. 1 Generating Station, to design an enlarged section in order to recover velocity head of water travelling 17 fps and reducing to 12 fps where it merges with water in the new canal leading to Sir Adam Beck No. 2 Generating Station. Included in the model was an inclined ramp and a large central pier, 12 feet by 60 feet, for de-watering purposes.

Work completed and model inactive.

MOUNTAIN CHUTE GENERATING STATION.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:80 scale topographic model of the power site was constructed to determine cfferdam layout, tunnel port details and operation with a hinged-flap closure gate, sluice location, and downstream training walls and rock excavation, tailrace configuration and excavation, and beneficial location of spoil excavation.

INTAKE STUDY.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:24 plexiglass model was constructed to determine the minimum opening in the dam face consistent with performance for a single-gated bell mouth type of opening. An upper transition from square to round and a lower transition made with a reducing elbow were also studied. Pressure pipes were also tested with piezometer rings for use with the Gibson Method of testing a short penstock. Variations in opening radii, height of sill above bed etc., will be investigated later.

BARNETT CHUTE GENERATING STATION.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:60 model was constructed for an existing station with a long headrace canal excavated in rock to which will be added two large units for peaking purposes. The model is being used to determine the design of a modified inlet to the enlarged forebay leading to the new units.

PICKERING GENERATING STATION.
(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:30 model of the hydraulic passages from Lake Ontario to the C. W. & Service water pumps for four 500 MW units of a nuclear plant are being studied. Of particular interest are the waterways from the screenhouse, under the spent fuel bay and the pump well design. The water requirement is over 1,000 cfs per unit. Surge heights at shutdown are also being examined.

LASALLE HYDRAULIC LABORATORY LTD.

MONTREAL - SOREL SHIP CHANNEL.
(b) Department of Transport.
(d) Theoretical and experimental design.
(e) Two models representing a section of the St. Lawrence River from Largisie Basin including Montreal Harbour to Sorel Islands were built at a scale 1/150 vertically and 1/600 horizontally.

The purpose of the model was to study the improvement of navigation in this section of the St. Lawrence River.

LITTLE CURRENT SHIP PASSAGE.
(b) Dept. of Public Works, Canada and consulting engineers.
(d) Scale model study of navigation problems in Little Current Narrows with the aid of radio-guided ship model.
(e) Study of corrective measures for currents induced by wind, tide and seiche action.
(f) Completed.
(h) Report submitted to sponsor.

ARROW LAKES LOCK.
(b) C B A Engineering Ltd.
(d) Experimental; design.
(e) The purpose of the study carried out on a 1/20 scale model is to ascertain the hydraulic performance of the design of the lock and make modifications suggested by these preliminary tests.
(f) Completed.
(h) Report submitted to sponsor.
(b) Dufresne Engineering, Montreal.
(a) Experimental and design.
(e) A 1/78 scale model was used to determine the current conditions along the centreline of the proposed cross-channel wave period bridge when a deflector with a total nose angle of 90° is placed in front. Elimination of the surging motion in the protected area was achieved. 
(f) Completed.
(h) Report submitted to sponsor.

729) SURGE TANK ORIFICE.
(b) Shawmont Engineering, Montreal.
(d) Empirical and design.
(e) An orifice was designed and tested on a 1/46 scale model, to obtain the required head losses. The corresponding head loss coefficient for flow conditions in both directions was measured.
(f) Completed.
(h) Report submitted to sponsor.

750) MANIFOLD DESIGN.
(b) Hydro-Quebec and consulting engineers.
(d) Theoretical and experimental.
(e) Two types of manifolds for the Manicouagan V Power project were tested on a 1/46 scale model. The head-loss coefficient pertaining to these two types were determined.
(f) Completed.
(h) Report submitted to sponsors.

751) ICE THRUST ON FILES.
(b) Montreal World Exhibition.
(d) Theoretical and design.
(e) Estimation of the ice thrust on the pile of a bridge in the St. Lawrence River.
(f) Completed.
(h) Report submitted to sponsor.

752) OUTARDES 4 POWER PROJECT: TAILRACE CANAL.
(b) Hydro-Quebec and consulting engineers.
(d) Experimental and theoretical; design.
(e) Study on a 1/96 scale model of the head losses at the exit from the turbines into the canal and from the canal into the river. Determination of the geometry best suited for minimum losses in both transitions.
(f) Completed.
(h) Report submitted to sponsor.

753) OUTARDES 3 RIVER: TAILRACE TUNNEL.
(b) Hydro-Quebec and consulting engineers.
(d) Experimental; design.
(e) Study on a 1/60 scale model of the head losses and surge waves in the tailrace tunnel. Determination of the dimensions of the tunnel best suited to ensure free surface flow.

754) SCOUR PATTERN UNDER SINKING CAISSON.
(b) Dufresne Engineering Ltd.
(d) Experimental for design.
(e) Model studies on scouring of fine material as floating caisson is slowly sunk on the bottom of the river.
(f) Completed.
(h) Report submitted to sponsor.

755) STUDY OF PARTIAL CLOSURE OF THE ST. LAWRENCE RIVER.
(b) Canadian Corporation for the 1967 World Exhibition, and Consulting engineers.
(d) Theoretical and experimental for design.
(e) Determination of water levels and current patterns as one arm of the St. Lawrence between the South Shore and an island is closed.
(f) Completed.
(h) Report submitted to sponsor.

756) DESIGN OF A DAM IN A TIDAL ESTUARY.
(b) Department of Public Works of Canada.
(d) Study of different construction stages as an MCGILL UNIVERSITY, Department of Civil Engineering
and Applied Mechanics.

(4546) CAVITATION AT HIGH-HEAD SLUICE GATES.

(b) National Research Council, Canada.
(c) Dr. A. J. Reynolds, Dept. of Civil Engrg. and Applied Mechanics, McGill Univ., Montreal 2, P. Q., Canada.
(d) Experimental; basic research for Doctoral thesis.
(e) Study of uniformly distorted turbulence to investigate the approach to equilibrium structure and the nature of that structure.
(f) Several distorting ducts have been constructed, allowing flow patterns and three-dimensionality to be observed. A rounded planar Froude number was studied in this work. A relationship has been found to respond to two respectively different degrees of turbulence for the case of plane flow. The degree of anisotropy attainable is much greater; the relaxation of anisotropy upon release of the strain is much more abrupt.

(5669) GENERATION OF SURGES AND SOLITARY WAVES.

(b) National Research Council, Canada.
(c) Dr. A. J. Reynolds, Dept. of Civil Engrg. and Applied Mechanics, McGill University, Montreal 2, P. Q., Canada.
(d) Experimental and theoretical; basic research for Doctoral thesis.
(e) Study of the generation and development of waves by a single stroke of a piston at uniform velocity.
(f) Apparatus being set up.

NATIONAL RESEARCH COUNCIL, Hydraulics Section, Division of Mechanical Engineering.

(4466) AIR BUBBLERS FOR PREVENTING ICE COVER FORMATION.

(b) Laboratory project.
(c) Dr. S. Ince, Head, Hydraulics Section, Natl. Research Council, Montreal Road, Ottawa 7, Canada.
(d) Experimental; field investigations.
(e) Field measurements and laboratory tests were performed to determine the mechanism whereby an air babbler prevents ice formation in an oceanic environment.
(f) Completed.
(g) Investigations revealed that the efficiency and success of the operation depend upon the thermal reservoir of the oceanic environment.

(4925) FORMATION OF ICE IN RIVERS.

(b) Laboratory project.
(c) Dr. S. Ince, Head, Hydraulics Section, Natl. Research Council, Montreal Road, Ottawa 7, Canada.
(d) Experimental; field investigations.
(e) Water temperatures are being recorded in the St. Lawrence River between Kingston, Ontario, and Three Rivers, Quebec, to obtain information on heat losses.
(f) Preliminary calculations show satisfactory agreement between measured and computed heat losses. For closer correlation more precise measurement of meteorological conditions—particularly radiation—will be necessary.

5080 CODROY HARBOUR, NEWFOUNDLAND.

(b) Department of Public Works, Canada.
(c) Mr. J. Floeg, Hydraulics Section, Natl. Research Council, Montreal Road, Ottawa 7, Canada.
(d) Experimental, for design.
(e) A 1:180 by 1:120 fixed-bed wave and current model of the harbour has been constructed to investigate silting conditions in the harbour entrance and to devise remedial works.
(5074) PERFORATED VERTICAL-WALL BREAKWATER.

(b) Laboratory project.
(c) Mr. G. B. Jarlan, Hydraulics Section, Natl. Research Council, Montreal Road, Ottawa 7, Canada.
(d) Experimental and theoretical.
(e) Two-dimensional flume experiments are being made to determine the behaviour of an erodible bed in front of the breakwater.
(f) Completed.
(g) Results obtained thither indicate that, for a non-erodible bed, no erosion develops at the toe of the breakwater regardless of the wave height or period.


(5765) CHURCHILL HARBOUR, MANITOBA.

(b) National Harbours Board, Canada.
(c) Mr. T. N. Dick, Hydraulics Section, Natl. Research Council, Montreal Rd., Ottawa 7, Canada.
(d) Field investigation.
(e) Surveys are conducted to determine ice formation and movement in the estuary to determine means of extending the navigation season.

(5767) WAVE CLIMATE STUDY, LAKE SUPERIOR.

(b) Dept. of Transport, Canada.
(c) Mr. J. F. Plog, Hydraulics Section, Natl. Research Council, Montreal Rd., Ottawa 7, Canada.
(d) Field investigation.
(e) Accelerometer type wave recorders are installed at four locations in Lake Superior to measure waves and correlate with the wind field.

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QUEEN'S UNIVERSITY AT KINGSTON, Hydraulic Laboratories.

(3364) LITTORAL DRIFT AND ITS EFFECT ON THE HARBOURS ON THE NORTH SHORE OF LAKE ONTARIO.

(b) The National Research Council of Canada.
(c) Dr. A. Brehner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
(d) Experimental and field; basic and applied.
(e) Two-dimensional investigation of mass transport and sediment movement with and without superimposed currents; three-dimensional model investigation of the waves generated by a moving vessel in shallow water.

(4057) THE TRANSPORT OF MATERIAL IN PIPE-LINES.

(b) The National Research Council of Canada.
(c) Dr. A. Brehner, Ellis Hall, Queen's Univ., Kingston, Ont., Canada.
(d) Laboratory investigation.
(e) Pipes of differing shapes being used to study the parameters affecting the critical velocity of deposition.

(h) "Derivation of Regime Equations From Relationships For Pressurized Flow By Use Of The Principle Of Minimum Energy-Degradation Rate," by K. C. Wilson, Queen's, C. E. Report No.51.

(5287) LABORATORY INVESTIGATION OF THE INTENSITIES OF SECONDARY CURRENTS IN AIR FLOWS.

(b) National Research Council of Canada.
(c) Prof. S. S. Laslier, Queen's Univ., Kingston, Ontario, Canada.
(d) Basic research for Master's Degree.
(e) Suspended.
(f) Report being prepared.
(g) Second Master's thesis accepted.

(5673) THE ATTENUATION OF WATER WAVES BY A FLOATING FILLWOOD BREAKWATER.

(b) The Pulp and Paper Research Institute of Canada.
(c) Prof. R. J. Kennedy, Queen's University, Kingston, Ont., Canada.
(d) Experimental project for Master's thesis.
(e) The attenuation of waves of various size and steepness by log masses of different characteristics was measured in the laboratory.
(f) Completed.
(g) Substantial dissipation of wave energy was achieved, a paper is being prepared.

(5674) STUDIES OF FLOW-THROUGH VORTICES.

(b) The National Research Council of Canada.
(c) Prof. R. J. Kennedy, Queen's University, Kingston, Ont., Canada.
(d) Experimental and theoretical project for Master's and Doctoral theses.
(e) Velocities, pressures and turbulence characteristics in a series of closed flow-through vortex chambers are being measured by photographic and electronic techniques.
(f) Master's thesis accepted.

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UNIVERSITY OF TORONTO, Department of Mechanical Engineering.

(1298) DISCHARGE CHARACTERISTICS OF WEIR-TYPE SPILLWAYS.

(b) Laboratory project.
(c) Prof. L. E. Jones, University of Toronto, Toronto S, Canada.
(d) Experimental; applied research for Master's theses.
(e) A long-term research carried out with a view to systematizing discharge characteristics for spillways having various pier spacings and proportions.
(f) Significant correlations obtained via special plotting techniques.
(h) Report in preparation.

(2252) HYDRAULIC FLOW IN OPEN CHANNELS OF VARIABLE SLOPE.

(b) Laboratory project.
(c) Prof. L. E. Jones, Univ. of Toronto, Toronto S, Ontario.
(d) Experimental and field; basic and applied research.
(e) A doubly-tilting, variable-section flume facility of 160 ft. length is under construction. Provision is being made for a wide range of experimental conditions.

(3003) ROUGHNESS PHENOMENA IN OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Prof. L. E. Jones, University of Toronto, Toronto S, Canada.
(d) Experimental and analytical; basic research for doctoral thesis.
(e) Critical analysis of the hydraulic radius concept and the effect of cross-section geometry on the resistance to flow in conduits. Detailed evaluation of mean flow parameters such as friction coefficients, static pressures, velocities, and wall shear stresses. The channel under study was 70 feet long and had a variable rectangular cross-section of 3 x 1, 3, 9 inches, respectively, and was used as the fluid medium.
(f) First project completed; others in progress.

(4889) UNSTEADY LAMINAR FLOW IN SHORT, CLOSED CONDUITS.

(b) Laboratory project.
(c) Prof. H. J. Leuthesser, University of Toronto, Toronto S, Canada.
(d) Experimental and analytical, basic research for master's thesis.
(e) Various cases of unsteady (oscillating) laminar flow as encountered in typical viscous damping devices are being investigated.

(f) Completed.

(h) Report in progress.

(4890) CHARACTERISTICS OF FLOW OF FLUID-SEDIMENT MIXTURES.

(b) Laboratory project.

(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada.

(d) Experimental, basic research.

(e) Evaluation has been achieved of mean flow parameters such as friction coefficients, static pressures, velocities and wall shear stresses in a two-dimensional closed conduit of 1:10 aspect ratio, for pure air flow. Work on fluid-sediment mixtures is in preparation.

(5256) OPTIMUM HEIGHTS OF CHIMNEYS.

(b) The Municipality of Metropolitan Toronto, Department of Works.

(c) Prof. G. R. Lord, University of Toronto, Toronto 5, Canada.

(d) Experimental, applied research for design information.

(e) Determination, in wind tunnel, of thickness distributions of zone of separated flow on roofs of various building shapes. Results will form basis for code on minimum heights of roof-mounted chimneys.

(5623) FLOW IN POROUS MEDIA.

(b) Laboratory project.

(c) Prof. L. E. Jones, Univ. of Toronto, Toronto 5, Canada.

(d) Experimental and analytical; applied research for master's thesis.

(e) As an approach to fundamental considerations of fluid flow in porous media, flow has been investigated in a two-dimensional wavy channel.

(f) Significant progress has been made on suitable computer procedures for various flow conditions.


(5624) OPEN-CHANNEL PROFILE ANALYSIS.

(b) Laboratory project.

(c) Prof. L. E. Jones, Univ. of Toronto, Toronto 5, Canada.

(d) Analytical, basic research.

(e) Fundamental computational projects are being reviewed and investigated by computer analysis.

(g) Improved extrapolation procedures indicate that significant accuracy of integration can be achieved with confidence and economy.

(5625) FLOW IN A WEDGE WITH POROUS WALLS.

(b) Laboratory project.

(c) Prof. W. B. Baines, Univ. of Toronto, Toronto 5, Canada.

(d) Experimental and theoretical; basic research for doctoral thesis.

(e) The flow of a fluid with a narrow wedge (less than 10 degrees included angle) is being investigated for walls made of screen. Pressure gradients and velocity distributions are being studied. Results indicate that the large eddy motions have a definite periodicity, not directly related to von Karman frequency. Indications are that large motions are initiated by interaction of von Karman street with a lateral periodic motion. A more detailed investigation of conditions during the breakdown into turbulence is under way.

(f) "The Uniform Distortion of a Turbulent Wake" by J. F. Keffer, Journ. of Fluid Mechanics, 22 (1965), pp. 135-139.

(5627) BUILDING AERODYNAMICS.

(b) Division of Building Research, National Research Council of Canada.

(c) Prof. H. J. Leutheusser, Univ. of Toronto, Toronto 5, Ontario.

(d) Experimental; applied research for design information.
Toronto, 5, Canada.
(d) Experimental and theoretical; basic research for doctoral thesis.
(e) Fluid separation from ceiling of closed two-dimensional conduit is studied. Motion is laminar and steady. Analysis is completed, experimental proof in progress.

(EFFECTS OF SKIN FRICTION ON PERFORMANCE OF HYDRAULIC JUMP.

(b) Laboratory project.
(c) Prof. H. J. Leutheusser, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental; basic research for master's thesis.
(e) Effects of floor roughness on the efficiency of stationary hydraulic jumps in horizontal rectangular channels is being studied.

(SMOKE DIFFUSION FROM INDUSTRIAL STACKS.

(b) Contract research.
(c) Prof. G. R. Lord, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental; applied research for design purposes.
(e) Wind-tunnel study of stack discharge as affected by a highly complex array of surrounding buildings. Model measured 25 ft. x 25 ft. and included 20 different industrial-sized stacks.
(f) Completed.

(JET SHEETS WITH LATERAL PRESSURE.

(b) Laboratory project.
(c) Prof. W. D. Baines, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental; basic research for master's thesis.
(e) Measurements are made of the shape, velocity and pressure distribution of a two-dimensional jet sheet across which a pressure difference exists. Comparisons are made with elementary theory.
(f) For low pressures the jet shape obeys the one-dimensional momentum equation and the velocity distribution is not affected. The shape is strongly affected by downstream obstacles.

(STRATIFIED FLOW THROUGH CURVED SCREENS.

(b) Laboratory project.
(c) Prof. W. D. Baines, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental and theoretical; basic research for doctoral thesis.
(e) Uniform flow with a small lateral temperature gradient passes through a screen of arbitrary shape. Downstream velocity and temperature profiles are being studied.
(f) Theory has been developed which indicates shape required to produce linear velocity distribution. Preliminary tests confirm

(REYNOLDS STRESS IN TURBULENT STRATIFIED FLOW.

(b) Laboratory project.
(c) Prof. W. D. Baines, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental; applied research for doctoral thesis.
(e) Measurements are being made of spread of temperature and velocity discontinuities in otherwise uniform flow of a temperature - stratified fluid, as well as of Reynolds stress and turbulent heat transfer.

(FLOW-INDUCED VIBRATION OF CANTILEVER BEAMS.

(b) Laboratory project.
(c) Prof. W. D. Baines, Univ. of Toronto, Toronto 5, Canada.
(d) Experimental and theoretical; applied research for doctoral thesis.
(e) Cantilevered vertical cylinders are mounted on elastic bases in an air stream. Reaction to the von Karman vortex trail produces a vibration which interacts with the trail. Fluid force produced on such an elastic body is being studied.

(PUMP AND PIPE SYSTEM TRANSIENTS.

(b) Laboratory project.
(c) Prof. L. E. Jones, Univ. of Toronto, Toronto 5, Canada.
(d) Analytical; applied research.
(e) Computer solutions of equations for various combinations of pump and pipe characteristics.
(f) Results to date indicate a significant effect caused by shape of characteristic curves.
(g) Report in preparation.

(MATHEMATICAL STUDIES IN HYDROLOGY.

(b) Laboratory project.
(c) Prof. L. E. Jones, Univ. of Toronto, Toronto 5, Canada.
(d) Analytical; applied research.
(e) Various methods of analysis are under study: deterministic and probabilistic methods, stochastic processes, synthetic flow series, regulation procedures over short and long time-periods, etc.

(LEAST-SQUARES FITTING OF RIVER RATING-CURVES.

(b) Laboratory project.
(c) Prof. L. E. Jones, Univ. of Toronto, Toronto 5, Canada.
(d) Analytical; applied research.
(e) Proper attention to statistical weighting requires involved computing techniques. Suitable simple alternatives have been developed which have a wide applicability.
(f) Report in progress.
BREMBAX (continued) rubber
scale effects, stability tests (2581) ..... 133
wave energy transmission (3616) ..... 12
wave refraction (5353) ..... 205
siltation control, Codroy Harbour, model (5030) ..... 227
stability, laboratory study (5717) ..... 46
bubbles, influence on downstream flow (5806) ..... 190
wave forces on (996) 
(see also Models) 

BRIDGE PIERS Hydrodynamic forces, model (5988) ..... 219
ice forces (5751) ..... 226
ice forces, model study (5850) ..... 219
scur (see Sour) 

BUBBLES air, to prevent shaling (5994) ..... 222
cavitation (see Cavitation) 
gas 
acoustic properties in pressure fields (5310) ..... 78
flow noise, effect (5499) ..... 71
oxygen transfer to water (5904) ..... 28
suspensions in shear flow (5195) 
(see also Cavitation, Bubbles) 

BUILDING AERODYNAMICS (5627) ..... 229

CAISSONS deflector effect on flow around (5726) ..... 225
ice forces on (5727) ..... 5724
scur, model study (5754) ..... 226

CAOLAS concrete, discharge capacity (5965) ..... 172
water movement to water table (5900) ..... 40
(see also Models) 

CASCADES, wetted and cavitation flow (3376) ..... 6 

CAVITATION abrupt pipe expansions (79) ..... 37
bubbles on rigid wall (5339) ..... 168
collapsing, light emission from (5719) ..... 59
dynamics of (1548) ..... 4
formation, nearly-surface flows (916) ..... 98
collapsing, laboratory (5335) ..... 175
concrete surface irregularities (3782) ..... 172
damage 
impact of liquid drops (5498) ..... 71
impact of liquid drops (5796) ..... 72
seals for surface protection (5498) ..... 71
theoretical study (5498) ..... 4


dredge pump model (5330) (3551) ..... 43
gas-nucleation effects (5125) ..... 168
hydraulic-structure models (993) ..... 190
inception 
TPTD headform (5792) ..... 72
prediction for hydrofoils (5855) ..... 181
roughness, various distributions (5542) ..... 90
vorticity, surface layers (5716) ..... 49
water-turbulent origin, effect (5354) ..... 161
jet propulsion of hydrofoil boat (5603) ..... 73
go on, laboratory study (5807) ..... 65
outlet, laboratory (5807) ..... 65
sluice gates, laboratory (5456) ..... 277
turbulent flow, wall pressure fluctuations (5709) 

CAVITY FLOWS effect of vortex shedding in (5324) ..... 161
(see also, Free-streamline Theory) 

CHANNELS alluvial (see Alluvial Channels) 
ephemeral, water balance (5535) ..... 143
erosion (see Erosion) 

improvement (see Models, River) laboratory (see Facilities) 
shoaling (3907) ..... 156
stabilization 
banks, suspended load reduction by (4821) ..... 116
methods, correction (4746) ..... 50
citation, jetties, spur dikes (6000) ..... 226
Washita River basin (4341) 
(see also Open-Channel Flow) 

CHECK TOWERS, Canadian River aqueduct (4792) ..... 172

CHIMNEYS optimum height for reduced washdown (5256) ..... 229
smoke diffusion, industrial stacks (6003) ..... 250

CIRCULATION, wind-driven (see Lakes) 

COAL-WATER SLURRY (4256) ..... 171

COASTAL INLETS field study 
Florida Inlets (3413) ..... 27
Lake Worth, Fla. (4174) ..... 27
Hillsboro Inlet, Fla. (4747) ..... 27
Macquarie Harbor, Tasmania (5686) ..... 28
Sebastian Inlet (4697) ..... 28
general studies (5252) ..... 201
sand by-passing methods (975) ..... 159
theoretical study (5086) ..... 28

COASTAL PROTECTION, Florida (4747) ..... 27

COASTAL SEDIMENT beach sand, radioactive tracers (3897) ..... 160
by-passing methods at Inlets (975) ..... 159
riparian protection methods (4127) ..... 57
galvanic bay tracers (3502) ..... 195
Galveston-Bay tracers (4539) ..... 84
groin effect on movement, laboratory (2195) ..... 159
coastal sand movement, search for (4785) ..... 161
sand movement by wind and waves (4530) ..... 113
suspended in surf zone, temperature effect on quantity (2660) ..... 160
wave-power sand-dredge feasibility (3836) ..... 162

COASTAL STRUCTURES wave forces on (5439) ..... 12

COMPRESSION WAVE, wave forces on (5439) ..... 12

COMPRESSIBLE FLOW compression waves in railroad tunnels (5783) ..... 52
radial, between parallel disks (5712) ..... 68

CONDUITS, exit-study portals (2543) ..... 43

CONSERVATION STRUCTURES 
leak, outlets and transitions (1723) ..... 107
COOLING SYSTEM air cycle, for supersonic aircraft (5782) ..... 52

CORE SAMPLERS (see Hydraulic Measurements) 

CORE samples protection, CaCO3 pipe coatings (4135) ..... 32
seawater, inhibition research (1554) ..... 10

CULVERTS hydraulics of pipe, box culverts (2455) ..... 166
inlets, outlets and transitions (1723) ..... 107
runoff measurement with (2865) ..... 60
steep grades, performance (5585) ..... 85

CURRENT METERS (see Hydraulic Measurements) 

CURRENTS density (see Stratified Flow) 
pump theory (5075) ..... 74
wind-driven (see Lakes) 

CUSB DEVICES, flow in (4123) ..... 20

CYLINDERS concentric, turbulent flow, inner cylinder rotating (4734) ..... 100
flow around (see Submerged Bodies) 

DAMS acoustic flowmeter, Summersville (5643) ..... 208
check dams 
puddle sheets (960) ..... 154
prefabricated concrete (3896) ..... 156
earth, flow through, laboratory (5076) ..... 14
effect on downstream temperature (5078) ..... 98
gallery drainage (777) ..... 168
in tidal estuary, design (5756) ..... 226
models (see Models, Dam) 
outlet prototype tests, Summersville (5643) ..... 208
prototype tests, Nolin Dam (5243) ..... 203
rockfill, flow through, experiments (4653) ..... 55
uplift pressure analysis (5328) ..... 14

DELTA FORMATION 

detention-structure effects (5566) ..... 121

DENSITY CURRENTS, (see Stratified Flow) 

DEPOSITION, conversion of, measurement (5384) ..... 10

DIFFUSERS, two-phase flow in (5554) ..... 52

DIFFUSION atmospheric; geometric, aerodynamic, 
thermal factors (3298) ..... 76
entrapped gas in porous media (5891) ..... 23
seawage, ocean outfalls (5618) ..... 11
smoke, from industrial stacks (6003) ..... 230
downstream of hill (5899) ..... 19
molecular-diffusion effect in boundary 
flow layer (5428) ..... 91
over simulated vegetation (5399) ..... 19

DIES, 
river, design research (5042) ..... 217
spillways, design criteria, bridge abutment (3086) ..... 44
effect of geometry on scour (4645) ..... 45

232
HYDRAULIC MEASUREMENTS (continued)

probes

Hydrologic balance

unsteady-forces measuring device (5853) 181
radioactive-particle movement techniques (5842) 171
reversal of stream direction (5944) 187
souc-depth floats recovery (5430) 24
reliability (5488) 69

sediment

concentration, size distribution by ultrasonics (5328) 86
concentration, size distribution by ultrasonics (5754) 91
density, gamma probes (4322) 126
density, nuclear device (4321) 125
loads, measurement methods (134) 73
loads, nuclear density probe (194) 73
neophelometry (5608) 169
oceanographic flow (4072) 165
radiometric dating (5210) 129
suspended, sampler development (194) 73
suspended, surf-zone sampler (2660) 160
suspended, turbidimeters (194) 73
ship wave resistance from wave pattern (5205) 98
slurry flow with elbow meter (5172) 45
soil-water apparatus, low flow rates (5220) 141
solid-liquid ratio (5054) 26
static-pressure hole errors (5502) 71
static-pressure hole errors (5680) 221
stream gauge, controls, instruments, alluvial
channels (5077) 168
Doppler meter (5680) 168
hydraulic methods (5077) 160
electric vehicle for large rivers (5843) 171
moving-boat technique (5600) 168
weirs (5684) 95
stream level, measurement of (5052) 74
tension in liquids (5106) 64
tides, instruments for deep-sea (5927) 74
total-head probe calibration, suspension flow (5162) 46
tracer methods

fluorescent tracers for discharge (5219) 141
radioactive tracers, beaches (5887) 160
radioactive in ground water (4928) 108
sediment drift (4127) 27
soils (5078) 41
soils (5205) 148
soils (5225) 99
tritium, other radioisotopes (4324) 126
turbine discharge, current meters (4441) 186
true ultrasonic calibration (5278) 105
for liquid hydrocarbons (6012) 165
turbulent flow meter (4068) 184
turbulence

data analysis system (4608) 17
electrokinetic transducer (5598) 19
electrokinetic transducer (2720) 15
electromagnetic pressure transducers (5112) 105
electromagnetic probe (5359) 99
electromagnetic probe (5501) 71
equipment comparison, liquid (5142) 108
hot film equipment (5112) 105
hot-wire, aging effects (73) 37
hot wire technique (5106) 105
hydrodynamic size effect (5128) 81
microphone size effect (1778) 177
optical method (5504) 31
probe calorimeter (5131) 118
spherical-head meter (1004) 191
unsteady flow, aperiodic-signal analyzers (2541) 38
velocity

Doppler-effect meter (5075) 167
Doppler-effect meter (5608) 168
hot-sphere probe (5852) 106
remote indication, ultrasonic (192) 191
semi-conductor strain gages, suspension wires (5164) 18
suspension wire (5027) 115
viscometer, ultra-low shear rates (4868) 184
waves

acoustemeter recorders (5767) 228
complex-wave analyzers (4135) 174
direction, Rayleigh Disc (5858) 162

HYDRAULIC MEASUREMENTS (continued)

wave direction, ultrasonic flowmeter (977) 159
directional-sensor measurement (5850) 181
height and direction gage (577) 159
hydromechanics of pier (1947) 219
Northumberland Strait, Canada (5987) 219
weirs

adjustable, laboratory study (3611) 172
approach-velocity effect (31) 56
broadestream, accuracy of (2902) 15
circumferential (5492) 24
irrotational flow (4086) 9
side, flow division by (5740) 95
stream gaging (5848) 95
HYDRAULIC MODELS (see Models)

HYDRODYNAMIC RADIUS (5089) 228
HYDRAULIC SERVOMECHANISMS

adaptive electro-hydraulic system (5356) 42
for missile control (4676) 64
hydrodynamic line dynamics (1670) 7
side, flow width modulation (4499) 66
switching techniques (2353) 41
HYDRAULIC STRUCTURES

free-streamline theory for (5452) 90
riprap protection (1987) 192
soil and water conservation works (4335) 130

HYDRODYNAMICS

forces on wetted and cavitated objects (5772) 7
torpedo drag, base vented models (5391) 184
water entry apparatus (5887) 183
water entry-exit, spheres (5055) 6
water exit, spheres (4002) 183

HYDRO_DYNAMIC NOISE

boundary-layer suction plates (4684) 80
fluid amplifier jets (5921) 31
fluid amplifiers (5653) 31
gas bubble in pressure field (5010) 78
heart values (5473) 55
micro-bubble influence (5499) 71
non-Newtonian fluids (5497) 71
turbulent boundary layer
pressure fluctuation (1778) 177
wall effect on sound radiation (5100) 4

HYDRO_DYNAMIC SENSITIVITY (see Stability)

HYDRO_DYNAMIC STABILITY

flat plate in turbulent flow (5189) 81
hydrofoil craft (5663) 75
relate to wake and separated boundary layers (5111) 105
supercavitating hydrofoils (5265) 76
(see also Flutter)

HYDRO_DYNAMIC PLANES (see Hydropower)

HYDRO_DYNAMIC RESOURCES, Idaho streams (5167) 30

HYDRODYNAMIC CRAFT

hydroelasticity (5663) 75
jet propulsion, jet models (5183) 77
rough water take-off resistance (5928) 78
smooth water performance, surface-percding foils (4227) 77

HYDRO dynamic

cavitation inception prediction (5855) 181
drag, induced, electric analog (5887) 182
flow separation, hydrodynamic observations (5128) 180
Flutter

planform-variation effect (5062) 77
theory and experiments (5284) (5285) 178
theory of (5175) 24
jet-flap theory (5108) 86
Kutta condition (5107) 64
lift of drag, Buships foil (5088) 182
oscillating forces, free surface effects (5775) 25
loads on (5284) 178
oscillating flap, forces, moments (5184) 25
pressure distribution around (5855) 181
ring, supercavitating and ventilated (5771) 7
sinusoidal waves, forces (5776) 25
supercavitating flap design considerations (5153) 70
flat plate, oscillating flap (5153) 70
Flutter (5500) 71
forces, gravity effects (4219) 76
forces and moments on (5363) 25
hydroelasticity (5265) 75
ring hydrofoils (5773) 179
steady-state forces on (4181) 179
LITTORAL DRIFT (continued)

laboratory study (4866) ........................................ 28
Lake Ontario, harbors (5364) ................................ 228
(see also, Coastal Sediment; Coastal Inlets)

LOADS
lifting surface (see Hydrofoils) ................................ 6
sediment (see Sediment) ........................................ 8

LOCKS
hunger force, Jackon Lock (5249) ............................ 204
(see Models) ........................................................

LONGSHORE CURRENTS
Lake Ontario harbors (5364) ................................ 228
longitudinal currents (5364) ................................. 161
Nags Head, N. C. (5225) ..................................... 46
(see also Littoral Drift) ...........................................

MACHINERY, spacing-effect experiments (5786) .... 62
MANIFOLDS, variable-diameter pipes (5040) ........ 76
MANOMETERS (see Hydraulic Measurements) ........... 26
MEANDERING (see Alluvial Channels; Open-Channel Flow)
MEASUREMENTS (see Hydraulic Measurements) .......
MENISCUS, energy loss, hydrodynamic surface (4430) 166
METERS, all types (see Hydraulic Meas.) ..............

MEASURES
hydraulics of solution cavities (5867) ............... 22
telescoping tubes, solution mining (5886) .......... 22

MIXING CHAMBERS
waters of different qualities (5865) ...................... 9

MODEL LAWS
air demand, closed conduit flow (5339) ............ 175
distortion effects (594) .................................... 190
flow into sub-sid water project (5732) ............... 23
ground water movement (4560) ......................... 19
harbor, wave models (1002) .............................. 191
movable-bed models (5555) ............................... 282
movable-bed models (5654) ............................... 282
porous media flow (5411) (5877) ....................... 21
rainfall simulation (5123) ................................... 143
rock protective structures (5806) ....................... 40
sedimentation basin (5541) ....................

ship, (see Ship) ................................................
silt-clay-water mixture flow (3441) .............. 44
solar pond (5544) ........................................... 51
surface run-off (5177) ...................................... 43
watersheds (5225) ......................................

MODELS
aqueducts, California studies (5866) ............... 9
beach profiles, scale effects (181) ................. 158
blood flow system for brain (4143) ............... 36
breakwater
Odney Harbour, Newfoundland (5909) .......... 227
Dana Point Harbor (5634) ............................. 205
rubble, scale effects (2681) .......................... 153
Santa Barbara Harbor (5614) .......................... 210
stability, Chandler Harbor (5177) ................. 227
stability, Kilo Harbor (5040) ......................... 217
stability, Noyo Harbor (5016) ......................... 211
bridge piers, ice-floe pressure, Northumberland- Strait, Can. (5602) .................................................. 219
bridge piers and tunnel sections, Northumberland Strait, Can. (5988) .................. 219
bridge scour, Big Sioux River (5423) ........ 70
caissons
deflector effects on flow (5726) ....................... 225
scour around (5754) .................................. 226

EASEWAYS
tidal action, Northumberland Strait, Can. (5613) .... 219
wave protection, Northumberland Strait, Can. (5618) .... 219

canals
Beck-Niagara (5691) (5692) ................................ 224
outlet works, Navajo Project (4950) ........ 173
tailrace, Cutaries 4 Project (5732) ................. 226
channel- diversion intake, Portage Diversion, Manitoba (5988) .................. 226
channel improvement, Soldier Creek, Ill. (5549) 32
coastal inlets
Fire Island inlet (6028) ................................ 214
Sebastian Inlet, Fla. (4897) ............................. 28

conservation, drainage structures (2789) .... 32
dams
Arrow Lakes (4455) ........................................ 223
Cabin Creek Pumped Storage (5269) ............ 102
De Valle, W. (5668) ......................................... 115
Kaysinger Bluff Dam (6552) ......................... 218

-/-

LABORATORIES (see Facilities; Instruction)
LADDERS, fish (see Fish) ..........
### MODELS (continued)

<table>
<thead>
<tr>
<th>Models</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hele-Shaw</td>
<td>Gates drop</td>
</tr>
<tr>
<td>Little Goose (4504)</td>
<td>north of Galveston, Texas</td>
</tr>
<tr>
<td>log-passing devices (5946)</td>
<td>-</td>
</tr>
<tr>
<td>Lower Granite Dam (5805)</td>
<td>Arkansas R. No. 3 (4391)</td>
</tr>
<tr>
<td>Mududa Bar (4735)</td>
<td>Arkansas R. No. 4 (5630)</td>
</tr>
<tr>
<td>navigation, Arkansas R. (4566)</td>
<td>Arkansas R. No. 8 (5022)</td>
</tr>
<tr>
<td>New Jersey No. 3 (5559)</td>
<td>Arkansas R. No. 9 (5658)</td>
</tr>
<tr>
<td>Nikjacket Project (8568)</td>
<td>Arrow Lakes dam (4574)</td>
</tr>
<tr>
<td>overturn weirs, Yellowtail Afterbay</td>
<td>Berkley Dam (2673)</td>
</tr>
<tr>
<td>Powerdale (5745)</td>
<td>Belleville Lock and Dam (4385)</td>
</tr>
<tr>
<td>rock fill at The Dalles (1464)</td>
<td>Burleigh Falls (5718)</td>
</tr>
<tr>
<td>sluiceway along Yellowtail Afterbay</td>
<td>Cannellon Locks and Dam (4465)</td>
</tr>
<tr>
<td>Sullivan Creek (574)</td>
<td>Columbus Lock, Ouchita R. (4595)</td>
</tr>
<tr>
<td>The Dalles (1462)</td>
<td>Cordell Hull Lock (5560)</td>
</tr>
<tr>
<td>West Point Dam (6050)</td>
<td>culvert discharge basins (5023)</td>
</tr>
<tr>
<td>diversion tunnel closure</td>
<td>empyting, filling systems (6084)</td>
</tr>
<tr>
<td>Dworshak Dam (5070)</td>
<td>Greenup Locks and Dam (5242)</td>
</tr>
<tr>
<td>evaporation studies (5550)</td>
<td>Hannibal Locks and Dam (3909)</td>
</tr>
<tr>
<td>performance studies (5174)</td>
<td>Holt Lock and Dam (4386)</td>
</tr>
<tr>
<td>drop structure</td>
<td>Intake, Lock 6 West, Weiland Canal (5911)</td>
</tr>
<tr>
<td>Cuyaga Inlet (5199)</td>
<td>Jones Bluff Lock and Dam (6024)</td>
</tr>
<tr>
<td>Fremont, Sandusky R. (5641)</td>
<td>Jonesville Lock and Dam (5247)</td>
</tr>
<tr>
<td>Gering Valley Project (5915)</td>
<td>Kerr Lock and Dam (5551)</td>
</tr>
<tr>
<td>Little Sioux R. (5699)</td>
<td>Little Goose Dam (5069)</td>
</tr>
<tr>
<td>Walnut Creek (6031)</td>
<td>low lift, Arkansas R. (4603)</td>
</tr>
<tr>
<td>electronic analog</td>
<td>Malpoline Locks and Dam (2674)</td>
</tr>
<tr>
<td>for ground water flow (2948)</td>
<td>Malpoline modernization (5914)</td>
</tr>
<tr>
<td>for river basin analysis (5140)</td>
<td>Millers Ferry Lock and Dam (4533)</td>
</tr>
<tr>
<td>for river basin analysis (5747)</td>
<td>Monongahela No. 4 (3943)</td>
</tr>
<tr>
<td>energy dissipator, baffled pipe outlet</td>
<td>Nickjack Project (5368)</td>
</tr>
<tr>
<td>fishladders</td>
<td>Nickjack Project-official (5368)</td>
</tr>
<tr>
<td>Hog Island (5524)</td>
<td>Outlet, Lock 7 West, Welland Canal (5920)</td>
</tr>
<tr>
<td>The Dalles (1728)</td>
<td>Ozark Lock and Dam (5231)</td>
</tr>
<tr>
<td>gates</td>
<td>The Dalles (1468)</td>
</tr>
<tr>
<td>Holoyke Power Development (5276)</td>
<td>Unoutlook Lock (5243)</td>
</tr>
<tr>
<td>Little Goose turbines intakes (5943)</td>
<td>Verdigris R. No. 4 (6100)</td>
</tr>
<tr>
<td>grit-removal channel (5805)</td>
<td>Webb's Falls Lock and Dam (5652)</td>
</tr>
<tr>
<td>harbors</td>
<td>manifolds, Manicouagan 5 (5780)</td>
</tr>
<tr>
<td>Brunswick, Ga., shoaling (5648)</td>
<td>mathematical</td>
</tr>
<tr>
<td>Burns Watersways, Ind. (4899)</td>
<td>flood routing (4565)</td>
</tr>
<tr>
<td>Charleston, S.C., pollution (5640)</td>
<td>hydrologic (see Hydrology)</td>
</tr>
<tr>
<td>Codroy, Newfoundland (5090)</td>
<td>tides, St. Lawrence estuary (5948)</td>
</tr>
<tr>
<td>Croquet City (6041)</td>
<td>orifices (5729)</td>
</tr>
<tr>
<td>Dana Point, Cal., small-boat (5642)</td>
<td>outlet works</td>
</tr>
<tr>
<td>Galveston Bay (5912)</td>
<td>Branched Oak Dam (6024)</td>
</tr>
<tr>
<td>Hilo Bay, Hawaii (5694)</td>
<td>Cochiti Dam (5645)</td>
</tr>
<tr>
<td>Hilo Bay beach erosion (5985)</td>
<td>DeGray Dam (4604)</td>
</tr>
<tr>
<td>Hilo Bay tsunami (3903)</td>
<td>Dworshak Dam, Idaho (5315)</td>
</tr>
<tr>
<td>Hilo tsunami barrier (6039)</td>
<td>Eau Galle project (6017)</td>
</tr>
<tr>
<td>Kewalo Basin (629)</td>
<td>Intake, Little Pankoche Creek (5347)</td>
</tr>
<tr>
<td>Monerey, Cal. (612)</td>
<td>Morrow Point dam (4807)</td>
</tr>
<tr>
<td>New Buffalo (6037)</td>
<td>Orovilie Dam (4498)</td>
</tr>
<tr>
<td>Noyo Harbor (6015)</td>
<td>Heritage Mountain Res. (551)</td>
</tr>
<tr>
<td>Ploms, Cal.</td>
<td>powerhouse, John Day Dam (5318)</td>
</tr>
<tr>
<td>Santa Barbara (6011)</td>
<td>pumped storage plants</td>
</tr>
<tr>
<td>Savannah, Ga. (2428)</td>
<td>Cabin Creek (5260)</td>
</tr>
<tr>
<td>heavy-water dump area (5720)</td>
<td>Intake, Cornwall development (4741)</td>
</tr>
<tr>
<td>Heli-seal</td>
<td>Intake, Muddy Run development (5021)</td>
</tr>
<tr>
<td>for record hydrographs (5303)</td>
<td>manifold, penstock, Cornwall development (5024)</td>
</tr>
<tr>
<td>for drainage studies (1819)</td>
<td>pumping plants</td>
</tr>
<tr>
<td>hopper dredges (5568)</td>
<td>canal surges, San Luis Forebay (4955)</td>
</tr>
<tr>
<td>hurricane barrier, Narraganset Bay (5980)</td>
<td>intake transition, San Luis Forebay (4954)</td>
</tr>
<tr>
<td>hurricane surge, Texas coast (6025)</td>
<td>Inlets, Utah-Black Station, India (5360)</td>
</tr>
<tr>
<td>hydroelectric projects</td>
<td>river</td>
</tr>
<tr>
<td>Barrett Chute generating sta. (5695)</td>
<td>Arkansas R., Ft. Smith reach (6019)</td>
</tr>
<tr>
<td>Beek-Niagara generating sta. (5516)</td>
<td>Arkansas R., Little Rock reach (5644)</td>
</tr>
<tr>
<td>Chong Yang, Korea (4740)</td>
<td>Arkansas, navigation (5506)</td>
</tr>
<tr>
<td>Ciceroz plant, Turkey (5273)</td>
<td>Besse Cutoff, Mississipp R. (5235)</td>
</tr>
<tr>
<td>Guna project, (4601)</td>
<td>Columbia, Oak Pt. to Vancouver (5317)</td>
</tr>
<tr>
<td>Hells Canyon (5521)</td>
<td>Columbia R. estuary (4535)</td>
</tr>
<tr>
<td>intakes (5694)</td>
<td>Delaware, Bay to Trenton (465)</td>
</tr>
<tr>
<td>intakes, Manicouagan 5 (5513)</td>
<td>Hudson, shoaling at N.Y.C. (2932)</td>
</tr>
<tr>
<td>Kawunakai Plant, (5696)</td>
<td>Illinois R. flood control (5549)</td>
</tr>
<tr>
<td>Keian Plant, Turkey (5274)</td>
<td>James River estuary</td>
</tr>
<tr>
<td>Lambton generating station (5517)</td>
<td>Little Current Narrows (5425)</td>
</tr>
<tr>
<td>Mountain Chute generating sta. (5693)</td>
<td>Mississippi Basin (256)</td>
</tr>
<tr>
<td>Pickering Generating Station (5668)</td>
<td>Niagara River (4026)</td>
</tr>
<tr>
<td>surge tanks, Manicouagan 5 (5497)</td>
<td>St. Clair submersible turbine (5653)</td>
</tr>
<tr>
<td>Wells Hydrocombine (4724)</td>
<td>St. Croix thermal density currents (5494)</td>
</tr>
<tr>
<td>intake gates, and Intake, (5696)</td>
<td>St. Lawrence, Montreal area (4517)</td>
</tr>
<tr>
<td>intake structures, pressure relief</td>
<td>Soldier Creek, channel improvement (5548)</td>
</tr>
<tr>
<td>Orroville Dam (5357)</td>
<td>Southwest Pass, Arkansas R. (5897)</td>
</tr>
<tr>
<td>intake towers</td>
<td>Turtle Creek channel improvement (4363)</td>
</tr>
<tr>
<td>DeGray Dam (4604)</td>
<td>Umpqua River estuary (6026)</td>
</tr>
<tr>
<td>Orroville Dam powerplant (4947)</td>
<td>salary intrusion,</td>
</tr>
<tr>
<td></td>
<td>seawalls, Texas City (5334)</td>
</tr>
</tbody>
</table>

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**Notes:**
- The document lists various water-related projects and studies with brief descriptions of their functions and locations.
- The projects include locks, dams, intakes, and other water management structures.
- The locations range from Arkansas to Texas, and projects like the Arkansas R., Ft. Smith reach, and Mississippi Basin are highlighted.
- The document contains a variety of hydrologic and water management topics, including reservoirs, water supply, and flood control.

---

**Mathematical Models:**
- Flood routing (4565)
- Hydrologic (see Hydrology)
- Orifices (5729)
- Outlet works
- Reservoirs
- Pumped storage plants
- Intakes, Penstock, Cornwall development
- Pumping plants
- Canal surges, San Luis Forebay
- Intake transition, San Luis Forebay
- Inlets, Utah-Black Station, India
- River systems: Arkansas, Mississippi
- Study areas: St. Lawrence, Montour area, St. Croix
- Other topics: Salinity intrusion, seawalls, Texas City.

---

**Resource Links:**
- [ Arkansas R. ]
- [ Mississippi Basin ]
- [ Little Current Narrows ]
- [ Umpqua River estuary ]
- [ San Luis Forebay ]
- [ Texas City ]

---

**Additional Information:**
- The document appears to be a compilation of information from various sources, likely intended for use in water management and engineering fields.
- The table format helps organize the data for easy reference and understanding.

---

**Conclusion:**
- The document provides a comprehensive overview of water-related projects and studies, highlighting their importance in various geographical locations.
- The detailed information can aid in understanding the complexities of water management and the challenges faced in different regions.

---

**Code Example:**
```
# Example code for data processing
for row in data:
    model = row[0]
    description = row[1]
    print(f"Model: {model}, Description: {description}")
```
NON-NEWTONIAN FLOWS
boundary layer (5787)..........................72
flow noise (5477)..........................71
slurry flows in pipes (3747)..................44
Taylors vortexes (5432)......................43
Taylors vortexes in (5496)...................71
turbulence in (5496)..........................71
turbulence in (5594)..........................71
velocity distribution (5594)...................85
visc-elastic, turbulent heat transfer (5980) 86
(see also Drag Reduction)
NOZZLES (see Hydraulic Measurements)
NUELEUS, gas, (see Cavitation)

OCEANOGRAPHY, air-sea interaction studies (5120)....57
OIL ROCKS, floating, mooring-problems (5802)........73
OPEN-CHANNEL FLOW
air entrainment, steep channels (5824)............70
backwater curve effects of approximations (4661).....55
bends
current geometry for (5522)........................96
turbulence and mean flow (4148)....................59
channel hydraulics relative to channel stability (4516) 124
check-structure efficiency (5866)....................9
critical slope, trapezoidal channels (5624)...........229
dispersion in (5773)................................5
division by side weirs (5740).......................55
division at junctions (5701)........................227
division at junctions (5701)........................23
end-depth relation to shape (5306)...................24
induction of air currents (5628)......................229
lunate waves, computation methods (4667)............57
meandering
Proud number, shape effects (4148)....................59
secondary currents (5408)..........................19
(see also Alluvial Channels)
resistance
alluvial stream roughness (2950)...................167
cobble-stream bed (5181)..........................92
crooked-channel discontinuities (5695)..............172
degraded channels (5436)..........................12
friction of deposited mud (5675).....................11
hydraulic roughness (5628)..........................328
relations between flow structure and bed character (5610) 169
ripples and dune roughness (5118)....................49
ripples and dune roughness (5118)....................49
roughness elements (5226)..........................36
schematic dune roughness (5753).....................91
semi-circular disk roughness (5753).................45
small rough channels (5426)........................117
temperature effect on bed form (1988)...............192
vegetation-lined channels (4537)....................150
wavy waves (see also Alluvial Channels)
rough-channel turbulence (5131).....................87
secondary-current measurements (4531)..............25
shear stress distribution
meandering plant (5131)............................104
microphotography (5660)............................55
river flow studies (4283)..........................115
sewers, drains (4541)..............................34
stable alluvial channels (5669).......................22
slug flow, steep channels (5360).....................5
slug flow, steep channels (5978).....................35
spatially varying steep mountain-steep channels (4285) 114
steep, rough flumes (3183)..........................86
supercritical transitions (5805)........................
transformations (5182).............................62
transitions (2586).................................70
systems analysis (5861).............................9
transitions, computer methods (5114).................8
transformations
efficiency, trapezoidal channel (5669)..............9
experiments for design (5948)........................
free pressure flow (5003)...........................229
(see also Open-Channel Flow, Supercritical)
unsteady
arbitrary cross-section, numerical (5144).............8
computer analysis (5874)...........................26
computer simulations in rectangular non-prismatic channels (5114) 49
concrete channels (5918)............................61
grass-lined V-channels (4536).......................131

MOUNTAIN-STREAM HYDRAULICS (4285)..............114
MULT-COMPONENT FLOW
coal-water (4436)................................171
pulpwood-water (5725).............................225
suspended solids in pipes (4057).....................228
(see also Two-Phase Flow)

MOUNTAIN-STREAM HYDRAULICS (4285)..............114
MULT-COMPONENT FLOW
coal-water (4436)................................171
pulpwood-water (5725).............................225
suspended solids in pipes (4057).....................228
(see also Two-Phase Flow)
SAND (continued)

fences (4482) ........................................ 28
fences (4760) ........................................ 28
fences (4895) ........................................ 28
fences (5294) ........................................ 28

transport

coastal, by waves and wind (4950) .............. 11
wind (4482) ........................................ 28
wind (4895) ........................................ 28

SCHWARTZ-CHRISTOFFEL TRANSPORTATION (5785) ........ 62

SCOUR

bridge pier

Big Sioux R. crossing model (5495) .............. 70
experiments (4626) .................................. 41
experiments (5665) .................................. 220
experiments, theory (4617) ....................... 18
cantilevered pipe outlets (1168) ................. 69
drop spillways, model study (2789) ............... 32
effect of spur dike geometry (4645) .............. 45
estuaries, bays, by tidal currents (4701) .......... 75
floats for measuring depth (5488) .............. 69
floats for measuring depth (5490) .............. 24

doch mechanical (4617) ............................ 18
doch-boundary flow at obstructions (4993) ....... 84
model laws, movable bed models (5285) ........ 226
relation to channel structures (5870) .......... 124
resistance of cohesive sediments (2878) ....... 162
scrapers operation (5263) .......................... 28
stones in open-channel flow (5705) ............... 23

SCRAFER (see Sand)

SEA IN INTERACTION (3120) .......................... 57

SEALS, (see Reservoirs; Gates)

SEAWALLS, overtopping by wind waves (5435) ..... 12
SECONDARY CURRENTS

air flows (5267) ..................................... 228
axial flow inducers (5592) .......................... 64
corners, open-channel flow (4531) ............... 25

SEDIMENT

concentration measurement, Gamma-Ray (5669) .... 220
core works, Washita R. basin (4341) ............. 131
origin, routing, in gully erosion (4320) ........... 125
radiocarbon dating (5310) .......................... 129
relation of stratigraphy to semi-arid watersheds (5589) ........ 143
reservoirs, (see Reservoirs) ........................ 74
sources and delivery, alluvial watersheds (5584) .......... 142
transport (see Sediment Transport)

SEDIMENT TRANSPORT

alluvial channels

evaluation of dependent and independent variables (5607) . 169
evaluation of formulas for (3671) .................. 4
laboratory research (5078) .......................... 169
laboratory, field research (2950) ................. 167

(see also Alluvial Channels)
bien forms

dune effect on resistance (4075) ................... 4
dune formation at low transport (4075) .......... 4
dune forms (5575) .................................... 129
dune forms (5576) .................................... 129
ripple and dune movement related to bed-load transport (5165) ........ 18
ripples, draws, basic mechanics (5118) ........... 49
ripples, effective roughness of (5905) ............ 40
ripples, wind-wave effect on (5866) ............... 22
statistical analysis (5612) .......................... 170

bed load

bed form, total load, laboratory study (3671) ...... 124
movable-bed models (5684) ........................ 28
New York mountains stream (4622) ............... 117
by waves and currents (5922) ........................ 74
clay deposition, L. Maracaibo Channel (5119) .... 49
climatic and watershed factors (4365) .............. 140
climate-conduit research facility (5304) ........... 26
climatic-tractive force, uniform sand (4625) .... 1
deposition prevention, air bubblers (5949) ........ 222
effect of simulated rainfall (4576) .................. 81
estuaries, summary knowledge (5676) ............. 12
fall velocity, irregular gravel (5165) ............... 18
forces on particle on model bed (5574) .......... 129
friction of clay deposits (3675) ........................ 11
Ganges-Meghna-Frinity Bay (4546) ............... 81
gully-control structure effects (4291) ............... 99
littoral drift, (see Coastal Sediment) ............... 81
particle step-length, rest periods (5609) ........... 169
SPECIFIC YIELD, laboratory and field research (526).................................................. 167
SPECTRAL ANALYSIS, agriculture (5877).................................................. 153
SPHERES, (see Submerged Bodies)
SPILLWAYS
closed conduit
(drop inlet investigation (111).................................................. 69
full-scale studies (4335).................................................. 130
discharge
effect of crest shape (5929).................................................. 54
irrotational pipe configurations (1428).................................................. 228
drop inlet, hydraulic design (1865).................................................. 54
irrotational flow through bucket (5860).................................................. 54
models (see also Roelofs).................................................. 205
prototype tests, Ft. Randall Dam (5250).................................................. 206
sour
silted-up pipe outlets (1168).................................................. 69
still water, vertical internal (4169).................................................. 54
STABILITY
branched pipe flow (4565).................................................. 37
laminar pipe flow (5870).................................................. 56
Taylor vortices, non-Newtonian fluid (5710).................................................. 45
turbulent theory, asymptotic expansions in (5779).................................................. 37
(see also Waves, Roll)
STEAL acoustic velocities in (5826).................................................. 183
STILLING BASINS
culvert outlets (5467).................................................. 88
dissipating, open-channel (4531).................................................. 137
drop inlets (2059).................................................. 178
vertical jet impingement on (3775).................................................. 175
vertical stilling well (4794).................................................. 175
(see also Energy Dissipators)
STRAIGHTFLOWS
estuaries (1986).................................................. 191
interfacial disturbances in zone of flow (4146).................................................. 39
internal waves
generation by moving spheres (4400).................................................. 166
generation by source-sink impulse (5013).................................................. 166
theory (4539).................................................. 89
(see also Waves, Internal)
detachment of waves (4560).................................................. 83
dipole disturbance (5343).................................................. 176
porous media; stability, dispersion (5013).................................................. 5
reservoirs
measurements, Pontas (5944).................................................. 187
mixing, effect on (5088).................................................. 176
release and outlet design (5543).................................................. 176
withdrawal studies (4651).................................................. 4
Reynolds stresses (6066).................................................. 250
salinity intrusion (Estuaries).................................................. 11
thermal density currents
cooling-water intakes (5723).................................................. 225
St. Croix River model (5454).................................................. 71
steam plant, calculation model (5365).................................................. 185
turbulence, through curved screens (6005).................................................. 230
turbulence currents, underflow (5561).................................................. 5
turbulence effects (5008).................................................. 40
turbulent mixing due to wakes (4160).................................................. 47
viscous non-diffusive flows (5826).................................................. 91
wake formation in (5560).................................................. 229
STEAM (see Hydraulic Eng.)
STREAM GEOMORPHOLOGY (see Hyd. Structures)
STRUCTURES, HYDRAULIC (see Hyd. Structures)
SUBMARINES
effect of flow separation on stability (5199).................................................. 93
SUBMERGED BODIES
bodies of revolution
coefficients, Douglas programs (5385).................................................. 185
near surface effects (2229).................................................. 177
model
velocity gradients
free surface effect on drag (5798).................................................. 91
free surface effect on turbulence (5757).................................................. 91
cylinder in velocity gradient, drag (4710).................................................. 83
drag, flows between curved and boundary-layer flow (5778).................................................. 37
fall velocities
sphere, horizontally oscillating fluid (5184).................................................. 65
SUBMERGED BODIES (continued)
forces, water tunnel study (2852).................................................. 65
hemisphere on
free surface effect on drag (5134) (5137), 88
free surface effect on flow (5755).................................................. 91
free surface effect on lift (5135).................................................. 88
seepage effect on forces (5765).................................................. 92
ITTC headform, cavitation inception (5792).................................................. 72
pressure distribution around nose (1776).................................................. 177
non-circular cylinder, drag, free surface effects (5761).................................................. 92
drag, various configurations (5760).................................................. 92
semi-submerged, heave and pitch (4570).................................................. 13
slender bodies, separated flow (5264).................................................. 56
sphere drag, non-Newtonian fluid (5582).................................................. 185
spheroids in potential flow (2091).................................................. 65
stability coefficients (2092).................................................. 65
unsteady flow
accelerated cylinders (2265).................................................. 11
bluff bodies, 2-dimensional (3778).................................................. 55
effects
ellipsoids (4180).................................................. 65
flat plate, impulse rotation (5671).................................................. 56
spheres, added mass (2799).................................................. 58
vehicles in tunnels, drag (5781).................................................. 62
vertical cylinders, vortex shedding in waves (3758).................................................. 47
vibrations of transmission lines (5743).................................................. 96
waves, in stratified fluids (5650).................................................. 292
waves, in stratified fluids (4160).................................................. 47
waves (see also Waves).................................................. 56
wall effect on forces (4161).................................................. 63
water generation by cylinder (4649).................................................. 166
wedges, supercavitating, in boundary layer (5506).................................................. 72
SUCTION (see Boundary Layer)
SURFACE CURRENTS
flow, through disks and wings (5772).................................................. 7
two-dimensional wedges (4677).................................................. 64
wedges in boundary layer (5506).................................................. 72
(See also Hydrotol; Propellers)
SURFACE RUNOFF, (see Runoff)
SURGE
dry bed (5143).................................................. 8
generation of, laboratory (5559).................................................. 227
harbor (see Harbors)
surge tanks (see Models).................................................. (see also Hydropower)
SUSPENSION FLOWS
clear-zone investigation (5555).................................................. 94
collidal
electrokinetic separation (5572).................................................. 60
porous media (5253).................................................. 59
fluid-sediment mixtures (4380).................................................. 229
irrotational flow, acceleration (5560).................................................. 85
pipes, variation of Karman K (5041).................................................. 26
settling velocities of solids (5302).................................................. 26
turbulent transport mechanics (4649).................................................. 56
viscosity theory (5560).................................................. 56
(see also Slurries)
SUSPENSION WIRE (see Hyd. Meas.)
SYNTHETIC HYDROLOGY (see Hydrologic Analysis)
T-
TAYLOR VORTICES, (see Vortices)
TENNESSEE VALLEY, precipitation (768) (779).................................................. 180
TENSION, in liquids, measurements (5106).................................................. 64
TERRACES
effect on moisture distribution (5976).................................................. 113
effect on runoff (5974).................................................. 112
TIDAL HYDRAULICS
Sacramento-San Joaquin Delta, analog methods (4953).................................................. 11
(see also Estuaries)
TIDES, (see Waves)
TORPEDOES, (see Hydroballistics; Submerged Bodies)
TOWERS, INTAKE (see Models)
TRACTION FORCE
critical (see Sediment Transport) distribution (see Open-Channel Flow)
TRANSIENTS, POWER PLANT
Garrison, Cabe Dams (3900).................................................. 196
(see also Hydropower)
TRANSITION
laminar-turbulent, porous media flow (5900).................................................. 30
turbulent to laminar, cooling liquid flow (6794) 92
(see also Boundary Layer; Pipe Flow; Stability)
VELOCITY, measurement (see Hydraulic Meas.)

VORTEX CHANGERS, Flow in (5674) ...

WASHES

biouf-type bodies of revolution

WATER

availability to plants, dynamics of (5226) ...

diffusion (5968) ... 142
ephemeral stream channel (5568) ...

ground water factor in semi-arid watersheds (5226) ...

-1-

underwater ordnance (see Hydroballistics)

underwater sound (see Hydrodynamic Noise)

unit source area (4856) ...

distribution, systems analysis (4558) ...

entry-exit (see Hydroballistics) farm

hydraulic studies in southern Piedmont

region systems (4351) ...

terrace systems (4351) ...

surface water storage and supply (9) ...

coastal-plains farms (4841) ...

wells and irrigation pits on coastal-plains farms (4842) ...

ground (see Ground water) quality

Alaska streams, logging effect (5355) ...

high changes, in ground water reservoir (5968) ...

land use effects in forested mountains (5413) ...

pesticide residue effect (5611) ...

watershed environmental and microbial dynamics (5407) ...

requirements

citrus in Rio Grande valley (5568) ...

irrigated areas of Southwest (5177) ...

lawns grasses (5585) ...

marshlands (5350) ...

WELL PLANS, state of Utah (5150) ...

resources (see water-resource rights, legal and hydrologic study (5703) ...

storage

management research (5879) ...

management research (5881) ...

saline aquifers (5711) ...

surface water investigations in Iowa (67) ...

-1-

WASHES

bodies of revolution

turbulence characteristics (4974) ...

turbulent, asymmetry effect (5311) ...

with momentum addition (4092) ...

drag by momentum method, effect of turbulent normal stresses (4589) ...

initial, in stratified fluids (5630) ...

ship, simulation of (4810) ...

turbulent

behind flat plate (2802) ...

drag by momentum method, effect of turbulent normal stresses (4589) ...

WATER

availability to plants, dynamics of (5226) ...

diffusion (5968) ... 142
ephemeral stream channel (5568) ...

ground water factor in semi-arid watersheds (5226) ...

-1-

underwater ordnance (see Hydroballistics)

underwater sound (see Hydrodynamic Noise)

unit source area (4856) ...

distribution, systems analysis (4558) ...

entry-exit (see Hydroballistics) farm

hydraulic studies in southern Piedmont

region systems (4351) ...

terrace systems (4351) ...

surface water storage and supply (9) ...

coastal-plains farms (4841) ...

wells and irrigation pits on coastal-plains farms (4842) ...

ground (see Ground water) quality

Alaska streams, logging effect (5355) ...

high changes, in ground water reservoir (5968) ...

land use effects in forested mountains (5413) ...

pesticide residue effect (5611) ...

watershed environmental and microbial dynamics (5407) ...

requirements

citrus in Rio Grande valley (5568) ...

irrigated areas of Southwest (5177) ...

lawns grasses (5585) ...

marshlands (5350) ...

WELL PLANS, state of Utah (5150) ...

resources (see water-resource rights, legal and hydrologic study (5703) ...

storage

management research (5879) ...

management research (5881) ...

saline aquifers (5711) ...

surface water investigations in Iowa (67) ...

-1-
WATER (continued)

surface water
treatment for farm use (2837) 66

table (see Water Table)
temperature (see Water Temperature) (5813) 66
treatment
Flocculents in playa water (5213) 135
for farm use (2837) 66
from small reservoirs (5810) 67
use (see Water Table) (5213) 67
(yield (see Water Yield)

WATER HAMMER
control by valve stroking (5817) 53
liquid column separation (4865) 53
resonance in triplex pump suction and discharge lines (4858) 53

WATER RESOURCES
atmospheric, in Utah (5750) 90
Kiowa-Bijou basins, Colo. (5862) 22
mathematical models, system analysis (5115) 49
mathematical models, system analysis (5115) 49
planning, Latin America (5116) 49

WATER TABLE
depth effect on irrigated cotton (4845) 133
fall of free board, soil moisture, winter (4832) 120
lowering effect on vegetable growth (5985) 136
topographic effects on shape (5819) 12

WATER TEMPERATURE
aquatic coal studies (5214) 42
cooling-water discharge (5914) 42
stratification break-up by turbulence (5737) 24
stresses
dam, downstream effect (5698) 98
reservoirs and streams (769) 188
reservoir-stream heat budget (4881) 186
St. Lawrence River (4543) 227
turbidity, turbulenc, radiation effects (5767) 62

WATER USE
analysis, Little Bear River Basin (5748) 90
Arkansas River basin, Colo. (5410) 20
municipalities and industries (5704) 23
optimizing conjuctive use of surface and ground water (5747) 77
organizational and procedural study (5394) 18
plans, State of Utah (5138) 88
plant growth (4828) 124
residential (3471) 42

WATER YIELD
atmospheric-turbulence relation (4110) 17
Gulf of Mexico (4735) 149
climatic and watershed factors
Edwards plateau, Tex. (4352) 132
Northwest rangelands (4312) 122
Texas blacklands (4349) 132
Washtucn River basin, Okla. (4944) 131
conservation-treatment effects (4297) 118
Hawaii (5001) 152
improvement programs
California forests (4998) 151
Southwest brushlands (5000) 151
northern plains rangelands (4310) 119
permanent grass watersheds (5208) 121

WATERSHED ANALYSIS
Allegheny plateau (4267) 108
Cascade region (4757) 148
Cascade Region (4758) 149
Colo. front range, small watersheds (5409) 20
logging effects (4758) 149
mathematical models (5724) 33
Medicine Creek, Nebr. (4302) 119
nonlinear hydrologic systems (5145) 8
Pigeon Roost Creek, Miss. (4325) 126
protection and reclamation, Utah (5297) 145
runoff-rainfall relations, Minnesota (5799) 72
semi-arid watersheds
soil and vegetation factors (4362) 139
valley and channel materials, vegetation (4361) 139
small agricultural watersheds, So. Calif. (5222) 141
small Indiana watersheds (2841) 104
small Missouri watersheds (4663) 55
small watershed model (5224) 59
Southeastern model (5226) 47
urban watersheds in Indiana (5882) 105
vegetation effects (4757) 148
(yield (see Watershed Management; Hydrologic Analysis; Runoff; Water Yield)

WATERSHED MANAGEMENT
Albuquerque, N. M. (169) 154
Alpine Hydrologic Lab. (5895) 156
Appalachian coal fields (4753) 144
California snow zone (4996) 143
Cotton Creek, Colo. (4880) 148
Fernow Exp. Forest, West Va. (1188) 147
Fort Collins, Colo. (3893) 152
Fraser Lab. (577) 153
Harrison, Ark. (5001) 157
Hawaii (5001) 152
Hubbard Brook Exp. Forest, N. H. (2419) 147
irrigation water supply (5935) 180
Lakeland, Wyo. (3569) 135
Lower Michigan (3890) 146
Northern Minnesota (5867) 146
Ontario, Miss. (6893) 155
Pacific Southwest (4997) 150
Parker Branch (3307) 155
Pine Tree Branch (5301) 155
Rapi City, High-Cascade (5868) 155
Southeastern forests (5860) 156
Southeastern Wisconsin (3889) 146
Suivusus University, N. Y. (4796) 147
Tempe, Arizona (657) 153
Upper Bear Creek (4884) 169
Upper Darby, Pa. (5323) 180
Western No. Carolina (3506) 186
Western foreboreal forests (5396) 157
White Hollow (5308) 188
(see also Watershed Analysis; Hydrologic Analysis; Runoff; Water Yield; Sediment)

WAVES
absorbers, rubble (5635) 205
beach-contour relations (1631) 74
breakers, forces on, longshore (5260) 12
conical, shoaling theory (4990) 83
complex, instruments for analysis (4159) 47
currents induced on beaches (5023) 74
deposition
by submerged spheres (5205) 72
effect of following wind (5252) 166
laminar boundary layer (4229) 177
over long distances, field study (4741) 166
turbulent liquid (4891) 166
viscous-damping summary (5013) 166
deep water, high-order nonlinear theory (5896) 155
diffraction through submerged reef (4953) 12
edge, laboratory study (5326) 161
energy flux (4126) 27
field observations
Lake Superior (5767) 228
various coastal locations (660) 158
floating ice (4924) 227
flood, dry-bed alluvial channels (5858) 138
forecasting
hindcasting techniques (5470) 57
Northumberland Strait, Canada (5987) 219
forces on objects, breaking on vertical wall (4908) 34
breakwaters (998) 130
coastal study, statistical (5433) 132
moored objects (5268) 92
moored oil storage tanks (5802) 75
vertical cylinders (5750) 47
structural interactions (4906) 34
generators
confused seas (5292) 179
general-purpose design (5999) 222
generators
wind-height prediction, shallow water (5079) 161
harbor oscillations induced by (5444) 47
interactions, long and short waves (5614) 166
internal
due to source-sink impulses (5615) 166
spheres in air (4403) 166
ocean, field and theory (4500) 74
(see also Stratified Flows)
long
amplification at circular islands (5893) 29
bore formation (4667) 57
diffraction by islands (4866) 81
in flords (5685) 28
metocean theory of (5760) 28
measurement, (see Hydraulic Measurements)
microwave scattering from (5564) 25
nonlinear properties (5120) 57
WAVES
plunger characteristics, laboratory (5326) 161
reflection
from cylindrical pile arrays (5821) 45
from floating rectangular bodies (5844) 44
sand beaches (5635) 205
refraction of wind waves (4934) 12
resonators (5635) 205
roll
in steep open channels (5360) 5
in steep rough channels (5597) 95
Rossby (4737) 101
run-up
effect of secondary waves (5327) 161
large wave shore run-up (5455) 76
on composite beaches (4155) 44
on shore structures, field study (2661) 160
run-up on Oahu (5896) 29
tsunamis
Hilo Bay model (3903) 195
run-up on Oahu (5896) 29
wind
effect on bed ripples (5888) 22
generation and growth (4) 74
mechanics of generation (3120) 57
mechanics of generation (4917) 76
overtopping of seawalls (5455) 12
overtopping of structures (5460) 85
two-dimensional spectrum (4934) 12
wind forces on (5252) 166
wind interaction, energy transfer (5454) 76
(see also Harbors)
WEATHER MODIFICATION
considerations for experiments (5878) 21
WEIR
oliver shaped, obtaining uniform flow along (5519) 96
free streamline theory (5452) 90
(see also Hydraulic Measurements)
WELL
multiple, interference effects (4857) 8
model study (4896) 28
use in area development (4857) 8
WING
ring, effect of geometry on loads (4873) 184
WIND DRIVEN CURRENTS
enclosed bodies of water (5806) 73
Lake Michigan (5472) 58
(see also Lakes)
WIND \(73\)
(see Pipe Flow)
WYES
(see Pipe Flow)

YAW
(see Ships, motions)
YIELD
(see Sediment; Water)
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