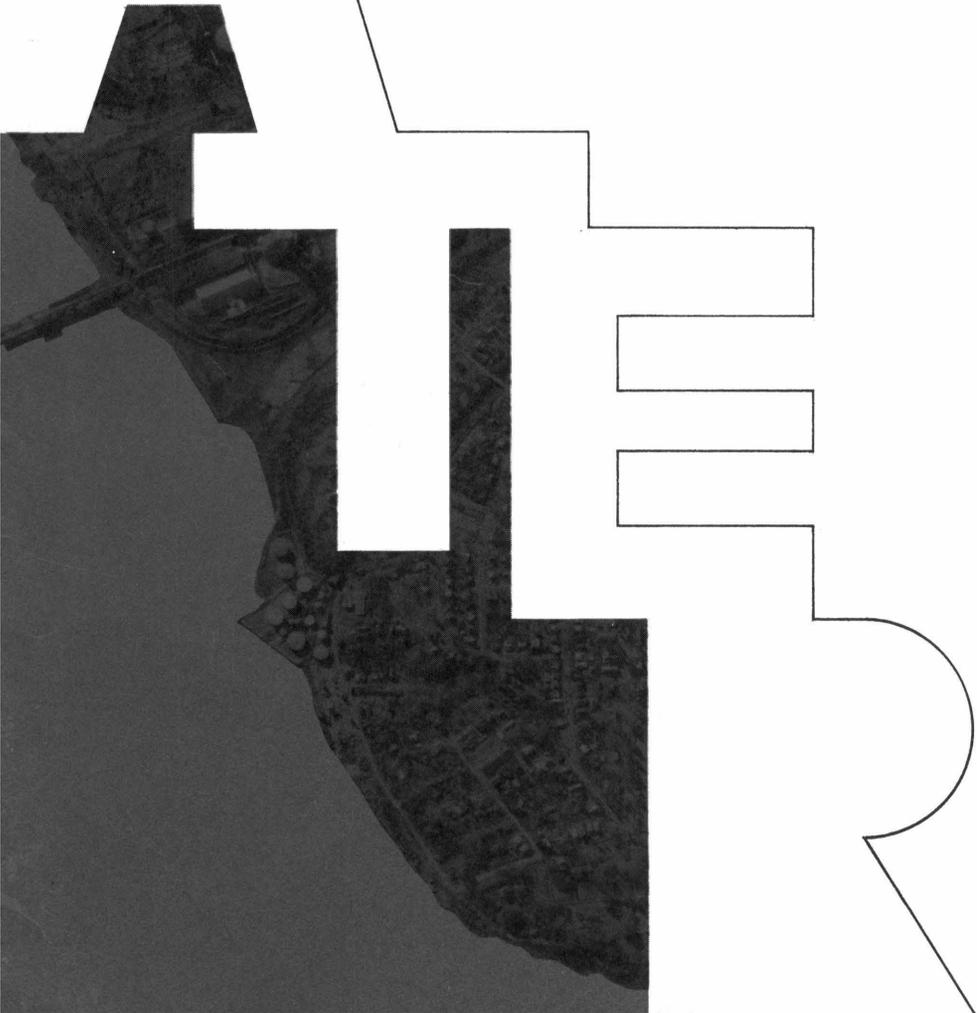


Bulletin 18:
WATER RESOURCES RESEARCH IN VIRGINIA
William R. Walker



WATER RESOURCES RESEARCH
IN VIRGINIA

William R. Walker
Director
Water Resources Research Center

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Virginia Polytechnic Institute
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PREFACE

To establish guidelines and priorities for the water resources research and development programs in Virginia, three basic reports are planned by the Water Resources Research Center. The first presents a detailed inventory of persons with water related research interests at Virginia Colleges and Universities; the second presents a detailed survey of active and current research projects now being conducted by Universities, Government Agencies and Industries; and the third surveys the water resource problems and research needs within the state.

This bulletin, "Water Resources Research in Virginia," constitutes the second report. The research projects are broadly divided according to the type of agency involved. The project information is presented in the following format:

1. Agency or institutional department
2. Title of project
3. Principal investigators
4. Description of project
5. Starting date
6. Termination date
7. Cost

The addresses of the participating agencies and institutions are listed in Appendix A.

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ACTIVE RESEARCH PROJECTS
CONDUCTED BY
PRIVATE INDUSTRY IN VIRGINIA

PRIVATE INDUSTRY

CELANESE FIBERS COMPANY

WASTE TREATMENT FOR THE ERADICATION OF SPHAEROTILUS NATANS IN THE LOWER NEW RIVER

Heavy growth of Sphaerotilus Natans immediately downstream of the outfall of this cellulose acetate producing facility is related to the organic loading. The relationship between the concentration of organic foodstuff and the growth and proliferation of S. N. is poorly defined despite several years of research by industrial and institutional investigators. Industries applying the techniques devised by these investigators have met with limited success. The present investigation is aimed at determining the practical level of BOD reduction in Celco waste that will reduce and perhaps eliminate the S. N.

BEGIN: May 1966 END: Nov. 1969 COST: \$64,000

DUPONT DE NEMOURS, E. I., & COMPANY, INC.

JAMES RIVER SURVEY

Mr. C. L. Black

A number of survey trips were made on the James River between Richmond and Hopewell. The dissolved oxygen profile in this reach of the river was determined to obtain a concept of the basic pollution that existed in the river prior to the operation of the Richmond sewage treatment plant.

BEGIN: Nov. 1957 END: Oct. 1958 COST:

VIRGINIA ELECTRIC AND POWER COMPANY

USE OF HYDRAULIC MODEL TO STUDY AND PREDICT EFFECT OF HEATED DISCHARGES

James River hydraulic model was used to determine and predict the temperature gradients which can be expected from the heated discharges from the Surry Nuclear Power Station.

BEGIN: July 1966 END: Sept. 1967 COST: \$35,000

USE OF HYDRAULIC MODEL TO DETERMINE THE PERCENTAGE USE BY A POWER STATION COOLING SYSTEM OF THE NET WATER AVAILABLE IN A TIDAL RIVER

Use of James River hydraulic model to determine and predict the percentage use by a power station of the net water available in a tidal stream.

BEGIN: July 1967 END: Aug. 1967 COST: \$15,000

P R I V A T E I N D U S T R Y

WEST VIRGINIA PULP AND PAPER COMPANY - CARBON DEVELOPMENT

CHARACTERISTICS AND KINETICS OF FIXED FILM BIOLOGICAL REACTORS

Dr. Billy H. Kornegat, Development Engineer

This research involves the application of the continuous culture theory to such fixed film processes as trickling filters in an effort to provide a rational method of design.

BEGIN: Sept. 1965 END: May 1967 COST: \$50,000

ACTIVE RESEARCH PROJECTS
CONDUCTED BY
THE COMMONWEALTH OF VIRGINIA

STATE AGENCY

VIRGINIA COMMISSION OF GAME AND INLAND FISHERIES

CLINCH RIVER DRAINAGE FISH POPULATION AND POLLUTION STUDY

Mr. R. E. Wollite, Fish Research Biologist

This study was developed to achieve the following objectives:

1. To determine relative fish productivity, species composition and year class survival of important sport fish of Little and Guest Rivers.
2. To evaluate changes in bottom fauna and water chemistries attributed to pollution in selected portions of Clinch, Powell, and Guest Rivers and Copper and Stock Creeks.

BEGIN: July 1967

END: June 1968

COST: \$21,600

GENERAL SURVEY

Mr. Norville Prosser, Fisheries Biologist

This study was developed to achieve the following objectives:

1. To collect sufficient information to determine the sport fishery potential of Eastern Virginia waters and to prepare recommendations for their management.
2. To investigate the availability of public access to certain Eastern Virginia waters and to propose additional access sites if needed.
3. To develop a backlog of potential public fishing lake sites within the assigned biologist's district, having low watershed to water surface ratios and over 50 surface acres in size, which would provide a basis for more detailed site feasibility studies.

BEGIN: July 1967

END: June 1968

COST: \$15,000

SHENANDOAH RIVER STUDY

Mr. Eugene W. Surber, Research Biologist

This study was developed to achieve the following objectives:

1. To determine the catches and fishing pressure on smallmouth bass and associated fishes in the South Fork and main stem of the Shenandoah River from Post Republic to the State line.
2. To determine the success of natural reproduction of smallmouth bass and other game fishes.
3. To determine the composition of fish populations, survival and growth of year classes, and abundance of forage fishes in the Shenandoah River.

STATE AGENCY

4. To determine the seasonal productivity of bottom fauna in the South Fork, main stem, and the North Fork and limiting factors; to determine physical and chemical factors affecting both bottom fauna and fish production.

BEGIN: July 1967 END: June 1968 COST: \$26,400

VIRGINIA DEPARTMENT OF HIGHWAYS BY THE UNITED STATES GEOLOGICAL SURVEY

HYDROLOGIC STUDIES

1. State wide flood frequency report based on currently available data.
2. State wide flood frequency report on drainage areas less than ten square miles. The report on the watersheds less than ten square miles is to be accomplished by installation of 100 flood hydrograph and rainfall recorders.

BEGIN: April 1964 END: 1974 COST: \$500,000

VIRGINIA DIVISION OF INDUSTRIAL DEVELOPMENT

REPORT ON AVAILABILITY AND POTENTIAL FOR DEVELOPMENT OF LARGE SITES FOR WATER USING INDUSTRIES IN VIRGINIA

The report includes the following topics:

1. General considerations (identifying large water using industries, potential for attracting new industries, water and air pollution control, recreation and river basin planning).
2. Available and potential large water sites above the Fall line (Rivers in far southwest Virginia, New River, Roanoke River, James River, and Potomac River).
3. Available and potential large water sites with water transportation (Identifying industries that require water transportation, problem of fresh water in quantity and quality in the Coastal plain, environmental factors, dependency of commercial fisheries on tidal estuaries, available and potential sites at Hampton Roads South, available and potential sites of the James River, York River, Rappahannock River, Potomac River, and facing on the Chesapeake Bay).

BEGIN: May 1967 END: March 1968 COST:

STATE AGENCY

VIRGINIA DIVISION OF MINERAL RESOURCES

GEOLOGY AND GROUND WATER RESOURCES OF VIRGINIA

This research program includes a summary of county studies with map locations of water wells, well data, and geologic logs associated with the Coastal Plain, Piedmont, and Valley and Ridge areas. Several thousand well records are listed. In addition, there are studies of geology and ground water resources of the Shenandoah National Park, Albemarle County, Rockingham County, Augusta County; and there are similar studies for the state parks including Douthat, Claytor Lake, Hungry Mother, Fairy Stone and Mt. Rogers. Another phase of this research program involves cooperative studies with the U.S. Geological Survey concerning the geology and ground water resources of Spotsylvania and Henrico Counties and of the Northern Neck Peninsula.

BEGIN:

END:

COST:

VIRGINIA DIVISION OF WATER RESOURCES

COMPUTERIZED MICRO-ANALYTIC INTRAREGIONAL INPUT-OUTPUT STUDY OF MANUFACTURING INDUSTRIES

Mr. L. F. Lombardi, Principal Economist

A crude 12 sector model has been developed. Matrices have been constructed which have resulted on a 12 x 12 input-output matrix for this physical area which is a key to additional matrix manipulations and theoretical economic analyses.

BEGIN: July 1967

END:

COST:

DEVELOPMENT OF WATER-RELATED VALUE THEORY

Mr. L. F. Lombardi, Principal Economist

Development of economic value theory which is consistent with engineering physical and planning objectives and is monetarily related to existing basin economies.

BEGIN: Set. 1966

END:

COST:

DISSOLVED OXYGEN-BIOCHEMICAL OXYGEN DEMAND RELATIONSHIP

Mr. R. L. Brown, Chief of Planning

Study of existing water quality data relating to the New River below Radford to establish a basis for predicting the effects of nutrient enrichment (nitrogen and phosphorous) on dissolved oxygen in the running stream. Future field surveys to more clearly

STATE AGENCY

define the relationship between various nutrient concentrations and their associated effect on dissolved oxygen and other parameters of water quality are planned.

BEGIN: Oct. 1966

END:

COST:

ACTIVE RESEARCH PROJECTS
CONDUCTED BY
THE UNITED STATES GOVERNMENT
IN VIRGINIA

F E D E R A L A G E N C Y

UNITED STATES GEOLOGICAL SURVEY FOR VIRGINIA DEPARTMENT OF HIGHWAYS

HYDROLOGIC STUDIES

(See entry for the Virginia Department of Highways for further information).

ACTIVE RESEARCH PROJECTS
CONDUCTED BY
COLLEGES AND UNIVERSITIES IN VIRGINIA

COLLEGE OF WILLIAM AND MARY

BIOLOGY

SNAKES & TURTLES AS VECTORS OF SELECTED BACTERIA

Dr. G. R. Brooks

This study concerns the possibility of water snakes and turtles spreading such bacteria as E. coli, salmonella sp etc. from one stream to another.

BEGIN: Nov. 1967

END: June 1968

COST:

CHEMISTRY

THE BEHAVIOR OF GALLIUM (AS A MODEL FOR ALUMINUM) IN WATER IN THE ACID RANGE

Dr. S. Y. Tyree, Jr.

Solutions of gallium perchlorate will be made up at various degrees of acidity and various total concentrations of gallium to see what the solute species are and how they vary with time and with temperature. The techniques used are those of the physical chemist, light-scattering, emf measurement, etc. (In cooperation with Prof. P. Schindler of the University of Berne).

BEGIN: Oct. 1967

END: March 1968

COST: \$10,000

THE BEHAVIOR OF THORIUM IN WATER SOLUTION

Dr. S. Y. Tyree, Jr.

Solutions of thorium salts will be made up at various degrees of acidity and various total concentrations of thorium to see what the solute species are and how they vary with time and with temperature. The techniques used are those of the physical chemist, light-scattering, emf measurement, etc. Other elements will be studied in a continuing program aimed at the general elucidation of the behavior of inorganic solutes in water.

BEGIN:

END:

COST:

KINETICS OF EVAPORATION OF LIQUIDS AND LIQUID PARTICLES

Dr. Joseph T. Zung

This study concerns the theoretical and experimental studies of the rates of evaporation of liquids from a flat surface and from droplets in assemblages. Mathematical models of cloud evaporation are proposed and experimental verification of these models is being conducted. Experimentation is also carried out to determine

COLLEGE OF WILLIAM AND MARY

the retardation effects on evaporation of clouds and sprays by monomolecular films and monolayers, soluble salts and immiscible impurities. Variation of electric charge in cloud droplets is determined in order to explain the nature of thunderstorms and other meteorological phenomena associated with clouds formed from salt nuclei which come from ocean water.

BEGIN: Oct. 1964 END: Nov. 1967 COST: \$75,000

GEOLOGY

HEAVY MINERALS OF THE JAMES RIVER SEDIMENTS

Dr. Bruce K. Goodwin

This is a study of heavy minerals in the bottom sediments of the James River in an attempt to determine the source of sediments, methods and directions of transport of sediment particles, and sites of deposition. This is currently being extended to include the sediments of the coastal plain and the Continental Shelf.

BEGIN: June 1966 END: Oct. 1969 COST: \$7,000

GEOLOGY OF THE HYLAS AND MIDLOTHIAN QUADRANGLES, VIRGINIA

Dr. Bruce K. Goodwin

The main purpose is to map the bedrock and surficial geology of these two quadrangles, and not to study the ground water by itself. However, a study of both ground and surficial water is commonly included in the scope of quadrangle mapping.

BEGIN: 1964 END: 1969 COST: \$3,500

GOVERNMENT

ROLE AND SYSTEM IN THE DEPARTMENT OF DEFENSE (A STUDY OF POLICY IMPLEMENTATION AND MANAGEMENT CONTROL IN THE DEPARTMENT OF DEFENSE, 1961-66)

Dr. James M. Roherty

This is a study of the planning-programming-budgeting system of the DOD as a public policy formulation device. The study is undertaken under a NASA contract and represents an interest on the part of other governmental agencies in DOD procedures. The allocation of resources for the support of competing public programs would appear to be a matter of widespread concern requiring continuing research.

BEGIN: Oct. 1967 END: Sept. 1968 COST: \$5,100
(Renewable)

OLD DOMINION COLLEGE

ENGINEERING

BUILDING AN AMPHITHEATER AND COASTING RAMP WITH MUNICIPAL REFUSE

Prof. William M. Beck, Jr.

This study is concerned with the variations of ground water flow and bio-chemical activity adjacent to and within the Virginia Beach project site resulting from the development of this solid waste project.

BEGIN: June 1967 END: Dec. 1969 COST: \$55,000

GEOLOGY

WATER SUPPLIES OF EASTERN SHORE OF VIRGINIA

Dr. Arthur C. Munyan

This study is concerned with the perched water tables and catchment areas of off-shore islands' development for the Cape Charles Peninsula region.

BEGIN: Nov. 1966 END: COST:

DAMSITE FOUNDATION STUDIES

Dr. Arthur C. Munyan

This study is concerned with the physical properties of residual soils and bed rocks - related to dam foundations and impounding areas in the Virginia-North Carolina region.

BEGIN: 1965 END: COST:

UNIVERSITY OF RICHMOND

BIOLOGY

A COMPARATIVE STUDY OF FEEDING BY THE CTENOPHORES BOLINOPSIS AND PLEUROBRACHIA

Dr. John W. Bishop

Rates of feeding were measured in order to ascertain the selectivity of prey and relative effectiveness of feeding by the ctenophores, at Friday Harbor, Washington.

BEGIN: June 1967 END: Sept. 1967 COST:

RATES OF FEEDING AS RELATED BY COLONY SIZE IN THE ECTOPROCT LOPHOPELLA CARTERI

Dr. John W. Bishop

Rates of feeding by colonies of varied size were measured. The results will be used to ascertain the value of colonial versus individual existence in terms of food procurement in L. carteri.

BEGIN: June 1967 END: June 1968 COST:

DIURNAL CHANGES IN PRIMARY PRODUCTIVITY IN WESTHAMPTON LAKE

Dr. John W. Bishop

Rates of primary production will be measured in order to ascertain diurnal changes in productivity by phytoplankton population in the lake due to changes in (1) size of the phytoplankton population and (2) concentration of chlorophyll "a" in the population.

BEGIN: June 1968 END: June 1969 COST:

EFFECTS OF ZOOPLANKTON ON PHOTOSYNTHESIS BY ALGAE IN LAKES

Dr. John W. Bishop

BEGIN: July 1968 END: June 1970 COST:

NATURE AND ACTION OF THE POISON OF STINGING NETTLES

Dr. Nolan E. Rice and Dr. W. Allan Powell

The main purpose of this research at the moment is to identify the poison of the common stinging nettle (Dactyloctenium aegyptium) in the region of the Chesapeake Bay.

BEGIN: 1966 END: 1969 COST: \$1,000

UNIVERSITY OF RICHMOND

ADDITIONS TO THE FILAMENTOUS MYXOPHYCEAE OF JAMAICA

Dr. J. C. Strickland

BEGIN: 1966

END: 1970

COST:

MYXOPHYCEAE OF VIRGINIA

Dr. J. C. Strickland

To include some culture work to test ideas of ecophenes or other factors that may be germane to present ideas of taxonomy of the group.

BEGIN: 1938

END: 1972

COST:

CHEMISTRY

NATURE AND ACTION OF THE POISON OF STINGING NETTLES

Dr. W. Allan Powell and Dr. Nolan E. Rice

(See entry under Dr. Nolan E. Rice, Biology, for further information).

UNIVERSITY OF VIRGINIA

CHEMICAL ENGINEERING

SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION

Dr. John L. Gainer and Dr. James T. Beard

Monolayers of certain substances reduce evaporation rates when applied to surfaces of lakes. This investigation is concerned with:

1. A study of the change of evaporation loss accompanying an increase in reservoir reflectance.
2. Experimental investigation of various surface film products which may increase solar reflectance.

BEGIN: Sept. 1967 END: June 1969 COST: \$12,128

ION REMOVAL BY CONTINUOUS COUNTERCURRENT ION EXCHANGE

Dr. Robert M. Hubbard

Apparatus has been developed for a continuous countercurrent moving bed ion exchange process for removing small concentrations of ions from water. Capacity and rate factors are being investigated.

BEGIN: In Progress END: COST:

STABILITY OF MULTIPHASE FLOWS IN NON-CIRCULAR CONDUITS

Dr. L. U. Lilleleht

A theoretical and experimental study of flow stability and interfacial interaction between water and another immiscible phase is being investigated. Hot-film anemometry techniques are being used to detect turbulent bursts, and to measure turbulence characteristics.

BEGIN: Feb. 1966 END: COST: \$20,000
(To date)

INTERFACIAL STRUCTURE

Dr. L. U. Lilleleht

The structure of interfacial waves, whether generated by wind or some other fluid or mechanism, has a marked effect on the transport processes across this interface. A description of the interfacial structure and a map of the regions where the different types of wavy structures appear is expected to yield a better understanding of processes involving two-fluid interfaces.

UNIVERSITY OF VIRGINIA

Not currently being pursued for lack of funds and students.

BEGIN: END: COST:

CIVIL ENGINEERING

POISEVILLE'S-LAW FOR DETERMINING SOIL PERMEABILITY

Dr. H. G. Larew

This study is concerned with the use of nuclear devices to determine in situ soil permeability by means of Poiseville's Law.

BEGIN: 1964 END: 1967 COST: \$22,000

THE PHREATIC LINE BREAKOUT POINT ON EARTH DAMS

Dr. H. G. Larew

This study is concerned with a comparison of the actual and theoretical breakout point of the top flow line on the downstream side of earth dams.

BEGIN: 1965 END: 1965 COST: Un-sponsored

STREAM POLLUTION SURVEYS IN THE JACKSON AND JAMES RIVERS

Dr. Clinton E. Parker

This study is concerned with the accumulation of information on specific reaches of the Jackson and James Rivers to characterize existing water quality conditions and to determine their capacity for assimilating waste discharges.

BEGIN: June 1966 END: Nov. 1966 COST: \$19,000

AN ANAEROBIC-AEROBIC LAGOON FOR TREATING VEGETABLE TANNINS

Dr. Clinton E. Parker

This concerns a demonstration project to study the physical, chemical, and biological factors of an anaerobic-aerobic lagoon system in treating spent vegetable tannins from a sole leather tannery that have been neutralized with other tannery waste streams.

BEGIN: July 1967 END: June 1968 COST: \$30,283

UNIVERSITY OF VIRGINIA

NATURAL FLOTATION OF COAGULATED ALGAL CELLS

Dr. Clinton E. Parker

This project is concerned with a basic laboratory investigation to define and establish parameters responsible for the flotation of coagulated algal cells, and to determine their influence on the design and operation of algal separation facilities that may be used in tertiary treatment.

BEGIN: Jan. 1968

END: Dec. 1969

COST: \$25,872

GEOLOGY

FORAMINIFERA IN THE RAPPAHANNOCK ESTUARY

Dr. Robert L. Ellison

This study is concerned with the distribution and ecology of microfauna, especially foraminifera. Distributions of species and numbers of foraminifera are useful in pollution studies. A thermal pollution study in the Patuxent Estuary of Maryland has recently been completed using these protozoans.

BEGIN: Summer 1962

END: Summer 1966

COST: \$15,000

MECHANICAL ENGINEERING

SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION

Dr. J. T. Beard and Dr. J. L. Gainer

(See entry for Dr. J. L. Gainer, Chemical Engineering, for further information).

RELATIVE REFLECTANCE OF CETYL ALCOHOL COVERED WATER SURFACES

Dr. J. T. Beard

1. Study of the optical properties required for significantly increasing reflectance.
2. Study of the influence of water waves on reflectance.
3. Experimental determination of change in reflectance due to a cetyl alcohol monolayer on water surfaces.

BEGIN: June 1964

END: Sept. 1965

COST: \$25,000

VIRGINIA INSTITUTE OF MARINE SCIENCE

SELECTION OF DISEASE-RESISTANT OYSTERS

Dr. Jay D. Andrews

This study concerns epizootiology and causes of oyster mortalities, in the lower Chesapeake Bay, especially those caused by protozoan MSX.

BEGIN: 1959

END:

COST:

REPRODUCTION AND GROWTH IN MOLLUSKS, ESPECIALLY OYSTERS

Dr. Jay D. Andrews

This study concerns monitoring, setting, and population dynamics; it also concerns distribution and fate of bivalve larvae (field and laboratory studies). Seasonality of reproduction, growth, predation, diseases, shell planting, harvesting, are all inter-related facets.

BEGIN: 1950 to date

END:

COST:

BIOLOGICAL AND CHEMICAL STUDY OF VIRGINIA'S ESTUARIES

Dr. Morris L. Brehmer

Biological, chemical and physical parameters of the Tidal James, York, and Rappahannock Rivers are determined. Nutrient levels and turn-over rates, phytoplankton response, and possible relationships to higher trophic levels will be evaluated.

BEGIN: Oct. 1967

END: Sept. 1970

COST: \$102,000

PESTICIDE AND HEAVY METAL MONITORING PROGRAM

Dr. Morris L. Brehmer

Shellfish are collected monthly from Virginia's estuarine systems and processed for chlorinated hydrocarbon and heavy metal analyses.

BEGIN: July 1965

END: Dec. 1968

COST: \$34,000

INVESTIGATION OF POTENTIAL FOR EXPANSION OF THE INDUSTRIAL FISHERY OF THE MID-ATLANTIC BIGHT

Dr. Jackson Davis

A trawl survey was made of approximately 75 stations in each of four seasons to determine seasonal distribution and abundance of

VIRGINIA INSTITUTE OF MARINE SCIENCE

fishes in the region of the Continental shelf - Cape May to Cape Hatteras.

BEGIN: Nov. 1965 END: June 1967 COST: \$170,000

BIOLOGY AND UTILIZATION OF ANADROMOUS ALOSIDS

Dr. Jackson Davis

This study is concerned with the location and description of spawning sites and nurseries, population dynamics, oceanic phases of life of shad, hickory shad, alewife, and blueback in the tidal waters of Virginia and the Atlantic Ocean.

BEGIN: March 1967 END: 1969 COST: \$475,000

DISTRIBUTION OF HARD CLAMS AND SOFT CLAMS

Prof. Dexter S. Haven

Surveys are conducted in lower Chesapeake and tributary rivers to determine abundance of hard and soft clams with hydraulic harvester.

BEGIN: Jan. 1968 END: COST:

SETTING OF OYSTERS

Prof. Dexter S. Haven

This study concerns the setting of small oysters in lower Chesapeake Bay and tributary rivers.

BEGIN: Jan. 1968 END: COST:

STUDY OF SHELLFISH INDUSTRY

Prof. Dexter S. Haven

This study concerns economics and other aspects of the shellfish industry in the lower Chesapeake Bay and tributary rivers.

BEGIN: June 1968 END: COST:

THE CORRELATION OF RIVER FLOW WITH SALINITY IN A COASTAL PLAIN ESTUARY

Dr. William G. MacIntyre

A statistical method to control estuarine salinity in the James River by regulation of fresh water input by dams or weirs is

VIRGINIA INSTITUTE OF MARINE SCIENCE

developed and tested with data collected by this laboratory. The idea is to make maximum use of available fresh water and to provide optimum estuarine environment for commercially significant organisms.

BEGIN: Jan. 1967 END: March 1968 COST:

SEDIMENTATION IN THE JAMES RIVER ESTUARY

Dr. Maynard Nichols

This study is concerned with the source, transportation and dispersal of bottom sediments in relation to dynamic conditions of flow and salinity in the James River.

BEGIN: July 1966 END: Jan. 1968 COST:

CONTINENTAL SHELF HYDROGRAPHIC SURVEY

Prof. J. J. Norcross

Each month 36 hydrographic stations are occupied on the Continental Shelf off Chesapeake Bay on transects located on parallels 37°10' N, 37°00' N, 36°50' N, and 36°40' N. The temperature and salinity structure is obtained on each survey. Plans are underway to intensify sampling periods to every two weeks and to conduct aerial surveillance of the sea surface using infra-red radiometry.

BEGIN: May 1965 END: Continuing COST:

CIRCULATION OF CONTINENTAL SHELF WATERS

Prof. J. J. Norcross

Drift bottles and sea-bed drifters, released from Navy aircraft, were employed to yield information on the circulation of surface and bottom waters of the Continental Shelf between Cape Henlopen, Delaware and Cape Hatteras, North Carolina.

BEGIN: June 1963 END: Oct. 1964 COST: \$75,000

ULTRASTRUCTURE OF DERMOCYSTIDIUM MARINUM, AN OYSTER PATHOGEN

Dr. Frank O. Perkins

This study concerns the investigation of the fine structure of the parasite in all stages of the life cycle and the fine structure of host reactions to the pathogen.

BEGIN: Nov. 1966 END: COST: \$2,000

VIRGINIA INSTITUTE OF MARINE SCIENCE

FINE STRUCTURE OF MUSCLE CONTRACTION IN THE JELLYFISH, CHRYSAORA
QUINQUICERA

Dr. Frank O. Perkins

BEGIN: June 1967 END: COST: \$2,000

CONTINENTAL SHELF HYDROGRAPHIC SURVEY

Prof. Evon P. Ruzicki

This study concerns the continuation of monthly surveys of the temperature and salinity structure of Continental Shelf waters off the Virginia capes in an attempt to eventually predict shelf circulation (continuation of work started by J. J. Norcross of VIMS).

BEGIN: 1959 END: Open COST:

CORRELATION OF DISCHARGE OF THE JAMES AND SUSQUEHANNA RIVERS WITH SALINITY IN THE LOWER JAMES

Prof. Evon P. Ruzicki

BEGIN: Jan. 1967 END: Dec. 1967 COST:

LIFE HISTORY, ECOLOGY AND POPULATION DYNAMICS OF THE CHESAPEAKE BAY BLUE CRAB, CALLINectes SAPIDUS

Dr. Willard A. Van Engel

The blue crab is the second most valuable species harvested in Chesapeake Bay waters. Research is designed for a better understanding of the species, with the ultimate aim of wise management for most efficient utilization of the stock.

BEGIN: END: Long-term COST:

LIFE HISTORY, ECOLOGY AND POPULATION DYNAMICS OF VARIOUS CHESAPEAKE BAY CRUSTACEANS, IN PARTICULAR THE XANTHID CRABS, EURYPANOPEUS DEPRESSUS AND RHITHROANOPEUS HARRISII, THEIR PARASITISM BY BARNACLES AND THEIR RELATIONSHIP TO THE ECOLOGY OF THE VIRGINIA OYSTER

Dr. Willard A. Van Engel

BEGIN: Nov. 1964 END: Long-term COST:

VIRGINIA INSTITUTE OF MARINE SCIENCE

SYNOPTIC STUDIES OF DISTRIBUTION AND ABUNDANCE OF DISSOLVED FREE AMINO ACIDS IN MARINE WATERS

Dr. Langley Wood

Samples have been taken on weekly basis in York River, Virginia, since July 1965, and analyzed by ion-exchange chromatography for identity and abundance of dissolved free amino acids. Measurements of chlorophyll, zooplankton, temperature, salinity, etc., also taken when possible. Transects of similar samples have been taken on an occasional basis from Chesapeake Bay, along shore Atlantic currents off Virginia and North Carolina coasts, and in the Gulf Stream.

BEGIN: July 1965

END: Continuing

COST: \$36,000

VIRGINIA MILITARY INSTITUTE

CIVIL ENGINEERING

PROGRAMMING WATER RESOURCES

Prof. S. W. Dobyns

This study is concerned with system development to meet industrial and community needs for water resources.

BEGIN: END: COST:

PREDICTING DEMANDS FOR WATER RESOURCES

Prof. S. W. Dobyns

This study is concerned with model preparation to predict demands for water resources for short-range and long-range plans.

BEGIN: END: COST:

PREDICTION MODELS FOR INVESTMENT IN URBAN DRAINAGE SYSTEMS

Dr. John W. Knapp

It is desirable to provide drainage systems which will give an optimal return on the monetary investment. The purpose of this study was to develop a method using charts and equations for predicting investment costs and design patterns of urban drainage systems as aids in planning and designing networks.

BEGIN: July 1966 END: June 1968 COST: \$10,073

VIRGINIA POLYTECHNIC INSTITUTE

AGRICULTURAL ENGINEERING

RELATION OF SELECTED ENGINEERING LAND TREATMENTS TO SOIL WATER STORAGE AND RAINFALL USE EFFICIENCY OF CROPS

Prof. James H. Lillard

This research compared the soil moisture use efficiency of various soil-crop systems, and includes the development of a mathematical model for computer analysis of hydrologic characteristics of agricultural watersheds.

BEGIN: July 1965 END: June 1968 COST: \$38,818

SIMULATION OF THE HYDROLOGIC CYCLE ON SMALL AGRICULTURAL WATERSHEDS BY DIGITAL TECHNIQUES

Prof. Vernon O. Shanholtz

The objectives of this study are to evaluate the Stanford Watershed Model on small agricultural watersheds in Virginia, and to modify the model as may be required to fit the flow regimes of these small agricultural watersheds. The set of model parameters resulting in the optimum fit of observed versus actual daily discharge will be determined for each watershed and sensitivity analyses made to obtain some insight towards their range of applicability.

BEGIN: July 1967 END: June 1970 COST:

AGRONOMY

ECONOMIC PRODUCTION OF CORN AND ALFALFA IN VIRGINIA

Prof. J. A. Lutz, Jr.

The effects of irrigation and N, P, K fertilization on the yield of corn is being measured on Davidson Clay loam. Also, the effects of irrigation and P and K fertilization on the yield of alfalfa is being determined. The levels of the above inputs that are justified under various economic conditions will be determined.

BEGIN: 1966 END: COST: \$15,000

ECONOMIC PRODUCTION OF CORN IN VIRGINIA

Prof. J. A. Lutz, Jr.

The effects of irrigation and five levels each of N, P, K fertilization on the yield of corn is being measured on Cecil fine sandy loam. The levels of the above inputs that are justified under

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various economic conditions will be measured. Certain micro-climatic and physical variables affecting corn yields will be measured.

BEGIN: 1966 END: COST: \$12,000

ADAPTING THE NO-TILLAGE SYSTEM OF FIELD CROP PRODUCTION TO VARIOUS CROPS AND SUCCESSIONS

Prof. William W. Moschler and Dr. George M. Shear

This study is concerned with corn, soybeans, and flue-cured tobacco being grown without tillage with a resulting increase in infiltration of rainfall. Practical systems of sustained production aimed at permanent adoption by farmers is the objective.

BEGIN: June 1967 END: 1972 COST:

BIOLOGY

EVALUATION OF THE EFFECT OF TRACE ELEMENTS ON THE ACTIVITY OF MICROORGANISMS

Dr. Robert E. Benoit

This study was established to accomplish the following objectives:

1. To isolate the "tardus" factor from various water sources in Southwestern Virginia which is responsible for the conversion of rapid fermenting strains of Streptococcus lactis to slow fermenting strains of Streptococcus lactis variation tardus, and correlate with trace element analyses.
2. To determine the extent of the geographic area in which the Streptococcus lactis variation tardus is more naturally predominant.
3. To illucidate the previously unknown metabolic pathway which Streptococcus lactis may use to ferment carbohydrates.

BEGIN: May 1965 END: June 1967 COST: \$11,597

DIVING PHYSIOLOGY OF SMALL BIRDS AND MAMMALS (CINCLUS MEXICANUS AND SOREX PALUSTRIS)

Dr. William A. Calder

Physiological responses to diving and breathholding have been extensively studied in larger birds and mammals. The metabolic intensity, and therefore, the oxygen requirements are inversely related to body size. Consequently, the small divers face a greater physiological problem in remaining under water where they

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cannot breath. The smallest divers among the birds and mammals are both found in the Rocky Mountains. Some preliminary data obtained this summer are presently being compared with the responses of non-diving animals of the same weights here at VPI, to get an idea of the extent of physiological adaptation in the true divers. Cardiovascular and thermoregulatory studies will be conducted this coming summer.

BEGIN: June 1967 END: Sept. 1968 COST: \$7,500

RESPIRATION OF FISH IN HOT WATERS

Dr. William A. Calder

The amount of dissolved oxygen decreases with increasing water temperature. Thus to support a given metabolic level, an aquatic animal in warm water must move more water over its gills, extract a higher percentage of the oxygen in the water, or both. The Utah chub, *Gila atraria*, is found in cold waters of the Jackson Hole region as well as in the hot waters downstream from geyser basins in the Yellowstone National Park, thus affording a unique opportunity for studies of respiratory and circulatory adaptations within one species. The exploitation of an extreme situation such as this should show, in exaggerated fashion, the mechanisms of adjustment which might occur to a smaller degree in the thermal variations within any watercourse.

BEGIN: END: COST:

CYTOCHEMISTRY AND MORPHOGENESIS OF MARINE PYRENO MYCETES

Dr. Paul W. Kirk

This study is concerned with determining the nature and origin of ascospore ornamentations, and their taxonomic significance.

BEGIN: END: COST:

SECONDARY METABOLITES OF MARINE FUNGI

Dr. Paul W. Kirk

This study is concerned with determining the secondary metabolite production by salt water fungi for their medical and taxonomic significance.

BEGIN: END: COST:

INVASION OF THE AQUATIC HABITAT BY AMPHIBIOUS POLYGONUM

Dr. Richard S. Mitchell

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Morphological, cytological, and anatomical comparisons of the amphibious polygonum and their capacity for invading lakes and estuaries is being studied.

BEGIN: July 1968 END: June 1970 COST:

THE EFFECTS OF PUMPED-STORAGE RESERVOIR OPERATION ON BIOLOGICAL PRODUCTIVITY AND WATER QUALITY

Dr. Stuart E. Neff

This investigation was to measure the effects of pumped-storage operation of an impoundment on the biological productivity and water quality. The effects of both the re-cycled water and the river effluent feeding the reservoir were measured.

BEGIN: July 1966 END: June 1968 COST: \$12,505

LACUSTRINE AND ESTUARINE FUNGI

Dr. Robert A. Paterson

The research is a continuation of an investigation of lacustrine fungi presently supported by National Science Foundation (GB-2703). It is planned to continue studies on estuarine fungi initiated in September, 1963. Research on these organisms from both fresh and salt waters has two phases. The first is a taxonomic and morphological investigation of fungi which infest plankton. In addition it involves a study of host ranges, host-parasite relationships, and their significance to the taxonomy of the lower fungi. Current studies indicate that research on host ranges will be profitable in the clarification of some chytridiaceous taxa, since many species have been established on the basis of host specificity. Another aspect of the work on planktonic fungi will be an investigation on the vertical and horizontal distribution of fungal parasites of phytoplankton. The second part of this program is a study of the occurrence of benthic fungi. The investigator believes these fungi to be more important in the breakdown of dead organic matter in lake and estuarine bottoms than is presently recognized by most limnologists and marine biologists. Some studies of benthic fungi have been made in marine waters, but very few investigations have been conducted in fresh water with the specific purpose of finding benthic fungi. Previous investigations of bottom decomposers have dealt primarily with bacteria, or have employed only bacteriological techniques in studying fungi.

BEGIN: Sept. 1967 END: Nov. 1968 COST: \$10,500

COMPARATIVE ANATOMY OF THE SKULLS OF THE CYPRINID GENERA SEMOTILUS AND CLINOSTOMUS

Dr. Robert D. Ross

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This is a study of water and salt transport through hydrophilic films compressed between sintered stainless steel, reverse osmosis study.

BEGIN: 1964 END: 1965 COST: \$7,000

TREATMENT OF DYEING BATH WASTE STREAMS BY FOAMING AND FLOTATION TECHNIQUES

Dr. Donald L. Michelsen

This is a study of using foam flotation techniques for removal of color bodies or organics from dye waste streams.

BEGIN: July 1967 END: June 1969 COST: \$6,430
(per year)

MULTICOMPONENT MASS TRANSPORT IN AQUEOUS AND MEMBRANE SYSTEMS

Dr. George B. Wills

The objective of this study was the development and critical evaluation of models for multicomponent mass transport in aqueous and membrane systems.

BEGIN: June 1965 END: July 1967 COST: \$25,000

TRANSPORT PHENOMENA IN ION EXCHANGE MEMBRANES

Dr. George B. Wills

This study is concerned with the prediction and experimental verification of transport phenomena in ion exchange membranes.

BEGIN: 1958 END: 1962 COST: \$10,000

CHEMISTRY

HYDROGEN FLUORIDE SOLVENT SYSTEM AND MÖSSBAUER SPECTROSCOPY

Dr. Alan F. Clifford

This study is concerned with:

1. Physical chemistry of solutions in liquid HF: polarography, electrode potentials, activity coefficients, solubilities, acid-base phenomena, complex ions, corrosion.
2. Mössbauer spectroscopic studies, especially of the rare earths and elements near iodine in the periodic table.

BEGIN: Dec. 1966 END: Nov. 1969 COST: \$50,000

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A VACUUM HEAD PERMEABILITY TEST

Dr. Robert D. Krebs

Quantity of flow in relation to hydraulic gradient in partially saturated compact clays immersed under vacuum is studied with a view toward defining the applicability of Darcy's Law under the laboratory test conditions.

BEGIN: June 1967 END: June 1968 COST:

WATER AND LIME MIGRATION AMONG LAYERS IN INHOMOGENEOUS STABILIZED CLAY SOILS

Dr. Robert D. Krebs

Multilayered compact clay specimens initially inhomogeneous with regard to lime stabilization and compaction water content are studied to detect movement of moisture and changes in pH from layer to layer with time and with closed-system freezing and thawing.

BEGIN: March 1967 END: March 1968 COST:

MICROBIAL RELEASE OF SOLUBLE PHOSPHATE IN AN ACTIVATED SLUDGE ENVIRONMENT

Dr. Clifford W. Randall

This study was designed to shed light on the mechanisms of phosphate uptake and release by activated sludge microorganisms. The effect of extended aeration and anoxic conditions on microbial phosphate release will be studied, and an attempt will be made to control phosphate release by chemical addition.

BEGIN: July 1968 END: June 1969 COST: \$7,695

INSTANTANEOUS UNIT HYDROGRAPH RESPONSE BY HARMONIC ANALYSIS

Dr. James M. Wiggert

It is the aim of this study to determine the efficacy of harmonic analysis in deriving an instantaneous unit hydrograph, as proposed by O'Donnell (Intern. Assoc. Sci. Hydrology, Pub. 51, 1960) as a predictor of streamflow for various hydrologic regions. O'Donnell's paper uses the harmonic analysis developed only as a predictor for the rainfall runoff relation from which it was derived. This study develops the IUH from data, and tests the derived IUH for other rainfall-runoff relationships of record. The results and suitability of the methods are presented and analyzed with consideration of computer applicability in operation on existing data.

BEGIN: July 1966 END: Feb. 1969 COST: \$4,800

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ANALYSIS OF HYDROLOGIC SYSTEMS

Dr. James M. Wiggert

It is the purpose of this study to examine the hydrologic runoff process in terms of fundamental systems analysis. The study investigates the response (discharge) of systems of simple configuration to inputs (rainfall) of simple description. The time constants and amplitude ratios so derived were used for synthesis of other flows to provide a check on the method. Also of primary interest was investigation of methods of similitude scaling essential in design. The results provide information which could ultimately lead to more rational design methods in urban drainage problems and to better descriptions of natural basin hydrologic features.

BEGIN: July 1966

END: Jan. 1968

COST: \$9,500

ECONOMICS

COST AND PRODUCTION RELATIONSHIPS IN INLAND WATERWAY TRANSPORTATION

Prof. Leland S. Case

The cost of freight transportation by water has never been subjected to rigorous economic analysis. This has in part been due to a lack of data about the operations of barge firms. Data has been collected from several of the major companies which will allow the cost of moving freight by water to be estimated. In addition, industry practices can be examined to see if more efficient methods could be used. Also, the pricing of water freight services will be examined to see if the charges that are made reflect the costs of providing the services. An examination of the waterway industry is of particular interest since the government (Federal) is involved in the construction and maintenance of the inland waterways.

BEGIN:

END: June 1968

COST:

DEMAND FOR WATER RECREATION

Dr. Norman L. Brown and Dr. Donald C. Darnton

This is a pilot project to measure demand for 3 types of combinations of water recreation at lakes: swimming, limited boating, and unlimited boating. Influence of income and other socio-economic variables is included.

BEGIN: July 1967

END: June 1968

COST: \$4,000

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OPTIMAL FINANCING OF WATER PROJECTS

Dr. Wilson E. Schmidt

Query: Should a given water project be financed by a gift, a direct government loan (or investment), or a guaranteed private credit?

BEGIN: 1968

END:

COST:

FORESTRY & WILDLIFE

SPECIAL STUDIES RELATED TO ACID-MINE POLLUTION DEMONSTRATION PROJECTS

Dr. Kenneth B. Cumming

Manganese strip mining in Smyth and Wythe Counties has contributed substantial pollution (sediment and metals) to trout streams draining the areas. Pollution abatement resulting from forest reclamation is being evaluated. Fish toxicity to manganese is being tested.

BEGIN: June 1966

END: June 1968

COST: \$11,000

SPECIAL STUDIES RELATED TO LIMNOLOGICAL AND BIOLOGICAL SURVEYS ON SMITH MOUNTAIN RESERVOIR

Dr. Kenneth B. Cumming

The pump-storage generators at Smith Mountain Dam have the potential of creating a varied assortment of ecological conditions within this 20,000 acre lake. The effect of this system on fish composition, condition, and distribution is being studied.

BEGIN: June 1966

END: June 1968

COST: \$12,000

THE EFFECTS OF ENVIRONMENTAL CONDITIONS ON PHOTOSYNTHETIC RATE, LEAF DEVELOPMENT, AND SUBSEQUENT GROWTH OF LIRIODENDRON TULIPIFERA

Dr. H. A. I. Madgwick

This study is concerned with a greenhouse experiment of growing plants under different moisture stresses and examining plant growth with respect to mechanisms of response.

BEGIN: July 1967

END: July 1968

COST: \$2,500

GEOLOGICAL SCIENCES

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EVALUATION OF GEOHYDROLOGIC FACTORS IN ESTIMATION OF RUNOFF COEFFICIENTS ON WATERSHEDS EMBRACING MULTIPLE GEOLOGIC TERRANES

Dr. Byron N. Cooper

This study is concerned with the determination of runoff coefficients on various kinds of Appalachian geologic terranes in Peak Creek watershed of New River Valley, Pulaski-Wythe counties, Virginia.

BEGIN: July 1965 END: July 1968 COST: \$28,657

GROUND WATER RESERVOIR RESPONSE TO EARTH TIDES

Dr. Edwin S. Robinson

Tidal water level fluctuation data will be analyzed to ascertain aquifer parameters from measured tidal response of wells. A computer capacity for harmonic analysis of the data will be developed.

BEGIN: July 1968 END: June 1970 COST:

PLANT PATHOLOGY & PHYSIOLOGY

ADAPTING THE NO-TILLAGE SYSTEM OF FIELD CROP PRODUCTION TO VARIOUS CROPS AND SUCCESSIONS

Dr. G. M. Shear and Prof. W. W. Moschler

(See entry for Prof. Moschler, *Agronomy*, for further information).

CONTROL OF UNWANTED PLANT GROWTH IN FORESTS AND INDUSTRIAL AREAS

Dr. John P. Sterrett

The objective of this project is to determine degree of selectivity of various growth regulants for removal of unwanted vegetation from forests and industrial areas such as railroad, highway and public utility rights-of-way.

BEGIN: July 1965 END: July 1968 COST: \$24,000

PHYSIOLOGICAL PROCESSES ASSOCIATED WITH DORMANCY IN WOODY PLANTS

Dr. John P. Sterrett

The objective of this project is to study the effect, degradation and distribution of synthetic auxins in relation to dormant buds in roots of black locust and other selected woody species, and to

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determine the activity of indoleacetic acid oxidase and inhibitors of indoleacetic acid oxidase in dormant and nondormant black locust roots.

BEGIN: Feb. 1967 END: Feb. 1970 COST: \$52,000

STATISTICS

TRAINING GRANT ENVIRONMENTAL ENGINEERING STATISTICS

Dr. Boyd Harshbarger

This involves stipends and research by one faculty member and fifteen graduate students.

BEGIN: July 1967 END: July 1972 COST: \$146,000

STOCHASTIC MODEL FOR POLLUTION IN STREAMS

Dr. Richard G. Krutchkoff

Given the stream parameters and the initial amount of pollution, this project predicts the probability distribution of BOD and DO downstream.

BEGIN: Jan. 1965 END: June 1966 COST: \$8,000

30-DAY PROBABILITY PRECIPITATION FORECASTING

Dr. Richard G. Krutchkoff

This procedure uses the weather Bureau's 30-Day precipitation forecast in the form of "Light", "Moderate", or "Heavy" adds past data and gives a forecast in the form of a probability distribution in inches of rainfall.

BEGIN: Jan. 1966 END: June 1967 COST: \$10,000

STOCHASTIC MODEL FOR POLLUTION IN ESTUARIES

Dr. Richard G. Krutchkoff

This study is an extension of the results of the project in streams to estuaries.

BEGIN: Nov. 1967 END: Oct. 1970 COST: \$134,000

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COMPUTER PROGRAM FOR POLLUTION

Dr. Richard G. Krutchkoff

This study is concerned with a computer program extending the results of the project for stream pollution to include variable stream parameters.

BEGIN: June 1968

END: June 1969

COST: \$8,000

ESSA WEATHER BUREAU STATE CLIMATOLOGIST, V.P.I.

PRECIPITATION PROBABILITIES IN VIRGINIA

Prof. Morton H. Bailey

Climatological probabilities of weekly, monthly and annual precipitation amounts for 22 stations in Virginia are being computed by fitting the gamma distribution to samples of data.

BEGIN: July 1967

END:

COST:

VIRGINIA STATE COLLEGE

AGRICULTURAL ENGINEERING

DETERMINATION OF GROUND-WATER LEVELS AND THE STATUS OF THESE LEVELS AT CERTAIN LOCATIONS IN CHESTERFIELD COUNTY

Prof. Adolphus J. Miller

Twenty places will be selected for investigation. Answers to these questions should be found.

1. Are the ground-water levels at these locations static?
2. Are the ground-water levels at these locations rising or receding?
3. If the ground-water levels are receding at certain locations, what are the rates of recession?

BEGIN: July 1968 END: June 1973 COST: \$6,000

BIOLOGY

ECOLOGICAL AND SYSTEMATIC STUDIES OF PONDS OF DINWIDDIE COUNTY

Dr. B. R. Woodson, Jr.

A survey of twenty-two ponds was made in Dinwiddie County, Virginia, and an attempt was made to determine the relationship between water chemistry and distribution.

BEGIN: June 1964 END: Aug. 1964 COST: \$3,000

AN ECOLOGICAL STUDY OF A POND IN CHESTERFIELD COUNTY

Dr. B. R. Woodson, Jr.

The Virginia State College Pond was studied for one year including such factors as rainfall, temperature, pH, light, wind velocity, and water chemistry as they may affect the population of algal forms.

BEGIN: Sept. 1965 END: Aug. 1966 COST: \$5,000

THE EFFECTS OF HALIDES ON CHLOROPHYTA DISTRIBUTION IN THE JAMES RIVER

Dr. B. R. Woodson, Jr.

The objective is to construct a taxonomic list of the Chlorophyta present and to determine which species may be considered euryhaline for the range of salinities as determined by mercuric and silver nitrate titrations.

VIRGINIA STATE COLLEGE

BEGIN: Feb. 1967

END: Aug. 1967

COST: \$3,000

LIMNOLOGICAL STUDIES OF A SMALL LAKE IN COLONIAL HEIGHTS, VIRGINIA

Dr. B. R. Woodson, Jr.

This study is to show daily variations of plankton to depth at different temperature, light, and nutrient concentrations. The effects of oxygen and carbonate content are being considered with seasonal influences also being studied as a factor.

BEGIN: Sept. 1967

END: July 1968

COST:

APPENDIX A

Mailing Addresses of Agencies Represented

Celanese Fibers Company
P. O. Box 1000
Narrows, Virginia 24124

DuPont de Nemours, E. I., & Company, Inc.
Spruance Plant
P. O. Box 1559
Richmond, Virginia 23212

Virginia Electric and Power Company
P. O. Box 1194
Richmond, Virginia 23209

West Virginia Pulp and Paper Company
Carbon Development
Covington, Virginia 24426

Virginia Commission of Game and Inland Fisheries
P. O. Box 1642
Richmond, Virginia 23213

Virginia Department of Highways
1221 East Broad Street
Richmond, Virginia 23219

Virginia Division of Industrial Development
1010 State Office Building
Richmond, Virginia 23219

Virginia Division of Mineral Resources
Natural Resources Building
P. O. Box 3667
Charlottesville, Virginia 22903

Virginia Division of Water Resources
911 East Broad Street
Seventh Floor
Richmond, Virginia 23219

United States Geological Survey
Charlottesville, Virginia 22901

College of William and Mary
Williamsburg, Virginia 23185

Old Dominion College
Norfolk, Virginia 23508

University of Richmond
Richmond, Virginia 23173

University of Virginia
Charlottesville, Virginia 22901

Virginia Institute of Marine Science
Glouster Point, Virginia 23062

APPENDIX A

Mailing Addresses of Agencies Represented

Continued

Virginia Military Institute
Lexington, Virginia 24450

Virginia Polytechnic Institute
Blacksburg, Virginia 24061

Virginia State College
Petersburg, Virginia 23803

WATER RESOURCES RESEARCH CENTER
VIRGINIA POLYTECHNIC INSTITUTE BLACKSBURG, VIRGINIA 24061

