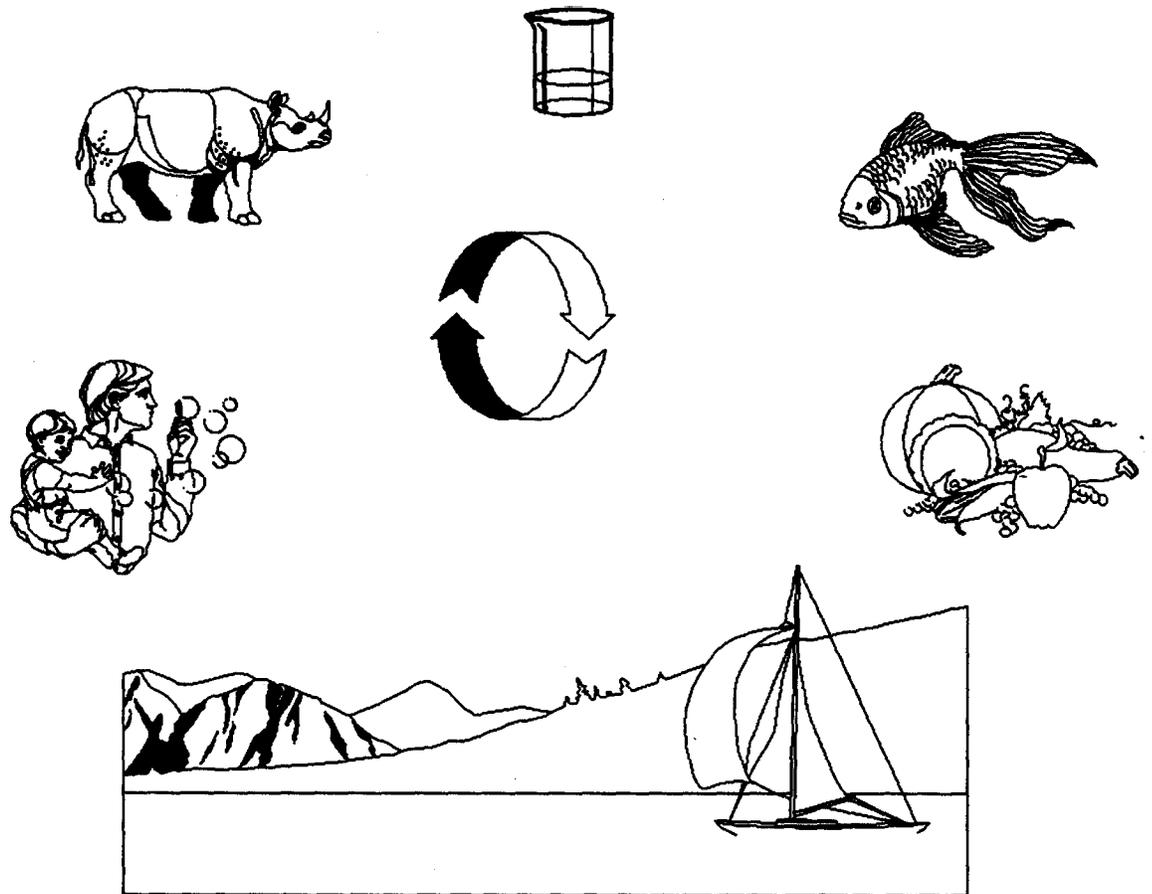


BOOK OF ABSTRACTS
2nd Edition: 1974 to 1994



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BOOK OF ABSTRACTS

- 2nd Edition: 1974 to 1994 -

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Preface

The DC Water Resources Research Center (DC WRRC) was established at the University of the District of Columbia (UDC) in 1973 under the Water Research and Development Act of 1964. The mission of the DC WRRC is *to* provide the District of Columbia with interdisciplinary research support to identify the District's water resources problems and to contribute *to* their solution. In addition, the Center promotes training, technology transfer and information dissemination on the water resources and related issues of the District of Columbia.

The DC WRRC research projects are based on the District of Columbia and the U.S. Geological Survey's Mid-Atlantic Region water resources priorities. This publication provides a comprehensive guide of research projects conducted or managed by the DC WRRC up to 1994. The report is organized according to the water resources research project classification scheme of the U.S. Geological Survey.

Most of the publications can be obtained at cost from:

National Technical Information Service (NTIS)
5285 *Port* Royal Road Springfield, VA 22161
(703) 487-4660

or from:

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I. Social Sciences

EVALUATION OF THE USE OF WATER PRICING AS A TOOL FOR CONSERVING WATER

Chiogioji, M.H. and Chiogioji, E.N. WRRC Report No. 2

DESCRIPTORS: Conservation, Pricing, Economics

Historically the economics of water supply has been oriented toward the provision of low cost water to consumers, with very little thought given to pricing principles and policies which could govern the efficient use and development of municipal water resources. Empirical data gathered in the Washington (DC) Metropolitan Area show that price increases do have an impact on water consumption. The use of demand management through price policy is proposed as a tool for rationing existing supplies. There is evidence that demand curves for industrial, agricultural, and some domestic uses are significantly price elastic. A two-part rate structure is also proposed to cover the off-peak winter period and the peak summer period. Other means for conserving water use also are suggested. -

INSTITUTIONAL ARRANGEMENTS FOR AREAWIDE WATER RESOURCES MANAGEMENT PLANNING IN THE WASHINGTON DC REGION UNDER THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

Lieber, H. WRRC Report No. 17

DESCRWWRS: Management, Planning

The project studied the formulation, acceptance and early implementation of areawide management planning for water quality management, water supply, land use and related functions by the Water Resources Planning Board of the Metropolitan Washington Council of Governments, established under provisions of P.L. 92-500. This study evaluated past arrangements and decision making procedures for water resources planning process and evaluated its success in limiting jurisdictional conflicts, integrating related functions and increasing citizen participation. The Washington area water resources planning under section 208 of the Clean Water Act was examined. The accomplishments and failures of the 208 plans were discussed.

NOTES ON WATER SUPPLY INTERCONNECTIONS INSTITUTIONAL FACTORS

Watt, M.H. and Svenljornson, H.
WRRC Report No. 22

DESCRIPTORS Institutional Relationships, Interconnections

One way to increase water supply reliability in a given area is through the construction of water supply interconnections. Such an approach encompasses engineering, environmental, legal, and management factors. Some comprehensive overview is provided on the potential benefits and problems associated with interconnections, with special reference to the Washington Metropolitan Area.

A brief description of basic features and historical examples of water supply interconnections is given, and recently proposed interconnections were analyzed. The WMA, due to the number of jurisdictions involved, provides a useful example of the potential problems to be overcome for achieving efficient regional water supply management. Completed water interconnections have been proven effective in providing added reliability and more efficient allocations of existing supplies. Institutional factors offer difficult barriers, however., Potential institutional obstacles to implementation of water interconnection projects were discussed.

*A CURRICULUM FOR WATER SUPPLY AND WASTEWATER OPERATION
MAINTENANCE AND MANAGEMENT*

Watt, M.H. WRRC
Report No. 23

DESCRIPTORS: Education

A curriculum was developed for water supply and wastewater operation/ maintenance/ management and is presented in two parts: (1) key water quality courses; (2) academic information to support the water resources courses. The description of the water quality courses includes updates and revisions; the courses separately address the chemical analysis of water, properties of fresh water, water quality management, wastewater technology, and hydrology.

*AN EVALUATION OF RECREATIONAL BENEFITS AND USE ESTIMATING
MODELS FOR WATER RESOURCES PLANNING*

Waters, R.C. and Moustakis, V.
WRRC Report No. 31

DESCRIPTORS: Recreation, Water Use

The objective of the study was (1) to collect and analyze the available recreational benefit estimating models applicable *to* the development of federal water resources plans, (2) to determine the degree of congruity and generality which exists in the present body of research, and (3) to evaluate the several recreational benefits estimation methods from the perspective that substitutes *to* the services provided by the new site are considered.

A literature search of over 300 abstracts was conducted resulting in the in-depth review of 45 studies (annotated abstracts are provided). Fifteen studies included a consideration of substitutes, however each lacks the inclusion one or more of the following consideration: income of participants, congestion, site quality, and the site as an intermediate destination. Furthermore, the validity and reliability of all the studies are undetermined. No exposit analysis of the model results has been conducted. Also, a number of the models are based on inadequate data collection methods and small sample sizes. Recently the U.S. Water Resources Council indicated it would publish regional recreational models (i.e., one which account for substitutes) that may be used to evaluate proposed projects. It is doubtful at present that the existing literature provides models which provide a sound basis for water resources plans. Additional research is necessary.

*WATER SUPPLY MANAGEMENT IN THE DISTRICT OF COLUMBIA:
AN INSTITUTIONAL*

ASSESSMENT

Beard, D.P. WRRC
Report No. 36

DESCRIPTORS: Institutional Relationships

The water supply management structure and its operation are described for the District of Columbia, as well as the issue it will face the 1980's and how the District is prepared to deal with these issues. They include: adequacy of future water supply; regional cooperation; water supply emergency and drought management; water supply system rehabilitation; water billing/collection; and rate increase and conservation price.

Major emphasis is given to detailed definition of the Potomac River Basin, the legal and institutional management of the river, the overall water supply network in the Washington metropolitan region, and the water management functions in the District. The District water supply was found to be reliable, inexpensive and of good quality. Other than some administrative concerns (e.g. billing/collections), the District water management system performs adequately. Recent studies do not forecast water supply shortages and regional cooperation appears to be improving. However, while the water supply future in the District area appears optimistic, caution is urged to ensure continued and improved cooperation as a critical factor in meeting future water supply needs.

Assessment of the State-of-the-A71 and Development of Proposed Improvements in the Recreation Benefit Evaluation for Water Resources Planning

Waters, R.C. and Moustakis, V.S.
WRRC Report No. 43

DESCRIPTORS: Recreation, Benefit Evaluation, Water Use

The objective of this study was to examine the issues related to the use of Willingness-To-Pay (WTP) based methods in evaluating recreational benefits. This research is a continuation of a research report 'An Evaluation of Recreational Benefits and Use Estimating Models for Water Resource Planning' available through NTIS. A literature search was conducted and its results are reported. The major findings of the research include (1) the use of any WTP based method does not lead to Pareto optimal social arrangements, (2) WTP does not take into account that public resources are commonly owned, which means that each member of a society is an equal resource owner, (3) WTP is an income biased approach, (4) use of the WTP via the travel cost method assumes that a well-defined individual (or household) recreation demand function exists, which is heroic assumption, and (5) WTP is not compatible to the political process involved in recreation planning. The report concludes that the Unit-Day-Value method, although minimally treated in the literature, represents a robust alternative to recreation benefits evaluation, and it presents a framework for effective agency UDV implementation. Guidelines for additional research necessary for UDV derivation are provided.

*DESIGN OF A WATER RESOURCES TRAINING PROGRAM FOR
OPERATION, MAINTENANCE AND MANAGEMENT*

Watt, M.H.

WRRC Report No. 56

DESCRIPTORS: Education

A long-term training program was designed for operating personnel in three bureaus (Water Services, Sewer Services, and Wastewater Treatment) within Water Resources Management Administration (WRMA), a division of the DC Department of Environmental Services (DES). The project consisted of an analysis of the agency's structure; a survey of the employees' background; a survey of job and task requirements; an assessment and documentation of training needs based on workers and supervisors views; analysis of job and performance functions; and the implementation of a pilot program aimed at providing information about the training level of workers, trainees and supervisors acceptance, selection of training methods, training facilities, and other factors relating to a long-term training program. Recommendations on a comprehensive long-term curriculum leading to certification are provided. The report also gives guidelines for apprenticeship, certification and, a comprehensive list of courses related to the water resources operators and technicians.

Special Water Resources Outreach Programs

Watt, H.M. and J. Hannsham WRRC
Report No. 108

DESCRIPTORS: Education, Technology Transfer

By far the most challenging aspects of education and training in the field of water resources are the processes of technology and information transfer. In order to be effective, these processes must target professionals, students, decision makers and the public. The report provides a highlight summary of experiences and some of the lessons learned during the process of designing either adhoc or institutionally related public enrichment programs. The paper also briefly highlights the environmental education programs of Historically Black Colleges and Universities (IBCU), and option that many pre-college students will select for their higher education.

*LAND DEGRADATION AND THE AMERICAN SOCIETY: AN
AGENDA FOR BLACK UNIVERSITIES AND COLLEGES IN
THE 21ST CENTURY*

Kargbo, Dave M.
WRRC Report No. 115

DESCRIPTORS: Education, HECUs, Land Degradation

An overall *view on* environmental problems, with a focus on the interaction between the environmental medium land and society, is presented. The problem of land degradation is a complex one. The many facets of the problem include technology, economics, and politics. The paper addresses the question of how black universities can become involved in this issue not just from the standpoint of solving the health and environmental effects of environmental degradation, but also on the basis of economic benefits that can be reaped.

*CITIZEN'S ATTITUDINAL SURVEY ON THE DISTRICT'S WATER
RESOURCES*

Choi, Y. and Azani, H.
WRRC Report No. 132

DESCRIPTORS: Public Policy, Drinking Water, Statistical Analysis, Economic Prediction

The study intended to measure the extent of public awareness, knowledge and understanding regarding the quality, availability, administration and management of water resources in the District of Columbia. Five propositions were tested: 1) Rich people are more concerned with water quality and water related issues than poor people. 2) DC residents believe that droughts and floods are acts of God. 3) DC residents are not aware of the regional care and management of water resources. 4) The water and sewer rate setting mechanism in DC is fair. 5) DC residents are concerned about the various issues related to the supply, quality, and management of water resources in DC. Questionnaires were distributed to 300 DC residents from varying demographic communities. 263 responses, deemed to be representative of the population under study, from follow-up telephone surveys and personal interviews were tabulated and analyzed using the SPSSX statistical package. 48% of the respondents were male, 52% were female. Income varied from \$15,000 to \$65,000. 14% of the respondents were dissatisfied with the water quality, 35 % were satisfied, but 51 % were not sure. Only 19 % stated that they use treated sewer plant water for drinking. The general water supply situation satisfied 60% of those surveyed, with 16 % disagreeing. The water and sewer rates were judged fair by 49.6 % and unfair by 50.4 %. Droughts and floods were considered acts of God by 60.2 % of those surveyed.

II. Ground Water Resources. Flow and Transport*GROUNDWATER PROBLEMS IN THE MID-ATLANTIC FALL LINE CITIES*

Watt, M. H., O'Connor, J.V., and Truong, H.V.
WRRC Report No. 62

DESCRIPTORS: Urban Ground Water Hydrology

In recent years, researchers and managers in the northeastern United States have focused most of their efforts on groundwater problems such as contamination and overdraft. However, little attention has been given to the groundwater regime of the major cities of the Fall Zone. The Fall Zone is a dividing zone between the Piedmont province and the Atlantic Coastal Plain province in the East Coast of the United States. The Fall Zone are referred to as Fall-line cities (e.g., Philadelphia, Wilmington, Baltimore, Washington, and Richmond). There are a number of problems related to groundwater underlying urban areas. These are related to the construction, tunneling, and history of land use activities. The purpose of this project is to develop an understanding of the groundwater situation of the Fall-Line cities. The impact of urbanization as well as institutional problems related to groundwater are discussed. Special emphasis was placed on the study of the District of Columbia's groundwater problems as they relate to construction, tunneling, and other urban activities.

GROUND WATER RESOURCE ASSESSMENT STUDY - BACKGROUND STUDY

Watt, H.M., O'Connor, J.V., Chang, F.M. and Wade, C.W. WRRC Report No. 103

DESCRIPTORS: Ground Water

Ground water is a resource of immense value that is heavily used by people in the United States. This project was conceived to generate baseline data for the protection of ground water in the District of Columbia. The background report provides information on the project itself, the geology and hydrology of Washington, DC, ground water quality in the District, including sources of ground water contamination, and some recommendations for ground water management.

*URBAN LAND USE ACTIVITIES AND THE GROUND WATER: A
BACKGROUND SURVEY OF THE DISTRICT OF COLUMBIA*

Schneider, Jutta; O'Connor, James V.; Chang, Fred M.; Wade,
Clarence W., and Watt, Hamé M.

WRRC Report No. 125

DESCRIPTORS: Ground Water Quality, Ground Water Movement, Ground Water Management, Urban Land Use, Urban Water Systems, Geographic Information System, Pollution Control, District of Columbia

While ground water is not used as a drinking water supply in the District, it is nevertheless necessary to understand the impacts of land use activities on the ground water and to alert citizens *to* the less obvious hazards associated with indiscriminate ground water pollution. The high possibility of contaminated ground water flowing into local streams, basements and construction pits, and the threat *to* the interstate aquifer, prompted this study of D.C.'s ground water and how it is affected by land usage is required. The research focussed on available land use and ground water quality data to identify and locate the common sources of ground water contamination. The main objective was to develop pollution potential maps that will aid in preparing monitoring programs, management plans and regulations for the prevention and control of ground water contamination. The multitude of data required for this project were compiled using a Geographic Information System (GIS). GIS maps were developed for hydrogeologic settings, land use categories, specific urban pollution sources, and voting wards. To determine ground water vulnerability based on hydrogeologic setting, a modified DRASTIC approach was applied. The modifications were necessitated by the limitations of data and software availability. Factors included in the analysis were recharge, depth to water/topography, aquifer media, soil media and vadose zone media. The resulting indices were displayed as a ground water vulnerability map. The probability of ground water contamination varies greatly across the city. The area with the highest pollution potential based on general land use categories is the industrial corridor. However, its location atop an area with low ground water vulnerability makes its impact most likely negligible. Areas with high probability of ground water contamination, i. e. with high ground water vulnerability and high pollution potential, are scattered throughout the downtown area and towards the eastern part of the city. The GIS maps can be used by city planners to establish environmental equity, to inform citizens on the interrelationship between ground water and urban land use activities and to design and implement ground water protection strategies.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC -
WELL INSTALLATION AND FIELD OPERATIONS REPORT (GROUP A WEDS)*

Schneider, Jutta; Atobrah, Kobina; O'Connor, James V., and Watt, Hamé M. WRRC
Report No. 126

DESCRIPTORS: Ground Water, Monitoring Well Installation, Hydrogeologic Setting

Five wells were installed in different hydrogeologic settings throughout the District of Columbia in order to characterize the quality and quantity of the city's ground water. One well was installed in the Piedmont rocks in the western part of the city, two wells were installed in the Coastal Plain Potomac Group aquifer, one well was installed in the river terrace deposits, and one well was installed in the alluvium/artificial fill of the lowest stream terrace. Pumping tests and their subsequent analysis resulted in highly varied transmissivities: the two terrace wells fell dry on pumping at a rate of 0.5 gpm, the bedrock well transmissivity was around 10^2 gpd/ft, and the Potomac Group aquifer transmissivities ranged from 10 to 10^2 gpd/ft in the shallower part near the recharge area to 10^2 to 10^3 gpd/ft in the deeper part east of the Anacostia River.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC - WELL
INSTALLATION AND FIELD OPERATIONS REPORT (GROUP B WELLS)*

Schneider, Jutta; Atobrah, Kobina; O'Connor, James V.; and Watt, Hamé M.
WRRC Report No. 127

DESCRIPTORS: Ground Water, Monitoring Well Installation, Nonpoint Source Pollution

Eight wells were installed in shallow ground water to determine the impact of nonpoint sources (i.e. golf course and community gardens) on ground water quality. Three wells each were installed at two community gardens, with one well upgradient and two wells downgradient. Two wells were installed at a golf course, at downgradient positions from tees and greens. The community gardens are located in the Coastal Plain part of the District, while the golf course is located in the Piedmont part of the District. Pumping tests were conducted to determine transmissivities, which ranged in order of magnitude from 10 to 10^2 gpd/ft at the golf course to 10^2 to 10^3 gpd/ft at the community gardens.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC -
MODELING REPORT*

Schneider, Jutta; Watt, Hamd M., and Pao, H.P.

WRRC Report No. 135

DESCRIPTORS: Ground Water, Modeling, Data Description

The purpose of this GWRAS component was to provide 1) an evaluation of currently available models for ground water flow and solute transport, 2) a delineation of currently available data, and 3) future data needs for the calibration, verification and operation of the selected models.

MODFLOW and MOC, two USGS models, were selected as the most appropriate for ground water modeling in the Coastal Plain portion of the District of Columbia. While general hydraulic and physical data are available for the two Coastal Plain aquifers, i.e. the confined Potomac Group aquifer and the surficial aquifer, the data are not of sufficient accuracy to yield a meaningful model. Compilation of more detailed data from a variety of sources is paramount to the modeling effort. The lack of a data base with respect to water levels, hydraulic conductivities and aquifer thickness precludes ground water modeling at the present time.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC -
SAMPLING AND ANALYSIS REPORT (GROUP A WELLS) PHASE II*

Schneider, Jutta; Montaser, Akbar; and Watt, Hame M.

WRRC Report No. 136

DESCRIPTORS: Ground Water, Water Quality

The purpose of this part of the GWRAS was to determine the concentrations, if any, of 14 pesticides and four herbicides in five wells installed to provide background water quality levels. Two ground water samples were taken at each well in quarterly intervals. Ground water from one of the wells contained Chlordane concentrations of 2 ppm, which is equivalent to the Maximum Contaminant Level established by EPA for that parameter. None of the other pesticides and herbicides were detected.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC -
SAMPLING AND ANALYSIS REPORT (GROUP A WELLS) PHASE III*

Schneider, Jutta; Montaser, Akbar; and Watt, Home M.
WRRC Report No. 137

DESCRIPTORS: Ground Water, Water Quality

The report provides the results of chemical analyses of ground water from five wells installed to provide background water quality levels. Quarterly ground water samples were taken to be analyzed for nine routine and indicator parameters, 25 inorganic parameters, 10 volatiles and 11 semi-volatiles. Also included in the report are the results of Phase II (see WRRC Report No. 136). Except for chloroform, no volatiles or semi volatiles were detected, and chloroform concentrations were well below the Maximum Contaminant Level.

*GROUND WATER RESOURCE ASSESSMENT FOR WASHINGTON, DC -
SAMPLING AND ANALYSIS REPORT (GROUP B WELLS)*

Schneider, Jutta; Montaser, Akbar; and Watt, Hame M.
WRRC Report No. 138

DESCRIPTORS: Ground Water, Water Quality

The purpose of the part of the GWRAS was to determine the levels of 14 pesticides and four herbicides in eight wells installed to evaluate the impact of potential nonpoint sources (golf courses and community gardens) on ground water quality. The pesticides and herbicides were selected based on priority pollutant lists from EPA and the Chesapeake Bay Program. None of the substances were detected during the course of a one-year quarterly analysis.

*CHARACTERIZATION OF THE NON-VOLATILE ORGANIC MATERIAL
DURING PHYSICAL AND CHEMICAL TREATMENT OF THE DISTRICT
OF COLUMBIA RAW WASTEWATER*

Aldridge, M. H.
WRRC Report No. 9

DESCRIPTORS: Waste Water Treatment

A physical-chemical treatment process used in a DC pilot wastewater treatment plant was examined; it consists of low lime clarification system which feeds effluent into two parallel systems: (1) breakpoint chlorination, carbon adsorption, and dual-media filtration, and (2) neutralization, carbon adsorption, and dual-media filtration. The systems were operated and tested for a 1-month period in September 1974. Systems, sampling and sample preparation procedures, separation scheme, analytical techniques, and reagents are described. The major portion of the organic materials in treated and untreated wastewater exists as nonvolatile materials, of which 90 % were classified as ether-insoluble, amphoteric materials. Organic bases represent the least amount of ether-soluble organic material; or more of the ether-soluble material existed as acidic and neutral materials. Following breakpoint chlorination and carbon adsorption, an increase in strong acids was observed; this may have been accompanied by a comparable increase in the volatile chloroform. Fifty percent or more of the nitrogenous organic material in both untreated and treated wastewater may be classified as volatile. The non-volatile nitrogenous organic material existed as ether-insoluble, amphoteric materials. Proteins and amino acids, carbohydrates and hydroxylated aromatic compounds represented about 30 % of the organic materials in the treated and untreated waters. Further study recommendations are included.

COLORIMETRIC ANALYSIS OF AMMONIA IN WATER

Carson, F.W. and Gross, R.L.
WRRC Report No. 11

DESQLWRORS: _____ Water Quality, Ammonia, Chemical Analysis, Methodology

An accurate, reliable method of determining concentration of ammonia in water solution was developed using colorimetric techniques. The procedure involves formation of a colored complex of ammonia with 2, 5-dimethoxyoxolane and (E)-p-dimethylamino-cinnamaldehyde. This intense blue complex has an alpha sub max of 630 nm and an extinction coefficient of 45,200 at a concentration of approximately 2×10^{-5} M. The color forms in about 6 minutes and has a half-life of 7.8 hours. The procedure takes only 3 minutes per analysis for multiple samples and involves a standard error of only 3 %. Also, the method is suitable for automation. The lower limit of ammonia concentration is 10^{-4} M but this could be reduced to 10^{-6} M by increasing cell path to 10 cm and by using a spectrophotometer of 0-0.1 absorbance units.

*THE DISTRIBUTION, TRANSPORT AND CYCLING OF
DISSOLVED PARTICULATE ORGANIC CARBON IN THE POTOMAC AND OTHER RIVERS IN
THE GREATER WASHINGTON AREA*

Champ, M.A. WRRC
Report No. 13

DESCRIPTORS: Organic Carbon, Water Chemistry

This project was undertaken to study the distribution, transport seasonal cycling, and sources of dissolved organic carbon (doc) in the two subjects. (District of Columbia area river), since river of high organic concentrations to levels that can have high BOD and COD values that lower oxygen concentrations to levels that can cause high mortality in aquatic life, DOC and POC concentrations were measured weekly for 17 main channel stations of the Upper Potomac River Estuary, and the distribution, production, transport and cycling of organic carbon were followed over a 12-month period. Special studies were conducted to evaluate the influence of tidal activity, flood storm crests and lateral variation on river DOC and POC levels. Mean DOC and POC levels reflected a seasonal and river mile sigmoid curve. DOC and POC transported annually by the Potomac to its estuary were estimated at 54,000 and 37,000 metric tons, respectively. River DOC did not correlate with discharge, which POC does. DOC and POC levels in street runoff, storm and combined sewer overflows were 4-10 times higher than in Potomac River water.

REMOVAL OF EUTROPHIC NUTRIENTS FROM WASTE WATER AND THEIR BIOCONVERSION TO BACTERIAL SINGLE CELL PROTEIN FOR ANIMAL FEED SUPPLEMENTS. PHASE I

DeCicco, B.T.
WRRC Report No. 14

DESCRIPTORS: Waste Water Treatment, Bioconversion

The hydrogen oxidizing chemolithrophic bacterium *Alcaligenes eutrophus* has been employed for the removal of eutrophic nitrogenous and phosphorus compounds from the final effluent digester elutriate from the Blue Plains WasteWater Treatment Plant.

Average removal levels from final effluent were 98 % for ammonia, 67 % for nitrate, 93 % of TKN, and 84% for total phosphorus. Mixtures of 1 part elutriate to 3 parts effluent yielded 88 % removal of both ammonia and total phosphorus. No pretreatment of elutriate or effluent was necessary to support growth, and sterilization of wastewater samples yielded results similar to unsterile samples, i.e., the chemolithotroph need not be grown in pure culture. A hydrogen oxidizing chemolithotroph different from *A. eutrophus* has been isolated from Blue Plains final effluent and has been classified as a member of the genus *Pseudomonas*.

REMOVAL OF EUTROPHIC NUTRIENTS FROM WASTEWATER AND THEIR BIOCONVERSION TO BACTERIAL SINGLE CELL PROTEIN FOR ANIMAL FEED SUPPLEMENTS. PHASE II

DeCicco, B.T.
WRRC Report No. 15

DESCRIPTORS: Waste Water Treatment, Bioconversion

The bacterium *Alcaligenes eutrophus* was grown in phosphorus supplemented digester elutriate from the Blue Plains WasteWater Treatment Plant using a microbial fermentor. Gaseous hydrogen, oxygen and carbon dioxide were supplied as carbon and energy sources. Ammonia and phosphate removal averaged 87 % and 93 %, respectively, at a time of cell harvest. The cellular biomass was washed, dried, chemically analyzed and employed as the protein component of chick diets. The biochemical composition of the wastewater grown biomass was 8.7 % RNA, 1.3 % DNA, 56 % protein, 3.2 % carbohydrate, and 30.8 % lipid and inert materials.

Chick feeding experiments demonstrated that the bacterial biomass had a protein quality of 88 % compared_ to reference casein. In sterilized samples of sludge: effluent at dilutions of 1:4, 1:8 and 1:20 under a H₂, O₂CO₂ atmosphere, growth of *A. eutrophus* was substantial and was

proportional to the sludge concentration, reaching 8×10 to the ninth power organisms/ml in the 1:4 mixture. When the gas atmosphere was replaced by air, growth was substantially less. Chemical analyses of the treated mixtures showed 89-92 % ammonia removal and 98-99 % phosphate removal from gassed cultures. Cultures incubated under air showed increases in ammonia levels 25.67 % and phosphate reductions of approximately 90 %. The bacterial system employed in these studies appears to be efficient means of removing nitrogenous and phosphorus pollutants from final effluent, digester elutriate and undigested sludge resulting from wastewater treatment. The bacterial biomass produced during elutriate treatment appears to possess high nutritive value as a protein source for chick feed.

*REMOVAL of EUTROPHIC NUTRIENTS FROM WASTEWATER AND THEIR
BACTERIAL SINGLE CELL PROTEIN FOR ANIMAL FEED SUPPLEMENTS.
PHASE III*

DeCicco, B.T. WRRC
Report No. 16

Descriptors: Waste Water Treatment, Bioconversion

We previously have demonstrated that the bacterium *Alcaligenes eutrophus* is an efficient and effective remover of nitrogenous and phosphorus compounds from municipal wastewater. Further, the biomass generated from growth on wastewater proved to be a source of high quality protein for the growth of chickens. During this phase a quantity of biomass grown in the fermentor on digester elutriate was treated with a variety of conditions in order to find those which promoted cellular aggregation since this would allow easier separation of cellular biomass from the treated wastewaters. Two treatments produced sedimentation of the cells; either addition of alkali to pH 11 or the addition of an anionic exchange resin (Cells D) produced aggregation of the biomass and clarification of the wastewaters. Elutriate samples that were unheated and then inoculated with *A. eutrophus* yielded little growth, while samples heated to 50 to 70 deg. C produced cell densities that were 74% and 94% respectively, as high as a sample sterilized by autoclaving. Thus a heat labile inhibitor of *A. eutrophus* was present in elutriate. Samples of digester elutriate, secondary digested sludge and primary undigested sludge were analyzed for the presence of mutagenic substances using the Ames Salmonella mutagenicity test. Samples were assayed both with and without metabolic activation with rat liver S-9 mix. Tests were negative with all samples and bacterial strains with the possible exception of the marginally positive response with both sludge and elutriate samples with strain TA 1537.

USE OF *ENZYMATIC CYCLING FOR HIGH SPECIFICITY AND SENSITIVITY IN THE
COLORIMETRIC ANALYSIS OF
AMMONIA*

Carson, F.W. and Davies, H.E.
WRRC Report No. 18

DESCRIPTORS: Water Chemistry, Ammonia, Chemical Analysis, Methodology

A new method was developed for the determination of ammonium ion concentration in water in the range of 0.0001-0.00001 molar, based upon enzymatic cycling. The sensitivity of the method could be extended well below the ten nanomoles/sample limit of determination, using suitable modifications of the procedure. This two-steps method involved the use of an ammoniaspecific glutamate dehydrogenase enzyme reaction with simultaneous oxidation NADH; followed by an enzymatic cycling reaction to measure oxidized NADH by means of measuring the cycling reaction product, a tetrazolium formozan, in the visible at 600nm. Using the procedure, linear plots of absorbance versus original ammonium ion concentration had correlation coefficients of 0.007-0.9998. The precision (coefficient of variation) of the method on replicate analyses of samples containing 0.0000441 molar ammonium ion was 2%. A calibration curve for the determination of unknown ammonium concentrations could be constructed from standard solutions carried through the procedure. Analysis time per sample was three hours, and all solutions were stable for at least two weeks.

*ANALYSIS OF INORGANIC ANIONS IN THE POTOMAC WATER SEDIMENT AND FLOC
BY ION CHROMATOGRAPHY*

Girard, J.E. WRRC
Report No. 37

DESCRIPTORS: Water Chemistry, Inorganics, Chemical Analysis, Methodology

Recent reports by the author have shown non suppressed ion chromatography, which uses conventional high pressure liquid chromatography (HPLC) instrumentation, to be a low cost analytical technique *for* the analysis of inorganic anions. A Varian model 5000 HPLC was coupled with a Wescan Conductivity Detector. All separations were achieved on a Vydac 302 IC Column at a controlled temperature of 30C. This system is designed to work without a suppressor column. Very efficient separations of anions such as Cl super -, NO sub 3 super, and SO sub 4 super-2 are easily achieved with this system. The sensitivity we have observed *for* Cl super-ions (0.5 PPM) is comparable to conventional suppressed IC method. Linearity is very good over a wide concentration range. By changing the eluting species, its concentration

or the pH, improved sensitivity, chromatographic efficiency, selectivity and resolution may be achieved. This technique has been successfully applied to the analysis of municipal water samples from Howard, Baltimore and Montgomery Counties in Maryland as well as the District of -Columbia. Samples of Potomac River water taken at the Chesapeake Bay/Potomac River interface are usually very difficult to analyze, since there is a small amount (10-15 PPM) of Chloride ion. Potomac River samples were also successfully analyzed.

*DETERMINATION OF NITRITE AND NITRATE IN WATER BY REDUCTION TO
AMMONIA FOLLOWED BY ENZYMATIC CYCLING*

Carson, F.W. and Rogers, P.L.
WRRC Report No. 42

DESCRBTORS: ___Water Chemistry, Nitrate, Nitrite, Chemical Analysis, Methodology

A procedure has been developed to determine the concentration of biologically significant nitrogen present as ammonia, nitrite and nitrate in water samples colorimetrically. In addition, the concentration of each of these constituents may be determined separately if desired. The method is sensitive and subject to the interferences commonly encountered in nitrate determinations. It involves the reduction of nitrite and/or nitrate to ammonia with Devarda's metal while simultaneously trapping the released gaseous ammonia. with dilute hydrochloric acid solution in a modified Conway diffusion cell. Subsequently, the ammonia is determined using the enzymatic cycling assay previously developed by Carson and Davies. Standard solutions of ammonium chloride must be carried through the procedure to prepare a standard curve from which unknown concentrations of nitrate may be determined. Using the established procedure, plots of absorbance change at 600nm versus original nitrate concentration were linear, with correlation coefficients ranging from 0.91 to 0.999. A series of replicate measurements had a coefficient of variation of 3 % for samples containing 2.70×10^{-5} M nitrate ion when compared to such a standard curve.

*ARTIFACTS AND LOSSES IN THE SAMPLING OF CHLORINATED
WATER BY XAD ADSORPTION*

Cheh, A.M. WRRC
Report No. 45

DESCRIPTORS: Water Chemistry, Chemical Analysis, Chlorination, Methodology

Chlorination of natural waters mutagens that most likely are electrophiles. These electrophiles are often recovered for testing and analysis by adsorption to XAD resins. It was found that the production of artifacts stemming from the action of free chlorine on XAD-4 resin could be suppressed at least ten fold by converting the free chlorine to chloramine. Kinetic studies indicate that free chlorine is consumed at least ten times as rapidly by XAD-4 as in chloramine. Sampling losses during XAD recovery of electrophiles and mutagens were also examined. Mutagenic activity bound to resins generally decreased over a period of several days, but some increase was seen. Electrophiles labeled by 4-nitrothiophenol generally decreased concurrently, but sometimes new species were seen. Organic concentrates in DMSO. Simultaneous electrophile assays, however, indicated up to 50 % loss of some electrophiles present in ethanol concentrates.

THE FATE OF ANTIFOULANT ORGANOTIN COMPOUNDS IN WATER SYSTEMS

Posey, I. and Eng, G.
WRRC Report No. 46

DESCRIPTORS: Water Quality

Several antifoulant organotin compounds were leached by suspending them in distilled water and mechanically for periods up to two weeks at room temperature. Benzene or chloroform extracts of these aqueous solutions were evaporated to dryness and the infrared spectra of the resulting residues were obtained.

Except for the residue resulting from the extract of aqueous pH 3 SnOCOCH₃, the infrared spectrum of each residue was identical to that of the starting organotin compound. The infrared spectrum of the residue obtained from the chloroform extract of the aqueous pH 3 SnOCOCH₃ which had been shaken for seven days showed the presence of pH 3 SnOH as confirmed by the presence of a small doublet around 910 and 897 cm⁻¹. The pH measurements on the aqueous solutions of these organotin compounds showed a decrease in pH with time. These results are perhaps indicative of an ionization of the organotin compounds in

water. TLC experiments using various developing solvents did not allow for the resolution of mixtures of pH sub 3 SnCl, pH sub 3 SnCl and pH sub 3 SnOCOCH sub 3; therefore, TLC was not feasible for use in this study.

TRihalomethane Removal and Formation Mechanism in Water

Chawla, R.C. WRRC

Report No. 48

DESCRIPTORS: Water Quality

Tribalomethane (T1DVt) formation kinetics and removal by Granulated and Activated Carbon (GAC) were studied. The formation studies showed that about 90 % of the total trihalomethanes (ITIDP formed is chloroform and the other 10 % included the remaining three (TTIM's namely CHCl sub 2 Br, ChBr sub 2 Cl and ChBr sub 3). The T= formation rate decreases with time and the formation potential of TTHIVI increases nonlinearly with the chlorine dosage. Over a wide range of solids (precursor) concentrations (15-150 mg/l), the mechanism of THM formation appears to remain unchanged. Similar results were also observed for chlorine concentration over a range 2-15 mg/l. A simple kinetic model was applied to the data and a reaction order of 0.3 was calculated for chlorine concentration in the THM formation rate. THM removal was studied using both batch data and continuous methods, Freundlich adsorption Isotherms fit the batch data very well. 86-97 % removal of THM was observed over a period of 1-8 days. In continuous methods, *the %* removal dropped significantly when carbon dose was reduced. The removal efficiencies were generally much lower for continuous method than for batch method.

CONCENTRATIONS of ORGANIC PHOSPHATE, NITROGEN, AND CARBON IN STORM RUNOFF AND COMBINED SEWERS IN THE GREATER WASHINGTON DC AREA

Champ, M.A. WRRC

Report No. 54

DESCRIPTORS: Storm Runoff, Combined Sewers, Water Quality

Concentrations of organic phosphate, nitrogen, and carbon have been determined in storm and combined sewers, sanitary sewers, street runoff, shopping center parking lot runoff, residential and industrial areas, and Rock Creek to determine their range of variation and relative magnitude. - Combined sewers exhibit tremendous variation in organic carbon, and nitrogen

concentrations. Estimates of the nutrient loads by major sources (storm sewers, combined sewers overflows, etc.) to the Upper Potomac River Estuary for 1977 indicate that during a low flow year, combined sewer overflow contributes an insignificant amount of phosphate, nitrogen and carbon. However, during the same period the storm sewer runoff did contribute high loads of carbon and was a minor source of nitrogen.

*ASSESSMENT OF THE IMPACT OF NON-POINT SOURCE POLLUTANTS ON THE
URBAN PORTION OF THE ANACOSTIA RIVER*

Watt, M.H., and Barikari, T.J.
WRRC Report No. 76

DESCRIPTORS: Nonpoint Source Pollution, Urban Runoff, Water Quality

Pollutants loads originating from non-point sources, in the estuarine portion of the Anacostia River located in the District of Columbia were evaluated. The non-point sources were identified according to the dominant form land usage in a given area. For the urban setting under consideration, these included residential areas with detached and semidetached dwellings, flats, garden apartment complexes, commercial establishments, parks and open spaces, parking and vacant lots, and construction sites. The AMUWQ simulation model was then used for analysis of the different pollutant constituents as well as their stream impacts. The uncontrolled annual pollutant constituent loads for sediment, lead, zinc, phosphorous, nitrogen as well as the BOD were evaluated for each type of land usage. A functional relationship between land usage and the various fractions constituting the pollutant was determined. From the projected future land use, an estimate of the rate of change of each fraction of pollutant with time was obtained. It is estimated that by year 2000 sediment and nitrogen will decrease by 10% and 1.6% respectively, while BOD increases by 21 %, phosphorous by 0.63 %, lead by 4.5 % and zinc by 3.3 %. It was determined that the present levels of pollution in the area of study has generally had an adverse effect on the environment.

*DETERMINATION OF SPECIATION OF TRIBUTYL TIN COMPOUNDS IN WATER AND
SEDIMENTS USING MOSSBAUER SPECTROSCOPY*

Eng, G. and May, L.
WRRC Report No. 79

DESCRIPTORS: Water Chemistry, Chemical Analysis, Methodology

It was found previously that when tributyltin (TBT) acetate and chloride were dissolved in water (sea) or treated with aerobic sediment, they did not react (Eng, Bathersfield and May, *Water, Air, Soil Pollution* 57, 191 (1986)). However, in aerobic sediments, they were converted to hydroxide. TBTO was converted to hydroxide in seawater and aerobic sediment, but in anaerobic sediment it was not. The identity of the product was one objective of this project. An examination of the Mossbauer spectra of several possible products, including TBTS, TBTS04, and TBTC03, revealed that none of these had the same parameters that were not in the spectrum of the treated sediment. It is possible that the spectrum of one of these compounds, in aerobic sediments may be found to be the same as TBTO in this same medium.

Another objective was to determine the effect of light on the speciation of TBT compounds in sediments. The results of the initial experiments suggested that there was no effect. A reexamination of the experiment revealed some difficulties with the design of the experiment. The measure of the speciation of TBT compounds that are found in anti-fouling paints that were not previously examined continues, for example. TBT methacrylate.

*IMPACT OF EROSION AND SEDIMENTATION ON THE WATER QUALITY
OF THE ANACOSTIA RIVER*

Chang, FM., Watt, M.H., Sreenivas, V. WRRC
Report No. 81

DESCRIPTORS: Water Quality, Urban Runoff, Sedimentation, Erosion

Increased urbanization in the Anacostia River basin over *the* past number of years has brought an increase in erosion not only from the land surface but also from the main channel. The excess eroded sediments are transported and deposited along the various areas where the sediments concentrations exceed the carrying capacity of the flow channel. As sediments deposits become more serious, dredging is required since these sediments deposits degrade the channel bed slope, increase flood potential along the lower basin, and result in environmental and water pollution by absorbing bacteria, viruses hazardous to fish and other sensitive

organisms which also pose a threat to humans. Hence, to determine and assess the sources of these pollutants and to develop monitoring programs, it is essential to predict the rate of sediment deposition on the river bed, variations in stages with velocity discharge an area of cross section along the main channel.

*MEASUREMENT OF 4-NONYLPHENOL IN WATER AND WASTEWATER
EFFLUENT*

Varma, M. WRRC

Report No. 91

DESCRIPTORS: Water Quality, Chemical Analysis, Methodology

Municipal sludges and wastewater effluents are contaminated by a wide variety of toxicants ranging from heavy metals, microbiological pathogens to complex organic substances. Chemical compounds of health concern are generated during treatment processes because many synthetic compounds are of exotic nature and are not biodegradable. These residual chemicals, along with pathogenic organisms, pollute the receiving waters.

Many organic substances have been tested for mutagens and teratogenic effects in vitro and in vivo. However, such studies are rather limited. For our purpose, the most promising instrument was the Gas Chromatograph Mass (GC/MS).

The results of this study will help in the maintenance of effluent water quality standards as applicable to industry discharges permit.

The analytical procedure for measuring nonylphenol will be standardized and municipalities will be able to elaborate and estimate treatment methodologies for removal of the 4-nonylphenol. A comprehensive understanding of the carcinogenic quality of wastewater and sludge by 4nonylphenol will be gained.

*SPECIATION OF TRIBUTYLIN COMPOUNDS IN WATER AND SEDIMENTS
USING MOESSBAUER SPECTROSCOPY*

May, Leopold and Eng, George
WRRC Report No. 96

DESCRIPTORS: Tributylin, Speciation, Sediment, Water Pollution, Moessbauer Spectroscopy

The overall objective of this research program was to investigate, using Moessbauer spectroscopy, the tin species that are produced in seawater, and anaerobic and aerobic sediments due to the leaching of tributyltin (TBT) compounds used in marine paints. The TBT compounds were treated with both seawater and sediment from the Anacostia River, Baltimore Harbor and the Chesapeake Bay. The mixtures were then shaken for at least a week in a closed vessel at room temperature. The sediment was separated from the supernatant by infiltration just prior to obtaining the Moessbauer spectrum, which was measured at 80K on the Moessbauer spectrometer in acceleration mode with distilled water and seawater. The resultant solutions were extracted with chloroform to remove the TBT compounds.

It was initially found that TBT in anaerobic sediments was converted to an unidentified product. To identify this product, Moessbauer spectra of several possible products were examined, but none of the spectra matched the one obtained from the treated sediment. To clarify differences with another study, an investigation of the potential impact of eH variations was also conducted. The different parameters found in the spectra in the different anaerobic sediments were not, however, related to the ehs of the sediments.

*AN ION CHROMATOGRAPHY FIELD METHOD FOR THE DETERMINATION
OF DISSOLVED METALS*

Girard, J. E., Tian, L. and Morrison, J.F.
WRRC Report No. 97

DESCRIPTORS: Municipal Water, Lead, Cadmium, Zinc, Pipeline, Ion Chromatography, Water Quality, Water Supply

The objective of this research was to develop and evaluate a field method capable of rapid on-site detection of ppb levels of lead, cadmium and zinc in water supplies, thereby addressing the problem of metal contamination of municipal water supplies resulting from

pipeline deterioration. Ion chromatography (IC) was investigated as a possible field method due to its compact, portable and rugged instrumentation, the sensitivity of the method, and undemanding, if any, sample preparation.

Using an approach introduced by Cassidy and Elchuck (1982), the analytes consisted of mixed standards and real water samples. Graphite furnace atomic absorption was used to confirm the metal concentrations in the samples.

Separation was achieved in under 11 minutes. Sensitivity and linearity were excellent for lead down to 10 ppb (EPA standard 50 ppb) and for zinc down to 5 ppb. Although it appears that cadmium is detectable down to 10 ppb, the results of the cadmium analysis did not afford acceptable reproducibility. Although these results seem promising, the analysis of real water samples presented problems due to interference of other ions which co-elute with the ions of interest, specifically lead. Further research is needed to identify the interfering ions and to further optimize separation. Sensitivity and reproducibility of the method were dependent upon the freshness of the PAR reagent and eluent, as well as the condition of the post-column fiber. Fluent and PAR had to be prepared almost daily in order to ensure a sufficiently "clean" chromatographic baseline. When a new fiber was installed, it took up to several hours a day to reach a new equilibrium. In conclusion, the IC technique, while promising, is unsuitable for field implementation at its present stage.

BACKGROUND REPORT ON LEAD IN DRINKING WATER - WASHINGTON, DC

Ocran_y Kwamena
WRRC Report No. 120

DESCRIPTORS: Lead, Drinking Water Quality

Lead poisoning remains the most common and devastating environmental disease of young children. The report is aimed at providing background information on lead in drinking water, its detection, and measures to reduce or eliminate lead in drinking water. The report summarizes the health hazards of exposure to lead, the sources and pathways of lead exposure, and shows EPA's recommendations for determining lead occurrence in plumbing profiles.

*DRY WEATHER FIELD SCREENING OF STORMWATER
OUTFALLS IN THE DISTRICT OF COLUMBIA*

Wade, C., Chang, F.M., Preer, J.
WRRC Report No. 121

DESCRIPTORS: Stormwater, Water Quality

To assess the impact of stormwater on surface water quality, 148 stormwater outfalls of 36" diameter or greater, located throughout the District of Columbia, were sampled during this study. The sampling and analysis of the water was conducted in accordance with EPA recommended methods. Samples were taken from flowing water in accessible stormwater outfalls or in contiguous manholes where outfalls were submerged. Samples were collected 72 hours after rainfall of 0.1 " or greater. Two grab samples were taken at each site, each within 24 hours of each other but at least 4 hours apart. Quantitative analyses were made for flow rate, pH, copper, fluoride, surfactants (detergents), phenols, and free chlorine. Qualitative analyses included color, odor, clarity and floatables. Details of vegetation growth and outfall conditions, such as structural defects, stains, and deposits, were also collected at each outfall. Concentrations for fluoride ranged from 0 to 1.2 ppm, for chlorine from 0 to 0.9 ppm, for copper from 0 to 0.15 ppm, for surfactants from 0.1 to 1.7 ppm, and for phenols from < 0.1 to 8.4 ppm. Measured flow rates varied between no flow and 1.35 cfs, and pH values fluctuated between 6.4 and 8.4.

IV. Biological SciencesSURVEY, ECOLOGY AND SYSTEMATICS OF THE UPPER POTOMAC ESTUARY BIOTA:
AUFWUCHS MICROFAUNA - PHASE ISpoon, D.M. WRRC
Report No. 6

Descriptors: Microfauna, Estuary

The aufwuchs microfauna was collected on inverted plastic petri dishes (Spoon & Burbank, 1967) supported by floats composed of styrofoam cup sections. These floats tethered to midstream buoys were colonized at one-month intervals at sites 3-1/2 miles apart, one below the outfall of the Blue Plains sewage treatment plant, and two downriver and two upriver from Blue Plains. Special effort was made to include all protozoan and micrometazoan species in the count. Their abundance was converted to numbers from one to seven representing rarity to super abundance. The species list is over 300. Physical-chemical data of the principal investigator is presented with the extensive E.P.A. data for these five collection sites. The biotic and abiotic data for 1974 was compared to similar data collected in 1971. The abiotic data showed a substantial improvement with increase in dissolved oxygen, decrease in turbidity, phosphorus and nitrogenous compounds and organic carbon. The 1974 microfauna showed a doubling in species number of protozoa and micrometazoa. Extensive study was made of the food web of the aufwuchs community using studies of isolated cultures, aquaria, and experimental rivers. It is concluded that predator pressure is a principal force determining aufwuchs species diversity and population numbers.

SURVEY, ECOLOGY, AND SYSTEMATICS OF THE UPPER POTOMAC ESTUARY BIOTA:
AUFWUCHS MICROFAUNA. PHASE IISpoon, D.M. WRRC
Report No. 8

DEscRuq°ORs: _____ Microfauna, Estuary

Two model rivers, representing Potomac River sites at Haines Point, Blue Plains Sewage Treatment Plant, Rock Creek, and Piscataway Creek connected to a common reservoir containing upriver water, were studied. Each model consisted of flour 24-gallon aquaria. In one model at aquarium 2 frozen sewage was added. Four attempts made to duplicate the

May 1974 fishkill, which took place when the river to sewage flow ratio was 20:1, failed; negative results were obtained with aquaria conditions representing river to sewage flow ratios of 20:1, 5:1, 1:1, and 4:4. It was concluded that the fishkill was caused by a toxin in the sewage and not a heat shock or toxin in the river. Dissolved oxygen sag curves in the river model closely approximated those at Potomac River sites at the same temperature. Other studies were done on a 50,000 gallon pilot activated sludge plant before and after hydrogen peroxide treatment of a bulking condition. A new method for counting and studying the activated sludge community was devised using thin plastic film (handiwrap) coverslips with plastic slides. It was concluded that the protozoan community was little affected by the treatment. The oxygen-included fragmenting of the filamentous bacteria allowed acanthamoeba to feed. Using tritiated thymidine, a food chain from bacteria to Spirostomum to the Ostracod Cypridopsis was confirmed. Capitata and a list of protozoan and micrometazoan species cultured in the laboratory is provided.

URBAN AQUACULTURE OF THE RAINBOW TROUT

(SALMO GAIRDERI)

James, A.J. WRRC

Report No. 29

DESCRIPTORS: Aquaculture, Rainbow Trout

The raising of the rainbow trout (*Salmo Gairderi*) in a closed recycling water system in an urban environment is described. Germ-free fingerling trout were raised on a controlled diet over a period of nine (9) months in specially constructed, refrigerated aquaria maintained at 10C and 15C. The results show that this trout adapts well to the environment provided for it and increases in weight and length comparable to or at a more accelerated rate than those raised by conventional fish-farming methods.

Rainbow trout raised at 10C have a somewhat slower rate of growth than those raised at 15C. Oxygen concentrations, temperature, and bacterial counts were constantly monitored. This process, with slight modifications, could be used to launch a commercial venture in the urban aquaculture of the rainbow trout.

*PHOTOSYNTHETIC PIGMENTS AS INDICATORS OF ALGAL
ACTIVITY IN THE UPPER POTOMAC ESTUARY*

Sze, P.

WRRC Report No. 30

DESCRIPTORS: Algae, Estuary, Indicator Parameter

The Potomac River was monitored at Key Bridge from May-September 1981. Temperature, major nutrients, photosynthetic pigments, abundance of major groups of photoplankton (direct counts), and potential photosynthetic production (oxygen method) were measured weekly in surface samples collected near mid river. Chlorophyll A showed the same general trends as the cell counts and production with greatest algal activity in late May and August and a minimum in /june. Centric diatoms and chlorococcalean green algae were the major algae in 1981, as in previous years. The accessory pigments were relatively insensitive measures of algal composition. Overall, the activity of photoplankton did not show any significance from previous years, and there was no evidence for prolonged nutrient depletion as a result of algal activity in the river.

*SURVEY, ECOLOGY, AND SYSTEMATICS OF THE UPPER POTOMAC
ESTUARY BIOTA: AUFWUCHS MICROFAUNA. PHASE III*

Spoon, D.M.

WRRC Report No.39

DESCRIPTORS: Microfauna, Estuary

These studies utilized two adjacent bench scale rivers, each composed of four interconnected 24-gallon aquaria, stimulating summer flow and temperature (30 degrees C) of the fresh water estuarine Potomac River from Haines Point to Piscataway Creek. Initially all eight aquaria were seeded with the filamentous blue-green alga, Anabaena. To all aquaria. was added a mixture of Daphnia, Copepods, and Ostracods from a swamp near Little Falls. The experimental side received activated sludge from the Blue Plains Sewage Treatment Plant, while the control received dechlorinated tap water. Temperature, D.O., pH, phosphate, nitrate and transmittance were determined. In experiment I, we obtained a pronounced algal bloom on the experimental side over the ten day run with reduction of zooplankters and their grazing. In experiment II, with sewage added to both sides, we used a heat shock of 10 degrees C in a bypass simulating the conventional power plant on the experimental side causing decreased zooplankters and increased algal growth.

*THE EFFECTS OF AUFWUCHS COPPER ON SPAT
SETTLEMENT OF THE OYSTER, CRASSOSTREA VIRGINIA*

Phelps, H.L. WRRC
Report No. 47

DESCRIPTORS: Oyster, Ecology, Aufwuchs copper

Studies on the recent failure of oyster spatfall in the Chesapeake Bay have led to speculation of an unknown toxic factor at the setting site. Oyster larvae set on oyster shell surfaces normally covered with aufwuchs which may have the capacity to bind toxic metals such as copper. Over 200 oysters were collected from six mid-Chesapeake Bay sites paired for high and low spatfall. Aufwuchs samples and oyster tissue analysis indicated no significant difference in copper concentrations between paired sites. In the laboratory, aufwuchs concentrated copper from enriched estuarine water up to 20 times ambient levels in one hour, failed to depurate copper over two hours, unlike agar (a neutral polysaccharide). Oyster larvae raised to setting stage from a single maternal spawn were exposed to copper-enriched aufwuchs surfaces. The number of larvae setting on aufwuchs surface vs clean (inner shell) surface decreased significantly with increasing copper in aufwuchs above 100 ug Cu/gm wet weight. Failure of larval metamorphosis ranged from 0 % (5 ug Cu/gm) but was significant only above 100 ug/gm. Since Mid-Bay aufwuchs samples average 35.5 ug/gm, ranging up to 103 ug/gm, it is unlikely that present levels are affecting oyster spatfall.

ENZYMOLGY OF HYDRILLA

Blackman, D.
WRRC Report No. 82

DESCRIPTORS: Hydrilla, Enzymology

Hydrilla Verticillata continues to pose major problems to the waterways in the Washington, D.C. area. The aim of this project is to provide preliminary biochemical data on a number of enzymes of hydrilla. The effects of freeze-thaw cycles on enzyme stability were investigated in order to avoid problems associated with storage-related lability of specimens. Variations in enzyme activities as a function of time over the course of the growth were studied. Hydrilla samples were collected manually at the Belle Haven Marina in Alexandria, VA, and were extracted according to a standard protocol. Most enzymes were assayed in coupled procedures involving production or utilization of nicotinamide coenzymes. Spectrophotometric data were plotted and analyzed on an Apple 2e microcomputer.

Hexokinase and malate dehydrogenase seem relatively insensitive to freeze-thaw damage, while aspartate transaminase is quite labile. Addition of glycerol does not appear to offer significant protection. Month-to-month variations in enzyme activity were investigated by assaying enzymes from the five collection dates. Activities of hexokinase, malate dehydrogenase, and aspartate trans aminase did not appear to vary significantly between June and October.

ACTIVATORS AND INHIBITORS of HYDRILLA ENZYMES

Blackman, D. WRRC
Report No. 90

DESCRIPTORS: Hydrilla

This project involves a determination of the fundamental kinetic properties of several enzymes of *Hydrilla Verticillata* and an examination of the effects on enzyme activities of concentrates of water indigenous to the hydrilla environment.

Hydrilla specimens were manually collected at the Belle Haven Marina in Alexandria, VA, and were extracted according to a standardized procedure developed in this laboratory. A redissolved and dialyzed 75 °lo ammonium sulfate precipitate was routinely used for enzyme assays. As part of each field trip for collection of hydrilla specimens, approximately 2 liters of water surrounding the harvested plants were also collected. These samples were concentrated to approximately 2.5 % of their original volume and were routinely referred to as "Hydrilla Water."

Several enzymes, e.g., malate dehydrogenase, aspartate transaminase, and hexokinase were assayed in coupled procedures involving production or utilization of nicotinamide coenzymes. While others, such as tyrosinase and beta-galactosidase, required more specialized assay systems. In all cases data were collected both in the presence and absence of added "Hydrilla Water". Spectrophotometric data were plotted and analyzed on an Apple 2e microcomputer.

ANACOSTIA RIVER *SEDIMENT TOXICITY: LOCALIZATION AND CHARACTERIZATION
USING A CURRICULA LARVA BIO-ASSAY*

Phelps, Harriette L.
WRRC Report No. 99

DESCRIPTORS: Bio-Monitoring, Sediment, Toxicity, Sedimentation, Clams

Mature clams with larvae for the sediment bio-assays were collected at the beginning of the clam spring spawning season along eleven sites at the Anacostia River. Control sediment was collected at Rosier Bluff on the Potomac River. Fresh sediment from each site was tested in triplicate with about 30 larvae per bio-assay. The simultaneous controls (Rosier Bluff) for water and sediment had similar average mortalities of 18 % and 22 % respectively. All Anacostia samples caused higher mortality of clam larvae, ranging up to 87 % at one hot spot. Except for that location, upstream sediments appear to have decreasing toxicity.

*THE ANACOSTIA RIVER: ECOLOGICAL STUDIES of RIVER POLLUTION
BIOLOGY*

Guerrero, Victoria
WRRC Report No. 100

DESCRIPTORS: Ecology, Anacostia, Pollution Biology, Water Quality, Water Resources, Plankton, Benthos, Contaminants, Sedimentation

To assess the water quality of the urbanized section of the Anacostia River, the biological, physical and chemical characteristics of the river were examined. Since organisms have varying tolerance to the degradation of their habitat, emphasis was placed on the biotic community as indicators of water quality. Nine stations were established to survey the ecology and water quality of the Anacostia River from August 1989 to July 1990. The collecting stations were located close to drainage outlets of either combined or separate storm sewers. The count of pollution-tolerant species in the river was high, but plankton diversity was low. This low diversity could be the result of the combined effects of water run-off, high concentrations and variations of hardness, chemical constituents, sedimentation and siltation and anthropogenic activities. The examination of plankton and benthos communities provided a better understanding of the river's condition. Species presence and dominance were influenced by controlling factors such as pH, nutrients, temperature, light, DO, water current, and conductivity. The river is constantly threatened by eutrophication and the resulting decline of the plankton, benthos and fish communities.

V. Engineering

*AN ASSESSMENT OF THE USE OF POTOMAC ESTUARY WATER AND A WT EFFLUENTS
FOR EMERGENCY WATER SUPPLY*

Young, G.K. and Palange, R.C. WRRC Report No. 1

DESCRIPTORS: Water Supply, Estuary

The Washington, DC area is experiencing resistance from public and private sectors to the continued development of upland dams to supply future metropolitan water needs. A result of this resistance is a heightened interest in the exploration of alternatives, one of which is direct or indirect reuse including the use of the Potomac estuary.

The purpose of this report is to study and evaluate the reuse of treated wastewater and of estuarine waters for domestic consumption. It is found that professional and lay opinion would generally weigh against direct reuse of wastewaters regardless of the adequacy of measurement and treatment practices. Furthermore, only one significant instance of direct reuse is discussed in the literature. Indirect reuse, such as pumping raw waters from the Potomac estuary, is practiced elsewhere and appears to be feasible for Washington.

The report presents guidelines for establishing criteria for safeguards in reusing estuary waters. Unit viral and bacterial measurement techniques are improved, physical-chemical monitoring is suggested for use in decisions concerning operating criteria. Such would include: free chlorination, turbidity control, ammonia monitoring, pH adjustment, and high energy mixing at the point of chlorination followed by high contact time. Other specific concerns are addressed, such as acute and chronic toxicity, storm water overflows, and public relations.

FEASIBILITY OF ALUM SLUDGE RECLAMATION

Goldman, M. L. and Watson, F. WRRC Report No. 5

DESCRIPTORS: Waste Water, Sludge

A study has been performed in which 96% sulfuric acid was added to sludge from Dalecarlia Water Treatment Plant. Aluminum was recovered and used for phosphorus removal from the preliminary effluent from Blue Plains Wastewater Treatment Plant. Alum sludge properties were measured and aluminum recovery determined therefrom as a function of pH amount of acid added. Optimal conditions for flocculation were determined with respect to flocculent pH, mixing speed, contact time, and Al molar ratio. Settleability and filterability of acidified alum sludge were observed as well as effluent quality after flocculation. An indication of technical and economic feasibility of alum sludge recycling is presented, as well as recommendations for additional study.

URBAN PLANNING CRITERIA FOR NONPOINT SOURCE WATER POLLUTION CONTROL

Young, G.S. and Danner, D.L.
WRRC Report No. 35

DESCRIPTORS: Urban Runoff, Nonpoint Source Pollution, Water Quality Control, Modeling

The research described in this document couples urban storm runoff quality and control alternatives within the context of an urban sewage system to evaluate various combinations of alternatives through their pollution removal efficiencies and their costs. A model has been developed which simulates the response of a typical urban area to a time series of rainfall events, and which uses the District of Columbia as an example.

The modeling of the flow of runoff and sewage has been performed at a macro level; the control alternatives examined include in-line storage, sewer separation, street sweeping, sewer flushing, stormwater detention, and increased treatment capacity. Each pollution abatement measure is described with a pollution function. The stimulation model with its associated decision criterion was validated against actual water quality data for Washington, D. C. The model demonstrates that a macro approach to cost/benefit analysis of non-point source water pollution can evaluate control tradeoffs in terms of costs or in terms of abatement effectiveness. The importance of the developed methodology is that it provides an

accurate estimate of urban pollution loads, pollution control capabilities, and control costs without requiring complex graphical techniques or large explicit simulations. The user is not required to supply any technical or specialized information to run the model; the only inputs to the model are readily available physical characteristics of the urban area.

URBAN STORMWATER CLEARINGHOUSE

Watt, Hamé M. and Mohammed Y. Mohammed
WRRC Report No. 128

DESCRIPTORS: Stormwater, Data Management, Clearinghouse,

The objective of the Clearinghouse is to disseminate technical and non-technical information related to stormwater and sediment control practices in local jurisdictions (D. C, VA, MD, PA) having a bearing on regional development. As such, the Clearinghouse will collect, organize and make available to interested groups information on:

- Local rules and regulations governing urban stormwater and sediment control
- Construction techniques and standards specified by local rules and regulations stormwater management and sediment control
- Best practicable emerging technology used in stormwater and sediment control
- Activities related to Chesapeake Bay rehabilitation and management
- Provide expert advice and know-how on engineering and design of stormwater management and sediment control

VI. Climate and Hydrologic Processes**PERSISTENCE MODELING FOR THE POTOMAC AND
ADJACENT RIVERS**

Young, G. K. and Jettmar, R. U.
WRRC Report No. 12

DESCRIPTORS: Drought, Modeling, Monte Carlo method

Case study of three rivers is used to analyze a persistence modeling strategy for the generation of synthetic stream flows for drought assessment probabilities and confidence levels. The Predominantly unregulated river sites used in the study are the Patuxent River near Unity, Maryland, the Potomac River at Point Rocks, Maryland, and the Rappahannock River near Fredericksburg, Virginia. In an effort to improve the use of Monte Carlo models to produce drought characteristics from synthetic data, the strategy employed for the study uses the least squares to fit theoretic autocorrelation functions to empiric functions. The model is designed to aid in critical period analysis in the designing of reservoirs to meet water requirements by solving the major problems of previous models, having a historic critical period or drought of greater severity than can be captured by the model. A key assumption of the modeling method used is that normalized monthly data are stationary. Flow analysis is discussed and illustrated with a chart. Two types of drought phenomena can be defined from the critical period analysis of historic streamflow, (1) short term drought (extreme low flow for six to eight months), and (2) long term drought (lower than historic yearly average flow for three to five years). Graphs of critical flows are given for the three cases studied. Results show that the least squares method produces lower errors, that all methods produce errors of about 10 % or less for critical periods of over three years, and for short drought's all methods produced errors of 10%.

RIVER BASIN MANAGEMENT: THE POTOMAC RIVER EXPERIENCES

Watt, M.H. WRRC
Report No. 52

DESCRIPTORS: Watershed Management

Although water resources management is site specific and depends on local and regional factors, such as geographic, demographic and legal and institutional factors, the Potomac River Basin experiences can be useful to many other river basins in the world. Like many other river basins, the Potomac River Basin counts among its main characteristics: a wide variety of uses, a large population center, a target of many federal, interstate and local interests. Providing water of good quality and sufficient quantity to meet people's reasonable needs, are key requirements for managing water resources. The Potomac River Basin has made great progress in improving both the water quantity and quality. This article describes the experiences that the Potomac River Basin has gained in managing its water resources for meeting, on one hand, for mitigating water quality problems. The progress accomplished by the river clean-up efforts is also described.

*STUDY of EROSION AND SEDIMENTATION of SELECTED SMALL STREAMS
IN THE DISTRICT of COLUMBIA*

Chang, F.M., Watt, M.H., and Troung, H.V. WRRC
Report No. 75

DESCRIPTORS: Erosion, Sedimentation, Tributary, Urban Runoff

The project studies the effects of urbanization on flooding and erosion of small streams in the District of Columbia. The Hickey Run, which covers 1075 acres (435 ha) of mildly urbanized areas, and the Watts Branch, which covers about 2580 acres (1945 ha) of heavily urbanized area, were selected for the study. The 100 year floods were estimated at 2,230 cu Vs (62 cu m/s) in the Hickey Run and 3292 cu Vs (92cu m/s) in the Watts Branch. The sediment yields from the two watersheds and streams were found to be 2,430 and 5,315 tons per year for the Hickey Run and Watts Branch, respectively. Upon the completion of the scheduled urbanization, the magnitudes of 100-year floods are expected to increase by 13 % in the Hickey Run and 17 % in the Watts Branch. Among many practical erosion mitigation measures, better land along the toe of the bank slope and drains placed within the bank slope of the streams are deemed cost-effective for small streams in the District of Columbia.

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