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THE DEVELOPMENT AND EVALUATION OF AN INNOVATED APPROACH TO ENVIRONMENTAL CONSERVATION BY INDEPENDENT STUDY THROUGH CORRESPONDENCE

by

Paul Franz Nowak

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in
The University of Michigan
1969

Doctoral Committee:

Associate Professor William B. Stapp, Chairman
Professor Lyle E. Craine
Professor Justin W. Leonard
Associate Professor Alfred W. Storey

A B S T R A C T

THE DEVELOPMENT AND EVALUATION OF AN INNOVATED APPROACH TO ENVIRONMENTAL CONSERVATION BY INDEPENDENT STUDY THROUGH CORRESPONDENCE

by

Paul Franz Nowak

Chairman: William B. Stapp

The purpose of this study is to develop and evaluate a representative segment of an environmental conservation independent study correspondence course. Environmental problems are growing and citizens in communities across our nation are being affected by them. However, many citizens are not sufficiently knowledgeable and skilled to participate in the development of solutions to these problems. Many adults are groping for educational materials which will help them understand their environment, because they have had little or no formal education in this area. Yet, in a democracy these are the people who are responsible, either directly or indirectly through their representative governments, for their environment. The purpose of the environmental conservation independent study course through correspondence is to provide citizens with the basic knowledge and skills necessary for informed citizen action.

The environmental conservation independent study course utilizes correspondence for the dispersal of independent study materials which are designed to help citizens wherever they may live understand and become involved with environmental problems. The basic materials of the course are the text which provides the minimal understandings necessary for informed citizen action and the activities which directly involve the participant with the environment and the environmental problems of his region and community. The water resources unit is developed as the representative segment of the course and is used with sample individuals - the majority of whom were identified by means similar to those which will be used in publicizing the completed course. The experimental procedures form the basis for evaluating the innovated concepts upon which the course is based and are a guide for developing course materials.

Three questionnaires were used to gather data about the changes which occurred because of the participants' involvement in the sample water resources unit. The relevant personal characteristics of the types of individuals who are interested in conservation by independent study through correspondence were also identified.

The participants involved in the experimental procedures increased both their general knowledge of water resources as well as their specific knowledge of the water resources of their community. They also became more aware of water problems, sources of

information about water resources which are available in their community, and public agencies and private groups in their community concerned with water resource issues.

In the opinion of the participants, the water resource materials were considered to be very worthwhile. Most participants liked both the text and the activities and made a number of relevant suggestions for improvement. They thought the water resources unit increased their knowledge, concern and interest in the water resource problems of their community. They indicated that this type of educational effort is valuable.

It can be concluded that environmental conservation by independent study through correspondence is needed and will be accepted. The component concepts which are blended to form the innovated basis for the course are a functional and viable way of helping adults understand and become involved with environmental issues. The most significant educational contribution this course may make is to act as a model for the development of courses from many disciplines which can use the participants' community as a laboratory for independent study.

ACKNOWLEDGEMENTS

My sincere thanks to Dr. William B. Stapp whose concern for people, education and nature has been a constant source of inspiration. He not only suggested this study but has given guidance, encouragement and understanding throughout its development. Working with him has been a distinct privilege.

Special thanks to Dr. Lyle E. Craine whose assistance, criticism and friendship have been deeply appreciated. I am especially grateful to Dr. Justin W. Leonard and Dr. Alfred W. Storey for their interest, assistance and critical comments throughout this study.

I would like to express my sincere appreciation to Dr. Spenser Havlick, the members of the correspondence education group, the course participants and many others who generously contributed their time and effort to this project.

I am grateful in so many ways to my parents who somehow knew thirty-five years ago that this would be possible.

To my wife, Joan, I must express my thanks very simply because it is impossible to express her sacrifices and contributions.

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CHAPTER I

INTRODUCTION

The dynamic growth and increasing urbanization of American society is creating a new and changing set of environmental problems. The demands upon our biophysical environment are impressive because of our increasing population and our rising standard of living. Large concentrations of people are congested in industrialized urban areas using massive amounts of resources and producing unprecedented outpourings of pollutants. Increasing apprehension within all segments of society is causing attention to be focused on the problem of maintaining environmental quality. The realization is growing that we and our biophysical environment are integral components of one environmental system and that we exist because of our interactions within this system. Our interactions with our biophysical environment have, however, become so extensive and so powerful that we now determine, to a large extent, environmental quality. Such decisions as how we utilize and manage our biophysical environment have, therefore, become increasingly important because of their influence on the quality of our existence.

The solution of environmental problems is a continuous process because our culture and the biophysical environment are constantly changing. The emerging environmental problems such as water pollution, water supply, air pollution, land pollution, lack of outdoor recreation

areas, land zoning, urban blight and urban sprawl, differ from the resource problems of the recent past because of their direct impact on individual citizens. In communities across our country growing numbers of citizens are sensing the need for finding practical and equitable solutions to the problems of the environment. Citizens are groping to develop an understanding of why environmental problems exist, how they were created and how they can be resolved. Education has a definite responsibility to help citizens, both individually and collectively, understand how they can effectively help resolve these problems.

Environmental education, because it deals with the relationship between man and his environment, should be a leader in perceiving and meeting the special educational needs which are generated by environmental problems. Because these problems are dynamic and variable, the educational response to them must be both flexible and continuous. Many public and private institutions are involved in fragmented efforts to inform and influence citizens on environmental issues. The need for a coordinated objective[1] educational program, designed to help citizens become involved in the solution of environmental problems, is evident. Most adults, however, have little or no formal environmental education and are being forced to face environmental problems which they have difficulty identifying, understanding or helping to solve. The growing and changing environmental problems of today, when viewed through the educational gaps which exist, point to the need for a comprehensive environmental education effort aimed at the

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[1]This program must be free from prejudice or personal feelings.

adult component of our population.[1]

An environmental education program for adults must meet a number of pre-determined criteria to be successful. One, the program must be built around a core of minimal knowledge necessary for informed citizen action because of the differences in formal education, the wide individual variations in casual information obtained and the changes which are occurring in our culture. Two, the educational materials must be easily disseminated to all who would like to participate, not just to those who can easily reach an educational institution. This is true in urban as well as rural areas. Finally, the program must be made relevant to the learner.

With these criteria as guidelines a group was formed under the direction of Dr. William B. Stapp, School of Natural Resources, University of Michigan to produce an independent study course through correspondence, entitled "Environmental Conservation: Opportunities for Effective Citizen Action." A number of innovated techniques were incorporated into the design of the course. These were aimed primarily toward helping citizens develop an awareness of environmental problems, an understanding of the environmental problems of their community and region, an understanding of their responsibility to participate in the development of solutions to these problems, and an understanding of how they can participate in the development of solutions to these problems. Correspondence study was the means selected through which the participants are reached so that the community and the region in which the

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[1]This does not imply that the adult segment of society should be the only target of environmental education. Environmental education should be a comprehensive program which is integrated into the curriculum from kindergarten through college.

person lives can be used as an environmental laboratory.

Purpose of the Study

In dealing with any new and innovated educational effort, many philosophical, practical and developmental questions must be answered. The purpose of this dissertation is to evaluate the innovated ideas and techniques which form the philosophical framework for the University of Michigan environmental conservation independent study course through correspondence.

Citizen concern, which can develop into citizen action on local environmental problems, is a function of involvement and knowledge. Directed citizen involvement in local environmental problems can be the start of the sequence of events which can lead to changed citizen behavior. Directed involvement should bring about an awareness and a concern for environmental problems which can motivate citizens to seek information upon which understandings can be built - understandings which can lead to changed citizen behavior in the form of citizen action. Citizen involvement should nurture the knowledge of why and how citizens can and should play an important role in helping to solve environmental problems. Involvement at the local level can provide the experience and the skills which are necessary to broaden the ability of citizens to participate effectively in solving problems not only at the local level but also at the state, national and even international level.

Citizens, individually or as members of action groups, can influence both public and private policy decisions by expending

political, economic or personal action power. In our democratic society, citizens are the government. It is their responsibility to direct or approve the decisions concerning their environment, because they, either directly with their votes or indirectly through their representative governments, set the parameters within which governmental policies control man's use of the biophysical environment. Throughout American history citizens have had the power to influence the enactment of laws and the formulating of precedents which control the relationship between the biophysical environment and governmental institutions, private institutions and individuals. All too often, however, citizens have paid little attention to environmental issues because they were uninformed, unskilled or unmotivated. The dynamic relationship between the biophysical environment and society requires that citizen involvement be a continuous factor in decision-making processes if the environmental policies of our complex urban society are not to be adversely affected. Education has the responsibility of providing the comprehensive range of information and skills needed by citizens in order to express their concerns.

This study is based upon the development of a representative segment of the environmental conservation independent study course through correspondence and the utilizing of this segment for evaluation of both the fundamental concepts which are the philosophical basis for the total course as well as the techniques which will be important to the development of course materials. The concepts upon which the course is based are directed toward involving citizens in

the environmental problems of their local community and region. Meaningful involvement is not a simplistic idea, however, but rather is made up of several important components. Citizens, in order to effectively involve themselves in helping to solve environmental problems need basic knowledge about environmental resources, specific knowledge of environmental community issues and knowledge on how citizens can help to resolve environmental problems. In order to gain this knowledge, they must first gain the minimal basic information for understanding environmental resources and then they must have the skills necessary to gather specific information about their community. They, in effect, must be able to ask the right kinds of questions at the proper time and they must know who can answer these questions. Citizens must be aware of community conditions and concerned if the situation warrants concern. Finally, they must have the skills and the knowledge necessary to act if they are motivated by their concern.

Throughout this discussion the implication is clear. Citizens need a variety of different kinds of knowledge to understand environmental problems. They need skills in order to collect information about these problems. They need to explore their community to understand the type and the intensity of the environmental problems which exist. They need to understand governmental structure, how policy is formulated and their role as citizens in influencing policy. And they need the articulation and organizational skills necessary for effective action if they choose to act. Environmental education should give citizens those understandings and skills necessary for them to act on

environmental problems. It must, however, leave the motivation and the time for citizen action up to the individual. Hopefully, concern about the situations which exist in the biophysical environment will motivate citizens to action. The decision for action must, rightfully, rest with the judgement of the individual.

General Procedure

This study is an evaluation of the innovated concepts which form the basis of the environmental conservation independent study course through correspondence. The objectives of the study are to determine the effectiveness of the course by measuring the changes which occur in a group of test individuals who are involved in a representative segment of the course. This evaluation should also provide important information which can be used in the development of course materials. The representative segment of the course used is the water resources unit and its integral activities.

In order to carry out the study a variety of materials were specifically developed for the project. The text and the activity materials were of primary importance and, therefore, were the first to be developed. Three evaluative questionnaires were also developed to collect data from the participants. Two basically similar questionnaires, the preliminary questionnaire and the final questionnaire, were used to collect the data necessary to measure the changes which occurred in the participants resulting from their involvement in the experimental unit of the course. An opinion questionnaire was also developed to collect data about the participant's evaluation of various

aspects of the experimental materials and experimental procedures.

The following is a chronological list of the development of materials and the experimental events of the study.

1. Development of the text.
2. Development of the activity materials.
3. Development of the preliminary questionnaire and the final questionnaire.
4. Development of the opinion questionnaire.
5. Identification of the test participants.
6. Administration of the preliminary questionnaire to the test participants.
7. Division of the test participants into an experimental group and a control group.
8. Utilization of the text and activity materials by the experimental group of participants.
9. Administration of the final questionnaire to the experimental and control groups.
10. Administration of the opinion questionnaire to the experimental group.
11. Analysis of the data generated by the test participants.
12. Write-up of the analysis and the conclusions drawn from the analysis.

Chapter II of this dissertation explains the history of the development of the course and the innovated ideas upon which it is based. Chapters III and IV deal with the development of the text, activities and questionnaires used in the project. Chapter V is concerned with the identification, organization and functioning of the experimental groups of participants. Chapter VI summarizes the results of the evaluation procedures.

Chapter VII analyzes the results of the evaluation and suggests some conclusions which can be drawn from the study.

CHAPTER II

SEQUENCE OF EVENTS LEADING TO THE DEVELOPMENT OF THE EXPERIMENTAL WATER RESOURCES UNIT

Independent study through correspondence is growing steadily in enrollment and in the variety and number of courses offered. Conservation and conservation related subjects dealing with the environmental problems with which citizens are concerned, however, have been almost completely neglected. A number of universities and even two private home study institutions provide conservation courses. These courses are basically concerned with the conservation of natural resources and are offered through departments of geography. Therefore, when Carl Johnson, then Chairman of the Conservation Commission, Michigan Department of Conservation,[1] first suggested a descriptive conservation course for the general public of Michigan, the idea was born in a relative educational vacuum.

Cornell University, Ithaca, New York, has for a number of years offered a descriptive conservation correspondence course for the general public. The Cornell conservation course is in reality two courses, the second one being an extension of the first. The two Cornell conservation courses have been an outstanding success. Course I was offered to the public six times between 1961 and 1967 with an

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[1]Now the Department of Natural Resources.

enrollment of 1403, and Course II was offered twice between 1965 and 1967 with an enrollment of 361. Some applicants for Course I were turned away in 1966 because the supply of texts was exhausted; many late applicants were also turned away.[1] Both of the Cornell correspondence courses are made up of a series of articles about the natural resources of New York state, written by a number of resource specialists.

The idea of a descriptive correspondence course for the general public was presented by Carl Johnson to both the University of Michigan and Michigan State University. Initially the University of Michigan was not receptive to the idea. It was apparent, however, that citizens across Michigan wanted educational material that would help them understand the environmental problems that existed in their communities and that previously developed materials were not meeting this need. Adding to the dimensions of the problem was the fact that interested citizens were located in communities across the state from the high density populations of Wayne County to the thinly dispersed populations of the upper peninsula. With these conditions as background, Dr. William B. Stapp, School of Natural Resources, University of Michigan developed some new concepts of presenting environmental conservation by using independent study through correspondence.

The innovative concepts upon which the course is built are based on the utilization of correspondence to reach individuals in

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[1]R. J. McNeil, "Cornell's Correspondence Courses - A Progress Report," Unpublished Mimeographed Report, May 1, 1967, pp. 1-3.

their own community with individual study materials that use the local community and region as a laboratory. The components of the new program were to be completely integrated and purposefully directed toward providing the information and the skills citizens need to participate in helping to solve environmental problems. The text would be designed specifically to help citizens understand environmental community problems. The activities, which are an integral part of the program, would direct citizens toward involvement with their local environmental situations in order that they may learn to collect information and understand the community environmental problems which exist.

Correspondence

Correspondence courses have been an effective means of distributing educational materials to dispersed individuals, and they also can be extremely sensitive to a wide variety of individual differences.

> . . . We have no educational design which is as sensitive to individual differences in motivation and learning rate as the correspondence course.[1]

Correspondence courses allow those individuals with busy schedules to fit their educational undertakings into available time.

Even though correspondence programs are convenient in terms of where and when the work can be completed, they would not be worthy of passing consideration if the theory behind them was not educationally sound. A number of studies of both test scores and grades

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[1]Harry L. Miller, Teaching and Learning in Adult Education (New York: MacMillan, 1964), p. 222.

earned has shown that correspondence students at the college level do as well or slightly better than their classroom counterparts.[1] Correspondence programs are already being used by a great number of people and the number is growing.

> A recent survey concludes that several million people each year are reached by correspondence programs; over 100,000 take college and university programs.[2]

Correspondence courses, because of their unique ability to reach almost anywhere, are being used by individuals for meeting new needs and for increasing general educational levels.

> Our adults are rapidly beginning to recognize that no one can complete an education. There is now much more to know, too much change from what was known, for an education received in youth to be adequate for the life of an adult.[3]

Independent Study

Correspondence courses are increasingly referred to as independent study because of the flexibility they provide for individual differences. Time is usually the only dimension of individual difference which is given active consideration in most independent study correspondence courses. The materials are designed to allow the student to work at his own rate and in those time periods when

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[1]Gayle B. Childs, "Review of Research in Correspondence Study," The Brandenburg Memorial Essays on Correspondence Instruction-II, edited by Charles A. Wedemeyer (Madison: University of Wisconsin, University Extension, 1966), p. 130.

[2]Miller, 222.

[3]John L. Davies, "The Demands of the Decade," The Brandenburg Memorial Essays on Correspondence Instruction-I, edited by Charles A. Wedemeyer (Madison: University of Wisconsin, University Extension, 1963), p. 20.

it is convenient. The environmental conservation independent study course through correspondence enlarges the idea of individual study by providing materials which allow the participant a choice of subject matter activities. The activities for the course are more extensive than any one individual is expected to complete and the participant will be asked to choose, within guidelines, those activities which are most interesting to him. The participant can, therefore, delve considerably deeper into those units which are particularly relevant to his concerns and the situations which exist in his local community.

The organization of the materials for independent study is concerned with motivating the participants and making the course relevant to the learner. By giving decision-making control of the activities to the learner a link between the interests of the individual, the environmental situations which exist in his community and the course materials can be made. These decisions cannot viably be made by the instructor even if he were in the individual's community because they are basic to the participant's personal motivation and interests.

Development of the Environmental Conservation Study Course through Correspondence

Thus the concept of the environmental conservation independent study course through correspondence was conceived at the University of Michigan, and it received strong support from individuals within the School of Natural Resources, from the administration of the School of Natural Resources, from the University of Michigan Extension Service, from individuals across campus and from agencies

and individuals outside the University. The following individuals agreed to contribute to the project by providing technical and advisory services or by assisting in the development of the text material:

Keith Arnold, Dean of the School of Natural Resources.

John E. Bardach, Professor of Fisheries, School of Natural Resources.

Burton V. Barnes, Associate Professor of Forestry, School of Natural Resources.

Marston Bates, Professor of Zoology, Department of Zoology.

Robert O. Belcher, Professor of Botany, Eastern Michigan University, Ypsilanti, Michigan.

Angus Campbell, Director of the Survey Research Center, Institute for Social Research.

Walter L. Chambers, Professor of Landscape Architecture, Chairman of the Department of Landscape Architecture, School of Natural Resources.

Archibald B. Cowan, Associate Professor of Wildlife Management, School of Natural Resources.

Lyle E. Craine, Professor of Conservation, School of Natural Resources.

Samuel T. Dana, Dean Emeritus, School of Natural Resources.

Hugh C. Davis, Project Leader, United States Forest Service, Cooperative Recreation Research Unit, School of Natural Resources.

George L. Fersh, Associate Director of the Joint Council on Economic Education, New York, New York.

Douglas J. Fulton, Conservation Writer, Ann Arbor News.

William R. Gable, Assistant Director, Institute of Public Administration.

Carl T. Johnson, Conservation Commissioner, Michigan Department of Conservation, Lansing, Michigan.

William J. Johnson, Professor of Landscape Architecture, School of Natural Resources.

Fred B. Knight, Professor of Forestry, Chairman of the Department of Forestry, School of Natural Resources.

Karl F. Lagler, Professor of Fisheries, School of Natural Resources.

Justin W. Leonard, Professor of Natural Resources, Chairman, Department of Resources Planning and Conservation, School of Natural Resources.

Roman H. Koenings, Regional Director, Bureau of Outdoor Recreation.

Gilbert W. Mouser, Professor of Wildlife and Fisheries, Department of Wildlife and Fisheries, Michigan State University, Lansing, Michigan.

William J. Mullendore, Chief of the Information and Education Division, Michigan Department of Conservation.

Merrill L. Petoskey, Supervisor Education and Training, Michigan Department of Conservation, Lansing, Michigan.

Jack Van Coevering, Lecturer, School of Natural Resources.

Burton E. Voss, Associate Professor of Science Education, School of Education.

Warren H. Wagner, Jr., Professor of Botany, Department of Botany.

Robert R. Wilson, Supervisor of Correspondence Study, Extension Service.

With this support a grant proposal was drawn up and submitted to the Bureau of Higher Education, State Department of Education for funding under Title I, Higher Education Act of 1965, for the development of an environmental conservation independent study course through correspondence. Due to lack of funds the Title I project proposal was rejected. The proposal was then submitted to and funded by the Ford Foundation on July 7, 1967. With this grant, Dr. William B. Stapp as project director, hired eight staff members to develop various subject

matter areas of the course. These staff members (Messrs. Anthony Abar, William Bryan, Seymour Gold, Stanley Goodnow, Paul Nowak, Demetrius Plessas, Brooks Sibley and James Swan) were graduate students from various programs of the School of Natural Resources. Later Miss Cynthia Meyers, Miss Jean MacGregor and Mr. Frederick Kingwell were added to the staff. By September 1968 a first draft of all the text units for the correspondence course had been completed. The following is a tentative outline of the units and their proposed order of presentation:

Unit	I	Man and the Environment
	II	Government, Politics and the Citizen
	III	Conservation and Economics
	IV	Population and Urbanization
	V	Urban and Regional Planning
	VI	Ecology
	VII	Geology, Soils and Mineral Resources
	VIII	Tree Resources
	IX	Water Resources
	X	Fishery Resources
	XI	Wildlife Resources
	XII	Air Resources
	XIII	Recreation
	XIV	Summary

Within this organizational framework of the independent study course, the water resources unit was decided upon as a representative unit which could be developed and used as both a unit for the course and as an experimental unit to test the validity of the innovated ideas upon which the completed course is based. It was also to be used to help in the development of various course materials.

A series of activities, designed to help citizen participants understand the environmental problems of their community, is an integral part of each unit of the correspondence course. A set of representative activities were developed for the water resources unit. These

activities are designed to help citizens understand how they can be effective in solving environmental community problems.

Citizen Involvement

A critical aspect in the development of any adult education program is the determination of the clientele which the program will serve and the identification of any of their relevant characteristics. Citizen awareness, concern and knowledge of environmental resources and problems are significantly important to the solution of many environmental issues. Citizens have a responsibility and should be involved in helping to solve a wide range of environmental problems.

Some of the most critical problems facing our nation are environmental problems. As former Secretary of the Interior, Stewart L. Udall has stated,

> Our mastery over our environment is now so great that the conservation of a region, a metropolitan area, or a valley is more important, in most cases, than the conservation of any single resource.[1]

The immense growing environmental problems of our urban areas are already directly affecting many citizens. By 1980 eighty per cent of our citizens will be living on approximately 1.5 per cent of the land. The environmental problems facing the communities of America can be solved most effectively and satisfactorily through the involvement of informed, concerned citizens. Citizens should influence a wide range of private and public

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[1]Stewart L. Udall, The Quiet Crisis (New York: Holt, Rinehart and Winston, 1963) p. 184.

decisions which affect the biophysical environment. Citizens, however, need to be informed about environmental problems, knowledgeable about the political process and motivated to action by personal conviction in order to be effective. Education plays an important role in helping citizens effectively participate in this process.

> Education not only tends to imbue persons with a sense of citizen duty and a sense of political efficacy; it also propels them into political activity.[1]

> . . . the more one participates actively in local affairs the more confident one is likely to be in one's capacity to be effective.
>
> Participation and political confidence evidently reinforce one another.[2]

Citizens, individually or as members of action-oriented groups, are able to influence decision-making processes by expending political, economic or personal action power. Citizens should have a directional influence on political leaders.

> . . . the leaders who directly control the decisions of political associations are themselves influenced in their choices of policies by their assumptions as to what the voting populace wants.[3]

The environmental conservation course is designed to give participants an opportunity to become involved in the political process of their community so that they can gain the knowledge, skills, experience and confidence necessary for active participation in environmental decisions.

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[1]V. O. Key, Jr., Public Opinion and American Democracy (New York: Alfred A. Knopf, 1961), p. 329.

[2]Robert A. Dahl, Who Governs? (New Haven: Yale University Press, 1961), p. 287.

[3]Dahl, 101.

Many private and governmental organizations are involved with the idea of citizen action as a viable means of solving community environmental problems. Numerous cases of successful action are already documented. A pamphlet distributed by the Citizens Committee for the Outdoor Recreation Resources Review Commission Report, called Action for Outdoor Recreation for America, includes a section that deals with effective citizen action which has resulted in solutions to local recreation problems. One example from that section is:

> Near the town of Plain Dealing, Louisiana, the local soil Conservation District built three reservoirs to protect farmland from floods. At the suggestion of the Lions Club, the Town Council submitted to the voters a $52,500 bond issue to develop the reservoirs for swimming, fishing and boating. The bonds carried 149 to 1.[1]

Direct citizen involvement is as important from an educational standpoint as it is from a political standpoint. It has been a long developing educational thesis that the maximum transfer of learning occurs in direct experience situations. The activities which are an integral part of each unit guide the participant into direct learning experiences. The participant is guided into self-conducted direct experience field trips and interviews. Participants involved in this way can see community situations as they exist with no gap between the abstract education material and the real world. Also, they are involved with real situations which present concrete examples of the understandings

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[1]Citizens Committee for the ORRRC Report, Action for Outdoor Recreation for America (Washington D.C.: Citizens Committee for the ORRRC Report, 1964), p. 25.

gained in text material.

One model which compares the effect of direct experience to other educational methods was developed by Edward G. Olsen (see Figure 1).

Readership

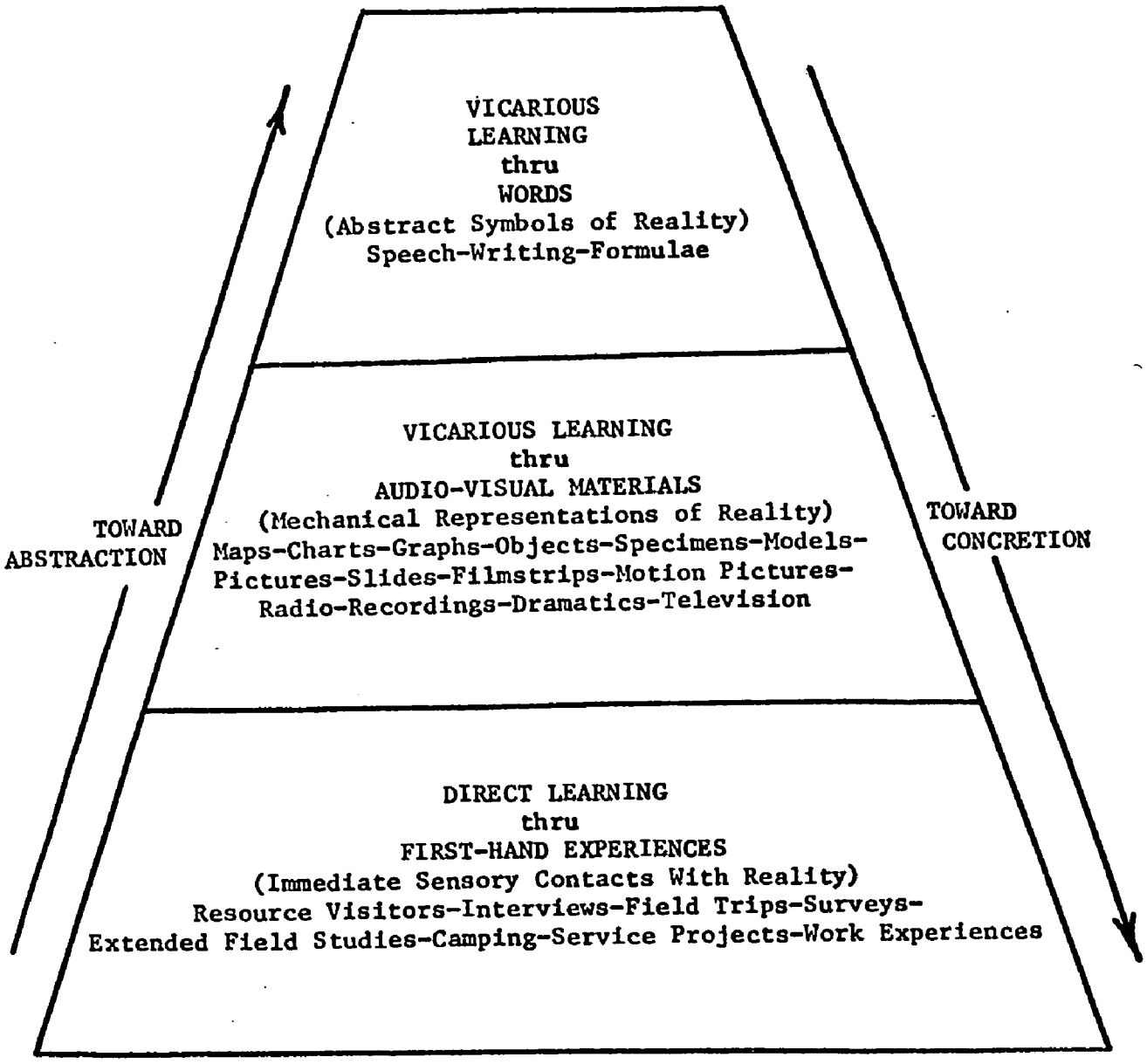
Because citizen involvement is one of the major objectives of the environmental conservation independent study course through correspondence, a decision had to be made initially regarding the type of person for whom the course would be designed.

The Cornell course offered some early indications of the type of people who are interested in conservation correspondence courses. This was later verified by our own findings. Participants would be predominently Michigan residents - a majority of whom would live in urban areas. They would have a mean age level of 36 to 45 years. A majority will have had college training, but most will not be professionals in the field of conservation. Most will be interested in conservation and many will be involved with conservation problems through their jobs or because of their participation in civic organizations.

Education programs which are broadly based lose much of their effectiveness in meeting specific needs. Therefore, it was decided that the course would be aimed at those individuals who are leaders and subleaders in influencing policy decisions. It is difficult to exactly define this group, but it was assumed that they would be motivated and influential in dealing with environmental

FIGURE 1

TRANSFER OF LEARNING DIAGRAM[1]



[1]Edward G. Olsen, "Perspective in Audio-Visual Education," Educational Screen, Vol. XXV, No. 3 (March, 1946), p. 120.

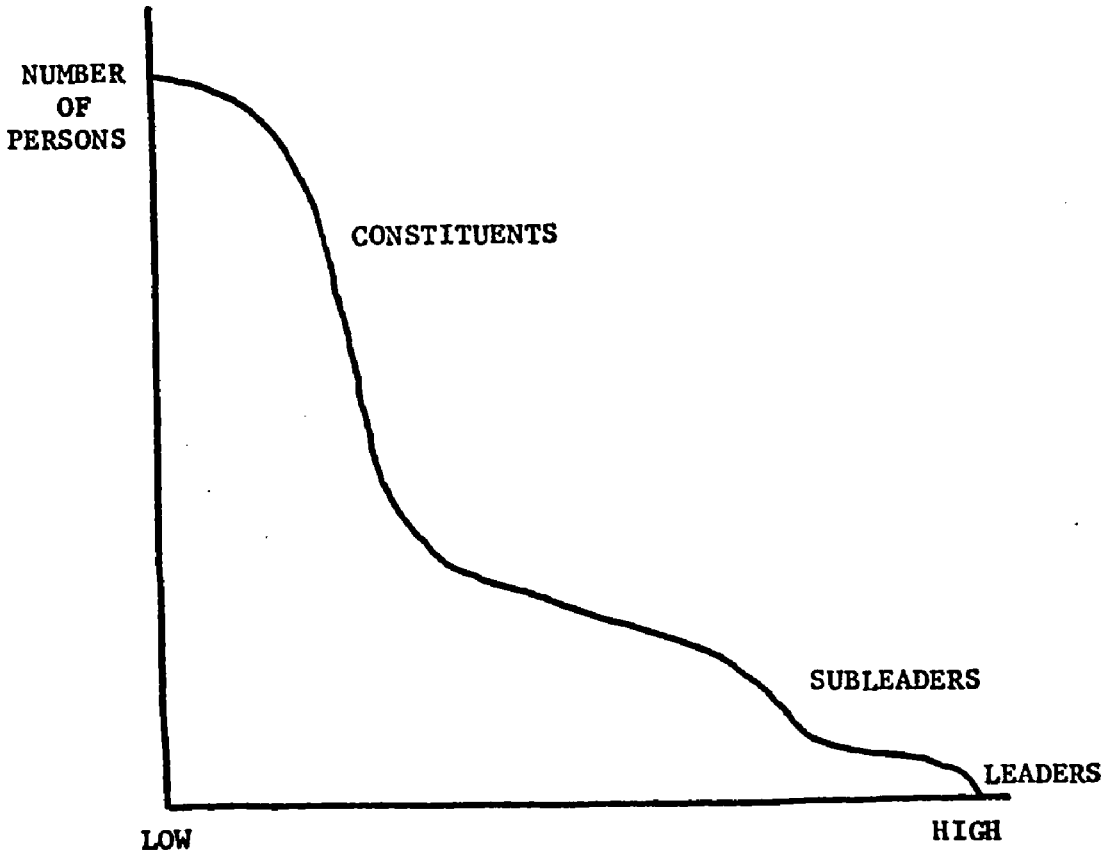
problems. (See Figure 2.)

The course, therefore, is intended for college seniors, college graduates and citizens who are concerned with conservation problems, but may have had little or no professional training in the field. It is assumed the participants represent varied areas of study. They may have expertise in one resource area, but probably lack knowledge in others. Motivated individuals from a wide range of backgrounds and even various educational levels should be able to participate in the course and find it challenging.

The innovation of the total concept of the environmental conservation independent study course through correspondence comes from the blending of sound educational techniques into a viable new educational program. One of the most important contributions of this course may be that it will act as a model for the development of a proliferation of various offerings which are based on independent study through correspondence and which help individuals understand their environment more fully.

FIGURE 2

A SCHEMATIC DIAGRAM OF THE DISTRIBUTION
OF DIRECT INFLUENCE ON DECISIONS[1]



[1]Dahl, 163.

CHAPTER III

THE DEVELOPMENT OF THE TEXT AND ACTIVITY MATERIALS FOR THE WATER RESOURCES UNIT

The text and the activities are the tangible components of the water resources unit. They are built upon the innovative concepts which form the basis for the complete environmental conservation independent study course through correspondence and are the means through which the objectives of the course are achieved. Through them the participant acquires the understandings about natural resources, environmental problems, man's relationship to the environment, and the organization and functioning of government. These understandings are the minimal prerequisites for informed citizen action. They also provide the guidance for developing the skills necessary for identifying problems, collecting information, communicating concerns, and effectively participating in solutions to environmental problems.

The Text

In order to proceed effectively with any educational endeavor it is necessary to communicate to the student a number of basic concepts. One of the primary assumptions of the total course is that the participants have only limited knowledge of the subject matter. This does not mean that the students lack a basic education, but rather that their experiences with natural resources on a formal

basis are either non-existent, out-dated or they have knowledge in one area of conservation but are lacking it in others. Therefore, the water resources unit is built upon the assumption that the participant has little or no knowledge in the area of water resources.

The text was written to include the basic minimum amount of information a citizen must know in order to understand water resources and water resource problems. The field of water resources is an extremely extensive and complicated field. Entire books have been written about single aspects of it. The water resource material had to be meaningfully reduced if it was to be presented in one unit of a correspondence course. The guidelines for this reduction were to identify those concepts which are basic to understanding water resources. These basic concepts were defined as "minimal understandings." When completed and organized into a logical pattern, they became simultaneously the basis and the outline for the water resources unit (Appendix A). The water resources unit was chosen as a representative unit for experimental evaluation, in part, because of its extensiveness and the fact that it would be necessary to use the concept of minimal understandings to reduce the material to a workable minimum.

A number of other important preliminary decisions having to do with style had to be made before the text was written. It was decided that the style should be straightforward, interesting and as clear and concise as possible. Logical organization with appropriate headings was important so that the material could be used for reference. Vocabulary was kept as general as possible. The terminology was as basic as possible with definitions of terms unfamiliar to the

public included in the body of the text. All the material was presented in a completely unbiased manner. Case examples were cited where appropriate, and charts, diagrams and photos were an integral planned part of the text.

With these considerations as background the first step in the development of the text material was the identification and the organization of the minimal understandings. When initially completed, these were reviewed by Dr. Lyle E. Craine, Dr. Spenser Havlick and Dr. William B. Stapp and some members of the correspondence study group. The minimal understandings were then rewritten in light of the review and utilized as the basis for the water resources unit.

Within these parameters a first draft of the text was completed in December of 1967 and read and reviewed by Dr. Craine, Dr. Havlick and Dr. Stapp. It was then revised and again reviewed, this time by a much larger group both inside and outside the University. Those evaluating the second draft were:

Dr. Lyle Craine, School of Natural Resources, University of Michigan.

Mr. Carlos Fetterolf, Michigan Water Resources Commission.

Mrs. Ralph Fletcher, citizen.

Mr. Dale Granger, Michigan Water Resources Commission.

Dr. Spenser Havlick, School of Natural Resources, University of Michigan.

Mr. Carl Johnson, Commissioner, Michigan Department of Natural Resources.

Dr. Justin Leonard, School of Natural Resources, University of Michigan.

Mr. William Mullendore, Michigan Department of Natural Resources.

Dr. William B. Stapp, School of Natural Resources, University of Michigan.

Dr. Alfred Storey, Extension Service, University of Michigan.

On the basis of these evaluations a third draft was completed and 125 copies were printed and bound into booklets to be used in the experimental evaluation. The bound text contains a table of contents and a table of diagrams and tables. It is divided into five major sections: Part I - Introduction; Part II - The Characteristics of Water; Part III - Water as a Natural Resource; Part IV - The Management of Water Resources; and Part V - Water Resources Policy. The text also contains a glossary and an annotated bibliography (Appendix B). This unit as it is presented in Appendix B is not in final form. Based on suggestions developed from the experimental procedures, the text will be revised and professionally developed graphics and photographs will be added before it is used as a unit in the complete environmental conservation independent study course through correspondence.

The Activities

The text material based upon the minimal understandings is directed at the development of a general understanding of water resources and environmental water problems. In order for a citizen to effectively participate in finding the solutions to environmental

water resource problems he must first acquire some understanding of specific issues which are a part of every environmental problem and he must also develop a variety of skills concerned with gathering information, articulating concerns and taking action on issues. The development of these specific understandings and skills, which are a vital part of the course, is undertaken through the course activities. These activities are aimed at involving participants in the environmental problems of their own community. In this way the participants can experience for themselves the local environmental situations which exist, the functioning and the responsibility of government in regard to environmental problems and the role citizens can and should play in the decision-making process.

The activities for the complete environmental conservation independent study course through correspondence fall into three basic categories. One type of activity is the survey activity, referred to as a self-guided field experience. The object of this type of activity is to help the student focus on his community and region and its environmental problems. By using his knowledge of his own community the student is asked to plan a field trip to view a number of resource situations. He is also asked to briefly describe and evaluate the conditions he sees. Because some of the specific information which is pertinent to the understandings of the student is not available by simple viewing, he is directed to phone local governmental units. The experimental water resource unit contains an extensive survey activity which is listed as Activity A in Appendix C: Activities.

The second type of activity is an interview activity. A vitally important percentage of the information necessary for understanding a specific environmental problem is so current that only the people who are interacting with the situation can supply the information. Therefore, if citizens are going to collect information about environmental situations they must be skilled in interviewing various individuals connected with the problem. Governmental officials are, of course, the first ones considered. However, a wide range of private citizens, individuals with industries and concerned private groups may be also vitally involved. The interview activity directs the student to interview one or more individuals connected with an environmental problem of the student's choice. In this type of activity the student can follow his own interests providing an excellent opportunity for independent study. The interview activity also directs the student, in part, to structure the interview so that specific information can be obtained and in some cases compared to information given from other sources. The students also are advised to allow a portion of the interview to be unstructured so that unexpected information can be collected. The final part of the activity is a brief written summary of the interview designed to draw the collected information together. The experimental water resources unit was accompanied by an interview activity. Refer to Activity B in Appendix C: Activities.

The final type of activity is a synthesis activity. This is basically a short paper on a problem in which the student is

interested. It is aimed at helping the student bring his thoughts together. This type of activity makes use of the text, the other activities and available information by directing the student to use all these sources in developing his paper. For example, the student can refer to the text, to other books in the field and to his interview as sources of information for his paper. Activity C for the experimental water resources unit is in Appendix C: Activities.

Included with the activities was a set of directions (Appendix C) which suggested to the student how the text and activities were to be utilized. This plan for utilizing the text and the activities suggested to the students that the activities be read first, the text was to be read second, and the activities were to be completed last. The reason for this order was so that the student would know the kinds of things which would be expected of him so that he could relate the relevant parts of the text to his proposed independent study activities.

The activities for the experimental water resources unit were interdependent and the student was expected to complete all of them. For the total course, however, the student will have a variety of choices to make in determining the activities he will complete. This will in effect determine the degree he is involved with a particular subject matter area. If each student of the total course had to do as much activity work for each unit as the experimental students had to do for the water resources unit, the course would be unreasonably long and give very little consideration

to individual differences. In the total course the student will select certain units in which he is particularly interested and do all the activities for these units. In the other units he will be asked to select one or two survey or interview activities. The types of activities will vary somewhat depending on the nature of the unit upon which they are based.

The text and the activities are designed to help the student basically understand natural resources and environmental problems, to survey the local environment and to delve specifically into personally interesting local issues. At the same time he will develop communication and information-gathering skills and will be exposed to government and private interests which are concerned with natural resources and environmental problems.

CHAPTER IV

THE DEVELOPMENT OF THE EVALUATION INSTRUMENTS

The data necessary for evaluating the changes which occurred in the individuals who participated in the experimental water resources unit was accumulated through the use of three evaluative instruments called questionnaires. These instruments were designed to probe the changes in knowledge and concern about water resources and water resource problems. The participants' opinions about the organization of the course, the text and the activities were also collected.

In the development of the questionnaires, advice was sought and obtained from both the University of Michigan Institute for Social Research and the Statistics Laboratory of the Graduate School. The questionnaires are, however, the sole responsibility of the author.

Preliminary Questionnaire - Final Questionnaire

The two basic data collecting instruments were the preliminary questionnaire and the final questionnaire. The preliminary questionnaire was in effect a pre-test and the final questionnaire a post-test. These two instruments are explained simultaneously because the two questionnaires are identical except for the removal

of the personal information section from the final questionnaire (Appendix D).

These questionnaires are composed of five different parts, each one of which was designed to collect a different kind of data. Part A was used to collect personal information about the participant. The purpose of these questions was to gain insight into the types of persons who are interested in environmental conservation subjects. The questions asked for such factual information as: name, address, sex, age, education, employment, income, marital status, number of children at home, and identification of where the participant lives. The personal information was followed by a question asking why the participant is interested in conservation which related to why he wanted to take the course. The last question was to name the citizen and public service groups to which the participant belonged, indicating how active he is publicly. Part A in the final questionnaire asked only the participant's name and address.

Part B was a series of multiple-choice questions designed to evaluate the participant's general knowledge about water resources. The questions were derived from the minimal understandings of the text. The reason that multiple-choice questions were used was to facilitate the use of the questionnaires by the participants. Time was an important factor because the questionnaires were extensive.

Part C was directed at evaluation of the change in the level of the participant's knowledge concerning the water resources and

the water resource problems of his own community. These questions were answered in one of three ways: "yes," "no" and "don't know." None of the information necessary to answer this part of the questionnaire came from the text. These questions could be answered only from the participant's personal experiences or through the experiences gained from participation in the experimental water resource activities.

Part C determined that the experimental individuals could be drawn only from selected areas. In order to check this part of the questionnaire the community in which the participant lived had to be surveyed.

Part D was built upon a series of colored pictures about various water resource situations. The participant was asked to describe three good and three bad situations from each picture. Those items which were considered bad were to be ranked by the participant and the degree of concern he felt about specific problems was recorded. The pictures afforded the participant a chance to identify the good and bad aspects of various water resource situations and to express his concern about the problems he could identify.

Part D was directed at two aspects of the evaluation. One was the ability of the participant to recognize water resource problems. The identification of environmental problems is critical to citizen involvement. Two, it was also directed at evaluating citizen concern about water resource problems. Concern is a very difficult area from which precise conclusions can be drawn. Even

though the participant registers concern about identified problems the concern which he records costs him nothing. To write on a questionnaire that you are extremely concerned about a specific problem has no economic costs, no political expenditures and no personal action work attached to it. Therefore, the degree of concern recorded can at best be looked upon as only an index of possible citizen involvement.

One of the primary purposes of any educational effort is to bring about a change in behavior. This, however, is difficult, if not impossible, to determine by means of written evaluations or through directed activities. Again it costs nothing in terms of effort to be willing to participate on paper in a variety of conservation activities. Even participation in directed activities does not assure changed behavior because of the internal motivation necessary in becoming involved in self-identified situations. Time can truly be the only judge of changed behavior for only over time can the two key elements of motivation and opportunity manifest themselves. The water resources unit is designed to facilitate the participant's ability to be involved by improving his knowledge, concern and awareness of water problems and his ability in identifying and helping to solve these problems. But only the participant's individual situation can provide the opportunities and only his own motivation can provide the catalyst for action.

Part E was designed to evaluate the sources of information about water resources which the participant perceived as available to him. It also indicated the number of public and private organizations

the participant knew in his local community which were concerned with water resources. These are sources of information and also could be avenues for action on water resource problems.

The preliminary questionnaire was a pre-test which measures the participant's initial levels of knowledge, ability to identify and concern about water resources and water resource problems. The final questionnaire measures the same facts after the participant has been involved with the text and activities of the water resources unit. The change which occurred is measured and analyzed in terms of the objectives of the course.

The preliminary and final questionnaires were tested on several volunteer citizens who acted as a pilot group. Changes were made in response to this pilot study.

Opinion Questionnaire

The third questionnaire, the opinion questionnaire, was developed to supplement the findings of the preliminary and final questionnaires. It was given to those individuals who participated in the experimental sequence, the preliminary questionnaire, the text, the activities and the final questionnaire. The questions were directed at the participant's opinions concerning various aspects of the text and activity materials. These questions supplied information which was important to the development of course materials as well as information about the acceptability, in the opinion of those tested, of the organization of the course and its materials (Appendix E).

The opinion questionnaire, directed at obtaining specific desired information, had no pilot group evaluation.

CHAPTER V

IDENTIFICATION AND ORGANIZATION OF THE EXPERIMENTAL PARTICIPANTS

A total of 168 individuals were identified as being interested in the University of Michigan short course on water resources. The identification of these test individuals and their organization into groups was a vital part of the study. The groups were designated by geographical area. Four groups were identified, three of which enter into the evaluation. The four groups identified were:

1) Ann Arbor-Plymouth
2) Grand Rapids
3) Holland
4) Outstate

Ann Arbor-Plymouth Group

The Ann Arbor-Plymouth group is the primary group of the study. This group was identified through the same procedures which will be utilized in publicizing the complete environmental conservation independent study course through correspondence. It is, therefore, most representative of the type of participant expected for the complete course. It was also the largest group to participate, having seventy-eight persons.

A standard letter stating various aspects of the project was given to various news media (Appendix F). The Ann Arbor News publicized

the short course on water resources on two different occasions. Besides the newspaper various local private organizations were asked to carry news of the short course in their newsletters. The Mackinaw chapter of the Sierra Club, the Washtenaw chapter of the Audubon Society, the Michigan Botannical Club, the Ann Arbor chapter of the League of Women Voters and the Natural Areas Council carried notices about the course. Various local radio stations were also contacted and provided free air time for announcing the course.

The addresses which were given to the different groups publicizing the course were coded so that an estimate of the effectiveness of the various methods of contact could be determined.

The course was publicized in Plymouth by a news article in the Plymouth Mail and Observer. Some individuals in Plymouth became informed through the Ann Arbor publicity. None of the other methods of group communication or radio were available in the Plymouth community.

Once identified, the Ann Arbor-Plymouth individuals were sent a letter of introduction (Appendix G). This letter explained the objectives of the water resources course and explained what would be expected of the participants. The Ann Arbor participants were asked to take the preliminary questionnaire at the University of Michigan Extension Service Building located at 412 Maynard in Ann Arbor. The testing center was open for one week from 9:00 A.M. to 8:00 P.M. Individual testing appointments were made with

the Plymouth participants either in their homes or in the author's home.

At this point 23.76 per cent of the individuals declined to participate. A telephone survey found two basic reasons for not participating: one, their commitments were too great to permit the type of involvement necessary; or two, it was impossible to participate in the testing.

When the preliminary questionnaire was administered and checked, the overall group was divided into an experimental group and a control group. The division of individuals into the two groups was based on test scores and a concerted effort was made to keep the groups equal in ability. The method used was to take individuals of equal scores on the general information section (Part B) of the preliminary questionnaire and randomly divide them into two groups. This method provided an excellent way of assuring equal beginning knowledge in both groups.

Once the groups had been formed the participants were notified of their group placement. The experimental group received a letter of instructions along with the text, activities and addressed-stamped envelopes for returning their activities to the University (Appendix C). The control group received a letter explaining their function and the required procedures they were to follow (Appendix H). At the end of a five week period, the final questionnaires were administered in the same way the preliminary questionnaires had been. The experimental group was particularly low in attendance for final testing so the Extension

Service was kept open an additional week during the day and two additional nights.

The breakdown of the Ann Arbor-Plymouth group is as follows:

- Of the 78 individuals who took the preliminary questionnaire, 48 were designated experimental and 30 control.
- Of the 48 individuals designated experimental, 32 finished the experimental procedures.
- Of the 30 individuals designated control, 27 completed the control procedures.
- The 19 individuals who completed only the preliminary questionnaire were placed in a group designated drop-outs.

The experimental participants completed an opinion questionnaire after they had taken the final questionnaire. The opinion questionnaires were not completed at the same time as the final questionnaire but were given to the participant in a self-addressed stamped envelope to be completed and sent in at the participant's convenience. The purpose of this was to provide the participant time to react to the questionnaire. It was felt that the final questionnaire was lengthy and that the two should not be administered at the same time.

When the control group had completed the final questionnaire, they were then given a complete set of course materials.

Grand Rapids Group

Fifteen members of a University of Michigan Conservation class at the Grand Rapids Extension Center used the water resources

unit and the activities in place of the normal classroom work on water resources. This group was made up of fourteen graduates and one senior. The testing procedures were done in class and class time was given to compensate for the outside activities.

The purpose for using the Grand Rapids group was to compare the differences which exist between the Grand Rapids students and the other experimental participants because the Grand Rapids group was striving for college grades.

Holland Group

A group of women from the Holland Garden Club volunteered to take the short course on water resources as a group. They provided fourteen individuals for the experimental group and thirteen for the control. The method of handling this group was the same as the Ann Arbor-Plymouth group except that the Holland group organized themselves into a discussion group to discuss the water resources and the water resource problems of their local community. Some individuals completed the activities as a group project with three to four persons in a group. Testing was done in the Holland area in homes provided by the organizers of the group.

The major reason for utilizing the Holland group was to evaluate the potential of group participation in the course. A number of individuals have suggested group participation in the total course, and the Holland group, besides generating basic data about the text and activities, also provided information about group involvement.

Outstate Michigan

One final group was identified and sent the materials, but did not participate in the evaluation procedures. These twenty-five individuals were spread throughout the state. Many of these participants became aware of the short course on water resources through the private organizational newsletters which, in some cases, received a rather wide distribution. A responsibility was felt to allow these respondents to use the water resource materials even though they could not be evaluated because the testing procedures could not be supervised. Some information about this group was helpful and is noted in later chapters.

Non-Participants

A final group of individuals expressed an interest in the short course on water resources but for a variety of reasons, mainly lack of time, did not participate in any of the experimental procedures. This group is mentioned only because it adds to the dimension of those who responded to the course publicity.

Designating of the Groups

To facilitate the explanation of the data in the next chapter (Chapter VI), Table I contains the code designation of the groups which participated in the study.

TABLE I

CODE DESIGNATION OF THE PARTICIPATING GROUPS

Group	Code	Number of Individuals
Ann Arbor-Plymouth Experimental	A-E	32
Ann Arbor-Plymouth Control	A-C	27
Ann Arbor-Plymouth Drop-outs	A-D	18
Grand Rapids Experimental	G-E	15
Holland Experimental	H-E	14
Holland Control	H-C	13
Outstate	0	25
Non-Participants	NP	24
Total		168

From these groups, the data were collected for evaluating the sample water resources unit. The data are presented and analyzed in Chapter VI.

CHAPTER VI

PRESENTATION AND ANALYSIS OF THE EVALUATION DATA

The data for the evaluation of the representative water resources segment of the environmental conservation independent study course through correspondence are presented in the order in which they were collected. This chapter is divided into three sections - one for each of the three different types of data which were collected. The first section deals with the personal characteristics of the participants. The second section indicates the changes which occurred due to the participants' involvement with the water resources segment of the course. The final section summarizes the opinions of the participants regarding the course organization, the text and the activities.

Personal Characteristics of the Participants

The information about the personal characteristics of the participants was drawn from Part A of the preliminary questionnaire (Appendix D). The purpose of these questions was to gain insight into the types of individuals who are interested in conservation and who are willing to take courses by correspondence. The individuals who were interested in the short course on water resources should be representative of the individuals that will enroll in

the completed course.

The Ann Arbor-Plymouth and the outstate groups are representative of the types of individuals who can be expected to be interested in the completed environmental conservation independent study course through correspondence. The Holland group enrolled as a group and therefore may not be typical. The Grand Rapids group represents a University of Michigan conservation class and again is not typical. Therefore, the data about the participants are taken from groups A-E, A-C, A-D and O (refer to Table I). The individuals in these groups were identified by the same means which will be employed for the completed course. One concern in using individuals from the Ann Arbor area as participants in this study is that, due to the influence of the University, they might tend to be unrepresentative of the total population. The areas of particular concern which could be affected by the Ann Arbor participants' characteristics are their sex, age, educational background, income and occupations. In the tables dealing with these subjects, each category is broken down into an Ann Arbor category and a Plymouth / Outstate category which includes the remainder of the sample. The differences between these two sub-samples can then be compared.

Some groups may choose to enroll in the complete course when it is offered, much like the Holland group has done. However, groups like the Holland group tend to have homogeneous types of individuals and, therefore, would bias the sample results.

The sample size for the different sets of data vary because

not all questions were answered by all participants. Each set of data contains a total which indicates the sample size upon which it is based.

The sex of the participants is an important characteristic in determining who is interested in conservation by correspondence. Table II shows that the participants are almost evenly divided between male and female and that no significant difference exists between the Ann Arbor participants and the rest of the sample.

TABLE II

SEX CLASSIFICATION OF PARTICIPANTS

Sex	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Fre- quency	Per Cent	Fre- quency	Per Cent	Fre- quency	Per Cent
Male	53	52.48	32	52.46	21	52.50
Female	48	47.52	29	47.54	19	47.50
Total	101	100.00	61	100.00	40	100.00

The age of the participants was the second personal characteristic which was tabulated. Two sets of data are given in connection with age: one is a frequency distribution to show the participation of various age classes; and second is the mean of all individuals.

TABLE III

AGE CLASSIFICATION OF PARTICIPANTS

Age Categories	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Frequency	Per Cent	Frequency	Per Cent	Frequency	Per Cent
11 - 20	2	2.02	2	3.33		
21 - 30	27	27.27	22	36.67	5	12.82
31 - 40	34	34.35	18	30.00	16	41.03
41 - 50	20	20.20	10	16.67	10	25.64
51 - 60	9	9.09	4	6.67	5	12.82
61 - 70	6	6.06	3	5.00	3	7.69
71 - 80	1	1.01	1	1.66		
Total	99	100.00	60	100.00	39	100.00
Mean	38.78		36.67		42.03	
High	73		73		65	
Low	13		13		22	

The frequency distribution of age groups shows that the bulk of the students came from the twenty to fifty year age group. The age classification data indicate that the Ann Arbor participants averaged 5.36 years younger than the Plymouth/Outstate participants. The difference is not large and is accounted for in part by the two youths from Ann Arbor who participated in the project.

The next characteristic of the participants, education, is particularly significant to the readership level of the completed

course. The most important aspect of the educational background of the participants is that a great majority of them were college graduates - many holding advance degrees. As Table IV shows, the Ann Arbor group had only a slightly higher educational level than the Plymouth/Outstate group.

TABLE IV

EDUCATIONAL BACKGROUND OF THE PARTICIPANTS

Educational Level	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Fre- quency	Per Cent	Fre- quency	Per Cent	Fre- quency	Per Cent
1. Less than High School	3[a]	2.97	2	3.28	1	2.50
2. Completed High School	5	4.95	3	4.92	2	5.00
3. 1-2 Years of College	8	7.92	1	1.64	7	17.50
4. 3-4 Years of College	8	7.92	6	9.83	2	5.00
5. Bachelor's Degree	33	32.67	19	31.15	14	35.00
6. Master's Degree	38	37.62	25	40.98	13	32.50
7. Doctor's Degree	6	5.95	5	8.20	1	2.50
Total	101	100.00	61	100.00	40	100.00
Mean	4.99		5.16		4.72	

[a]Two participants were junior high school students.

The occupations of the participants were extremely varied as shown in Table V. It is evident that people from many walks of life are interested in conservation.

TABLE V

OCCUPATIONS OF THE PARTICIPANTS

Occupation	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Frequency	Per Cent	Frequency	Per Cent	Frequency	Per Cent
Housewife	29	28.71	16	26.22	13	32.50
Public School Teacher	11	10.89	9	14.74	2	5.00
Engineer	10	9.91	5	8.20	5	12.50
College Instructor	6	5.94	5	8.20	1	2.50
Planner	6	5.94	4	6.56	2	5.00
Researcher	6	5.94	5	8.20	1	2.50
Student	6[a]	5.94	4	6.56	2	5.00
Accountant/ Bookkeeper	3	2.97	0	0	3	7.50
Real Estate	3	2.97	1	1.64	2	5.00
Secretary	3	2.97	2	3.28	1	2.50
Editor/ Publisher	2	1.98	2	3.28	0	0
Librarian	2	1.98	2	3.28	0	0
Industrial Manager	2	1.98	1	1.64	1	2.50
Architect	1	.99	0	0	1	2.50

TABLE V -- Continued

Occupation	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Frequency	Per Cent	Frequency	Per Cent	Frequency	Per Cent
Director of City Government	1	.99	0	0	1	2.50
Gardener	1	.99	1	1.64	0	0
Insurance Salesman	1	.99	0	0	1	2.50
Mechanical Designer	1	.99	0	0	1	2.50
Naturalist	1	.99	0	0	1	2.50
Nurse	1	.99	1	1.64	0	0
Pharmacist	1	.99	1	1.64	0	0
Retired	1	.99	0	0	1	2.50
School Principle	1	.99	1	1.64	0	0
Scientist	1	.99	1	1.64	0	0
Technician	1	.99	0	0	1	2.50
Total	101	100.00	61	100.00	40	100.00

[a]Two of the students were in junior high and four were in college.

Closely related to occupation is income level. This question received the most resistance by participants and was the least answered item of the personal information. As shown in Table VI

the Plymouth/Outstate group had a slightly higher income level than the Ann Arbor group. The mean income for the complete group was in the $12,501 to $15,000 category. This is above that of the general population.

TABLE VI

INCOME LEVEL OF THE PARTICIPANTS

Income Categories	Complete Sample		Ann Arbor		Plymouth/ Outstate	
	Frequency	Per Cent	Frequency	Per Cent	Frequency	Per Cent
1. 0- 5,000	3	3.49	2	3.70	1	3.13
2. 5,001- 7,500	11	12.79	6	11.11	5	15.62
3. 7,501-10,000	10	11.63	8	14.82	2	6.25
4. 10,001-12,500	18	20.93	12	22.22	6	18.75
5. 12,501-15,000	15	17.44	7	12.96	8	25.00
6. 15,001-17,500	11	12.79	7	12.96	4	12.50
7. 17,501-20,000	6	6.98	5	9.27	1	3.13
8. 20,001 plus	12	13.95	7	12.96	5	15.62
Total	86	100.00	54	100.00	32	100.00
Mean	4.72		4.70		4.75	
Mean Category	12,501-15,000		12,501-15,000		12,501-15,000	

The category of hours worked per week showed that only seven of the 101 participants in the sample group worked less than full

time. Many housewives did not indicate the number of hours worked per week. They were placed in the full time employment category because of the nature of their responsibilities.

As shown in Table VII a majority of the participants were married. Further data showed that there was an average of 1.93 children per married couple.

TABLE VII

MARITAL STATUS OF PARTICIPANTS

Marital Status	Frequency	Per Cent
Married	79	78.22
Single	18	17.82
Divorced	3	2.97
Widowed	1	.99
Total	101	100.00

The categories of residence were listed as inner city, urban residential, suburban and rural. The course materials are designed to be effective for urban and suburban residences and as the data show, most participants came from these two categories. It would seem probable, however, that with greater dissemination of information about the correspondence course in rural areas, that more ruralites can be expected to be interested and willing to participate.

TABLE VIII

RESIDENCE OF PARTICIPANTS

Residence Category	Frequency	Per Cent
Inner City	6	5.94
Urban Residential	52	51.49
Suburban	36	35.64
Rural	7	6.93
Total	101	100.00

The means by which individuals were informed about the short course on water resources is important in the strategy used to publicize the completed course. One important fact about publicizing the short course is that the news media were most considerate and willing to provide space or time as the case may be. Table IX shows how the participants became informed about the short course on water resources.

TABLE IX

HOW THE PARTICIPANTS BECAME INFORMED ABOUT THE SHORT COURSE

Source	Frequency	Per Cent
Newspapers	43	42.57

TABLE IX -- Continued

Source	Frequency	Per Cent
Club Bulletins or Newsletters	36	35.65
Friend	17	16.83
Miscellaneous	5	4.95
Radio	0	0
Total	101	100.00

The participants were asked by open-ended questions why they were interested in conservation. The answers were extremely diverse covering a great many reasons. As shown in Table X two meaningful categories emerged: one, personal interest, and two, occupational interest. These two categories are extremely important because they relate how the course materials will be used.

TABLE X

PARTICIPANTS' INTEREST IN CONSERVATION

Category	Frequency	Per Cent
Personal	69	72.63
Occupational	26	27.37
Total	95	100.00

The number of citizen and public interest groups to which the participant belonged was the last item in the personal information section of the preliminary questionnaire. The range was from a low of zero to a high of seven, with an average group participation rate of 1.37 groups per individual.

Change in Knowledge and Concern

One of the major purposes of this study is to evaluate the changes which occur in the experimental participants who used the text and the activities of the water resources unit. These experimental participants are in groups A-E, G-E and H-E. The control groups A-C and H-C were used to determine the amount of change exhibited by the participants who used just the questionnaires. Three basic reasons account for an increase in knowledge in the control groups on the post test: one, exposure to random information in the news media; two, the awakening of past knowledge which is often slow in returning; and three, familiarity with the test instrument.

To test the changes which occurred in the experimental participants, several hypotheses were formulated and then tested with the data. The hypotheses are concerned with the changes which occur in both Parts B and C of the preliminary and final questionnaires.

Part B is made up of forty-three multiple-choice questions. In each question the fifth possible answer was either "all of the above" or "none of the above." The sixth possible answer in each question was "don't know." The participants were urged to use "don't know" rather than to guess. The right answers for each of the questions were randomly divided between the five possible choices.

Part C is made up of forty-three questions which are answered "yes," "no" or "don't know." These questions are directed at the individual's knowledge about his local community water resource situation.

In analyzing the data a t-test was used to determine whether the difference of the means was significantly different from zero. The degree of confidence is noted along with the mean difference.

> Hypothesis I: The pre-test means of the experimental groups should not differ significantly from those of the control group.

Table XI shows that no significant initial differences existed between the experimental and the control groups in terms of their general knowledge about water resources and their specific knowledge about their community's water resources.

TABLE XI

COMPARISON OF THE PRE-TEST MEANS
OF PARTS B AND C

Group	Pre-Test	Mean	Difference of the Means	t-Score	Difference from 0
A-E	Part B	23.35	1.72	.96	No significant difference
A-C	Part B	21.63			
H-E	Part B	16.71	1.48	.66	No significant difference
H-C	Part B	15.23			
H-E,G-E,H-E	Part B	20.85	1.30	.94	No significant difference
A-C,G-C	Part B	19.55			
A-E	Part C	25.52	.04	.02	No significant difference
A-C	Part C	25.48			
A-E,G-E,H-E	Part C	24.40	.90	.63	No significant difference
A-C,G-C	Part C	25.30			

Hypothesis II: The experimental groups should achieve a significant improvement in knowledge by utilizing the water resources material.

Table XII shows that a significant difference occurred in the means of the experimental group from the pre-test to the post-test. For Part B the average gain was 9.3 more questions answered correctly on the post-test than on the pre-test. It would be tempting to infer that this represents a 44.6 per cent gain in knowledge from the pre-test; but to make this assumption, it would be necessary to assume that Part B was a complete test of the knowledge in this area. This, of course, is not possible. Part C showed a 35 per cent gain in knowledge about community water resources.

This is not an absolute gain in knowledge about community water resources, but rather, the per cent of gain shown by the use of Part C.

With the five week interval between the test procedures, the control group improved in both its general knowledge about water resources as measured by Part B and its specific knowledge about community water resources as measured by Part C. On Part B the control group in Ann Arbor-Plymouth increased an average of 2.48 more questions answered correctly on the post-test than on the pre-test, and the Holland control group increased 4.3. For Part C the Ann Arbor-Plymouth group increased 1.37 more questions answered correctly and the Holland control group increased 2.41. The total increase for the control groups on Part B was 3.07 and for Part C, 1.69. Familiarity with the terminology of the questionnaires, incidental information because of increased interest and the awakening of past learning all account in part for this increase.

TABLE XII

COMPARISON OF THE EXPERIMENTAL GROUPS:
PRE-TEST/POST-TEST MEANS
OF PARTS B AND C

Groups	Test	Mean	Difference of the Means	t-Score	Significantly Different from 0 at the
A-E	Pre-test B	23.35	8.03	10.96	0.01 level
A-E	Post-test B	31.38			
G-E	Pre-test B	19.53	11.40	7.62	0.01 level
G-E	Post-test B	30.93			

TABLE XII -- Continued

Groups	Test	Mean	Difference of the Means	t-Score	Significantly Different from 0 at the
H-E	Pre-test B	17.31	9.84	5.23	0.01 level
H-E	Post-test B	27.15			
Total E	Pre-test B	20.85	9.3	13.02	0.01 level
Total E	Post-test B	30.15			
A-E	Pre-test C	25.52	6.87	6.92	0.01 level
A-E	Post-test C	32.39			
G-E	Pre-test C	19.33	13.42	6.04	0.01 level
G-E	Post-test C	32.75			
H-E	Pre-test C	26.58	8.00	5.91	0.01 level
H-E	Post-test C	34.58			
Total E	Pre-test C	24.40	8.55	10.01	0.01 level
Total E	Post-test C	32.95			

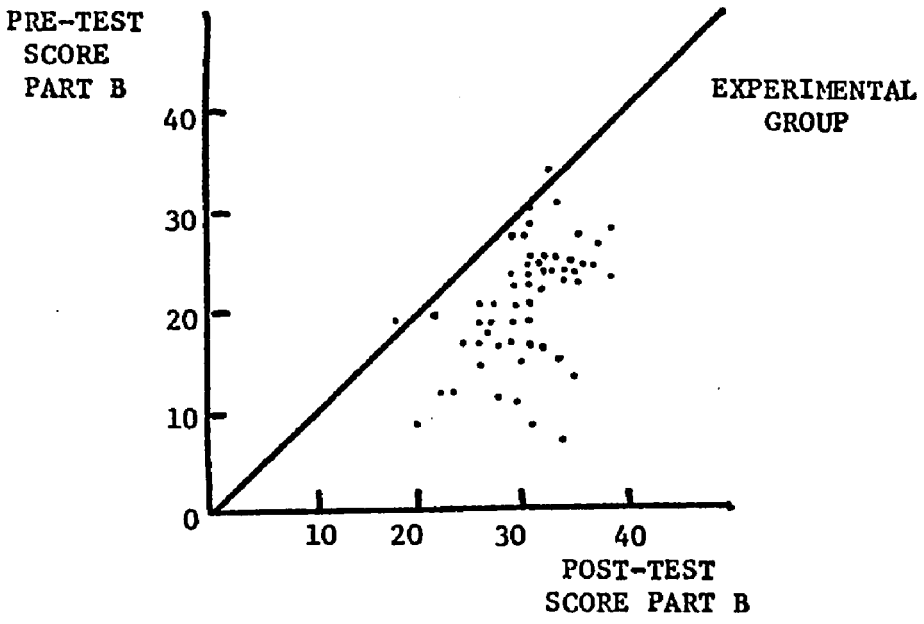
The changes in knowledge which occurred in Parts B and C of the questionnaires are portrayed graphically by means of scatter diagrams in Figures 3 and 4. These diagrams show the changes in both the experimental groups and in the control groups.

Hypothesis III: The difference of the pre-test/post-test means of the experimental groups should be significantly different from the difference of the pre-test/post-test means of the control groups.

Table XIII shows that the experimental groups achieved a significant increase in knowledge over the control groups. The improvement of the experimental groups was much greater than that of the control groups indicating that the increase in knowledge

FIGURE 3

SCATTER DIAGRAMS OF PART B PRE-TEST/POST-TEST SCORES OF THE EXPERIMENTAL AND CONTROL GROUPS



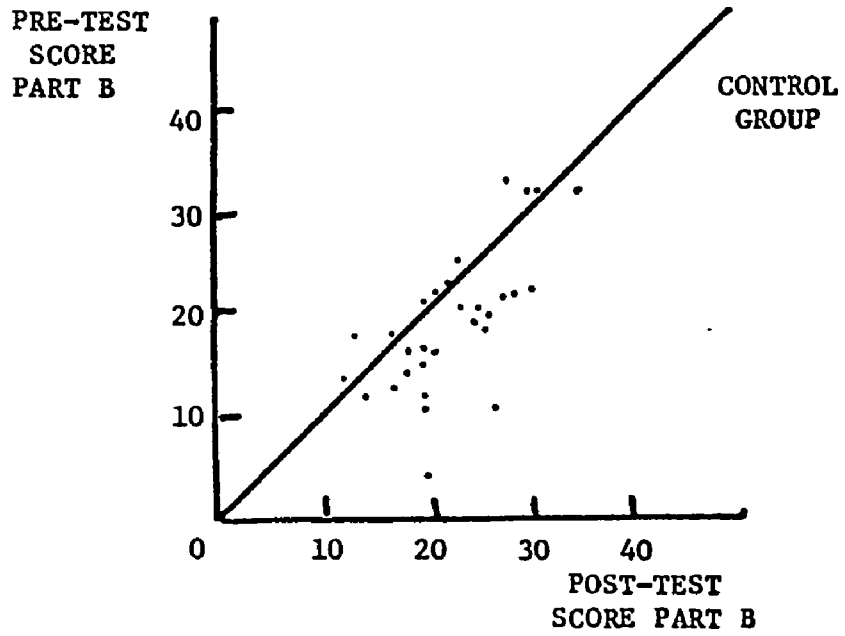
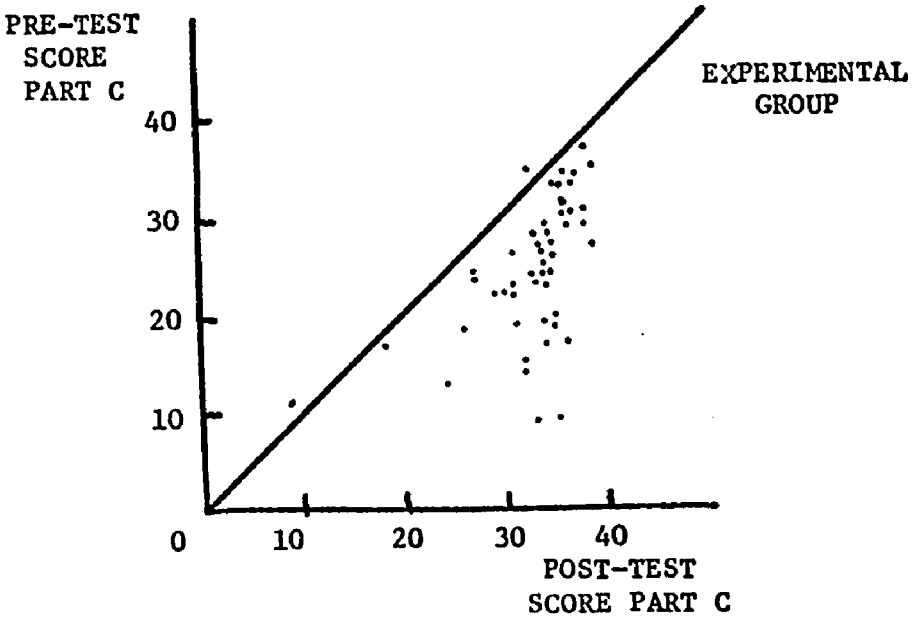
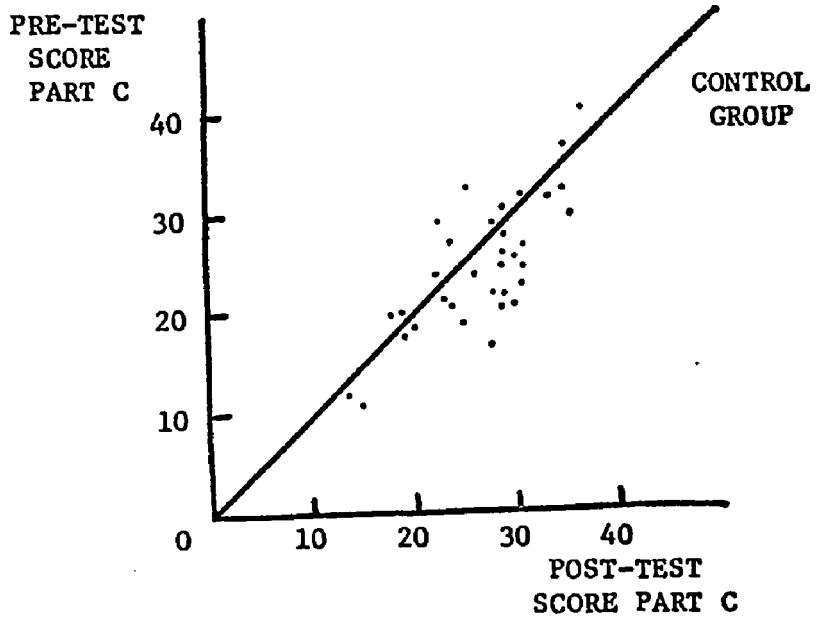


FIGURE 4

SCATTER DIAGRAMS OF PART C PRE-TEST/POST-TEST SCORES OF THE EXPERIMENTAL AND CONTROL GROUPS





was a function of the course materials and not caused by familiarity with the terminology of the questionnaires, incidental information because of increased interest or the awakening of past learning.

TABLE XIII

COMPARISON OF THE EXPERIMENTAL AND CONTROL GROUPS: DIFFERENCE OF THE PRE-TEST/ POST-TEST MEANS OF PARTS B AND C

Group	Test	Pre-test Minus Post-test Mean	Difference of the Means	t-Score	Significantly Different from 0 at the
A-E	Part B	8.03	5.55	6.45	0.01 level
A-C	Part B	2.48			
H-E	Part B	9.86	5.55	2.07	0.05 level
H-C	Part B	4.31			
Total E	Part B	9.30	6.23	7.10	0.01 level
Total C	Part B	3.07			
A-E	Part C	6.87	5.55	4.30	0.01 level
A-C	Part C	1.32			
H-E	Part C	8.00	5.59	3.23	0.01 level
H-C	Part C	2.41			
Total E	Part C	8.55	6.86	5.97	0.01 level
Total C	Part C	1.69			

Hypothesis IV: The difference between the post-test means of the individuals who took the course by correspondence should not be significantly different from the post-test means of the individuals who took the materials as part of a college conservation course.

It is not possible to indicate just how much the course materials increased the participants' knowledge about water resources.

However, it was possible to compare correspondence individuals with those who were responsible for the material as part of a college credit course. The Ann Arbor-Plymouth group who took the short course on water resources by correspondence on a non-credit basis was not significantly different in its final knowledge level from the Grand Rapids group which was responsible for the water resources material as part of a college credit course. The final achievement of both groups was approximately equal. The Grand Rapids group, however, showed more growth because its initial test scores were somewhat lower than the Ann Arbor-Plymouth group. The important implication is that correspondence students without the motivation of achieving college credit can learn approximately as much from the material as students taking it for college credit. Table XIV compares the final knowledge achievement level of the Ann Arbor-Plymouth and Grand Rapids groups.

TABLE XIV

COMPARISON OF THE ANN ARBOR-PLYMOUTH AND THE GRAND RAPIDS EXPERIMENTAL GROUPS: POST-TEST MEANS OF PARTS B AND C

Group	Post-Test	Mean	Difference of the Means	t-Score	Significance
A-E	Part B	31.38	.45	.30	No significant difference
G-E	Part B	30.93			
A-E	Part C	32.39	.36	.23	No significant difference
G-E	Part C	32.75			

In Part B the Ann Arbor-Plymouth group and the Grand Rapids group achieved approximately the same post-test mean. The Grand Rapids group, however, was initially lower on Part B and so made a larger increase even though it did not completely equal the Ann Arbor-Plymouth group's achievement level on post-test Part B. The Holland group had a pre-test Part B score lower than both the other experimental groups, and although it achieved a marked amount of growth, it was still well below the others on the post-test Part B.

The scores for Part C again show the growth of the Grand Rapids group to be greater than the other groups in community resource knowledge. This can be accounted for because of the lower initial knowledge of community water resources. One interesting fact about the Holland group, pointed out by its Part C scores, is that it is further removed from formal educational experiences, but closer to its community and its problems because of higher citizen group participation. While scoring low on general knowledge, the Holland group scored highest on community knowledge.

Table XV shows a comparison of the experimental groups' pre-test/post-test means of Parts B and C.

TABLE XV

COMPARISON OF THE EXPERIMENTAL GROUPS:
PRE-TEST/POST-TEST MEANS OF PARTS B AND C

Group	Test	Mean	Mean Increase
A-E	Pre-test B	23.35	8.03
A-E	Post-test B	31.38	
G-E	Pre-test B	19.53	11.40
G-E	Post-test B	30.93	
H-E	Pre-test B	17.31	9.86
H-E	Post-test B	27.15	
A-E	Pre-test C	25.52	6.87
A-E	Post-test C	32.39	
G-E	Pre-test C	19.33	13.42
G-E	Post-test C	32.75	
H-E	Pre-test C	26.58	8.00
H-E	Post-test C	34.58	

Part D of the preliminary and final questionnaires was aimed at measuring the change in the participants' ability to identify water resource problems and the amount of concern they had for the problems which they identified. This section was composed of four colored pictures of different water resource situations (Appendix D). The participants were asked to identify three problems in each picture. The pictures basically showed water resource situations, not specific problems. It was up to the participant to, in effect, generate the problems which he perceived in the setting.

Analysis of Part D was difficult because one-third of the

individuals were able to initially identify the full number of problems allotted. Three problems were to be identified for each picture. Those individuals who could not identify three problems for each picture on the pre-test increased an average of 25 per cent on the post-test. The pre-test average of problems identified, out of twelve possible, was 8.3; on the post-test this jumped to 11.3. It seems apparent, that even though this is a very crude scale, it still points out that the course materials helped the participants to identify water resource problems.

A second aspect of the pictures was to measure concern about water resource problems. For each problem identified from a picture the participant was asked to express his concern about the problem. The problems were checked using a scale of extremely concerned, very concerned, concerned, slightly concerned and not concerned. The concern for each problem was given a numerical value and an average of pre-test concern and post-test concern was tabulated. The results showed no significant difference in concern. It would be extremely interesting to pursue this point in greater depth, however, the design of the questionnaires does not permit a more detailed conclusion than that which has been presented. If more was to be done in this area a new test instrument would have to be developed.

Part E, the last part of the preliminary and the final questionnaires, was directed at evaluating the experimental participant's ability to identify sources of information on water resources in his community and the identification of public

agencies and private organizations involved with water resources and water resource problems in his community. These are important to citizens who are going to be actively involved with water resource problems because one of the prerequisites of effective citizen action is for the citizen to be informed about specific information and varied viewpoints on water issues from persons, agencies or organizations interested in water resources in his community.

Each question of Part E had six blank spaces for possible answers. In the first of the three open-ended questions, the participant was to identify sources of information about water resources and water resource problems in his community. Question two asked the participant to identify public organizations involved with water resources and water resource problems. Question three asked the participant to identify private organizations involved with water resources and water resource problems.

Table XVI is a summary of the ability of participants to identify these various areas.

TABLE XVI

PARTICIPANT'S ABILITY TO IDENTIFY SOURCES OF KNOWLEDGE, PUBLIC AGENCIES AND PRIVATE ORGANIZATIONS CONCERNED WITH WATER RESOURCES IN HIS COMMUNITY

Question	Group	Test	Mean	Mean Gain	Experimental Group Gain Over Control Group Gain
Identification of information sources	Experimental	Pre	2.60	1.57	.97
	Experimental	Post	4.17		
	Control	Pre	2.70	.60	
	Control	Post	3.30		
Identification of public agencies	Experimental	Pre	1.81	1.42	.50
	Experimental	Post	3.23		
	Control	Pre	1.82	.92	
	Control	Post	2.74		
Identification of private organizations	Experimental	Pre	.88	1.65	1.02
	Experimental	Post	2.53		
	Control	Pre	.82	.63	
	Control	Post	1.45		

Even though the range is small the average gain of the experimental groups shows that they are more familiar with both the sources of information and organizations interested in water resources. It was evident from the data that many individuals have given very little consideration to these items before being involved in the course. The private community organizations concerned with water resources were particularly low due to the invisibility and in some cases the non-existence of these groups.

Opinion Questionnaire

The opinion questionnaire (Appendix E) was the final data gathering instrument. It asked a series of questions designed to probe the experimental participant's opinions on various aspects of the course. The first series of questions was about the text; this was followed by a series of questions concerning the activities.

The text (Appendix B) was rated in a number of ways by the opinion questionnaire. Text difficulty was the first to be covered. It was evaluated by the participants on a five-point rating scale. Table XVII indicates the choices, the frequency of each choice, the per cent and the mean. The participants considered the text to be just on the "easy" side of "about right."

TABLE XVII

TEXT DIFFICULTY

Category	Frequency	Per Cent
1. Very Difficult	0	0
2. Difficult	3	5.45
3. About Right	41	74.55
4. Easy	10	18.18
5. Very Easy	1	1.82
Total	55	100.00

Mean - 3.16

Text length was the second item to be covered on the opinion questionnaire. It was evaluated by the participants on a five-point rating scale. Table XVIII indicates the choices, the frequency of each choice, the per cent and the mean. The text length was considered to be somewhat long by many of the participants and in view of this criticism a strenuous effort will be made to meaningfully reduce its length in the final copy.

TABLE XVIII

TEXT LENGTH

Category	Frequency	Per Cent
1. Too Long	5	9.09
2. Long	21	38.18
3. About Right	29	52.73
4. Short	0	0
5. Too Short	0	0
Total	55	100.00

Mean - 2.44

Text completeness was the next item to be covered on the opinion questionnaire. It was evaluated by the participants on a four-point rating scale. Table XIX indicates the choices, the frequency of each choice, the per cent and the mean. The participants felt the text was complete. The use of the minimal understandings played a vital role in the development of text completeness.

TABLE XIX

TEXT COMPLETENESS

Category	Frequency	Per Cent
1. Very Complete	21	38.18
2. Complete	26	47.27
3. Somewhat Incomplete	7	12.73
4. Incomplete	1	1.82
Total	55	100.00
	Mean - 1.78	

Text style was the next item to be covered on the opinion questionnaire. It was evaluated by the participants on a four-point rating scale. Table XX indicates the choices, the frequency of each choice, the per cent and the mean. The text style was considered to be in the "good" category. The most frequent complaints about style were that sentences were too long and sometimes the sentence structure was complicated.

TABLE XX

TEXT STYLE

Category	Frequency	Per Cent
1. Very Good	9	16.36
2. Good	35	63.64
3. Poor	10	18.18
4. Very Poor	1	1.82
Total	55	100.00
	Mean - 2.05	

Text interest level was the last item to be covered on the opinion questionnaire regarding the text. It was evaluated by the participants on a four-point rating scale. Table XXI indicates the choices, the frequency of each choice, the per cent and the mean. The interest level was between the "interesting" and "very interesting" categories.

TABLE XXI

TEXT INTEREST LEVEL

Category	Frequency	Per Cent
1. Very Interesting	19	35.18
2. Interesting	30	55.56
3. Low Interest	4	7.41
4. Not Interesting	1	1.85
Total	54	100.00
	Mean - 1.76	

A general statement about the participants' opinions of the text would be that it is good but can use some improvement. This segment of the opinion questionnaire was important in the development of the final draft of the text.

The activities (Appendix C) were evaluated next. In general, the same technique was used for the activities as was used for the text. The questions were either accompanied by a rating scale or were open-ended. The open-ended questions

were coded to facilitate their use.

Reaction to the activities was the first item tabulated. It was evaluated by the participants on a four-point rating scale. Table XXII indicates the coding of the categories, the frequency of each category, the per cent and the mean. The participants liked the activities. In general the self-directed field experience was particularly well accepted.

TABLE XXII

PARTICIPANTS' REACTION TO ACTIVITIES

Category	Frequency	Per Cent
1. Very Well	20	37.73
2. Quite Well	30	56.60
3. Not So Well	3	5.67
4. Not At All	0	0
Total	53	100.00
	Mean - 1.68	

All but one person in the entire study found Activity A, the self-directed field experience, to be worthwhile. Activity B, the interview, and Activity C, the paper, were somewhat less enthusiastically received. Some of the participants did not respond as favorably to Activity B as they did to Activity A because they did not feel at ease in finding, setting up an appointment with and interviewing a knowledgeable person. Some individuals expressed real surprise about the way in which governmental officials reacted

to the interview - while some seemed guarded, others seemed very open. Many participants were impressed with the knowledge and dedication of the governmental officials they interviewed, while others expressed concern about a lack of knowledge or reticence to discuss water resource problems. Activity C, the term paper, was least enthusiastically received. A frequent comment was that it had been a long time since the participant had worked on a paper; it was difficult, but worthwhile.

The amount of time spent on the text and the activities seems to be indicative of the interest and value these items had for the participants. Table XXIII shows these results.

TABLE XXIII

TEXT AND ACTIVITY TIME

Category	Mean Time Hours
Text	6.42
Activities	11.75
Total Course	18.17

The last set of questions on the opinion questionnaire probed how the participants felt about the entire short course on water resources and how much they thought they gained from their involvement. Table XIV shows the participants' overall feelings about the water resources unit.

TABLE XXIV

PARTICIPANTS' FEELINGS ABOUT
THE WATER RESOURCES UNIT

Category	Frequency	Per Cent
1. Very Good	31	60.78
2. Good	16	31.37
3. Not Very Good	4	7.85
4. Not Good At All	0	0
Total	51	100.00

Mean - 1.47

The next five questions probed the values which the participants felt they derived from the course. These include: interest, concern, general knowledge, community knowledge and political knowledge about water resources and water resource problems. The following tables show these results.

TABLE XXV

DEGREE OF INCREASED INTEREST

Category	Frequency	Per Cent
1. A Great Deal	36	65.45
2. Some	16	29.09
3. A Little	1	1.82
4. Not At All	2	3.64
Total	55	100.00

Mean - 1.44

The results of Table XXVI show that the citizens who took the course became more concerned about water resources and water resource problems. However, in the picture sequence in Part D of the preliminary and final questionnaires, when they were asked to rate their concern on specific problems the concern index did not change significantly from the preliminary questionnaire to the final questionnaire. These two facts show the difficulty of evaluating concern when working with people.

TABLE XXVI

DEGREE OF INCREASED CONCERN

Category	Frequency	Per Cent
1. A Great Deal	34	64.15
2. Some	14	26.41
3. A Little	2	3.77
4. Not At All	3	5.67
Total	53	100.00
	Mean - 1.51	

TABLE XXVII

DEGREE OF INCREASED GENERAL KNOWLEDGE

Category	Frequency	Per Cent
1. A Great Deal	39	70.91
2. Some	13	23.64
3. A Little	3	5.45
4. Not At All	0	0
Total	55	100.00
	Mean - 1.35	

TABLE XXVIII

DEGREE OF INCREASED COMMUNITY KNOWLEDGE

Category	Frequency	Per Cent
1. A Great Deal	34	61.82
2. Some	14	25.45
3. A Little	6	10.91
4. Not At All	1	1.82
Total	55	100.00
	Mean - 1.53	

TABLE XXIX

DEGREE OF INCREASED POLITICAL KNOWLEDGE

Category	Frequency	Per Cent
1. A Great Deal	8	14.55
2. Some	27	49.09
3. A Little	13	23.63
4. Not At All	7	12.73
Total	55	100.00
	Mean - 2.35	

The participants were satisfied with how the water resources material increased their interest, concern, general knowledge and community knowledge. They were not as satisfied with how the course increased their political knowledge. The water resources materials in themselves were not designed, because of the space limitations,

to fully develop the political aspects of the situation. The water resources material will have to rely on the specific chapter of the environmental conservation independent study course through correspondence that deals with Government, Politics and the Citizen to cover this area.

Last questions, answered briefly with "yes" and "no," asked the participants if they would recommend the course to their friends. Almost all, 96.36 per cent said "yes." More than half, 62.75 per cent said they wanted to take the completed course for credit. Many people who would like this type of educational experience want to participate for personal reasons and have no need for college credit. The plans for the completed course now call for it to be offered on both a credit and a non-credit basis.

The last question was extremely important to the evaluation. It asked the participants if they felt the short course on water resources was a worthwhile educational experience and 100 per cent said "yes."

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS BASED ON THE EVALUATION

A basic concern of this study was to develop and evaluate the combination of environmental conservation and independent study through correspondence. It is not the purpose of this undertaking to prove where in the continuum of educational effectiveness environmental conservation by independent study through correspondence would rank, but rather to determine if this is a viable and acceptable method of presenting this type of program. The question, therefore, is not one of finding the one educational method which is most effective in transfering learning, if in fact one really exists, but rather to find a method which is viable, acceptable and will be used.

The advantages of independent study through correspondence in coordination with the participant's environment and the subject matter of environmental conservation make this type of program uniquely suitable to the needs of a great many individuals who could not otherwise participate in environmental education programs. Correspondence courses can reach out to all the people, not just to those within commuting distance of an educational institution. They can reach out at any time, not just when a program at an institution can be scheduled. And they can fit into

almost any time schedule. An extremely important and regretably growing adult education problem is the decreasing use of extension buildings in some urban areas. Many individuals are becoming concerned about their own safety and have not been willing to attend night school programs in some metropolitan areas as has been shown by a drop in attendance at some inner city extension services. Correspondence courses do not suffer from this difficulty. They can serve urban dwellers as well as they have continuously served the needs of dispersed individuals in rural areas.

All types of educational programs are growing. The growth of leisure time, population, complexity of society, interest in new subjects and our standard of living all add to the pressure upon educational institutions for increasing educational offerings at all levels, but particularly at the adult level. These needs have been met in part by courses being given by universities in local communities, by educational television and by correspondence. Each of these methods has its own particular strengths. As part of the adult educational picture, correspondence has some definite strengths. Research has shown that it can be as effective as other teaching methods in the presentation of subject matter. It can bring individuals organized material, direct them into activities and provide motivational feedback, by mail, between the student and the university. The approach is very flexible because it allows the student to proceed at his own rate in those time periods available to him, it can be utilized continuously at any time of the year, it can be given on either a credit or a non-credit basis,

and it can be made flexible in terms of subject matter and activities, if this is desirable. It can tap resources such as the participant's own community environment which are somewhat remote and difficult for most university classes to utilize.

Correspondence courses also have some weaknesses that must be understood and buffered against if programs using correspondence are to be effective. One important problem is the maintenance of motivation. With limited structured requirements, it becomes all too easy for the student to conveniently evade his correspondence studies. A number of techniques are effective in combating this problem: question and answer activities which can be sent to the university and returned quickly with comments; the organization of courses so that the student is always receiving new materials; telephone interaction with course instructors; audio-visual aids; and regional meetings between instructors and students. It is planned that as the environmental conservation independent study course through correspondence becomes a reality some of these techniques will be employed to fulfill this need. The activities which are planned for the completed course are designed to maintain motivation by quick feedback from the university. The course is also organized to provide a constant flow of motivating materials which are in part participant selected. The student's interest in the subject matter, its relevance to the learner and the use of the student's own community as the setting for the activities are all considered as important motivational components of the environmental conservation independent study course through

correspondence.

A second consideration in correspondence materials is that they must be self-explanatory. In the development of course materials careful consideration must be given to how they function, and an active pilot program must be utilized to assure that they are performing their programmed function. An important aspect of this study is the evaluation of the acceptability of the types of activities for the course by testing sample activities with the experimental groups.

Conclusions

The short course on water resources did increase several aspects of the participants' knowledge. It increased their knowledge about water resources in general as was measured by Part B of the preliminary and final questionnaires. It also increased their knowledge about their community water resources and water resource problems as was measured by Part C. Both of the knowledge components increased and the difference proved to be significant. The experimental procedures also indicated that the correspondence participants who took the course for non-credit (Ann Arbor-Plymouth Group) did as well as the students who took the course for credit (Grand Rapids Group). This evidence suggests that the materials used through correspondence increase the learner's understanding of water resources and water resource problems.

The materials increased the participants' awareness of water resource problems and an ability to identify these problems.

They also increased the participants' abilities to identify sources of information about environmental problems as well as the knowledge about private and public organizations which are concerned with water resources and water resource problems.

The opinions of the participants strongly supported the data that the short course on water resources increased their general knowledge, specific community knowledge, interest and concern in water resources and water resource problems.

The combination of environmental conservation and independent study through correspondence is viable. With the limited publicity and without the long range interest which can be generated for this type of course by personal communication, the 153 people who applied for the course prove that there is definitely a need for conservation offerings at the college level and that correspondence is acceptable to many citizens as a vehicle for these offerings. As indicated by the personal information, individuals who are interested in a university offered conservation course, are mostly college educated people who are involved in public service or citizen action groups and are concerned about their environment and willing to be involved in public and private decisions about environmental problems. Because the short course on water resources was offered by a university, those who expressed an interest were mostly people who were college educated. It is evident that these citizens feel the need to be better informed about their environment in order to be more effective in dealing with its problems.

An adult clientele exists who want environmental education experiences and who will accept correspondence as a means of obtaining these experiences. From the personal data about the participants of the short course on water resources, it was possible to approximate the projected population of the completed environmental conservation course. From the comparison of the personal data it was evident that the individuals from Ann Arbor were not significantly different from the rest of the sample and they did not bias the representativeness of the sample.

The individuals will be divided between male and female and be basically between the ages of twenty and fifty with the mean age of approximately thirty-eight. Most will have a college education - many with a master's degree or more. Most, however, will have little or no professional training in the field of conservation. Their average income will be $12,500 to $15,000, with a wide range of incomes outside of this classification. They will be for the most part busy people who are either employed full time or who are homemakers. They will come from a wide range of occupations and about twenty-five per cent of the individuals will be interested in the course because it relates to their work. A greater percentage will come from urban or suburban areas, although with additional rural publicity, the ratio may change. Almost eighty per cent will be married with an average of two children. They will be publicly active with sixty-three per cent belonging to one or more citizen or public interest groups.

From this profile of the projected course population, it

is apparent that the readership of this course will possess a sound basic education and that the materials produced need to be stimulating and directed at a college level. It is also extremely important that the course materials be completely correct and unbiased. They must be designed to help the individual see ways of gathering additional information which may be unique or particularly relevant to his situation.

The basic concepts and the organization of the course were very well accepted. The text was considered interesting or very interesting by 90 per cent of the participants; 85 per cent thought it was either complete or very complete; and 79 per cent felt its style was good or very good. The length was considered about right by 52 per cent of the participants, however, the other 48 per cent thought it was either long or too long. The participants felt that the organization was logical and complete which facilitated its use as a reference. They also found the glossary and annotated bibliography to be helpful.

The activities were accepted with varying interest. Activity A, the self-directed field experience, was enthusiastically received. The participants found it informative and interesting. Many participants used the word "fun" or "interesting" in verbally describing it. Activity A is the prototype of a group of similar activities that are the core of the correspondence course effort to help the student familiarize himself with his community environment and to

increase his awareness of environmental problems.

Activity B, the interview, and Activity C, the paper, were less enthusiastically received because of the types of effort they demanded. Direct confrontation with knowledgeable people is not usually easy. Most participants, however, found this activity worthwhile. Activity C, the paper, was least enthusiastically received and yet many individuals felt it was worthwhile because it forced them to draw together facts and arrive at conclusions. Some of the ways in which Activity C was done showed a great deal of perception and thought on the part of the participants. Activity C has the power of drawing the total experience together and is readily accepted by those who are doing the work for credit.

Even though Activities B and C were not as enthusiastically received as Activity A, they are a vital part of the course and were used to accomplish the designed objective of involving the participants with knowledgeable individuals in the field of water resources and in focusing the experience on a specific water problem. In the completed course there will be only one Activity B and one Activity C for every three units. The Grand Rapids group, who took the course for credit, readily accepted Activities B and C. Approximately 62.7 per cent of the participants wanted to take the course for credit.

The short course on water resources had a number of interesting spinoffs that should be duplicated by the completed course. Mr. Jerome K. Fulton, Executive Secretary of the Huron River Watershed Council said in a letter (Appendix I) to Dr. William B. Stapp:

> During the past few months the Watershed Council has had more calls from and interviews with citizens in the Ann Arbor area than ever before.
>
> The interviews indicate an unusual depth of understanding of both the physical and the socio-political aspects of water resource problems. Most of the citizens were enrolled in the "Independent Studies in Water Resources" offered by the School of Natural Resources.[1]

In a note from Mrs. Carl S. Cook (Appendix I) she emphasized her feelings about the course and its effect on the Holland group.

> . . . Nothing has happened to our garden club in recent years to match the interest the study course is causing.[2]

The author was also invited by a course participant to speak about water resources at the Willow Run Laboratories of the University of Michigan. This meeting was the direct result of involvement in the course. At that time several individuals expressed an interest in the correspondence program.

Recommendations

A number of practical recommendations are evident from the evaluation. The newspaper and private group newsletters were the most effective means of publicity. The completed course will benefit from the Extension Service News announcements as well as from announcements in many governmental and private magazines. This was not desirable for the short course because it had to be geographically limited.

The completed course should be offered for both credit and

---

[1]Jerome K. Fulton, personal letter to Dr. William B. Stapp, November 26, 1968.

[2]Mrs. Carl S. Cook, personal letter to the author, October 27, 1968.

non-credit because each meets the needs of a different group of participants. The text will be improved by the addition of photos and professionally developed graphics.

An important recommendation concerning the activities is to make the self-directed field experience activities into manageable segments of approximately one hour duration. The directions for the activities, because of the lack of direct communication with the university, need to be very explicit. Also, more guidance is needed in the directions for the interview activity. The participants thought that the activity sequence was somewhat long. This will be remedied in the completed course by dividing the activities among a number of units.

The evaluation indicates that the University of Michigan environmental conservation independent study course through correspondence, "Environmental Conservation: Opportunities for Effective Citizen Action" is needed and will be accepted. It is apparent that many individuals for personal reasons are extremely interested in this area of study. A number of individuals feel that this type of education program is relevant to their occupational endeavors. It seems likely that this type of program, with constant updating, can become an important continuing educational offering.

The most important future possible development from this effort, hopefully, would be the extension of its basic concepts into a whole spectrum of correspondence courses which would use the student's own community as a laboratory for independent

study activities. These courses could cover many topics, including and outside of the field of conservation.

APPENDIX A

MINIMAL UNDERSTANDINGS

MINIMAL SCIENTIFIC UNDERSTANDINGS

I. The physical and chemical properties of water are important to its use as a resource.

   A. Water's density in relation to temperature, its physical state in relation to temperature and its thermal properties are all factors that determine water's ability to function as a resource.

   B. Water exerts force when it is pulled downward by gravity.

   C. Chemically, water is a necessary component of all life - a very stable substance and an excellent solvent.

II. Water on the earth in the presence of sunlight, results in the hydrologic cycle.

   A. Evaporation occurs whenever water is exposed to the atmosphere.

   B. Precipitation which is formed from the condensation of water vapor in the atmosphere, is affected by winds and the local topography.

   C. Runoff and ground water are the manageable segment of the hydrologic cycle.

      1. Water is stored and moves in many ways under the surface, on the surface and between the surface and the subsurface of the earth.

      2. The supply of water available to man varies depending on the time of the year and specific local conditions.

      3. Water in the soil is divided by a line called the water table. The soil below this line is saturated and the water from below travels up into and through the unsaturated soil above by capillary action.

      4. An excess or lack of runoff and/or ground water can cause problems of water supply, pollution, siltation, erosion and flooding.

III. Man's development and use of land directly affects the quality and the quantity of runoff and ground water.

IV. Water, because of the hydrologic cycle, is a flow resource with no critical zone.

V. The watershed is a logical unit (system) for physically managing water, but it seldom coincides with political, social or economic systems.

VI. Man influences water systems in many ways as he uses them.

MINIMAL UNDERSTANDINGS DEALING WITH WATER AS A RESOURCE

I. The demand for water resources is growing.

A. Population increases have caused a growth in water demand.

B. Shifts in population to urban areas have caused regional increases in water demand.

C. The growth of the standard of living has increased the per capita demand for water.

D. The demand for water resources exceeds the developed supply in many areas causing difficult allocation problems.

II. The supply of fresh water is relatively fixed by the hydrologic cycle.

A. There is no nationwide shortage of water resources, but there are regional shortages due to the irregularity of supply, availability of regional supplies and concentration of demand.

B. Man's use of water resources and his development and use of land have directly affected the quality and the quantity of regional water supplies.

III. The uses for water are growing, and they are affecting the quantity demanded, the quality demanded, and the allocation of water resources.

A. Water resource use is often determined by historical accident and maintained by vested interests and outdated laws.

B. Man uses vast quantities of water for a wide variety of purposes.

1. Man must have water physiologically.

2. Water is a basic factor in determining domestic, municipal and industrial development.

a. Water is used physiologically.

b. Water is used for waste disposal.

c. Water is used for cooling.

d. Water is used to transport materials, goods and people.

e. Water is used in manufacturing processes.

3. Water is used for the disposal and assimilation of wastes.

a. Water is used to transport wastes.

b. Water is used to dilute wastes.

c. The action of organisms in the presence of dissolved oxygen in water can reduce most organic and some inorganic materials to basic environmental substances.

d. Bodies of water have a limit to the amount of wastes they can assimilate. Rivers and streams can assimilate wastes better than lakes because their movement helps oxygen dissolve and mix into the water.

e. The carrying, diluting and assimilating of wastes may affect the ecological, economic and aesthetic qualities of water.

f. Many types of wastes are difficult to control because of their persistent and cumulative nature.

g. Some materials which are not pollutants may cause conditions which are considered pollution. These materials are called corollary pollutants.

4. Water is used for irrigation.

a. Irrigation tends to cause evaporation and, therefore, is a consumptive use of water.

b. Irrigation tends to add minerals and often pesticides to runoff.

c. Irrigation, largely by sprinkler methods, is being used more frequently in humid climates such as Michigan.

5. Water resources are used in the production of electricity.

a. The development of hydroelectric power demands a large and constant flow of water.

b. The development of hydroelectric power needs large reservoirs which can be built only in a limited number of places.

c. Cooling of steam electric generating plants with water raises the temperature of receiving water bodies which affects the living organisms in them.

6. Navigation needs water; various types of development may be necessary to maintain minimum depth requirements.

7. Recreation is a growing use of water.

a. Water is a necessary component and a focal point for many types of recreation.

b. Public access to water for recreation is severely limited in many areas due to private holdings and prior development.

c. Many types of water use and development are not compatible with recreation.

8. Water of good quality is needed as habitat for fish and wildlife.

MINIMAL UNDERSTANDINGS IN WATER RESOURCE MANAGEMENT

I. Project planning, development and operation are all a part of water resource management.

II. The available water management alternatives are determined by the physical environment and the social institutions.

A. Many water management alternatives are expensive and some are irreversible.

B. The solution to many water resource problems should be a system of varied water management techniques.

III. The competitive market or the political process can be used to allocate water resources to specific demands or demand sectors.

IV. The supply of water available as a resource can be increased and stabilized in a number of ways.

A. Watershed management can stabilize runoff, increase ground water and decrease siltation.

B. Reservoirs can help stabilize runoff and prevent the loss of surplus water.

C. Reuse of water can be an effective means of better utilizing the available supply.

D. Transportation of water and the tapping of new supplies can be an important method of increasing regional supplies.

V. Water quality can be increased by a number of different methods.

A. Pollution can be defined ecologically, economically and aesthetically.

B. There are many types of pollution.

1. Organic pollution - animal waste, food waste, etc.

2. Chemical pollution - salt, phenols, etc.

3. Physical pollution - silt, junk, heat, etc.

4. Pathogenic pollution - disease organisms.

5. Radioactive pollution - chemical isotopes.

6. Aesthetic pollution - mud, smell, dye, noise from motorboats, etc.

C. The reaction when pollutants are mixed may be antagonistic, synergistic or compatible.

D. Pollution can be controlled by segregation, dilution or waste treatment.

1. Some waste materials such as radioactive isotopes must be kept out of natural water bodies.

2. Maintenance of sufficient stream flow is critical to the adequate assimilation of waste materials.

3. Some types of pollutants need specific control.

VI. Decision-making is a vital process in the management of water resources.

A. Water resource decision-making institutions should evaluate the tangible and intangible social and political benefits and costs of water resource decisions.

1. Water resource decision-making institutions should be as politically broad as possible.

2. Water resource decisions should strive to maintain flexibility for the future.

3. Water resource decision-making processes should be continuous.

4. Citizens have a responsibility in helping to determine the goals of water resource management by being involved in the decision-making process.

B. The planning process is vital to comprehensive decision-making.

1. The planning process has many characteristics in common with the decision-making process because it is an important component of decision-making.

2. The planning process should be responsible for outlining the alternatives available to water resource management.

3. The planning process should draw from the experience of many types of professionals in determining alternatives.

4. The planning process should encompass political, legal, psychological, economic and physical factors.

C. Economics should play an important role in the decision-making process.

1. Economics evaluates the costs and the benefits of various alternative methods of handling problems.

2. Economics analyzes the results of carrying out a given alternative.

3. The economic cost of pollution is often borne by the downstream users not by the polluter.

VII. Economic help may be needed from higher levels of government if some local water management problems are to be handled effectively.

VIII. A vital responsibility of water resource management is the maintenance of water resource research because new types of problems are constantly occurring.

IX. A vital responsibility of water resource management is the maintenance of water resource education because of its impact on the political process.

X. New water resource management institutions which cut across local governmental jurisdictions, may be needed to handle complex present and future water problems.

MINIMAL UNDERSTANDINGS IN THE AREA OF WATER RESOURCE POLICY

I. Water resource policy has its basis in a multiplicity of laws and precedents at all levels of government.

II. Policies and laws are formulated and changed by a multiplicity of institutions at all levels of government.

III. Effective water management requires consideration of the water system, the water consumer systems and the governmental systems through which legal and financial constraints are imposed.

IV. Effective water management requires facilitation of public expression and confrontation of conflicting values associated with water management proposals.

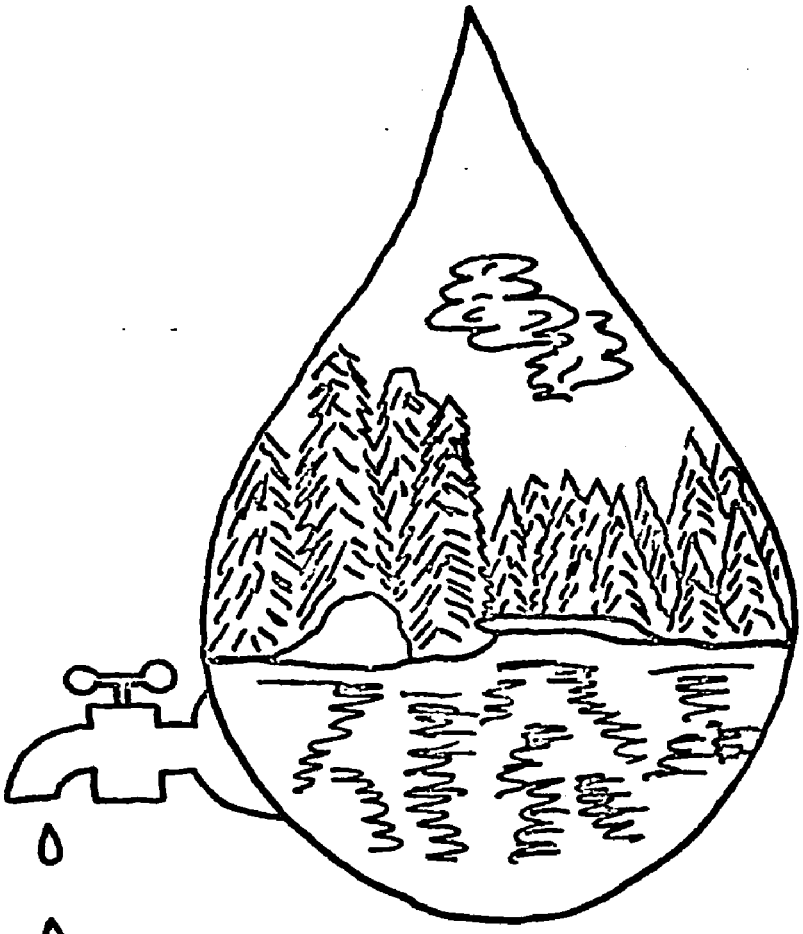
V. Informed citizens, acting through the political process, should be a factor in influencing water resource policy.

APPENDIX B

TEXT

THE
UNIVERSITY OF MICHIGAN
SHORT COURSE IN

WATER RESOURCES



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A SHORT COURSE IN WATER RESOURCES

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PART I: INTRODUCTION

Water is one of the most important substances of man's physical environment. It covers more than 70 per cent of the earth's surface, dominating the physical environment in which man lives. It determines weather, topography and life itself. For example, more than 60 per cent of the human body is composed of water. All living organisms, including man, must maintain a complex set of interactions with their environment to obtain the substances they need such as water. Modern man, however, uses water for more than just his body functions. In the United States the per capita use of water is 150 gallons per day and it is growing. Water is needed to produce the goods and services upon which modern society depends. Without water man cannot exist.

Modern man, however, has only recently started to worry about the quality and the availability of water even though it has played a key role in the development and downfall of a number of human civilizations. The massive use of natural resources necessary to maintain growing human populations has triggered an outpouring of pollutants which threaten to drastically degrade man's physical environment. Because man exists as part of an environmental system, the quality of his existence depends upon the quality of his environment.

In a democracy, citizens are individually responsible for their environment. Citizens can control the influence man has on the environment directly or indirectly through the governments that represent them. Privately and publicly, citizens should work toward maintaining or

improving their environment. Our standard of living, perhaps our very existence, depends upon the quality of our environment. Citizens should be concerned.

The age old water problems of shortage and flood have been joined in many areas by the critical water problem of modern society - pollution. While no national water shortage exists regional and local shortages of usable water are growing. Natural water supplies are large, but it is difficult to capture and retain all that man wants and needs. Man, however, degrades water which he uses making reuse more difficult. These problems have caused the demand for water to exceed the usable supply in many areas of the country. The use of water and the demand for it have grown to the point that allocation, management and pollution problems exist even in areas of water abundance such as Michigan.

Unlike many states, Michigan is endowed with abundant quantities of fresh water. This resource profoundly affects the economy of the state and the lives of its people. Although Michigan has abundant water resources, a profusion of water problems have developed that affect not only local and regional areas, but in some cases, cross state boundaries and become national and even international issues.

PART II: THE CHARACTERISTICS OF WATER RESOURCES

Without water, life, as we know it, cannot exist. This simple fact vividly points out how vital water is as a component of the natural environment. However, no single statement can adequately describe the complex and continuously interacting system which constantly provides the world's supply of fresh water. Sunlight, the earth, the atmosphere, living organisms and man are all factors which influence the quality and the quantity of water that is needed in the natural ecosystem and used by modern society. Man has changed from a simple animal consumer of water to a technological user and controller of water. His influence on water has become so profound that he is now a factor in determining the availability of water supplies. He has affected water quality to the point that important changes in the living organisms of the natural environment have occurred. As a natural resource water is part of a complex environmental system and it has some unique chemical-physical characteristics. These characteristics impose fundamental constraints upon the physical, economic and political systems man has devised for the control, development, allocation and use of water.

Some of the Physical-Chemical Characteristics of Water

Water has a variety of physical-chemical characteristics which make it uniquely suitable as a natural resource of man and as a vital component of the natural ecosystem. It can dissolve or physically carry a wide variety of materials because it is chemically very stable. It is a stable compound

because its one atom of oxygen and two atoms of hydrogen are held together by a strong internal molecular force.

Water has the highest thermal capacity of any natural substance. It can absorb and then give off large amounts of heat. It must also take in or give off extra heat when it changes from one physical state to another. When solid ice changes to liquid water or when liquid water changes to gaseous water vapor, extra heat must be absorbed from the environment. This extra heat, called latent heat, is given back to the environment when the process is reversed. Because of these phenomena, water plays a vital role in determining the climate of the world. It can also be used by man as both a holder of heat and as a coolant.

Water is relatively heavy and it exerts a force when it responds to gravity. The amount of force exerted is determined by the volume, the velocity and the distance it moves. Erosion, floods and water power are all the result of the force of moving water. The transformation of water power into electrical energy is an important energy resource. Erosion and floods on the other hand can be the destructive result of uncontrolled water power.

Density (the mass per unit volume) is an important characteristic of water because it directly affects stratification and mixing. One of the major determiners of water's density is temperature. Because temperature affects density, it also affects the stratification and the mixing of waters of different temperatures (in reality different densities). The density of water is greatest at 4° Centigrade (39.2° Fahrenheit). For temperatures above 4° C., warmer water is lighter than cooler water. The unique part of the process is that as the temperature drops below 4° C., water, unlike most other substances, starts to expand. When the change is made from liquid water to ice, the

the density of the ice formed is nine per cent less than that of the liquid water. Warm water will float on top of colder water, but ice will form and float on top of liquid water enabling life to continue below the frozen surface of lakes.

Many of water's unorthodox physical characteristics can be traced directly to its molecular structure. In the formation of a water molecule, the two hydrogen atoms always are attached to the oxygen atom on one side, thereby creating a molecule with concentrations of electrical charges on opposite sides. Because of this structure, water molecules are able to attach themselves to other molecules by forming hydrogen bonds (a hydrogen bond is the joining of two molecules by a negative electrical force attracting a positive electrical force forming the strongest bond which can exist between molecules). Water can form hydrogen bonds with other water molecules as well as with substances other than water. Each water molecule has two positive hydrogen atoms but only one negative oxygen atom. When water changes to ice, all the molecules form hydrogen bonds causing a lattice arrangement with spaces between the molecules. These spaces account for the nine per cent difference in the densities of ice and liquid water.

Water's ability to form hydrogen bonds is the reason for the capillary action of water in soil and for water's surface tension. Capillary action is the process by which water moves upward in soil against the force of gravity by forming hydrogen bonds with the soil molecules and pulling itself upward. Water moves upward in this way from lower levels when the soil moisture is depleted. Surface tension results from the hydrogen bonds which are formed between water molecules. This force causes a surface barrier on water. Even though surface tension is relatively weak, it is strong enough

to be a real problem to small living things. It is also a factor which affects the movement of water through soil with fine pores such as clay.

Because light is essential to photosynthesis (the process by which water and carbon dioxide are, in the presence of sunlight, converted by green plants into food and oxygen) turbidity and color are important water conditions. Turbidity is the clouding of water by suspended organic or inorganic material. The color of the water is usually related to the amount and kind of dissolved materials present. Both turbidity and color in water interfere with the photosynthetic process by blocking light penetration.

Water can act as a solvent for a wide variety of substances. It weathers rocks and man-made materials by dissolving them, thereby weakening them. It affects soil by dissolving the minerals which are important to soil fertility and carrying them away - a process called leaching. Because water is such an excellent solvent, it can carry dissolved (unwanted or harmful) substances. Salty ocean water cannot be used by man directly for drinking because the salt content is too high. Salt, and many other substances which are in the earth or are made by living things, may find their way into water and make it unfit for many uses. One condition which is often recognized as a problem is "hardness" (a quality of water which is caused by dissolved minerals, usually calcium and magnesium). When hard water is used, the minerals precipitate out and cause damage. Some dissolved materials, such as phenol, produce unpleasant tastes, while others, such as D.D.T. impose health hazards.

The terms fresh water and salt water refer to the relative amount of dissolved salts in water. Fresh water tends to be low in dissolved salts while salt water tends to be high. The point is that fresh water usually

contains some dissolved salts; only pure water would be salt free. Hard water and soft water are similar types of terms - the difference being the relative amounts of minerals, mainly calcium and magnesium in the water. Even though these terms are very inprecise, they are, nevertheless, widely used and should be understood.

Water is able to dissolve oxygen which is needed by most organisms living in water. The oxygen which is in water is called the dissolved oxygen (D.O.) and it is expressed in terms of parts per million (p.p.m.). Thus four p.p.m. of D.O. means four parts of dissolved oxygen to every one million parts of water. Water also dissolves carbon dioxide and minerals which are vital to the life process of water plants and water animals. A wide variety of dissolved substances are vital to the functioning of water habitats. All living things, both those in the water and those on land, use water to carry dissolved materials into and out of their bodies.

All organisms, including man, use water to serve a multiplicity of life functions. For many plants and animals water is their living space. It is a chemical raw material used by green plants for making food; it serves as a solvent for minerals, food and other materials which living organisms need; it is an indispensable component of living protoplasm; and it acts as a carrier for the removal of waste products. To all these biological functions, water's ability to act as a coolant and as a solvent of dissolved oxygen must be emphasized. Water is truly a most vital part of the natural ecosystem.

The Hydrologic Cycle

The hydrologic cycle is the process by which the earth gets its continuous supply of fresh water. Water evaporates into the atmosphere, moves

about with the wind, condenses, precipitates back to the earth where it remains on the surface, seeps underground, or finds its way into the oceans to remain until it evaporates again. (See Figure 1)

The amount of fresh water that is returned to the earth by the hydrologic cycle is tremendous - amounting to some 95,000 cubic miles per year. Seventy-five per cent of this or approximately 71,000 cubic miles of water falls directly back into the ocean. The 24,000 cubic miles of fresh water which does fall on the land is extremely unevenly distributed. In the United States, for example, the average precipitation rate is thirty inches of rain per year. This varies, however, from 140 inches per year in the northwestern part of the country to five inches per year in the Mojave desert. A closer look at the mechanics of the hydrologic cycle will explain some of the reasons for these vast differences.

Water is naturally found on the earth or in the atmosphere as solid ice, liquid water and gaseous water vapor. Only a very small percentage of this vast amount of water is (at any one time) in the form of fresh water that can be used as a resource by man. More than two-thirds of the fresh water that is present is frozen in the polar icecaps. (See Table 1)

The hydrologic cycle gets its supply of fresh water by the evaporation of water from many different sources. Evaporation provides fresh water because as water molecules break free from a water surface they come off in a pure state leaving behind dissolved salts, minerals and other materials. Water, in order to change to water vapor, must pick up extra heat (latent heat). The heat that is necessary for the evaporative process to take place is provided by sunlight. Because of the surface area involved and the heat present, the oceans, principally in the tropics, are a primary source of the

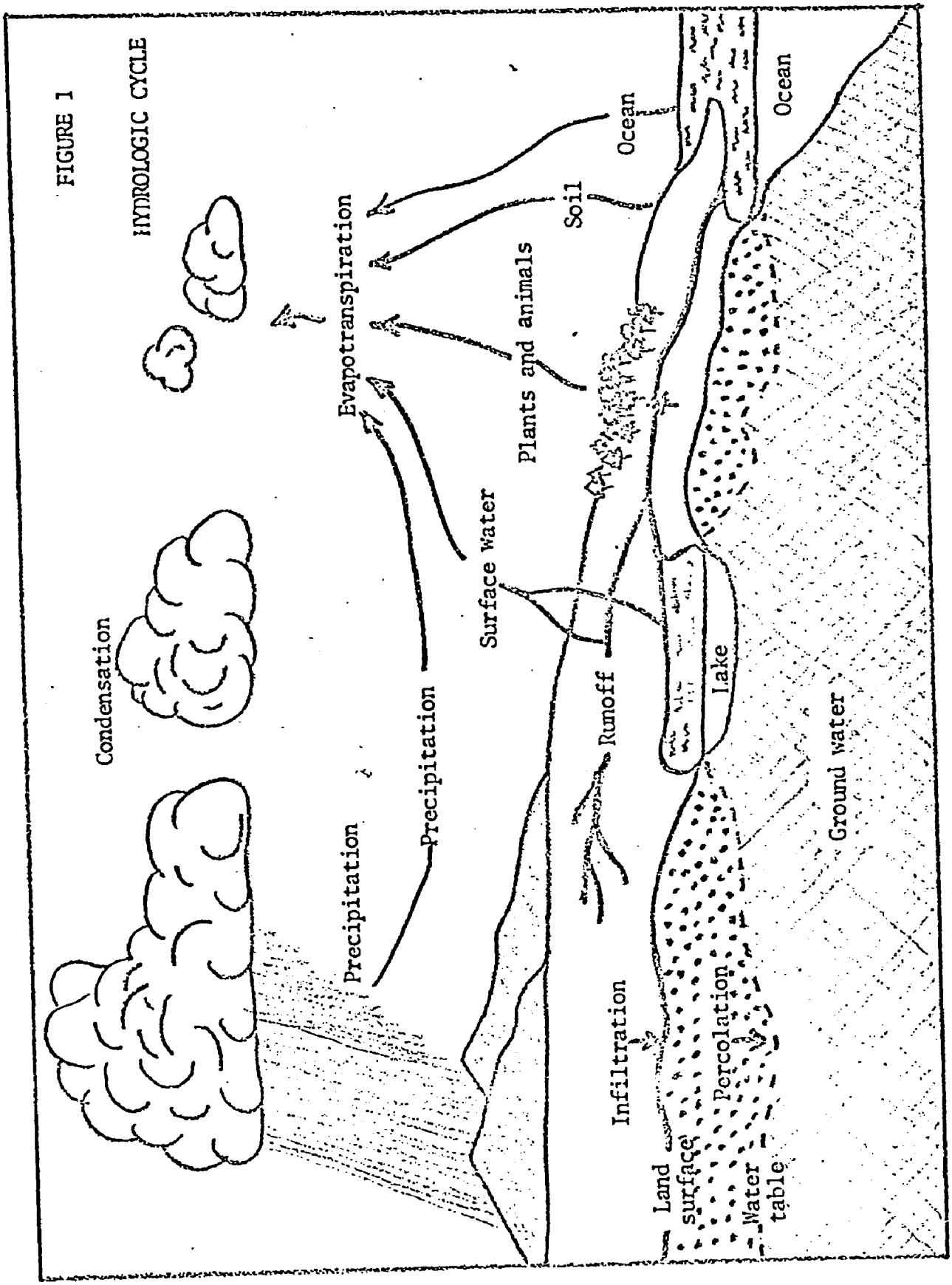

FIGURE 1
HYDROLOGIC CYCLE
Condensation
Precipitation
Precipitation
Evapotranspiration
Surface water
Plants and animals
Soil
Ocean
Ocean
Runoff
Lake
Infiltration
Land surface
Percolation
Water table
Ground water

TABLE 1

THE WORLD'S WATER SUPPLY[1]

Location	Water Volume (Cubic Miles)	Percentage of Total Water
Surface Water		
Fresh-water lakes	30,000	.009
Saline lakes and inland seas	25,000	.008
Rivers and streams	300	.0001
	55,300	.017
Subsurface Water		
Soil moisture	16,000	.005
Ground water to a depth of one half a mile	1,000,000	.31
Deep-lying ground water	1,000,000	.31
	2,016,000	.625
Icecaps and Glaciers	7,000,000	2.15
Atmosphere	3,100	.001
Oceans	317,000,000	97.2
Totals (approximate)	326,000,000	100

[1]Luna B. Leopold, Kenneth S. Davis and the Editors of Life, Water, (New York: Time Inc., 1966), p. 38.

atmosphere's water vapor. As water evaporates, it is distributed by winds over the surface of the earth.

Oceans are only one source of water vapor. There are a wide range of other sources even though the amount is relatively small in comparison to that supplied by the oceans. A percentage of all precipitation, depending on the humidity and the temperature, will evaporate before it reaches the earth's surface. Water vapor also evaporates from plants and animals. Plants in particular evaporate large quantities of water from their leaves - this process is called transpiration. Plants transpire a great deal of moisture because they use water to transport minerals and other materials to their leaves. The water is then evaporated from the leaves into the atmosphere and as a side effect, the leaves are cooled. Animals also give out water vapor by evaporating water on the surface of their skin and in the respiratory process. Besides plants and animals, soils are a source of evaporation. Evaporation from the soil may be larger than expected because of capillary action. Water can move up from ground water sources in the soil by capillary action toward the surface where it can either be absorbed and transpired by plants or it can evaporate directly from the soil into the air.

The amount of evaporation is increased by man when water is used for irrigation, cooling or when it is held in reservoirs. The added sources of water vapor that man allows or forces to escape can bring about local atmospheric changes. The total of all evaporation from bodies of water, animals, the soil, or plants, is called evapotranspiration.

The reverse of evaporation is condensation - the changing of water vapor into liquid water by the giving off of latent heat to the environment. The cooling of water vapor causing condensation in the atmosphere takes place

in two primary ways. Water vapor in the air can be carried upward into the cooler part of the atmosphere or it can be cooled when it is carried into colder climates. Both types of phenomena are important in providing precipitation. Michigan is a good example of how this works because of its geographical location. In Michigan, the winds generally blow gently from the west. This means that most of the precipitation received should come from the Pacific Ocean carried by the prevailing westerlies. However, the moisture laden air coming off the Pacific Ocean onto the continent must rise in order to go over the western coastal mountain ranges and the Rockies. As the moisture laden maritime air mass is forced up and over the mountains, it cools and most of the moisture condenses and precipitates out. The resultant dry air causes the wide band of desert and prairie conditions which occur to the east of the Rockies. Michigan, because it is located far to the east of this mountain barrier, should have a relatively dry climate. The reason it does not, is that the action of the winds tends to draw moist air from the Gulf of Mexico into the Mississippi Valley and into the mid-section of the United States. As this warm moist air moves northward, it irregularly meets cooler northern air bringing about condensation followed by precipitation. Enough precipitation is formed in this way to give Michigan (and the whole eastern half of the United States) a relatively humid climate. Michigan has an average annual rainfall of between twenty-four and thirty-six inches per year. Annual rainfall is the average of all precipitation in terms of rain. For example, ten inches of snow is equivalent to about one inch of rain.

Precipitation falls in the form of rain, snow, sleet, slush, etc., depending on the temperature. It has the ability to clean the atmosphere to some extent by dissolving gases in the water and by carrying out dust

particles of all types. Water vapor can also come directly out of the air on cold surfaces in the form of dew or frost.

The amount of precipitation is a highly local and variable condition. It varies in yearly average in local areas bringing wet and dry years; it also varies as to the time of the year and intensity. Some areas of the country receive most of their precipitation during one season of the year, but even during that season, the precipitation may come in one or two heavy storms. The result of these conditions is a highly variable situation that means spring and winter floods, late summer and fall droughts and wet and dry years.

The runoff segment of the hydrologic cycle is important to man because it is during this time that the water is available as a natural resource. During the runoff segment water also causes the problems of flooding, erosion and siltation. In dealing with runoff, it is necessary to think of surface waters, and underground waters and the interaction between them.

All surface runoff is in the process of evaporation and/or moving either across the land to the ocean or to underground supplies due to the force of gravity. In streams and rivers the velocity of the moving water causes varying amounts of erosion. Water is the primary agent of erosion in America. From the time a water droplet first hits the land surface until it reaches the ocean, it can erode the land surface mechanically by moving the soil and rock particles or chemically by dissolving materials and carrying them away in solution. Erosion damage is not confined to just the removal of material - as the water slows down, damage can occur in the form of deposition and

siltation. Lakes and stream channels can be filled, making navigation impossible and requiring dredging. Because of siltation, water loses its aesthetic appeal, reducing its usefulness for numerous recreational activities. Siltation can also reduce the penetration of light into water, thereby reducing the quality and quantity of the aquatic plant growth.

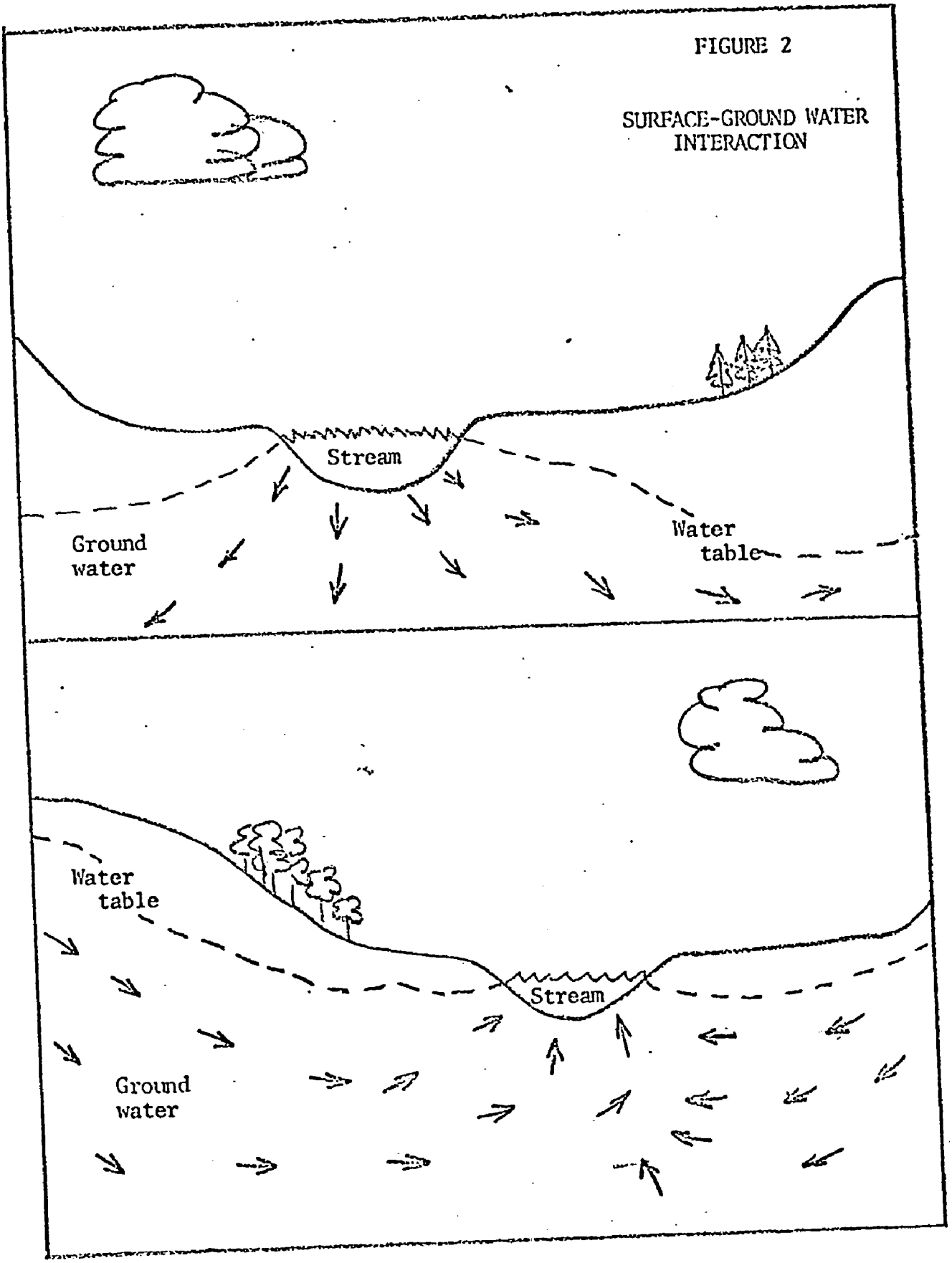
The damage that moving water can do is controlled by two conditions - the amount and the velocity of the water. The amount of water is dependent upon the supply; the velocity of the water is dependent primarily upon the slope of the land. Each local or regional area can be different due to the variability of these factors. There are a number of ways that man speeds up erosion; most of these could be reduced or controlled by proper water management techniques.

The transition between surface water and ground water is very subtle; as gravity pulls on water, it moves readily, governed by the porosity of the soil, into the ground. It also may move out of the ground and back into the surface runoff under proper conditions. (See Figure 2) Surface and ground water are parts of the same interacting system and, therefore, must be considered together.

Water moves on the surface of the earth and underground in response to the pull of gravity. The explanation for water's underground movement is basically the same as its surface movement, namely, supply and slope. However, underground water movements are more complicated than surface water movements; for example, the supply depends on the amount of precipitation, on the runoff, on the ability of the surface of the soil to hold the water, and the porosity of the

FIGURE 2

SURFACE-GROUND WATER INTERACTION



soil (the size of the spaces in the soil which is mainly determined by the size of the soil particles). The rate at which water enters the subsurface supplies is known as the rate of infiltration (water entering the soil).

Perhaps the most important factors in determining the amount of water which will join the underground supplies are the topography and cover of the land. The soil types involved and the porosity of the soil determine the length of time necessary for water to infiltrate and percolate (percolate means to move through the soil and underground layers) to the ground water supplies. The longer water remains on the surface of the land the more chance it has to infiltrate. The storage of water, either natural or artificial and the plant cover on the land are important in determining the amount of water which can penetrate into the soil. The plant cover prevents the soil from eroding and the plants slow down runoff giving the water more time to enter the soil. Plant cover breaks the fall of raindrops preventing splash erosion. Trees provide blockage to the rays of the sun which slows the melting of snow in the spring and allows the water more time to enter the soil. However, when plants are actively growing, they intercept, use and transpire a great deal of water before it can reach the ground water supply.

The development of urban complexes has definite affects on both ground water and runoff. The buildings, the paved surfaces and the sewers of urban areas, profoundly affect runoff and infiltration. Runoff is quickly collected from roof tops and pavement by sewers and

carried either to the sewage treatment plant or directly to the local river or stream. The water collected has little chance to infiltrate the soil and reach the underground supplies. Even though the amount of water entering the ground water supplies is reduced, the demand for underground water in urban areas is usually high. Urban developments, therefore, tend to aggravate the situation that exists between supply and demand. On the other hand, the surface water is collected quickly and brought to the local stream, greatly increasing its volume, making erosion and floods a much greater possibility.

Once water (pulled by gravity) has infiltrated the soil, it may proceed along different paths. It may, as it enters the soil, be picked up by the roots of plants, carried to the leaves and transpired to the atmosphere. It may remain on the outside of soil particles as a film or it can percolate slowly downward reaching that place in the soil where all the spaces between the soil particles are filled with water. The level below which all the spaces in soil are filled with water is the zone of saturation. Above the zone of saturation is the zone of aeration where the water present is in the form of a film on the soil particles. The line between the two zones is called the water table.

Water that has reached the water table still has a number of different ways it may move depending on the supply, earth formations and gravity. Water that has reached the water table can move back into the soil by capillary action. As the water that clings to the soil particles evaporates or is used by plants, water from the water table can move up some distance by capillary action and replace that which is lost. As water moves up in this manner the water table is lowered.

If the supply of water from precipitation or surface supplies continues to infiltrate the soil and move down to the water table, the water table will rise. As the water table rises in the soil it acts very much as if the water was on a hill causing the water to flow through the soil. In some cases the water will reach the surface and rejoin the runoff. Underground water may move great distances through porous soil or it may enter deep porous beds and travel great distances in the underground stratum. If the infiltration rate is slow or the soil becomes completely saturated, floods can result.

Water, as it moves in the underground stratum, has several significant characteristics. New water that is added tends to form a layer on the top. If the ground water is moving, the new water with any materials that may be dissolved in it, tends to move as a layer on the top. Ground water can also pick up dissolved minerals from the materials through which it flows.

Water, in most underground situations, is in the small openings between the soil particles or in the small cracks in the rock layers. Because of these conditions, underground water movement is not similar to surface movement. It is slow in speed and often laminar in nature, that is, it moves in layers. (See Figure 3) Because of the development of the earth's layers, it is possible for water to move in some layers (pervious layers) and not in others (impervious layers). The interspersion of these layers can result in water carrying formations known as aquifers. (See Figure 4) Aquifers function because of slope and porosity. Water is picked up at one end of the aquifer either from the soil or from a surface water body. Because the bottom

FIGURE 3

LAMINAR FLOW OF GROUND WATER

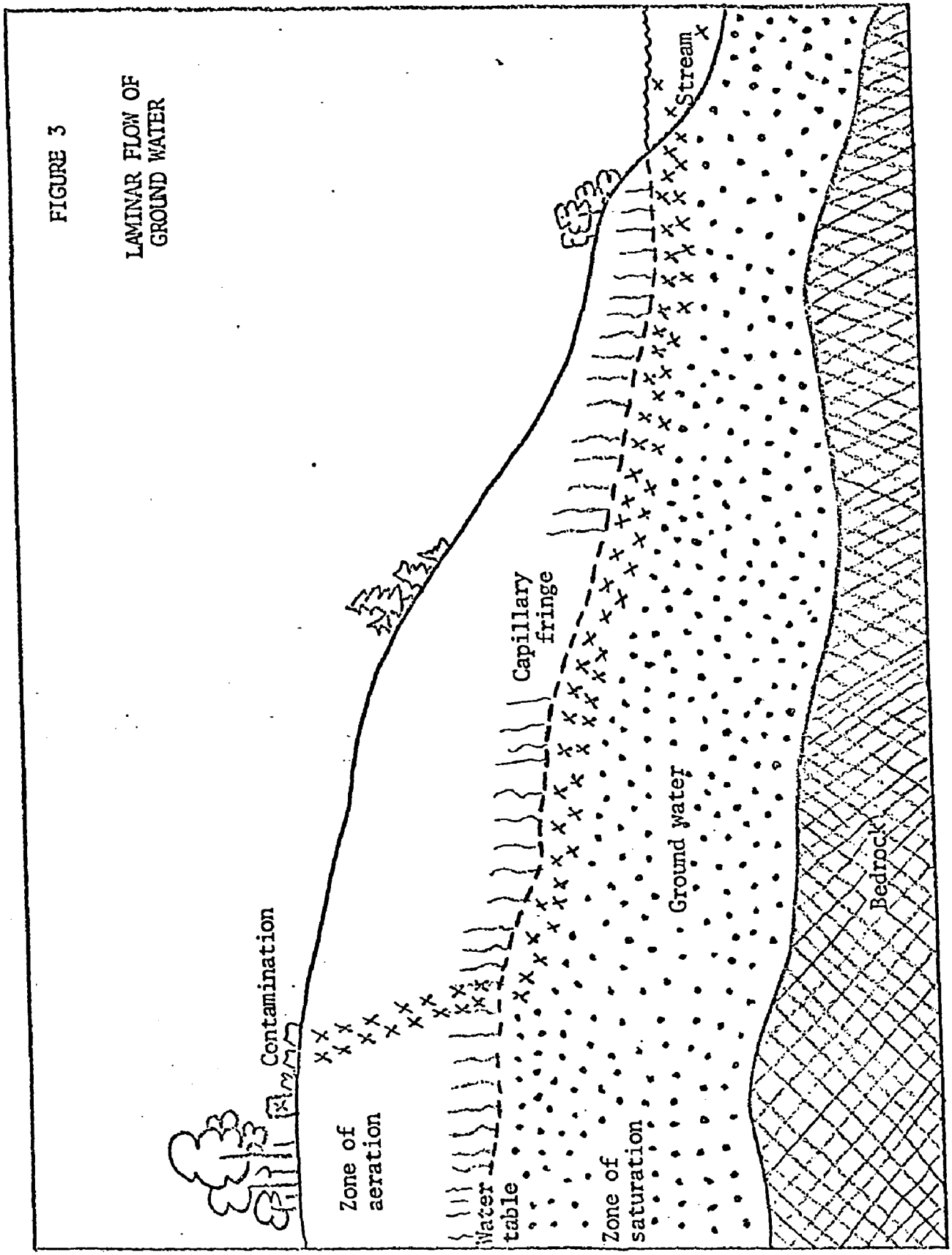
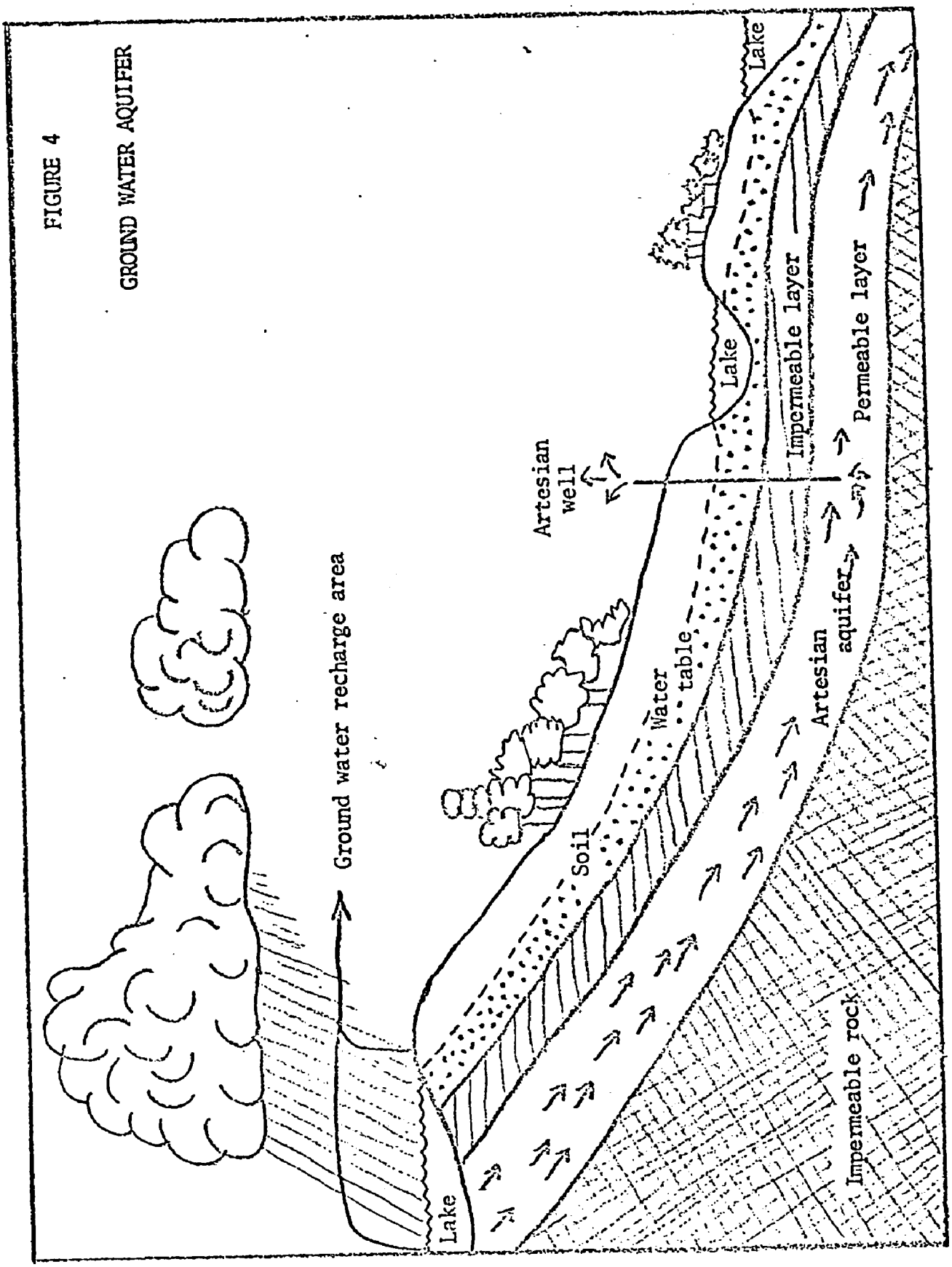


FIGURE 4

GROUND WATER AQUIFER



of the aquifer is composed of an impervious bed, the water is forced to move in the aquifer by gravity to lower levels. This condition can cause water to move great distances, and if the pervious layer is covered by an impervious layer, flowing wells and springs can result where the water breaks through the top layer. Aquifers can carry water long distances, but the water movement in them may be very slow. They are of considerable importance in supplying underground water for industrial and municipal use.

Water can infiltrate to ground water supplies through the bottoms of bodies of water, such as streams and lakes. The flow through the bottoms of water bodies is particularly significant when it is supplying an aquifer.

Water is termed a fugitive resource meaning that it is hard to capture and hold because it can evaporate and seep away, often doing both at once. As water moves underground, it can dissolve and carry materials causing the problems of "hardness" and "saltiness." Many areas in Michigan suffer from problems which make the water difficult or impossible to use.

No matter where on the land surface water falls, it will be in the drainage area of some watercourse. The area that feeds a given watercourse, be it a stream, river, brook, etc., is termed its watershed. Around every watershed an imaginary line can be drawn called a divide. This line passes over the tops of the higher lands which surround the watercourse and separates one watershed from its neighbors. Underground boundaries also exist which cause underground watersheds. These do not always coincide with the surface boundaries. A watershed

is in reality two watersheds - one over the other. This concept is important for understanding availability of ground and surface water supplies.

The concept of the watershed is a useful physical unit for the management of water resources and it is often used as such. The problem that exists is that watersheds often do not coincide with the social, political and economic systems which man has imposed on the land.

The Water System

Water is a major component of a vast, complex and interdependent physical and biological system. The water system is provided with a never ending supply of water and a direction of flow by the hydrologic cycle. Man changes both the physical and biological components of the system when he controls, develops and uses water resources. An important concept that is often overlooked when dealing with a natural system, like the water system, is that when changes are made in one part compensations occur throughout.

Man has been able only slightly to alter the evaporation, condensation and precipitation segments of the hydrologic cycle. He does have the ability, however, to significantly alter both the physical and biological components of the runoff and ground water segment of the cycle. Changes in the land, changes in the plant cover of the land, urban developments, industrial developments, drilling of wells, building of dams, erection of levees and the use of irrigation systems are just some of the ways man has changed the physical water

system. These changes have affected the total water system both physically and biologically. The addition of pollutants has caused further changes in the biological component of the water system. All too often, however, the political, economic, and physical systems which man has devised to control water resources have neither been able to fully consider the problems nor realize the potential benefits from the interdependencies which exist in water systems.

Michigan's Geologic Background

The natural geologic setting which an area such as Michigan inherits, determines a number of important characteristics of its water supply. Michigan has a limited amount of relief due to its past geologic history. The vast ice sheets which advanced and retreated over the face of the state laid down huge amounts of gravel, sand, clay and other materials on top of beds of sedimentary rocks which were formed in ancient seas. Many of these materials are porous and provide storage for vast quantities of water. The drainage patterns of the region as well as the depth and shape of the Great Lakes were influenced significantly by the glaciation.

Michigan, being centrally located in the major western Great Lakes region, is endowed with the world's greatest supply of stored fresh water. The water is stored on the surface as well as in underground reservoirs. An important relationship exists in the Great Lakes region between watershed size, precipitation and the amount of stored water. The Great Lakes watershed is neither very large nor is the precipitation rate extremely great compared to the amount of stored

water in the basin. This means that the movement through and out of the lakes is relatively small and pollution problems can easily arise because pollutants are not flushed away. Because the Great Lakes dominate the basin, the rivers and streams of the region tend to be quite short.

The underground water resources of the Great Lakes region are vast and, in most areas, highly mobile due to the porosity of the materials of the area. One persistent problem throughout part of the region is salt or hardness in the water. Other chemicals such as iron also make ground water supplies undesirable for use. For the most part, however, the ground water of the region is an important complement to the surface supplies.

Michigan has a multitude of streams, rivers and inland lakes as well as being more than fifty percent covered with forest. These resources along with the Great Lakes, provide a wonderful outdoor recreation base. Fishing, hunting, canoeing, boating, swimming, water skiing, sightseeing and skin diving are some of the activities which utilize the 36,350 miles of streams, 3,121 miles of Great Lakes shoreline and the 35,068 lakes and ponds.[1]

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[1] A Summary of Water and Related Land Resources in Michigan, (Lansing, Michigan: Department of Conservation, Water Resources Commission, 1966) p. 76 and p. 10.

Human Influence

Water has caused a significant impact upon the settlement and the development of Michigan and the Great Lakes region. The lakes provided the earliest pioneers with travel, transportation and communication which subsequently opened up the Great Lakes region early in the development of the North American continent. The furs, lumber and ores of the lakes region were easily transported out and new settlers brought in. Many of the first settlements were located along waterways to provide access to transportation. As these settlements grew and spread the original areas remained as towns. The settlers looked for water in their choice of land. Water was needed for both domestic use and for the watering of stock. Modest industry grew up using water power to perform simple tasks. Throughout this era an abundance of fish and waterfowl were also taken.

Water made the exploitations of the early lumber industries possible. The logs were floated in streams to the mills and transported by boat to link up with eastern and midwestern markets. Copper and iron accented the use of the lakes as transportation arteries and brought about the need for locks at Sault Ste. Marie. The St. Lawrence Seaway has opened up the entire middle northern part of the continent to water commerce from all over the world.

Industry, using the transportation arteries and the natural resources of the region has constructed vast industrial complexes which use water for processing and waste disposal. Urban developments, many of them connected with the industrial developments, have also tapped the abundant supplies of fresh water.

The recreation possibilities of the area have not been overlooked. Many millions of people use the region for a wide variety of water based recreation. The development of industries and cities along waterways have reduced the amount of available recreation space, but the boating and fishing pressure has never been greater.

The development of much of Michigan today depends on the availability of water. Rural areas, with considerable space between homes, still utilize individual wells. However, as the urban complexes develop and move out, they depend on water not only for domestic use but also for industries and commercial establishments. Michigan's natural water supply is great, however, many problems must be solved if this supply is to be fully utilized and not degraded by pollution.

The Measurement of Water

Table 2 is a brief list of water measurement terms. These terms are important in understanding the quantitative dimensions of water situations.

TABLE 2

WATER MEASUREMENT TERMS

1 gallon of water	= 8.33 pounds
7 1/2 gallons of water	= 1 cubic foot of water
1 cubic foot per second	= 450 gallons per minute
43,560 cubic feet of water	= 1 acre foot
1 acre foot	= 1 acre covered to a depth of one foot

PART III: WATER AS A NATURAL RESOURCE

Man uses water as a natural resource to satisfy his needs and his wants. The concept of a natural resource implies a user, a need or a want and something, provided by nature, which can satisfy the need or want. Water is a naturally available substance which man uses in vast quantities to satisfy numerous human needs and wants. The water resource picture is made up of three basic elements: water demand, water use and water supply. These three elements affect and often conflict with one another, requiring man to manage water resources to stabilize and effectively increase the supply of water, to maintain water quality and to allocate water when it is scarce.

Many projections have been made which estimate the growing future use of water. In most cases these projections point out that the demand for water will exceed the supply which will be provided in many areas of the country sometime between 1980 and the year 2000. The word demand as it is used in this situation has two different meanings; it means how much people would like to use, and also how much they will use. Human wants usually are greater than human use; therefore, it is logically clear that no matter how great the wants and needs are, the use of water can never exceed the supply.

Society must provide the means of maintaining a balance between demand, use and supply if economic growth is not to be stagnated and the quality of the environment is not to be degraded. The water supply can be effectively increased and its quality, an important aspect of supply,

can be maintained by a number of presently developed technological means. Some of these are better water storage and stabilization facilities, better watershed management, better waste water treatment facilities, tapping of new water supplies, better transportation of water and more reuse of water. All of these measures cost money. However, it is the cost, to a great extent, which controls demand. If water continues to be a relatively free good, the demand for it will be ever expanding, but as its cost to either individuals or society increases, the demand will decrease.

Demand for Water Resources

Water demand is the amount of water people want to use and is determined to a great extent by cost. Water has always been very low in cost in the United States. Subsidies for water development have kept the price of water to the consumer low even in regions of the west where it is scarce. Because of the low cost, Americans have become accustomed to using large quantities of water and have geared their living around the use of water. Several trends which can be identified point to an ever increasing demand for water in the future.

The first trend which points to more water use and, therefore, a greater demand for water, is the increase in population. The simple fact that more Americans will be sharing the same relatively fixed amount of water means that each of us will have a smaller share.

Much of the growth in the demand for water has come from the expanding industrial and agricultural complex which depends on water to

increase our standard of living. With an increase in population should come a simple matching increase in the use of water; but while the population of the United States doubled between 1900 and 1950, the use of water increased fourfold. This extra use is the result of an increasing standard of living which has caused a jump in the per capita use of water. Those activities which improve the standard of living generate a demand for water in many areas of the country; they also cause many of the problems which are centered around water quality.

With an increase in population has come a shift in population from scattered rural areas to concentrated urban-suburban complexes. These shifts in population have focused the demand into relatively compact areas, thereby placing greater strains on regional water supplies.

The growing demand for water has also been generated by an increase in leisure time coupled with an increase in income. Americans now have more leisure time, while their industries continue to function at a high level, using massive amounts of resources, including water. With the leisure time, water consuming activities around the house can be pursued. Washing of cars, the growing of gardens and amenities such as swimming pools, which use large quantities of water, are becoming more common. Not only is water use increasing around the home, but Americans now have more time for outdoor recreation, many forms of which require high quality water.

The growth of population, the growth of the standard of living and the growth in leisure time, point to an increasing demand for a constant supply of water which is becoming depreciated in its natural state.

Water Supply

The supply of water which the continental United States and the state of Michigan receive is basically a function of the hydrologic cycle. The amount of water that is received and that can be captured and used by man as a resource is a function of the topography of the regional land surface, the characteristics of the plant cover, the soil and rock layers that determine the underground supply and man's development of the land and construction of water storage facilities. The natural supply of water, except in very limited situations, must be considered the total supply. There are a number of ways of artificially producing fresh water, such as desalinization, but the cost of producing water in this manner is too high except in individual cases where the need is high and cost is not the primary concern. Even though it is expensive to increase the actual natural supply of water, it is possible to utilize the existing supply more completely. Water can be retained in reservoirs from times of excess or it can be reused - sometimes it is reused a number of times. These methods do not increase the actual natural supply, but they do increase the supply which can be effectively used as a resource.

The continental United States receives an average of thirty inches of precipitation per year; of this, twenty-one inches returns to the hydrologic cycle by evapotranspiration. This water supports the natural vegetation, the forests and the non-irrigated farms; of the remaining nine inches, which represent 1,160 billion gallons a day, three inches are used by man; two of the three inches which are used by man find their way to the oceans

through some watercourse; the other one inch is consumed.[1]

Michigan's water budget looks somewhat different from the national figures in that Michigan receives an average of thirty-one inches of annual precipitation; of this, sixty-one per cent is returned to the hydrologic cycle by evapotranspiration. Approximately forty per cent of the annual precipitation is available as a natural resource for human use. Approximately five per cent of the annual precipitation is used as a resource and only two-tenths of one per cent is consumed. The Michigan water supply situation differs significantly from the national one because in Michigan evaporation rates are lower due to the humid climate and the lower temperatures. Water storage in Michigan, both on the surface, particularly in the Great Lakes, and also below the surface, makes it readily available for human use. Two-thirds of the water used in Michigan comes from the Great Lakes; the rest comes from inland lakes, reservoirs, streams and wells.[2]

The problems of water supply, although not as acute as in some regions of the country, center around the variability of supply. The rainfall in Michigan is generally well distributed throughout the year but is usually low during late summer and early fall. The supply per year may also vary between twenty-six and thirty-six inches per year. With a vast natural supply and natural storage, Michigan has no general water supply problems even though some locally difficult supply situations do exist.

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[1]U. S. Congress, Senate, Select Committee on National Water Resources, Water Resource Activites in the United States, 86th Cong., 1960, S. Res. 48 p. 3.

[2]A Summary of Water and Related Land Resources in Michigan (Lansing, Michigan; Department of Conservation, Water Resources Commission, 1966) p. 32.

The growth and concentrations of urban populations in southern Michigan have caused local supply difficulties. Water treatment facilities and transportation facilities have not kept pace in some areas with the growth in population. If increased water supplies to local areas are going to be developed to meet growing concentrated needs, extensive planning and construction must be done to keep pace with the fast growing urban situation. The supply is vast; only the technological means of storing, treating and distributing water are limits on its use in Michigan.

Water Quality

A critical aspect of water supply is water quality. The ability of water to function in the natural ecosystem and for human use is determined in large measure by its quality. The word quality for our purposes will be considered anything above the minimum level compatible with a given use. The quality of water can be looked at in three different ways: ecological water quality, economic water quality and aesthetic water quality.

The ecological quality of water is determined by its ability to maintain specific groups of living organisms. Because of water's vital role in maintaining a wide range of life functions, any physical-chemical change in its condition can cause it to become a limiting factor on the growth of organisms which depend upon it. For example, a stream with a high oxygen level can support a sport fishery, but as water quality falls due to a drop in dissolved oxygen, the fish population will change to trash fish. If the process continues, a point is reached where no fish can survive. The maintenance of ecological quality of water is important to man's use of water, for himself and for the living organisms, both plant and animal, which he

depends upon; it is also important to the aesthetic quality of the environment by maintaining the natural setting; and it is important to the economic function of modern society by providing water which can be more readily used for many economic purposes.

The economic quality of water is very close to the ecological quality of water, in fact they overlap in many ways; water that is of good ecological quality is economically more valuable because it serves many economic uses at little or no cost. Water can, however, be unfit to support living organisms and yet it may be perfectly suitable for an economic use such as industrial cooling or navigation. The point is, in most cases, economic and ecological quality go hand in hand. Economic water quality is determined by the cost which must be paid in making water serve a particular function. In other words, low cost means high economic quality and high cost means low economic quality. The economic quality of water is variable depending upon its use.

The aesthetic quality of water is tied very directly to ecological water quality and is usually sustained by keeping water ecologically fit. In some cases water may remain ecologically fit and yet may lose its aesthetic appeal. An example of this could be metal junk alongside or in a river which would be unsightly but would have little affect on ecological water quality. Junk may make an area unpleasant for recreation. If this happens the area may lose its economic value as a recreational area.

If must be pointed out that although a water body may ecologically support a population of organisms, water quality changes may drastically alter the make-up of the populations and the aesthetic appeal may be lost. If areas lose their aesthetic appeal there may be a significant loss in

economic quality in terms of use for recreation and visual pleasures.

Pollution

Pollution of water is difficult to define. The word pollution means to make something unpure. Unpolluted liquid water, therefore, would contain only water molecules - a condition that is difficult to find in nature. Pure water is unacceptable for some uses because it tastes flat and it is an unlivable habitat for many living organisms. Natural water usually contains a small amount of many dissolved and suspended substances. It is the type and the amount of material water contains that determines if it is polluted. Water can be ecologically, economically and aesthetically polluted.

Ecologic pollution is caused by pollutants which alter or kill the organisms of the natural environment. The pollutants which cause ecological pollution can be separated into two types: one, those materials which are present in the natural ecosystem but which are in greater than normal amounts; and two, those materials, chemicals and poisons, which are not normally present in nature. Pollutants that are already present in the natural ecosystem but may be increased in volume by man can be effectively handled by presently developed waste treatment systems. The principle behind most modern sewage disposal systems is to provide an artificial ecosystem which can degrade pollutants into harmless substances. If pollutants, such as poisons and chemicals, cannot be broken down into harmless substances, every effort should be made to keep them out of the natural ecosystem.

Economic pollution is anything which lowers the quality of water to the point that it can no longer be used for a specific beneficial purpose

without treatment. Economic pollution is determined by use and is, therefore, highly variable. Ecologic pollution and economic pollution conflict because water may be of a quality acceptable for an economic use, such as cooling, when it is hopelessly below the ecological limit.

Aesthetic pollution is indefinite because it depends on the perception and tastes of the individual. The threshold of personal aesthetic pollution can occur before either ecologic or economic pollution has occurred. In some cases, no aesthetic pollution may be visible when, in fact, the water may be grossly economically and ecologically polluted. Aesthetic pollution is important because it has a real impact on certain economic uses for water, particularly in the area of recreation.

Because water is a good solvent and carrier of materials, a wide range of materials can be pollutants. To name even a portion of all the materials which can be pollutants would be impossible in the space available. Pollutants can, however, be divided up into meaningful categories, and the more common pollutants in each category can be covered.

Organic Pollution

Organic pollution provides the greatest bulk of materials which are considered pollutants. In this category would be all the waste plant and animal materials which man must dispose of. These materials are found in both municipal as well as industrial wastes. In municipal wastes the main organic materials are the sanitary human wastes and the food wastes which are discharged by households. These wastes contain not only oxygen demanding materials, but they may also contain pathogenic organisms.

Industry produces vast quantities of organic wastes from many

different types of industrial processes. The food industries such as sugar, canning, meat packing, brewing, baking and many others, produce significant quantities of organic pollutants. Such industries as pulp and paper, chemical and oil produce organic pollution. Some of these by-products, such as the liquers and fibers from pulping operations, are particularly difficult to degrade into harmless substances.

Organic pollution affects the receiving waters by increasing the oxygen demand, increasing the turbidity and changing the water color. It adds salts and minerals to the water which act as fertilizers. The general effects of excessive organic pollution are to strain the natural assimilation process of the receiving water body.

Chemical Pollution

The list of chemical pollutants is long. With the technological developments of industry, the list continues to grow because of the new chemicals which are being developed and used. A wide variety of chemical pollutants are added to sewage from domestic use. This list is growing as industry markets new products for home use. Just a partial list of some of the common chemical pollutants would be: phenol, arsenic, iron, chlorine, copper, sulfates, acids, chromium, cyanide, alcohols, chlorinated hydrocarbons, lead, mercury, nickel, nitrates, phosphates, sodium, etc. Just to give some perspective to the problem, it should be noted that over 500,000 organic chemicals have been synthesized and a substantial and variable number of them are found in low concentrations in water supplies.[1]

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[1]Allen V. Kneese, The Economics of Regional Water Quality Management (Baltimore: The John Hopkins Press, 1964) p. 76.

Chemical pollutants can generally be divided into the poisonous group and the non-poisonous group. Chemical pollutants can also be categorized in terms of their persistence in the ecosystem. Some chemical pollutants break down readily due to natural processes and are termed non-persistent. Others do not and, therefore, they remain in their original form for long periods of time and are termed persistent. The poisonous group is, of course, of the most concern because it endangers both man and other living organisms. The persistent poisons such as the chlorinated hydrocarbons (used extensively as insecticides - DDT, dieldrin, aldrin, etc.) do not break down very readily in the natural ecosystem. Even though persistent pollutants are in very minimal quantities, they remain in the ecosystem for long periods. They can accumulate in the bodies of lower organisms and then move up the food chain becoming more concentrated in the higher life forms until they affect reproduction, health or even bring about death. The less persistent pollutants may also be dangerous, but they are degraded in the ecosystem rather quickly and, therefore, present less of a long range problem.

Each chemical pollutant has its own individual affect on water conditions - some may demand oxygen; some may affect the turbidity and color of the water; others may simply inhibit the growth of natural organisms; while others may act as fertilizers which greatly increase plant growth. The chemical pollutants, either between themselves or with organic pollution may react in unpredictable ways. Some combinations of pollutants may be antagonistic; that is, if two pollutants react together they may neutralize one another and become less toxic. Certain chemical pollutants from industry, if they are discharged in regular amounts, may be used in waste water treatment plants to neutralize one another. Pollutants may be synergistic; that

is, two pollutants may make each other more toxic. An element of the unknown exists when chemical and organic pollutants are indiscriminately mixed.

Chemical pollutants find their way into water from industry, from domestic sewage and from agriculture. These pollutants may be directly placed in the water as wastes or they may be dissolved in water and accidently find their way into either surface or underground water. Chemical pollution makes it difficult to use water for domestic supplies, industry and cooling. Toxic chemical substances from industry or agriculture may kill fish and other organisms directly, they may disturb some phase of their life cycle or they may destroy a necessary food source. Increased temperatures, excessive acidity or alkalinity and low dissolved oxygen, which can result from pollution, can increase the sensitivity of organisms to chemical toxins.

Thermal Pollution

Thermal pollution is caused by increasing the temperature of natural water. Thermal pollution is one of the important physical changes industry makes in water by using it for cooling processes. Industry uses more water for cooling than for any other purpose; both fresh and salt water are used. The temperature of water is important, at times critical, for certain uses; it, therefore, greatly influences economic water quality. Water temperature is important to water's use for industrial cooling, and it affects the suitability of the habitat for aquatic life; it, therefore, greatly influences ecological water quality. In many areas, rivers and streams are used by a number of industrial plants for cooling. Downstream plants have a difficult time using water, particularly in summer, which is low in flow and high in temperature for cooling purposes.

Temperature causes a wide range of problems in the aquatic habitat. An increase in temperature decreases the oxygen capacity of water, and at the same time, increases the biological and the chemical activity - thereby increasing the demand for oxygen. It also increases the putrefaction of sludge deposits and stimulates the growth of odor and taste producing organisms.

Increased water temperature changes the aquatic habitat's oxygen content and its metabolic rate thereby affecting the composition of the organisms, including the fish. Certain valuable sport and commercial fish, such as trout and salmon, must have cold water with a high oxygen content. An increase in temperature alone will make the aquatic habitat unsuitable for these species.

Pathogenic Pollution

Pathogenic pollution has always been of prime concern in determining water quality. Infectious diseases such as typhoid, dysentery and cholera can be carried by water. Natural stream processes deal effectively with these dangerous organisms because they tend to die off quickly after leaving the body. A new danger in this area has been the identification in sewage and in watercourses of varieties of viruses which are more resistant to disinfectants and more viable outside the body than the pathogenic bacteria.

Neither the bacteria nor the viruses are in sufficient concentrations in most waste water to be identified by themselves and so most measures of bacterial pollution are centered around the "coliform count." The coliform count is only an indicator of bacterial pollution and is used because a direct search for a given pathogen may be difficult and time consuming.

Water is examined for fecal contamination by counting coliform organisms which come from the digestive systems of warm blooded animals. This then acts as an index to the amount of fecal pollution present. Coliform organisms can come from other sources such as decaying matter and other animals, so concentrations of them can be used only as an index since they are, in themselves, only indicative of pollution.

Pathogenic pollution has been and continues to be of prime concern in the use of water resources. Water can also harbor other living nuisances in the form of disease carrying insects, lesser pathogens than those already mentioned and such irritating organisms as the fork-tailed larvae of swimmers itch (schistosome dermatitis).

Radioactive Pollution

Radioactive pollutants may be both natural and man caused. Radioactive pollution is dangerous to man's health either by direct consumption of the water or through consumption of plants and animals which have accumulated radioactivity. Water may acquire radioactivity from natural sources, from the mining and refining of radioactive ores, from atmospheric nuclear explosions, from the use of radioactive isotopes for medical and research purposes or from the wastes of nuclear reactor operations.

Radioactivity is an indestructible property that cannot be neutralized and can only be reduced by natural decay over time. The two principle means of handling nuclear wastes, depending on the hazard involved, is to dispose of them by dilution or to permanently store them. The Atomic Energy Commission carefully controls and checks potential radioactive sources before discharges are made. The best method of dealing with nuclear wastes, however,

is to contain them before they enter the ecosystem.

Physical Pollution

Physical pollution is that wide range of materials from silt to junk cars that find their way into water. Physical pollution can be more than just aesthetically displeasing; it can, in the case of silt, block up navigation channels, fill in and reduce the efficiency of reservoirs, cause problems in using water for municipal purposes and kill aquatic organisms. Some physical pollution is natural to streams and rivers and must be considered part of the geologic process. Most of the physical junk and much of the silt, however, finds it way into water bodies by the careless or wanton action of people. Silt from farms and urban developments removes valuable soil from the land only to make it a nuisance in the nation's watercourses. Junk, on the other hand, causes aesthetic problems as well as representing a real physical danger. Trash, cans and bottles in water often cause painful and serious physical injuries.

Aesthetic Pollution

Aesthetic pollution depends on the tastes and sensitivity of the individual. Most any pollutant can become aesthetically displeasing. Many types of pollution become aesthetically displeasing long before they are dangerous. The easthetic quality of water plays a vital role in outdoor recreation. Water can be displeasing in sight, smell and taste - any of which can make it unusable for a wide range of activities. Perhaps the most important point about aesthetic pollution is that it spoils the quality of man's living experience even when it does no other harm.

Uses of Water

The uses for water are numerous and a great volume of water is needed to satisfy these uses. The different uses for water may be compatible, antagonistic or complementary. Water uses which are compatible would be those which can occur together without causing any difficulty but also would have no added benefits. An example of this would be the use of water for navigation and industrial cooling. Water uses can also be antagonistic which means that the two uses function poorly together or cannot function together at all. An example of this would be the use of water for waste assimilation and total body contact water recreation. Water uses can also be complementary meaning that they, in fact, work better together than either would separately. An example of this would be wildlife and reservoirs - the wildlife help to promote a healthy water environment and the reservoir provides a living space for the wildlife. Economically, the uses for a river may be complementary in that one single use may not by sufficient to promote development, but two or more uses may make the venture economically feasible. An example of this would be a large dam which provides hydro-power, irrigation, navigation and flood control.

Great amounts of water are needed to supply the various water uses. As an example, industry needs from 17,000 to 65,000 gallons of water to produce a ton of steel, 2,000 gallons of water to produce a dollar's worth of paper and from seven to 70 gallons of water to refine a gallon of gasoline. Agriculture uses 6,250 gallons of water to produce a bushel of corn, 7,500 gallons of water to produce a bushel of wheat and 200,000 gallons of water to produce a ton of alfalfa hay. One thousand pounds of water are needed to produce one pound of wood. Immense quantities of water are needed to

produce hydroelectric power, float ships for commercial navigation and provide space for water recreation.

Industrialized societies need approximately 1,800 gallons of water per capita per day in order to maintain their standard of living compared to less than 100 gallons of water per capita per day in underdeveloped countries. In industrialized countries approximately 150 gallons of water are used per day by individuals; the rest of the 1,800 gallons are used by agriculture and industry to produce the food, goods and services which determine the standard of living.

Water quality as well as water quantity must be considered for most uses. For industry, agriculture and municipal supplies, quality is very important if expensive purification is to be avoided. Water that is used directly in its natural setting must be of sufficient quality to be conducive to recreation, wildlife and fish. The problem is that many of man's uses for water degrade its quality.

A most important use characteristic of water is that it can function as a multiple-use resource. As water moves through the ground water and runoff segment of the hydrologic cycle it can be used to serve many functions. An example of multiple-use can be developed by following water from the headwaters of a stream to the outflow. In the upper reaches of the watershed the water can be used for recreation and fishing, it can then be impounded for irrigation and hydropower, and it can finally be used for water supply and waste disposal by an urban community. Multiple-use can also be thought of in terms of reuse. Many streams are used for water supply and for waste assimilation by urban areas. As the water moves between urban areas, if the natural assimilative processes have sufficient time and capacity or if the

water has been treated, it can be reused a number of times for the same purpose as it moves downstream.

The uses man makes of water can be meaningfully divided into a workable number of categories which include:

1. Water for domestic and industrial water supply
2. Water for disposal of wastes
3. Water for food production
4. Water for the generation of electric power
5. Water for navigation
6. Water for wildlife and fish
7. Water for outdoor recreation and natural beauty

These categories are not clearly divided and it is difficult to give the relative importance of the uses because all of them are significantly important to society. Their relative importance to our complex expanding society and their local (or regional) impact must be individually determined.

Domestic and Industrial Water Supply

In the past people took their water directly from streams or from surface wells without much thought of water quality. In most rural areas, water for domestic purposes is still taken from wells; however, they are now usually deep rather than shallow surface wells. This type of supply works well as long as the concentrations of people and livestock are not too great and the waste disposal facilities can be kept far enough away from the water supply. The use of surface water for domestic purposes has virtually disappeared for even in remote undeveloped areas, campers and other vacationers are now advised to purify all surface water which they may consume.

As urban areas with dense concentrations of people develop, providing water for domestic purposes becomes increasingly difficult. Water in urban areas is used for domestic purposes, for transporting, diluting and

assimilation of wastes and for industrial uses. Modern urban centers have come to rely on either ground water supplies or surface water which are made potable (drinkable) by extensive water purification procedures. The problems which have developed as urban communities have extended and merged, have been the development of water supplies, the transportation of water and the maintenance of the quality of water supplies.

Fresh water which is supplied to domestic users needs to have certain important characteristics. It must be free of poisons, dangerous organisms, undesirable odors and tastes, and it should be relatively soft. All of these conditions are considered in modern water treatment facilities.

The problems associated with supplying water to urban areas center around the transmission system which must bring the supply to the urban area and, through a vast network of pipes, pumps and meters, provide service to water customers. Water must be stored after it is purified until it is used. This means that storage reservoirs must be constructed which can hold water and maintain its quality until it is distributed to the water user. Water use is uneven, being greater during the day than at night. Peak loads must be handled in most situations by stored supplies. The water in the transmission system must be maintained under pressure so that it can be distributed to the consumers. This means either the maintenance of towers, which maintain water pressure by gravity, or pumps which can maintain the pressure. Because water is maintained under pressure, leakage in most water systems can be a factor which adversely affects supply. Water usually does little damage when it leaks slowly from a water supply system. However, leaks which are difficult to locate, adversely affect the supply situation. Many leaks may occur on the private side of the water meter in the form of

leaky faucets which, of course, cannot be checked by the distributing agency even though they adversely affect the supply situation. The whole idea of the water meter is interesting when it comes to considering the supply, because even though water costs the consumer money, the cost is so low in most cases that it is not a significant inducement to cause people to restrict their use of water and to be careful so as not to waste it.

Water is used extensively in many urban and suburban areas to irrigate (water) lawns. This use of water has become significant in many regions of the country. The important implication of this use is that it often occurs most heavily just when water supplies are at their lowest.

Most of the water that enters the home is not consumed and when it is returned as used water it carries with it a wide range of wastes. The waste removal function of water is important to urban life, yet it causes a distinct burden on the receiving water body if it is not treated in some way. Wastes that come from domestic uses are both dangerous and troublesome - dangerous because they often contain harmful living organisms, and troublesome because they cause undesirable conditions in the receiving water bodies if they are not treated.

Municipalities depend upon water as the primary agent in fire fighting. The amount used for this purpose is not usually large, but the capacity to handle the quantities necessary in an emergency means that reserve supplies must be maintained and delivery systems must be large enough to handle the emergency flows. Municipalities also use water to clean streets and to provide water for swimming and street showering of children in hot weather.

Water is a most important resource to many industries. It is so important that some industries locate directly on waterways. The use of

water by industry is varied and industry often uses water for many of the same purposes as domestic users.

Industry uses cooling water, potable water and process water. Many industrial processes use great quantities of water for the cooling of machines and products. The use of water as a coolant has little affect on water purity, but it is an important factor which affects the biological quality of the water because it causes thermal pollution.

Industry uses water in many of its manufacturing processes. Water is used to transport materials, as for example, in the making of paper. Water is used as a part of the product in the food processing industries. Water is used to separate materials as, for example, in the processing of ore.

Perhaps the most difficult problem which industries cause is their use of water as a carrier and as an assimilator of wastes. Many industries produce vast quantities of organic pollution which they dump directly into water bodies. These types of pollutants can be handled by natural assimilation, if the capacity is available, or by effective treatment facilities. Industries also produce a wide range of inorganic and highly persistent organic materials which are difficult to dispose of. Some of these materials, many of which are highly toxic, cannot be assimilated by the natural processes in the receiving water bodies and have an extremely detrimental affect on the natural environment. Special facilities must be constructed to handle these difficult pollutants. Many industries which have provided treatment for persistent pollutants have recovered some of their cost of treatment through chemical recovery.

Industry is mainly a non-consumptive user of water. Ninety-two

per cent of the water industry uses is for cooling. About six per cent of the water which industry uses is consumed. Most of the water which industry uses is withdrawal use.

In 1962, seventy-two per cent of Michigan's population was supplied with treated water; the rest depended upon untreated well water for their supply. Approximately twenty per cent of urban water is consumed, in that it transpires into the atmosphere.[1] The rest of the water is returned to the runoff, carrying wastes with it.

Water for the Disposal of Wastes

Modern society depends upon water for the transportation, dilution and assimilation of wastes. These vital functions of water are extremely important economically to both industry and urban complexes. The increased production of wastes due to the growth and concentration of population and the increase in the standard of living, have, in many places, exceeded the ecological ability of the natural water environment to handle them. The result has been a lowering of the economic, aesthetic and ecological quality of the environment.

The transportation of wastes is a relatively simple function of water. Water that is supplied to domestic, commercial and industrial users in urban areas must be returned to the runoff segment of the hydrologic cycle if it has not evaporated. Water that is returning is used to carry a wide range of substances which are considered wastes. These wastes may be either

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[1] A Summary of Water and Related Land Resources in Michigan (Lansing, Michigan: Department of Conservation, Water Resources Commission, 1966) p. 33.

suspended or dissolved in the water. Water transportation of wastes in urban areas is important to the functioning of concentrated domestic, commercial and industrial facilities where the piling up of wastes could create impossible situations. Many of the wastes which water carries would be difficult to handle in other ways.

Water is used to dilute wastes. The dilution of wastes serves two purposes. It can be used to disperse wastes to the point that they lose their identity or cease to be a problem. This is one way of getting rid of wastes, even those with dangerous qualities. It, of course, demands great quantities of water. An always possible danger is that through some natural process, wastes, which may be toxic, can be reconcentrated. It is difficult if not impossible to handle the huge amounts of modern wastes by dilution. The other way that dilution is important is that it increases the volume of water in which the natural ecological processes of assimilation can occur.

A most vital function of water is its assimilation of waste materials. Natural organisms which inhabit water have the capacity to break down harmful wastes into harmless basic environmental materials. This process occurs in nature and is most effective in dealing with non-persistent organic materials.

Water, in combination with oxygen and certain living organisms, can reduce most organic and some inorganic matter into harmless substances, thereby purifying itself. Man has long depended on water's self purification, but as the natural purification capacity of water bodies is exceeded, the problem of pollution shows itself.

Many substances, including a wide range of gases, are soluble in water. Carbon dioxide and oxygen, which are readily soluble in water, play an active role in the natural aerobic purification process.

When any organic matter enters natural water, it is immediately attacked by bacteria which oxidize it; this is a process similar to fire only at a lower temperature. The living organisms reduce waste to carbon dioxide, water and a residue of simple organic salts which fertilize the water and promote the growth of green plants. Green plants, in the presence of light, absorb carbon dioxide, fixing the carbon as food while releasing oxygen to the water. Thus, oxygen which the bacteria originally used is restored to the water again.

Oxygen, therefore, plays an important role in the natural purification process and must be available in sufficient quantities so that the aerobic bacteria can function properly. It is also required for respiration of all living things, particularly by fish and insect populations. If the oxygen supply drops due to increasing demand, those organisms which can swim away (if there is some place to go) and those which can tolerate low oxygen supplies may survive; the rest will die. This means that if too great an amount of organic matter is added to a water body, the bacteria will deplete the available oxygen supply, and those organisms which must have oxygen will die. If only a small amount of organic matter is added, the living organisms in the water can naturally deal with it in a short time without seriously reducing the amount of oxygen in the water. The fish and other living things will not be harmed, and the ecological balance of the stream can be maintained.

The problem of using the natural purification processes for waste assimilation in a natural water body is generally one of maintaining the oxygen while the waste matter is being reduced to harmless substances. The amount of oxygen which is available is determined by two factors: the photosynthesis of green plants and the turbulence of the water body. Green plants,

in order to produce oxygen, must have sunlight; therefore, during the night, on dark days, when snow is on the ice cover, or if the water is turbid or colored, the green plants may generate little, if any, oxygen. This means that the existing supply of oxygen must last through the time of the problem or result in a kill of the oxygen using organisms. Oxygen can dissolve directly from the air into water so that turbulent streams and rivers have a better chance of maintaining their oxygen. The contact between the turbulent water and air not only dissolves oxygen into the water, but it also mixes the oxygen throughout. Lakes, sluggish rivers and streams may take oxygen in on their surface, but due to the lack of mixing, the oxygen may remain close to the surface. Stratification of water in lakes, due to temperature-caused density differences, may result in the lower depths being low in dissolved oxygen.

One of the most common measures of organic pollution is the Biochemical Oxygen Demand (BOD). BOD is the rate at which organic wastes (and some inorganic wastes) demand oxygen in a water body. The demand is really exerted by the aerobic bacterial action which uses the oxygen to degrade organic wastes into simple inorganic materials. Oxygen use occurs in two stages: the first stage, which is the general degrading of carbonaceous matter, occurs directly after the sewage is placed in the water body and may last for some time (this varies with the type of pollution and with the condition of the receiving water); the second stage which occurs from five to seven days after the sewage is placed in the water is due to the conversion of nitrogen in the sewage to nitrites and nitrates by aerobic (nitrifying) bacteria. This second BOD is less intense than the first stage. The total BOD may last up to twenty days.

BOD and the rate of oxygen recharge are, therefore, critical factors in determining the dissolved oxygen (D.O.) content of a water body. Once oxygen demanding organic sewage is added to a river or stream there is a characteristic drop in the D.O.. This is called the oxygen sag. From this low point, the oxygen in the water is replaced by dissolving through the surface or by the action of green plants. The fact that oxygen readily dissolves into water from the air is important to the D.O. content of streams for not only does the oxygen dissolve at the surface, but it is mixed through the water by the movement. Lakes, because they suffer from a lack of mixing, due to thermal stratification, tend to be very poor assimilators of waste. If the BOD is greater than the dissolved oxygen supply, the water body may be completely depleted of oxygen causing septic conditions to occur. Septic conditions are characterized by anaerobic bacteria which do not utilize free oxygen in degrading waste products and which produce foul odors.

The common method of testing for BOD is to take a sample of sewage and place it in an amount of water saturated with oxygen. This is sealed and then incubated at 20° C. (68° F.) for five days. Then the amount of dissolved oxygen in the sample is measured. The difference between the amount of D.O. originally present and the amount present after five days is a standard way of measuring BOD.

Specific poisons and other materials, mainly produced by industry, may not be handled by the natural purification process in water bodies. Some poisons may kill the bacteria and other organisms which are necessary for purification, while other materials simply cannot be reduced to harmless substances by living things. These materials should be kept out of natural waters if at all possible.

The process of natural purification using oxygen is limited to water with oxygen present. In past times when most human developments were small, scattered and rural, the natural watercourses were able to handle the waste given them. In fact, through the fertilization from the wastes added, they most likely became more productive, thereby increasing the plants, lower animals and the fish in the stream. Industry, which was less sophisticated and largely connected with agriculture, was no significant problem.

With population growth and the development of urban centers, the problem of stream purification has jumped in intensity. As water was brought into homes and industry and was used to carry wastes away in sewers, large concentrations of wastes were produced in relatively small areas. Wastes that used to be relatively fresh in rural areas, as they are carried by sewers, become partially decayed and develop large populations of bacteria. When fresh sewage is passed into a water body, the bacteria build up slowly, thereby stretching the oxygen demand over a period of time in the receiving water body. Sewage from sewer pipes which contain large populations of bacteria may make a sudden oxygen demand on receiving water bodies. Instead of the natural purification process in which the oxygen is replaced almost as fast as it is consumed, a massive depletion of oxygen occurs. This kills the aerobic bacteria, the animal life and even the green plants - for they all must have oxygen to live.

In areas where the oxygen has been depleted and cannot keep pace with the demand, the bacteria cannot completely purify the sewage, and so part of it sinks to the bottom, forming a layer of organic mud. Nothing will grow on this organic mud and a different kind of bacteria (anaerobic bacteria) attack it producing foul gases which are carried by the water

poisoning the downstream areas. When the dissolved oxygen is low or depleted, anaerobic bacteria become active. They use organically and inorganically bound oxygen from common substances and give off gases such as hydrogen sulfide and methane.

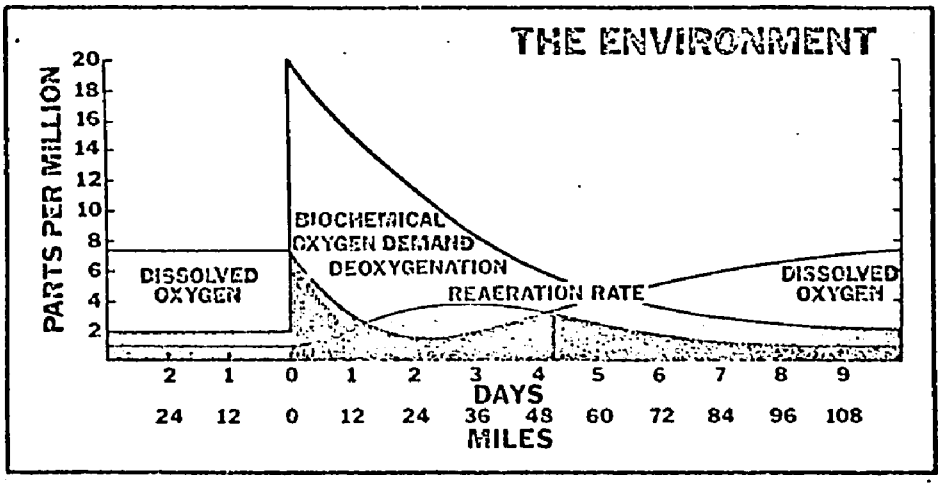
As the amount of pollution decreases downstream, and oxygen is again present, algae and other water plants appear, using the organic silt as fertilizer and producing great volumes of organic matter. This, as it dies and decays, can add to the oxygen demand of the stream. As the water moves downstream in a degraded state, the addition of more sewage before it recovers, may cause ecological death (See Figure 5)

Two final points must be made in connection with the natural purification process: one, that the period of low flow is particularly significant because during this time the living organisms have less water from which to draw the necessary oxygen; and two, an increase in the temperature of the water may be harmful because bacteria grow more readily at warmer temperatures and water is not able to hold as much dissolved oxygen at warmer temperatures. Late summer and early fall can be a critical time for many streams, rivers and lakes, because water levels and dissolved oxygen are low and temperatures are high.

The use of water as a carrier of waste is both a withdrawal and an instream use. That is, water is removed and carried to the place where it is used and the waste is added. The water with the waste, if the water is not treated in some way, is returned to the runoff segment of the hydrologic cycle either to surface or underground supplies. Dilution may occur where the water is used and some assimilation may occur as the water is being transported, but for the most part, both of these are instream functions. Water

FIGURE 5

SCHEMATIC PRIMARY OXYGEN SAG AND REAERATION[1]



The above diagram represents the oxygen situation in a stream when sewage is added. The assumptions in this hypothetical pollution case are a stream flow of 100 cubic feet per second, a discharge of raw sewage from a community of 40,000, and a water temperature of 25° C, with typical variation of dissolved oxygen and BOD. The dissolved oxygen concentration in the stream is partially destroyed by the pollution load. Full depletion is avoided by reaeration processes.

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[1]Alfred F. Bartsch and William Marcus Ingram, "Stream Life and the Pollution Environment," Public Works Publications, Vol. 90, No. 7,(July, 1959), p. 105.

for waste assimilation is not a consumptive use except to the degree that some evaporation may occur during transportation.

In Michigan some communities provide no treatment for their sewage but depend upon streams, rivers, lakes and underground water to absorb their wastes. In many areas of the state this has caused extensive ecological changes in the receiving waters. Many communities do provide waste treatment facilities, but these are often limited in the degree of treatment or are overloaded and, therefore, ineffective. Many miles of Michigan's streams, rivers and lakes have been overcome by industrial and domestic pollution.

Eutrophication, an increasing water problem, is the development in a water body of a good supply of food. Many of the lakes and streams of Michigan which we prize for recreation and natural beauty, such as Lake Superior, Torch Lake and Higgins Lake, are oligotrophic (few foods) waters. The limiting factor in the production of food in these waters is the lack of minerals. If minerals are supplied, these waters become more productive, producing rich growths of algae and other water plants. Limited additional food production is usually welcome, but if the process continues, the growths of water plants, as they decompose, can impart a bad taste and smell to the water. They can interfere with swimming and boating, and they can change the habitat to the point that the species of fish may change.

Many streams, rivers and lakes such as Houghton Lake, the Au Sable River and Lake Erie are becoming increasingly eutrophic (many foods) due to the addition of nutrient fertilizing materials. These fertilizers find their way into water from municipal outflows, from agricultural drainage and from the septic tank overflows of homes and cottages along lakes, streams and rivers. Even after sewage treatment, much of the nitrogen, potash and phosphates still remain in the effluent; these then are available as fertilizer

in the natural water habitat. Much of the fertilizing effect of these materials is lost, however, if just the phosphates are removed. Fertilizing materials are referred to as "corollary pollutants,"[1] because they are not in themselves pollutants, but they cause conditions which are considered pollution. The methods of solving this problem will come from continuing research and from the development of sewage systems which collect and treat wastes from even remote areas.

The eutrophication of lakes is a totally different problem than the eutrophication of streams and rivers. Lakes accumulate and tend to recycle nutrients so that once eutrophic conditions occur it may take a considerable period of time for them to disappear after the source of the nutrients is removed. Streams and rivers, on the other hand, flush nutrients down and out of the system and therefore return to their original condition rather quickly once the influx of nutrients has been stopped.

Water for Food Production

Most food production can be carried out without the addition of extra water to supplement the normal natural supply. Farm wells or ponds can provide the necessary water for livestock and most farming is done in areas which have enough natural moisture to make crop production possible. Some areas of the far west, however, have been extensively developed for irrigation. In any irrigation project there are several important elements. Some method of obtaining water must be developed, such as a dam or wells, and these must be

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[1]Jack Edward McKee and Harold W. Wolf, Water Quality Criteria, (Sacramento, California: The Resources Agency of California, State Water Quality Control Board, 1963) p. 6.

connected to the land by a distribution system of canals or pipes. Irrigation has brought food production on millions of arid acres in the west that would have been barren without water. Even in the humid parts of the country, such as Michigan, irrigation has been growing because it gives farmers better control over the growth of crops and results in more abundant production.

Irrigation has some peculiar difficulties. It is a high consumer of water which means that much of the water used is transpired and evaporated by the plants and soil back to the atmosphere. This loss can be as high as ninety per cent in arid areas. The waters which do find their way to underground supplies or to surface runoff tend to be heavily loaded with dissolved materials, some of which may be dangerous pollutants, such as pesticides.

Water which is used for irrigation is used during that season of the year when the supply is usually at its lowest. With irrigation, not only is pollution due to pesticides and salts a problem in those waters which are returned, but a great percentage of the water is lost as evaporation. Irrigation in the west is carried out in water short areas, and the consumptive use of water for irrigation often means a limit to other types of development which depend on water.

Water for the Generation of Electric Power

There are two ways in which water is used in the generation of electric power. Water is the motive force in hydroelectric power generation and water is used as a coolant for both thermal (steam power) electric generation and for atomic electric generation. The conditions which affect these uses are different, so each will have to be handled separately. In terms of relative use, the hydro-generation of

water power is remaining relatively constant while thermal and atomic production are increasing. Atomic production of electricity will apparently increase significantly in the near future.

The generation of electricity by hydro power is a most important energy resource to the country. The fact that hydroelectric production will not increase significantly in the future is due to a number of constraining factors. In order to be effective, a hydroelectric power plant must have large and constant supplies of water and a drop of some distance. In many of the flat areas of the country, hydroelectric generation is at best ineffective. In mountainous terrain, successful hydroelectric power is achieved by dams with storage reservoirs. The dams provide the head (the height of the water above the electric generator) which determines the force involved and also holds back the water providing a reservoir so that the inconsistencies of supply can be overcome. Hydroelectric generation in itself is an instream use of water and a non-consumptive use, except for reservoir seepage and evaporation losses, with no waste products being added to the water.

The use of water as a coolant for thermal electric and atomic electric production, on the other hand, is a withdrawal use and causes a significant change in the temperature of the water. The change in temperature may be up to 15° F. or 20° F. and huge amounts of water may be used. This increase in temperature significantly affects the ecological quality of the water environment. Small quantities of high quality water are needed by both thermal and atomic power plants for the production of steam. That steam which is lost to the atmosphere makes the steam generation of electric power a consumptive use of water.

Water for Navigation

Water has long functioned as an important means of transporting man and his goods. Water transportation, particularly for bulk materials, is still the cheapest form of transport. A constant amount of water and a series of capital works are needed to make navigation possible in difficult areas. In most areas rivers in connection with lakes provide the main transportation arteries. Capital works such as canals, locks, dams, dredging, etc. are used to make these types of waterways more suitable for navigation purposes. The use of water for transportation is an instream use.

Water for Wildlife and Fish

Water habitats are a necessity for fish and certain types of wildlife. The encroachments which civilization has made into much of the natural habitat have placed a great deal of pressure on some species of animals, and they have limited many others. It is now necessary to manage many water areas so that they provide habitat which can maintain wildlife and fish. Certain species of wildlife, both fur bearing animals and waterfowl, depend upon swamps, lakes, streams, ponds and rivers for their feeding, resting and nesting areas. Without these areas, their numbers are severely curtailed. Many of man's urban development's and industrial activities take up or pollute wildlife areas. Development of industry along watercourses, the drainage of swamps and the building of cottages along rivers, lakes and streams have utilized wildlife lands.

Wildlife plays an important role in the aesthetic quality of the environment and is also important ecologically and economically. Wildlife,

in the past, has supplied fur, feathers and meat. Today these products have diminished in importance. Wildlife now mainly contributes to recreation. The economic value of wildlife in the form of hunting has grown steadily. The economic impact from the purchase of equipment, lodging and fees which hunters pay to get a chance to hunt is great. Important as many hunting areas are, they are often used more by sightseers throughout the year than they are during the brief fall hunting seasons. Sightseers also make a considerable economic contribution. The value of these recreational pursuits must also be considered in terms of the well-being of the individual who pursues them.

Fish, like wildlife, are an important recreational resource and in the Great Lakes, they are still a commercial commodity as well. The sums of money which sportsmen spend in the pursuit of fish is by now legendary and the demand remains high. The coho salmon experiences point out vividly the intense desire which many fishermen possess.

Maintaining of water habitat which is suitable for both sport and commercial fishing is one of the difficult problems of water management. Pollution is, of course, the biggest menace because it can render water habitats unlivable. Many forms of pollution conbribute to the problem; some pollutants may entirely destroy the habitat, while others render it useless to certain species and thereby change the species which are present. This usually is undesirable to both the sport and the commercial fishermen.

Fish and wildlife alike contribute to the ecological health of the communities in which they live. They are an important link in the food utilization patterns and are important in the maintenance of the natural communities.

Water for Outdoor Recreation and Natural Beauty

Water, because it is a vital component of the natural ecosystem, directly affects many types of outdoor recreation. Water supply and its ecological quality are direct determinants of the quality of many types of outdoor recreation. Water tends to be a focal point for recreation activities as was pointed out by the Outdoor Recreation Resources Review Commission (ORRRC) report. There are many recreational activities, such as boating, sailing, canoeing, which simply use the water physically. On the other hand, such recreational pursuits as swimming and water skiing, demand water of high quality. As the quality of water declines, the organisms, including the fish, change until the quality reaches the point that higher life is impossible. In the case of waterfowl, the water habitat supplies food and a living area, both of which are determining factors in the number of waterfowl which can exist. Moreover, with migrating waterfowl, there must be a series of suitable quality habitats in their summer and winter living areas and on their migration paths as well. Many waterfowl use Michigan as a flyway during their migrations.

Water is often a most welcome addition to parks and increases the enjoyment of them. Water quality is significantly important in wilderness and wild river areas. Water for drinking and cooking is needed for camping, picnicking and hiking.

One of the most critical problems of water recreation in many areas is limited water access. Industrial, commercial and private development and ownership have closed off most of the valuable recreational shoreline. Many of the areas which remain are poor in quality and costly to develop. Water

access in and around urban areas is particularly difficult to obtain. Water access can be a significant limiting factor to the use and enjoyment of water based recreation.

Most of the uses of water for recreation are non-consumptive instream uses and do not affect water quality.

PART IV: THE MANAGEMENT OF WATER RESOURCES

The management of water resources is the process through which water resource policy decisions are implemented. Water resource policies are determined by legislative and administrative authorities and are the legal basis for water management. These policies set the goals for water management and the parameters within which water management must operate. The three primary water resource management functions are administration, planning and project development and operation.

In our democratic society the administrative responsibility for handling the separate aspects of water resources is carried out at various levels of government (local, state and national). Water resource responsibilities are often divided among a number of administrative agencies, within a given level of government. A good example of this is the federal government which has delegated specific administrative responsibility for water resources to the Corps of Engineers, the Bureau of Reclamation, the Federal Water Pollution Control Administration, the Bureau of Outdoor Recreation and others. This fragmenting of responsibility, much of which is historical accident, has made the logical and comprehensive development of water resources extremely difficult. Administrative organizations which have development responsibilities often have been too narrow in their authorization to effectively consider the total interaction of the physical water system.

Michigan is fortunate because its Water Resources Commission is a single agency with the responsibility for coordinating the various aspects of water management within the state. Even though the state has one

administrative agency with the responsibility for water resource coordination, important divisions of water management responsibility still exist. The actual management activities still are carried out by various state agencies which makes the task of coordination difficult. The important water management functions which remain highly unorganized are those for which local units of government are responsible. Water supply, land use and waste water treatment are all traditional local responsibilities. It is important, however, to have the different levels of government represented in water management because of the different perspectives they have on the problems.

Administration, at all levels of government, has the responsibility of translating policy decisions by planning and implementation into water management programs. This responsibility exists both before and after policy decisions are made. Before the policy decisions are made, administration must provide a whole parcel of services under the heading "planning." After the decision, administration is, of course, responsible for implementation and operation of the program. The problem inherent in this situation is that both the policies and the administrative organizations tend to be too limited in their authority to develop water resources in a logical, comprehensive way.

The planning process is often affected by administrative fragmentation. Planning should generate and evaluate the technological, economic and political feasibility of alternative solutions (oftentimes referred to as alternatives) to water problems. If water resources are not managed as a system, fragmented planning can result in inefficient programs or cause conflicts between political areas or water uses. If administrative organizations do not integrate their planning efforts with other organizations, difficult problems of management and allocation occur.

The development and operation of water management programs are another aspect of water management which suffers from the division of authority. Small units of government may have the authority for certain aspects of the water management picture, but they often do not have the fiscal base necessary to build the scale of project which is necessary for the most efficient management program. Local governments at times do not undertake water management programs even though the mandate of the people is implicit. When the benefits of a project are diffuse, hidden or subtle, incentive for management may be lacking. An excellent example is the treatment of municipal waste - the local municipal government derives limited benefits from waste treatment, and yet must generate significant funds to provide treatment facilities.

The alternative physical solutions to water resource problems that are available to water management have some important characteristics in common. Water management programs tend to be expensive - no matter at what level of governmental authority they are chosen. Once a particular program is developed, limitations are placed on the flexibility and the number of management alternatives available. The cost and the physical changes which are made in the water system make reversal of the program or changes to a different program very difficult.

The fact that water forms an interacting physical system means that usually no single technique, no matter how massive, will solve the system of problems which occur. The solution to many water resource situations should be a multiplicity of techniques. The complexity and the variety of water problems call for a wide range of techniques to bring about effective management programs. If a system of techniques is to operate in an optimal manner, it must be coordinated between all the responsible policy and administrative

authorities which exist in a given water system.

There are four areas which water management must deal with: water demand, water supply, floods and water quality. Each of these factors must be dealt with separately and though there are some important interconnections, each is basically handled by different management techniques. The methods which are available for the management of water resources are limited by the water system involved and by man's knowledge. They are often hampered by the social, economic and political organizations which man has superimposed on the physical water management area.

Management of Water Resource Demand

The demand for water resources is the desire by man to have water for many uses. This demand is unlimited, and it is basically controlled by cost. Cost, either to the individual or to society, is an effective way of reducing the demand for water resources. The problem is that Americans have had such an abundant supply of water that systems using water have been developed which have kept the price of water extremely low. In many cases the cost of water to the consumer is the cost of transporting and treating it. While water has become more of a scarce good both in quantity and in quality, Americans have not had to accept a price increase. Difficult allocation problems have occurred because price has not been allowed to act as an allocater of water. Because the price of water is low, it is often used in greater quantities than is necessary. Even though the price to the individual is not a factor in most demand situations, it could be a future means of allocation.

Without price to act as an allocater of water supply, a whole group of political allocation measures have developed. The primary political means of allocating water are the basic water rights' laws which have developed.

There are two basic types of water rights' laws in the United States. They are divided between the water rich states of the east which have the riparian doctrine of water rights and the arid states of the west which have the prior appropriation doctrine. These rights govern the use of water. There are a number of other ways of politically controlling the demand for water. Legislation which sets restriction on the amount and priority of uses can control water demand. A whole group of economic restraints which substitute for the market situation can be placed on demand. These economic restraints can be taxes, fees and metering. In periods of low supply, rationing can be enforced. Zoning and easements can be used to control the demand for water access. Education can also be an effective factor in determining the demand situation by helping citizens understand the importance of demand in relation to water supply (See Figure 6).

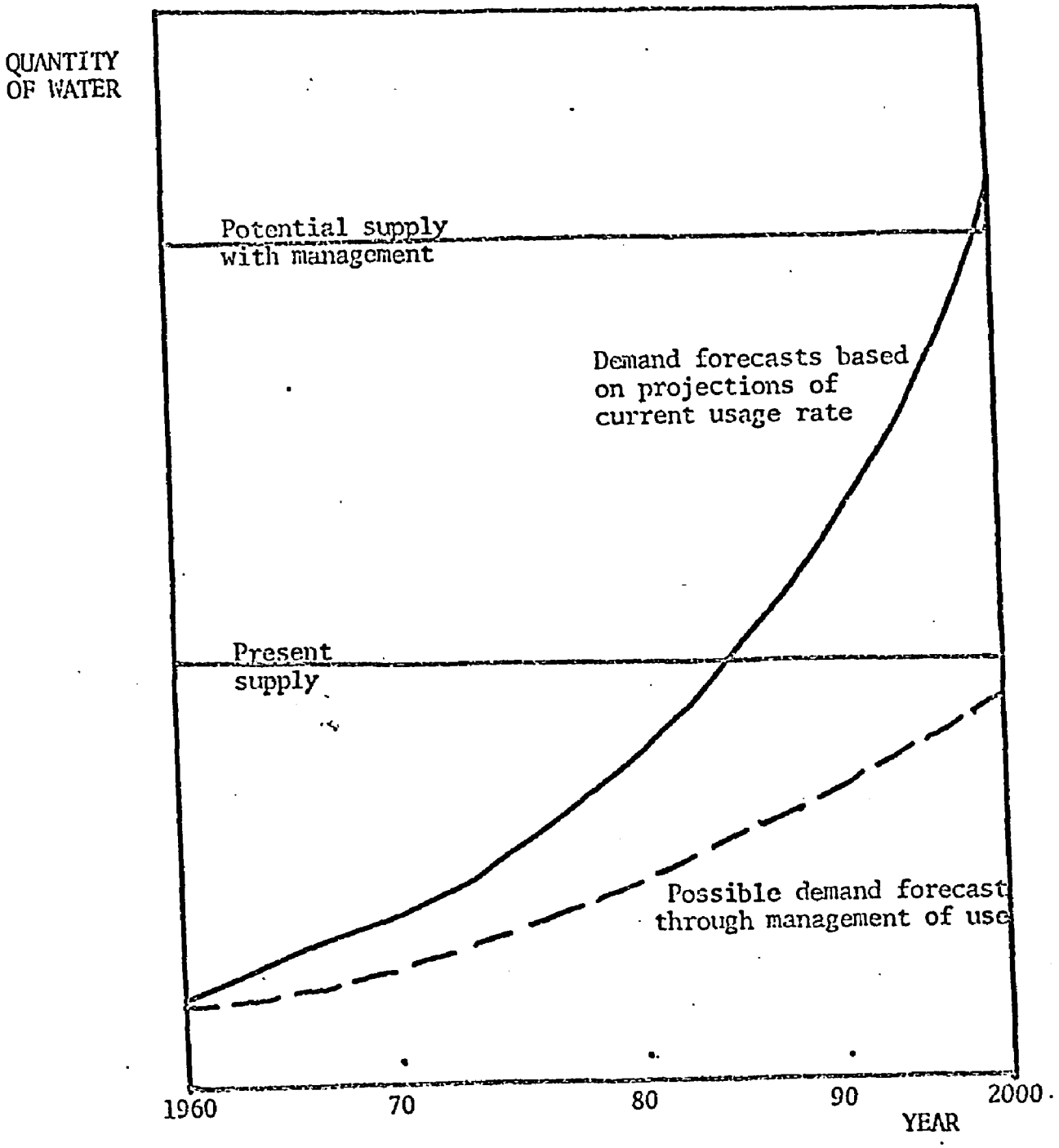
Management of Water Supply

Many techniques for effectively increasing and handling water supplies have been developed. In most cases the supplies of water are sufficient to meet the needs, but they are poorly distributed over time. Most of the significant techniques for increasing the amount of water available are simply means of stabilizing the supply by controlling and storing the runoff.

Runoff may be stored either on the surface or as underground water. In both cases special consideration must be given to water's fugitive characteristics. The following management techniques for increasing and stabilizing water supplies each have different applications and are often used in different intensities and combinations to solve specific problems.

FIGURE 6

COMPARISON OF DEMAND/SUPPLY FORECASTS[1]



[1] James C. Kellogg, Project Director, Strategy, A Report Prepared by the Technology Planning Center, Inc. (Ann Arbor, Michigan, 1966), p.64.

Watershed Management

Watershed management is the control of the surface of the land to improve its water holding and infiltration capacities. It is a program which tries to control water as it reaches the land before it has a chance to collect and to generate destructive force. Watershed management is concerned with a wide range of problems, such as runoff, infiltration, percolation and storage. It is an extensive type of program and each individual part contributes toward its success. Watershed management has important ramifications for land management because the two resources of water and land are closely interrelated.

Watershed management is determined by the land shape of the watershed. The steeper the gradient, the more chance water has to bring about erosion. In certain areas which have relatively steep contours, it may be important that they be kept covered with vegetation at all times to protect them from erosion. As the precipitation meets the land the way it is intercepted is extremely important. A foremost element in protecting the land is the plant cover. Plant cover tends to break the fall of the precipitation. In the case of rain, if the soil has little or no plant cover, splash erosion can occur, whereby the raindrops throw up the soil particles and carry them off. This can also seal up the soil in such a way the runoff increases. If plant cover exists either as forests, shrubs or grasses, the precipitation's fall is broken by the foilage and the branches and falls gently to the ground. On reaching the ground the plants may hold or at least slow down the movement of the precipitation off the land surface so that it has more chance to infiltrate the soil. Low grasses and other small plants keep rain from running quickly over the surface of the land which not only allows better infiltration,

but also cuts down on erosion. Trees and shrubs block sunlight, providing slower snow melt in northern areas. This gives more time for infiltration and cuts down on the chance of severe flooding. Plant cover on the land then slows down runoff, retards erosion, increases infiltration and the recharge of ground water, and promotes stabilized flows helping to prevent floods.

In many areas human development, both urban and rural, have created watershed management problems. Forestry techniques and farming practices have removed the trees and other plant cover from the land particularly from the slopes of hilly land. This has caused not only quick runoff, resulting in a lack of infiltration, but also erosion leading to silting and deposition in streams, lakes and reservoirs. In urban areas in particular little attention is given to land cover during the development and construction of buildings, housing complexes and roads. Land is bulldozed and left uncovered causing erosion which is carried to streams, lakes and rivers where it causes problems as both silt and deposition. Ugly scars left on the land after development are often removed only by expensive landscaping techniques. Serious local flooding of homes and forests may result if water drainage is not given proper attention in road construction.

Watershed management, then, begins with the landowner, whether he is a private farmer, developer, homeowner or a governmental agency. The development and the maintenance of a suitable plant cover on erodible land is important. Structures such as check dams (small dams which impede quick runoff) can be valuable. Swamps and marshes can be left as storage areas rather than being drained and tiled, a situation which adds to the runoff problem as well as removing valuable wildlife land. Where they are appropriate, farm ponds can be constructed. In urban development, consideration should be given to

the land surface; special care should be taken during the actual construction to see that erosion is kept at a minimum. The paved surfaces and roofs of developed land will always be in direct opposition to good watershed management techniques, but urban-suburban land can still be managed in small ways to increase infiltration. In areas of porous soil, water from roofs and paved areas can be directed over grassy areas where infiltration can occur. This must, of course, be done only where local conditions permit or flooding will result. Urban-suburban landowners also can be careful to cut down erosion by keeping their lands in plant cover where possible and particularly after development in new areas.

Government and industry must also be concerned with watershed management techniques and should be urged by the public to show care in land use. The mining industries in particular have been careless in handling tailings (waste materials from mining) which are eroded into streams and rivers causing silt problems. Mine wastes have also contributed mine acids and other undesirable dissolved chemicals which find their way into watercourses. Municipalities have often given little consideration to the problem created by solid waste disposal. Many dumps contribute pollutants to both surface and underground waters when precipitation passes over or through them.

Like many problems that occur in a water system a share of the benefits of watershed management occur in places other than where the corrective measures must be initiated. The downstream area receives the benefits of cleaner water and a more stabilized flow which means less chance of floods, less damage when floods occur, and more water in low flow periods. The landowner, by cutting down erosion and increasing infiltration, receives the benefits of better land and better ground water supplies. Good watershed

management is beneficial to all.

Reservoirs

Reservoirs are used for numerous reasons in the management of water resources. They are used to increase the effective water supply for many purposes, and they are also used to maintain water quality. Reservoirs can be used as an integral part of an effective watershed management program. They have some significant characteristics which are important in their development and use.

The term reservoir can mean any type of water impoundment. In most cases there will be a dam with the resultant backwater. In order to construct an effective reservoir, two conditions must be met at the site: one, a logical place for the dam to be built; and second, a sufficient area which can be flooded to provide storage. The dam site itself must be such that the work necessary to close the stream is at a minimum. The geologic structure of the area must be suitable for construction. The area to be flooded must be sufficiently large and contain the depth necessary to make the project effective. If reservoirs are too shallow, they produce several unwanted water conditions. The evaporation rate of shallow reservoirs is greater than deep ones, resulting in greater loss by evaporation. Shallow reservoirs, when they are emptied to provide low flow augmentation, water for irrigation, or water for hydro power, expose wide mud flats which can look bad and oftentimes smell bad. Shallow reservoirs cause water to heat up faster than deep reservoirs, and they have a much shorter economic life span in the presence of silting. These constraining factors dictate that only a limited number of reservoir sites are physically available. Reservoir sites being a limited

resource must be allocated among many uses, and other management techniques which can do the same job need to be developed.

Reservoirs can be affected by water's fugitive properties; that is, due to the attempt at storage, water can both evaporate and seep away. Particularly in the warm summer months, evaporation causes the concentration of dissolved materials which can be a problem.

Dams also effectively block streams thereby creating problems of transportation and fish migration. Transportation can be continued if the cost of locks is provided. The problem of fish is another thing; fish ladders have been provided at those dams where migrating fish must pass, but in many cases they have not proved successful. Reservoirs also tend to warm water, depleting the oxygen, thereby affecting the biological communities at and below the site. In some reservoirs the location of the outflow source is important in controlling outflow temperature.

Reservoirs can serve many purposes and often they can serve more than one purpose at a time. When reservoirs are used for more than one purpose, they are spoken of as being a multiple-purpose development. The multiple-purpose aspect of reservoirs is very important because reservoir sites are limited. It is critical in the development of a reservoir site to give attention to the multiple-purpose aspect of the situation because once construction has been completed, it is difficult, if not impossible, to include a new use.

Transportation of Water

Water supplies can be effectively increased regionally by the transportation of water from one area to another. With the development of land

continuing at a rapid rate, this problem increases because areas rich in water supply become more difficult to find. Often the transportation of water means water storage in the headwaters of the watershed and then distribution as needed to areas of concentrated use. In some areas of the arid west, water transportation is of prime importance in providing water. In Michigan many communities now import water from the Great Lakes to supplement surface supplies thereby reducing the need to construct storage facilities.

The main problems that exist with water transport are finding adequate supplies, moving the supplies without evaporation or seepage losses and the cost of transmission. The transportation of water can affect the source watershed by removing water from one drainage area to another or from the headwaters of a watershed to its lower reaches, both of which cause important physical and biological changes. In the case of Michigan - when water is withdrawn from the Great Lakes, used and then returned, except for evaporation and pollution, most of the side affects of increased stream flow are beneficial.

Techniques for Developing New Water Supplies

The water available for man's use can be increased by better utilization of existing supplies and by technological developments which make formerly unusable supplies usable. Many of these methods are presently in limited use because their cost is high. As research proceeds, the cost of some of these techniques will drop and they could become an integral part of many water supply systems. Besides the better utilization of runoff, fresh water supplies can be effectively increased in a number of ways. Desalinization of salt or brackish water, better utilization of ground water supplies, utilization of polar ice, reuse of waste water and the modification of the weather, all could

provide more fresh water for man's use.

The processes of desalinating sea water have improved greatly in terms of efficiency and cost reduction since they were first developed. With the lowering of cost, small applications in water short areas have already proved economical and as the cost continues to drop and the efficiency improves, many more applications are likely. Because desalinization requires large amounts of energy, the process for the foreseeable future will have difficulty competing with natural water supplies except in areas of extreme need. Brackish water, which is less salty than sea water, can be found in many parts of the United States, including Michigan. It is also susceptible to desalinization procedures at even a lower cost than the desalinization of sea water. This may prove to be an effective new source of water for many water short inland areas just as the desalinization of sea water may prove to be an extremely important source of fresh water for areas near the oceans.

The polar ice caps of the world contain about two-thirds of the world's fresh water supply. A number of recent suggestions have been made for ways to utilize this resource. These suggestions are at present only speculations, they do, however, present another remote alternative. Again, as is often the problem, the cost of transportation is extremely high; however, this vast resource should not be overlooked as a possibility for the future. Weather modification may also prove to be an effective way of increasing water supplies for a given area, but the problems inherent in this process make its extensive use doubtful at this time.

The increased use of ground water is yet another way of increasing the effective water supply. The underground reservoirs of fresh water have

only been partially tapped for man's use. These supplies represent a significant resource close to man's needs. The problems of extracting the water and contending with the minerals that may be in it, are a significant hindrance to its utilization. The main problem which water management faces in effectively utilizing ground water supplies more extensively is the lack of research and information which exists about them; as this body of knowledge increases so surely will its utilization.

The reuse of waste water is a most important way of effectively increasing water supplies. Many industries have proven that reutilization is possible and in some cases profitable. As the cost of water and water treatment increases, reutilization can be expected to increase.

Management of Water Quality

Water quality cannot, of course, be completely separated from water supply. Yet under our present conditions, water quality has become such a significant factor in the use of available water supplies that water management must now deal directly with this problem. There are a number of developed techniques which water management can employ for maintaining and improving water quality. The problem of managing water quality lies in the cost of constructing pollution control facilities and in the research that must be done in keeping up with difficult, persistent and exotic pollutants.

Pollution Control

There are a number of techniques which have been developed for handling pollution. The three basic methods of dealing with pollution are through natural assimilation, dilution and pre-treatment. Natural

assimilation depends upon the natural process which occurs in water bodies to take care of pollution. This process has been relied on through the centuries; however, with the advent of industrialization and urbanization, natural assimilation can no longer handle the growing pollution problem. Like many other problems which demand new solutions, the old methods play a role in the new techniques. The new techniques which man employs to improve the pollution situation are designed to help the natural assimilation process, but all treatment facilities depend on natural assimilation for handling at least a part of the pollutants.

Dilution enhances the important natural characteristics of water's ability to assimilate wastes as well as physically separating them so finely that they lose their harmful concentrations. Many of the techniques which are used to provide increased water supplies are also effective in providing water for waste dilution. The low flow time of the year is, of course, the time when dilution problems become most difficult. Watershed management, reservoirs and the importation of water all help in providing for dilution during these critical low flow times. This is often referred to as low flow augmentation. Simple dilution increases a water body's natural assimilation ability, but it does not answer the question of persistent chemicals, poisonous materials and pathological organisms. Although the natural processes help to reduce pollution, dilution can no longer be counted on as sufficient means of maintaining water quality.

Man has technologically developed a number of pre-treatment techniques which can greatly improve waste water quality. These treatment facilities have already come into use in many municipal and industrial applications even though their cost is relatively high.

The basic concept of pre-treatment is that it is easier to deal with pollutants when they are most concentrated. The more water that is added to the effluent containing the pollutants, the greater the task becomes of separating the water from the pollutants. Persistent and dangerous pollutants in particular should be removed before waste waters are released. Many industrial institutions have treatment facilities where specific wastes are treated so that they can be removed before they are passed on to the general sewage treatment facilities.

The most effective types of pre-treatment facilities utilize basically natural processes but intensify and localize them. The materials they produce, like those of natural stream assimilation, are the relatively harmless materials of the natural ecosystem. In some particularly difficult situations dealing with specific poisons or chemicals, more complicated mechanical and chemical procedures are used. These are very specific, usually quite limited in extent. A look at the basic types of artificial biological treatment will be attempted to familiarize the reader with the simplicity and the effectiveness of this type of water treatment.

Biological treatment is one of the most common types of waste water treatment in the United States. This type of treatment is used extensively by both municipalities and industries. Biological treatment closely resembles the waste assimilation process found in natural water. It does an effective job of handling most organic as well as some inorganic pollutants. Most biological treatment facilities used in the United States at present are a two step process, however, if more treatment is needed or desired, this can be expanded to three or even four steps.

In any sewage treatment system, the first consideration must be given

to the sewers themselves. Many communities across the nation have combined storm and sanitary sewers. This causes difficult problems when storms occur. In times of sudden increased flow the average waste treatment plant cannot handle the extra volume which must be sent directly into the receiving water body. Adding to this problem is the condition of the sewage in the sewers, particularly in the hot summer months when it has had a chance to develop a wide range of unpleasant odors and organisms. Many new urban developments build separate storm and sanitary sewers, but in some cases such as Detroit and Wayne county, single sewers were installed in the past and development of separate sewers would cost a great deal. One of the proposed methods of handling this problem is to develop controlled flow in the sewers to hold back storm flow. The sewers have considerable extra capacity particularly in the dry summer months. This stored flow would then be released as the treatment facilities could handle it. This system shows some promise for many milder storm situations, but it still leaves the problem basically unanswered for a large percentage of the time during heavy storm conditions when untreated sewage would be directly vented into the Detroit River.

When separate storm and sanitary sewers are constructed, the storm sewers are usually vented directly into the receiving water body. Many undesirable materials are washed into storm sewers with the waste water. A significant problem is the salt which is used for the melting of snow on the streets in many Michigan communities.

The sewers themselves are the start of the sewage treatment system but all too often in Michigan as well as many other parts of the country, the sewers are the entire system. Open sewer pipes in many communities empty raw sewage directly into receiving watercourses. Often the sewage is

released under the water where it may go relatively unnoticed. The natural assimilation process in the receiving water body must then handle all the BOD, sediments, nutrients, debris and pathogenic organisms which may be present.

Sewage itself is 99.9 per cent water. It tends to be light gray and cloudy with a soapy or oily odor. It contains a large amount of miscellaneous matter floating in it. Obviously the exact characteristics of any sewage will depend on the sources which contribute to its make up. There is a small amount of grease and oil floating on most sewage. The solids which make up one-tenth of one per cent of the total sewage may be classified into suspended solids, dissolved solids and settleable solids. Suspended solids are generally colloids that are so finely divided they will not settle out. Dissolved solids in solution in the water tend to be low in organic matter and will not settle out. The settleable solids are heavier than water and will settle if given time. Sewage may also contain up to 5,000,000 bacteria per milliter, most of which are harmless. The problem is that some of the bacteria may be pathogenic.

The main objective of sewage treatment is the stabilization of the organic matter in sewage. Stabilization is the process by which organic matter is broken down by bacterial action into simple substances. These substances are water, carbon dioxide and simple salts which act as fertilizers for higher plants. Stabilization may be brought about by aerobic or anaerobic bacterial action. Aerobic bacteria need free oxygen to bring about stabilization. Anaerobic stabilization occurs in the absence of free oxygen. The main difference between the two processes is that aerobic stabilization is quicker and is odor free while anaerobic stabilization takes more time and produces foul odors. In most biological treatment facilities,

these two processes are used together because they complement one another.

When the sewage arrives at any treatment facility the first step in the treatment process is the removal of floating objects and grit. The removal of floating objects is done by screening out the large objects and shredding the small ones. The grit is removed by trapping it in a small chamber.

Primary Treatment

The first real stage of sewage treatment, called primary treatment, is a sedimentation process. Included along with sedimentation is a skimming process to remove materials such as volatile floating fats and oils. The main purpose of sedimentation is to give the heavier solids a chance to settle out. In the sedimentation stage the sewage is slowed down in a large tank. While the water is moving slowly, the top is skimmed off. The sediment falls to the bottom and is collected. Both the skimming and the sediment are collected with considerable amounts of water. Sludge, the material from the skimmings and sedimentation, is taken to a digestor tank where it is held so that anaerobic decomposition (sometimes called septic action or digestion) can take place. This process, which may take a number of days, produces gas (usually methane and carbon dioxide), water and a thickened residue sludge from which the water is removed, often by a vacuum filter. The dewatered sludge is then disposed of in many ways, often it is dried and burned. The effluent that results from sedimentation, if that is the extent of treatment, usually is chlorinated to kill pathogenic organisms and released to the receiving water body.

While the sewage is in the primary settling tanks some bacterial

action may begin the assimilation of the organic materials. Because of the short holding time, between half an hour and two hours, the amount of bacterial action is minimal. In the case of storm flows, the time may even be less. If the effluent is chlorinated before it is released the bacterial population will be destroyed requiring organisms from the receiving water body to repopulate the effluent before assimilation can start again.

Secondary Treatment

While primary treatment is mainly a mechanical process, secondary treatment is essentially biological. The two common types of secondary treatment, trickling filtration and the activated-sludge process, use living organisms to remove, assimilate and concentrate the dissolved and suspended organic and inorganic matter from the sewage effluent. The living organisms used in both processes form a biological floc which is a collection of microorganisms such as bacteria, yeasts, molds, protozoa, rotifers, worms and insect larva in a gelatinous mass.

Both trickling filtration and the activated-sludge process have other characteristics in common. In order to be effective both must be preceded by a grit and screening process and by primary treatment. These greatly reduce the amount of settleable solids and oil which must be handled by the living organisms. Both types of secondary treatment are followed by chlorination before the effluent is released to the receiving water body.

Trickling Filtration

In the trickling filtration process, the effluent from the primary treatment process is passed over a filter made of pieces of stone or slag

about three inches in diameter on which a biological slime has developed - the floc. In operation the sewage effluent is sprayed, often intermittently, so that it trickles over the bed of stones. The living organisms of the floc use the oxygen from the air and remove, assimilate and concentrate the dissolved and suspended material in the sewage. A trickling filter can remain in operation for long periods of time because as the floc builds up it sloughs off and moves with the effluent to a secondary settling basin or clarifier where it is collected and disposed of like the sludge from primary settling. The effluent from the secondary settling tank is then chlorinated and passed to the receiving water body.

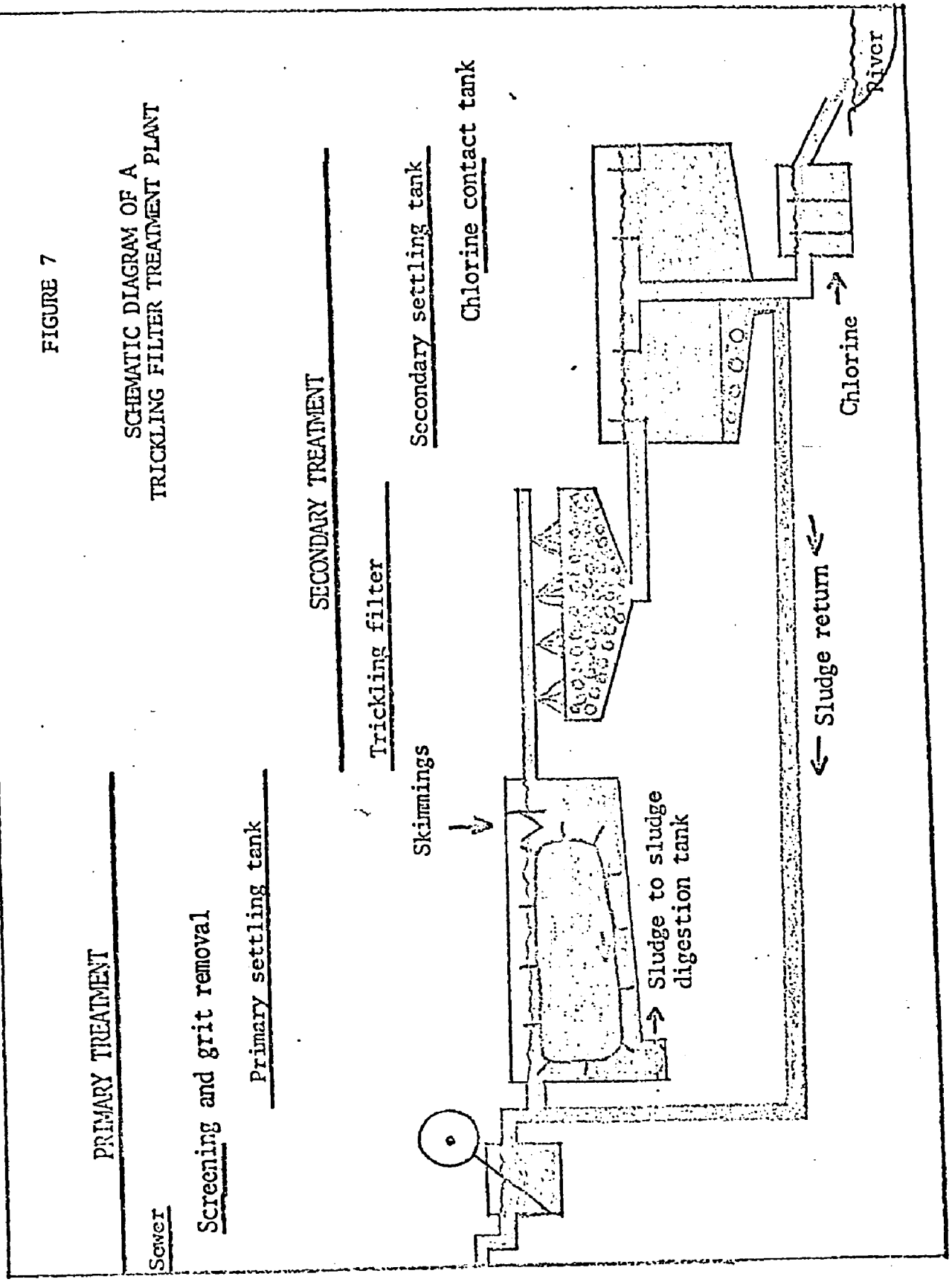
Trickling filters have some rather important difficulties in regular operation. They are bulky because of the size of the stones. A new development to reduce this problem is a honeycomb plastic which increases the area for the living organisms while at the same time reducing the overall size of the filter. Trickling filters are unable to handle excess volumes of sewage which means that in times of increased flow, the excess must be stored and handled during slack times. They also lose as much as thirty per cent of their efficiency in cold weather. On the positive side, trickling filters are excellent in handling some industrial pollutants because the populations of organisms which develop can specifically handle certain pollutants. (See Figure 7)

The Activated-Sludge Process

In the activated-sludge process the effluent from the primary treatment process is placed in an aeration tank where air is bubled through it for from four to eight hours. The oxygen of the air is necessary for the

FIGURE 7

SCHEMATIC DIAGRAM OF A
TRICKLING FILTER TREATMENT PLANT



living organisms. Activated-sludge (this is floc which has been in the aeration process and is richly endowed with living organisms) is also added to populate the effluent with living organisms. During aeration the living organisms utilize the sewage to live and build their bodies. The effluent from the aeration tank is then passed to a secondary settling tank where the floc is settled out, collected, and then sent to the sludge digestion tank. A small amount of the floc is recirculated to the aeration tank. The effluent from the secondary settling tank is then chlorinated and passed to the receiving water body.

The activated-sludge process can produce a high degree of purification in a short length of time, it is not subject to insect and odor problems, and it performs almost as well in winter as in summer. The process does run into some problems that occur with biological organisms upon which the system depends. (See Figure 8)

Chlorination

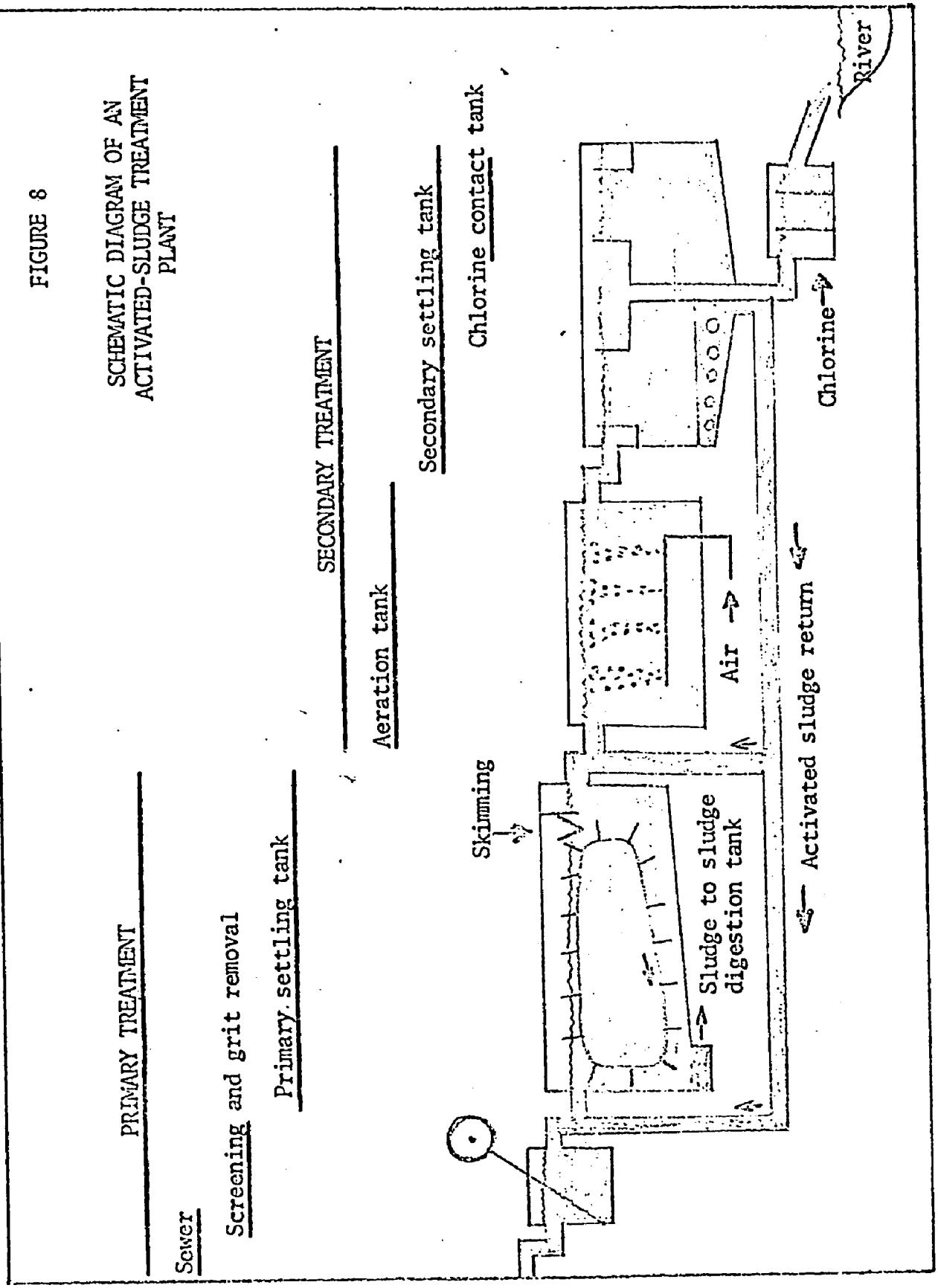
Chlorination is a final treatment which is used with all types of treatment to disinfect the effluent. Chlorination helps to remove odors and to precipitate some inorganic materials, but its primary purpose is the disinfection. Many states, such as Michigan, require chlorination of municipal sewage effluent continually.

Other Types of Sewage Treatment

There are a wide range of different types and combinations of treatment processes and facilities which can be used for sewage treatment. In rural areas and for some industrial applications, septic tanks are used.

FIGURE 8

SCHEMATIC DIAGRAM OF AN ACTIVATED-SLUDGE TREATMENT PLANT



Septic tanks are a combination of settling and anaerobic decomposition. As the sewage enters the tank, which is usually divided into sections, it is given time to settle out the solids which it contains. On the bottom of the tank these are stabilized by anaerobic bacteria. The effluent then passes to a second compartment where the same procedure takes place. The remaining effluent is then usually distributed to a pipe which is located underground and the water can then join the water table. Septic tank effluent must be given careful consideration so that it does not find its way into water supplies.

There are a wide range of other chemical, biological and mechanical treatment processes which are used in specific industrial waste situations to remove inorganic and exotic organic materials. These processes are numerous, often complex, and difficult to describe. They must be mentioned, however, because their impact upon the natural ecosystem may be significant.

Liquid wastes are sometimes disposed of by allowing them to infiltrate land areas or by forcing them into underground strata. Industry in particular has used these methods of disposing of difficult pollutants. The problem with this method of disposal is the same as with any pollutant which finds its way into underground water supplies. It is difficult to predict how these wastes may move underground and where they may reappear.

Stabilization ponds are one form of treatment which are widely used either by themselves or in connection with some other treatment process. The purpose of these ponds is to allow the water time to slow down so that aerobic bacteria and algae can reduce the organic matter. These ponds are low in cost, if land prices are low, and are suitable for low use areas and small industrial applications. At times these ponds are harvested either by

removing the algae or by removing the fish which thrive at the end of a food chain that starts with the algae.

Tertiary (third order) treatment may consist of a chemical process such as activated carbon, rapid sand filtration, micro strainer, or algae growth in controlled ponds or other systems. It can produce water which is up to 99 per cent pure.

TABLE 3

RELATIVE EFFICIENCIES OF SEWAGE TREATMENT PROCESSES[1]

Treatment Process	BOD Removed	Suspended Solids Removed	Bacteria Killed
1. Screening	5-10%	2-20%	10-20%
2. Chlorination of raw sewage	15-30%	--	90-95%
3. Sedimentation	25-40%	40-70%	25-75%
4. Trickling Filtration	80-95%	70-92%	90-95%
5. Activated-sludge	75-95%	85-95%	90-98%
6. Chlorination of biologically treated sewage	--	--	98-99%

Water Pollution Research

Research has played a vital role and is presently making important contributions to the solution of water pollution problems. Water research, however, is plagued by the fact that it is costly and time consuming. These factors point to the need for intensifying the research activities of both

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[1]Karl Imhoff and Gordon Maskew Fair, Sewage Treatment, (New York: John Wiley and Sons, Inc., 1956), p. 6.

industry and government. Research is one of the key methods of keeping up with the currently exploding problems of water pollution because it is the means through which new technologies are developed and evaluated.

Social Problems of Water Pollution

Natural assimilation is an economic resource providing for the stabilization of wastes without cost to society. Natural assimilation has limits. If the process is overwhelmed by pollution, it is lost as a resource. Natural assimilation provides a valuable service to society, however, the rights to this use of water are difficult to control.

The stabilization of water pollutants by natural assimilation occurs over time which means that pollution can be accumulative. There are two aspects to the accumulative nature of pollution: one, pollution may take considerable time to dissipate, up to twenty days and any pollutants which are added before this time is up will enter a degraded situation; and two, no matter how long the natural processes are allowed to work, some characteristics of water are returned to their original condition only after they have moved through the evaporative segment of the hydrologic cycle. Pollution, therefore, tends to build up by increments. It becomes very difficult to place the cause of pollution on one polluter when in reality many polluters may be adding to the problem. In certain cases where specific or exotic pollutants are involved, it is sometimes possible to identify a specific polluter; in most cases dealing with small amounts of general pollutants, this is not possible.

Cost is a basic part of the problem of water pollution. In areas where water conditions permit natural assimilation to occur, there is a

saving of cost in using this as a resource. In those areas where water pollution is not totally dissipated by natural processes, the cost of water pollution is transferred from the polluter to subsequent water users. In cases where natural assimilation is incomplete, higher treatment costs for downstream users occurs; in other cases downstream uses may be entirely foreclosed. These costs of pollution which are borne by downstream users are often referred to as "external diseconomies" or "externalities." Because the cost of pollution is transferred from the upstream user to the downstream user, the upstream user has lower cost because he has costless waste disposal. The downstream user has additional costs if he must provide treatment before he uses the water. This arrangement results in too few resources being spent on the treatment of waste and carelessness in the generation and disposal of wastes. The reason for this is that most users have little reason to treat wastes because they receive no benefits from waste treatment.

Society through government must provide the control which can bring about water quality by making the polluter face the costs of pollution. This is a very difficult process when the damages caused by pollution are so diffuse, having been caused by accumulative pollution from many polluters and occurring to many water users. The cost of waste disposal to any one user may be small, but the aggregate cost may be very large. Water pollution costs also tend to be unevenly distributed over time which means that control measures may be needed only periodically.

Government organizations must be developed which can keep the cost of pollution within a physical water system. All too often government organizations which are imposed over a given physical water system are fragmented in authority to the point that the efficient management of water

pollution is impossible. Governmental organizations are needed to make polluters pay their share of the cost of pollution and to give some rational value to recreation and aesthetic uses of water. All too often, because the recreational and aesthetic values of water are hard to determine, they are neglected in determining the level of waste treatment which is developed. Governmental organizations which can cut across local and regional governmental units could provide a rational unit to deal with the external affects of water pollution.

Citizens have a responsibility in determining the goals of water pollution control for, in the long run, they pay the costs and receive the benefits. If industrial costs go up, if the cost of water increases because more treatment is necessary, or if recreational or aesthetic use for water is lost, citizens pay the cost. If industrial costs rise, consumer prices rise. If the cost of water supplies goes up, so does the price of water to the consumer. Citizens should have a vital interest in the level of treatment that is desirable and in the equitable distribution of costs.

Education can play a vital role in helping citizens understand the way in which pollution affects society and the alternatives available in handling it. Citizens bear the costs of pollution, receive the benefits of pollution control, and should be concerned about the success of management programs. Citizens can help to determine management decisions by taking part in the planning and the decision making processes. Education must help citizens understand water resources, water resource problems, how government functions and how citizens can be effective in influencing government so that water resource management reflects the interest of the people.

Education also has a responsibility in helping citizens develop a personal awareness of their environment. Citizens must understand that in our modern environment, each individual has a responsibility for the way he acts toward the environment. Each individual has a wide range of small but important ways which he can follow to keep the environment from being degraded.

The Treatment of Water Supplies

Water supplies for urban or rural use often must be treated so that the quality is suitable for human use. Many of today's treatment problems are caused by pollution. The United States Public Health Service has set certain standards which have been endorsed by the American Water Works Association as "minimum standards for all water supplies." These standards are important because they act as minimum guidelines to what can be considered acceptable. They are a benchmark for citizens to use in comparing the quality of their water supplies to minimum acceptable conditions.

The standards of water quality are split into biological, physical and chemical categories. Bacteriological quality is defined in terms of coliform group. The water to be used must be sampled from different parts of the water distribution system (the sampling frequency depends on the population served). When ten milliliter (ml.) samples are examined, not more than ten per cent shall show the presence of the coliform group in any one month. The physical characteristics of drinking water should be limited to no impurity which would cause offense to the sense of sight, taste or smell. The chemical characteristics of water should not exceed the following chemical concentrations.

TABLE 4

CHEMICAL CHARACTERISTICS OF DRINKING WATER

Substance	Concentration in mg/l
Alkyl Benzeme Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Carbon Chloroform Extract (CCE)	0.2
Chloride (Cl)	250.0
Chromium (hexa-valent)	0.05
Copper (Cu)	1.0
Cyanide (CN)	0.01
Iron (Fe)	0.3
Lead (Pb)	0.05
Manganese (Mn)	0.05
Nitrate (NO_3)	45.0
Phenols	0.001
Selenium (Se)	0.01
Silver (Ag)	0.05
Sulfate (SO_4)	250.0
Total Dissolved Solids	500.0
Zinc (Zn)	5.0

Radioactivity should be avoided because the affects on humans when exposed to radiation are considered harmful.[1] The amounts allowable are determined by the Atomic Energy Commission.

Water supplies may be drawn from many sources. Most rural users depend on well water for their potable supply. In many areas of the country this water can be used directly. In some parts of the country including Michigan, water softeners are used to remove hardness from the water. In some rural areas potable well water is not present and these

[1] U. S., Public Health Service, Public Health Service Drinking Water Standards, Rev. 1962, Publication No. 956.

areas must depend on surface supplies or bottled drinking water.

Water for urban uses may come from surface or underground supplies. In both cases it is carefully analyzed and treated if necessary. Many areas maintain reservoirs and water transportation systems to supply water, particularly in short water periods. Water which is used for urban supplies may vary widely in quality. Well water tends to be cool and colorless but often hard. Surface water, on the other hand, tends to be warm, contains living organisms and dissolved and suspended substances.

The following is a description of the steps generally followed in the treatment of water. The exact system that is used in a specific community, however, is determined by the local water conditions.

Coagulation is usually the first process in the treatment of water. Coagulation is the forming of flocs from the finely dispersed colloidal and mineral particles. Alum and a wide range of other chemicals work well in this process. The floc settles readily so that the water is conditioned for the filtration process.

Filtration, the clarification of water by removal of the suspended and dissolved materials, is accomplished by a variety of filters such as sand, stone or anthracite coal. The sand filter is used most often. Clarification in a sand filter is brought about by a colloidal slime which coats the sand particles. This coating traps the suspended and dissolved materials both by biological and by mechanical action. The biological action results from the action of the colloidal slime. The mechanical action of the filter is brought about by the sand grains themselves which are placed on top of a layer of gravel to block the passage of small particles.

The next process is disinfection of the water. Such disinfectants

as ozone and ultraviolet radiation can be used, but the most common disinfectant used in water treatment is chlorine. The use of chlorine is preferred for most installations because of its simplicity, reliability and low cost. Chlorination is often used in two steps. The first application prior to filtration (pre-chlorination) reduces the bacteria level at all steps in the purification process. Most of the chlorine which is added to water for pre-chlorination is consumed by the organic material. The second application of chlorine is after filtration (post chlorination). Water treatment often contains an aeration step which gives the water a chance to come into contact with air. The purpose of this step is to improve the taste and to remove excess chlorine and hydrogen sulfide gas. Carbon particles are often added during water treatment to remove tastes and odors. Fluoride is also added by some communities to prevent tooth decay in young children.

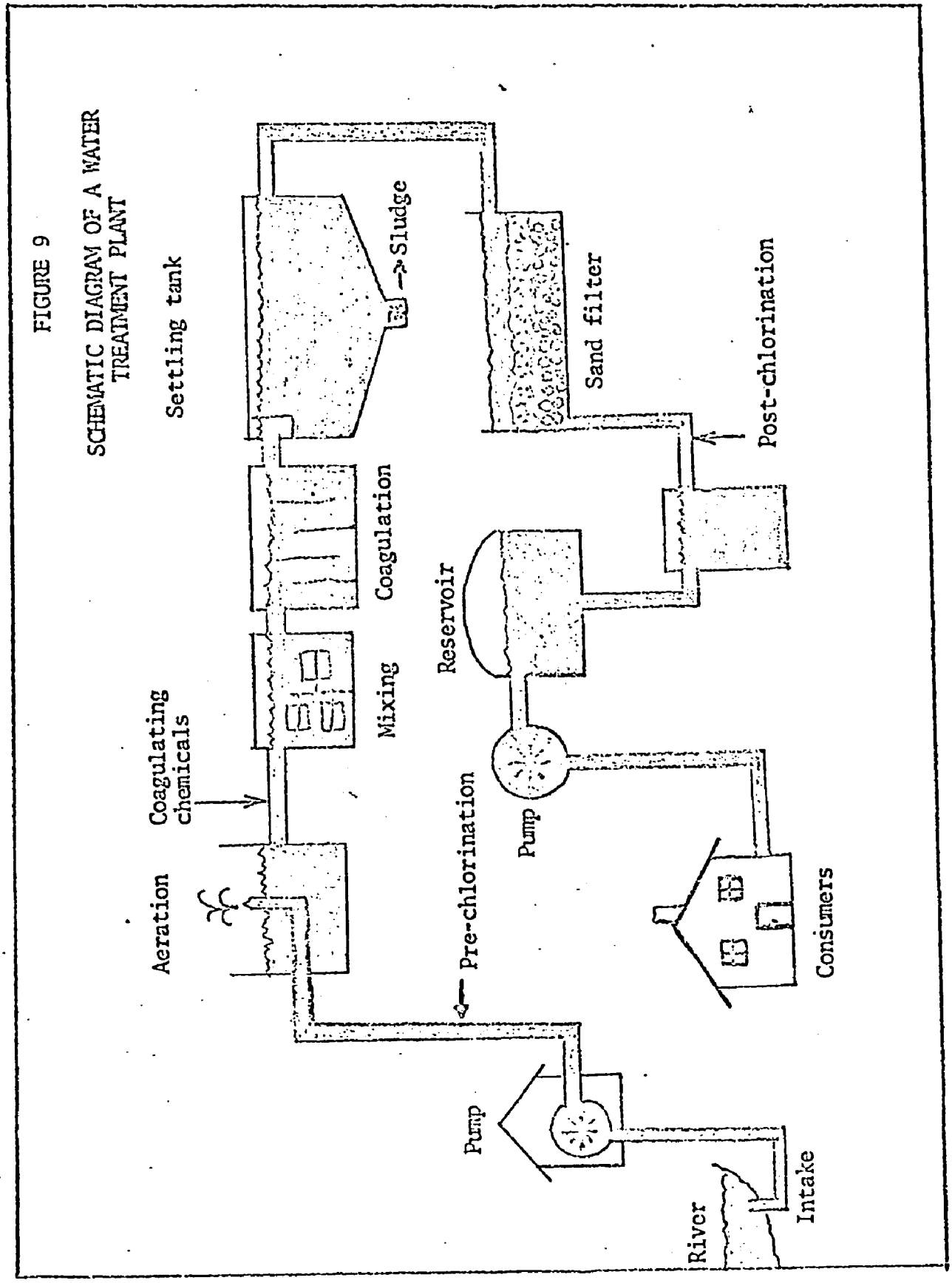
If conditions warrant it, water is also softened as part of the treatment procedures. Hardness in water is caused principally by the presence of calcium and magnesium in solution. The usual ranges used to designate the degree of hardness are "very hard" - greater than 180 ppm of hardness; "hard" - 121 to 180 ppm of hardness; "moderately hard" - 61 to 120 ppm of hardness; and "soft" - less than 60 ppm of hardness. The principle method of handling hardness is to treat with lime and flocculate out the residue. (See Figure 9)

Management of Floods

Floods are excess supply situations and can be expected in various degrees of intensity periodically. The reasons for floods are natural factors of climate and precipitation which release water in greater quantities

FIGURE 9

SCHEMATIC DIAGRAM OF A WATER TREATMENT PLANT



than the streams and rivers of an area can hold. In Michigan the rivers are short and the capacity of the Great Lakes to accept the overflow is great. Even though danger of flooding is not severe, costly damage often occurs.

Many of the same types of water management techniques which improved the supply of water will also be appropriate in flood control. Watershed management tends to retain water in the upper reaches of the watershed, releasing it slowly and allowing it to infiltrate the ground water reservoirs. This helps reduce the severity of flooding. Reservoirs are also an important means of restraining flood waters; however, to be effective, they must be relatively empty so they can accept the flood water. This causes conflicts between the uses of reservoirs for water supply, recreation, hydro-power and flood control. Most reservoirs can make some contribution to flood control simply due to the fact that they depend on high water periods to replenish their supplies.

Important flood management techniques used in flood control include levees and dikes. These provide direct flood protection, but they tend to increase the flood stages. If the flood should overtop the levees or dikes the results are often considerably worse than if no protection were provided. Protection by dikes and levees is particularly important to concentrated industrial and urban areas.

Stream channel improvement such as straightening, widening or deepending are also helpful for flood conditions because they allow the water to be carried away faster. This again may cause downstream burdens.

A most important part of any flood control program is the water level monitoring system. The ability to predict flooding and to warn people in affected areas is a most important water management function.

Water management agencies have responsibility for coordinating flood control activities and disseminating information about flood danger.

Floods cause damage in a number of ways. They are a destructive erosional force causing land to be eroded away and then often causing damage by depositing the silt in unwanted places. Floods are a distinct health hazard because they disrupt sewage facilities and sewer lines and expose the populace to dangerous diseases. Floods, of course, cause death and displacement of people. They also cause economic losses by disrupting economic activities as well as through the destruction of material, equipment and buildings.

Some new flood management techniques are centered around controlling the use of flood plains. It has been difficult to keep man out of flood plains because the land is often good and water with all its attendant services is located there. One method of reducing the loss due to flooding is through the use of zoning and easements which would limit the amount and the type of activities which could occur on the flood plain. Many types of recreational and agricultural activities are somewhat compatible with flooding. At worst the loss to flooding is minimal compared to other types of developments. Parks and golf courses, for example, when developed in flood plains are damaged very little during floods and are quickly returned to use once the high water has subsided.

The cost of flood protection should be placed on those who insist on using flood plains for development. This could be done by requiring realistic flood insurance, by requiring buildings in flood plains to be water proofed, or by controlling relief grants and loans in such a way that they do not encourage the imprudent use of flood plains.

Water Resources Planning

The planning process is an important function of water resources management. In a complex and highly interrelated society, planning takes on added importance. In the past the actions of individuals, industries or governmental units had less impact upon the environment; the need for planning was almost non-existent. In our modern society continued economic and population growth depend upon planning techniques which can predict future needs and generate resources to meet these needs. Because the needs of the people have changed, the objectives of water resource management have changed and these changes should be reflected in the planning process. Present planning policies are often concerned with development in terms of economic production and to some degree neglect the non-market values. The objectives of society have increased significantly in non-market areas such as recreation and the quality of the environment. The planning process must be broadened so that it can include these objectives as a part of the decision making process.

The planning process should have the following list of recognizable objectives:

> First, the process must generate and evaluate alternatives for consideration by the people of the United States and their representatives. Second, it must report and disseminate such alternatives and evaluations for the broadest possible discussion in the political arena. Third, it must strive to assay as well as possible the values that all segments of society place upon specific uses, abuses, enjoyment, or appreciation of water resources. Fourth, the appraisal of values must include an attempt to ascertain how values develop or degenerate with the passage of time, either because action is too slow and the advantage is lost or because action is so precipitous that future opportunities are foreclosed. Fifth, the process must recognize that all

> concerned private, local, state, and national groups can and should contribute to the planning and development of water resources.[1]

Governmental administrators, legislators and citizens should all be interested in bringing about these objectives. It is to the advantage of all that adequate expression of the relative values which different groups and individuals place on given alternatives be brought out in public discussion. Citizens and interested groups should have the chance to air their views on tangible as well as the intangible benefits and the costs of given alternatives. The administrators and legislators, on the other hand, should be better prepared to act after having reviewed the public's interest.

There are two specific tasks that planning must perform to bring about realistic public discussion. It must present to the public the technically feasible alternatives which are available for meeting particular water management objectives. It must describe the costs and benefits both tangible and intangible which are associated with a given alternative. One way of handling this is through public hearings. It is inevitable, and rightly so, that the more difficult issues will find their way into the political arena.

In order for the planning process to function properly it must be cognizant of political, social, economic and physical factors in developing alternatives. The planning process should draw from the experience and the expertise of many professionals. Not only should the physical scientist

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[1] A Report of the Committee on Water, Division of Earth Sciences, National Academy of Sciences, National Research Council, Alternatives in Water Management (Washington, D. C., 1966) p. 14.

and engineer be involved, but the behavioral scientist, the political scientist and the economist as well.

The physical scientist and the engineer should provide the technological feasibility and the benefits and detrimental changes which will occur in the water system. It is their responsibility to evaluate how the problem can be solved and what types of management techniques, and on what scale they will have to be constructed and maintained.

The social and the political scientists must be able to put the scientific alternatives into perspective with the social and political realities of the situation in which they exist. They must also envision the strategy necessary for getting the ideas across to the citizens who will be involved. If citizens are going to be effectively involved they must be informed.

Economists should play a major role in the planning process. They should evaluate the costs and the benefits of various alternatives. This is a difficult but most important task. Many of the costs and benefits may go to intangibles which are very difficult for economists to evaluate. These may properly be left to the public and to their representatives, but to the greatest degree possible, economists should handle the values of the tangible benefits and costs. The costs and benefits of given alternatives may fall unequally upon given segments of the public; these must be pointed out so that they become a part of the decision making process.

The planning process should be continuous because as decisions are made and brought to reality, they affect the water system. The management of water resources must be a continuous process, and therefore, the planning

process which develops the management activities must also be a continuous process.

Because society is changing rapidly, it is difficult to predict future needs. Planning should strive to maintain a high degree of flexibility for the future. Because needs change with time and because many water management decisions are irreversible, it is advisable for planning authorities to carefully predict the consequences of a given project before construction begins. This is not a plea for maintaining the status quo, but rather, a word of caution against precipitous action which is ill conceived.

In order for the management of water to progress and meet the changes which are developing, it must maintain an adequate research capacity. Just as research is important to the control and the management of pollution, it also plays a fundamental role in the total water management picutre. Research should be maintained not only in the scientific and engineering aspect of water management but in the political, economic and educational aspects as well. These areas are often more difficult to deal with and less well known than the scientific and engineering side of the problem. The fragmentation of water management can cause the same detrimental affects on research as it does on some of the other aspects of water management by fragmenting and narrowly defining research objectives.

Water resource management has a responsibility for developing and maintaining a comprehensive education program. The education of citizens in water problems is a critical factor in their political involvement. Education should develop both the understandings necessary for dealing with problems as well as the ability to show citizens how they can be effective

in working toward solutions to the water problems. Water resource education should help the citizens understand and become involved in the decision making process, but it should also help him to understand what he as an individual should do in maintaining his own property and how he should act when he is on public property. Perhaps the greatest reduction in the freedom to use and enjoy the water resources of our nation and our state are the result of unthinking or wanton poor citizenship.

One of the obvious points which has developed throughout this discussion of water management is that in many areas new water management institutions need to be developed which can more comprehensively handle complex and persistent water problems. Water management institutions need to be developed which can internalize the cost of water supply and water quality, which can more effectively deal with the social, political and economic problems of water and which can replace the present fragmented way of dealing with water problems with a systematic comprehensive approach that can meet and solve the difficult future problems which are now developing.

PART V: WATER RESOURCES POLICY

Water resource policies are made up of the laws, directives and the decisions which are generated by legislative process, administrative authorities, the courts, the people or custom. These public policies govern the formal management of water resources. The fact that some policies are static has intensified the problems of today. Water resource policy should be dynamic so that it can meet the needs of both today and tomorrow.

Water resource policy is pluralistic, meaning that there is no single all encompassing policy. It is in reality a whole group of policies, of varying importance, some of which overlap. Public policies are political means of dealing with resources in the future. Our knowledge of present water problems is, however, limited and our knowledge of future problems is almost non-existent. These facts argue for both a flexible and a continuous decision making organization which can viably meet new evolving needs. Because of our pluralistic system of water policies, decisions can be made in increments as situations warrant change and planning and decision making should be continuous processes.

In our American society, many forces are at work trying to determine how resources, such as water, should be used. Many groups and individuals are concerned about influencing, directing or controlling water resource decisions. Many people seek power in the political decision making process for economic reasons. Many of those who seek to influence water resource decisions have been so effective that the general public has become under-

represented in the entire area. If citizens are to be heard and be effective in the decision making process, they must be willing to join with others to work to promote their interests. Public policy is the end result of political struggle. Citizens, if they are going to enter this struggle effectively, must basically understand water resources, water resource problems, the working of government, how to ask the right kinds of questions to gain information, and how to work with others to influence water resource decisions.

If we could stop the dynamic forces of government for a short time and look at water resources policy we would find a complex and conflicting network of policies which are carried out by an amazing array of management units. Some policies have remained viable through the years, while others are very new responses to current problems. The main bulk of water resource policies are laws that have been generated by some legislative body (national, state or local). Most laws either direct water management organizations to perform certain prescribed functions, or they set forth the objectives which water management is to achieve and leave the means of achieving it up to the management unit. Some laws which make up a portion of water policy are simple restrictive laws which limit what can be done to or with water and surrounding lands.

Most policies leave some of the decision making up to the management unit. Many policies have changed over time, pointing out that legislative and administrative policies do have flexibility, and they can be changed or voided if necessary. The fact remains that once policies are enacted, it is sometimes difficult to bring about change.

Not all water policies have their origin with legislative and

administrative bodies. Some are generated by custom, such as our basic water rights policies, some are decided by court action, and others are decided by a vote of the people. All these contribute to the total water policy picture, but they are minor in comparison to the amount of policy which is generated by national, state and local legislative and administrative authorities.

Water Law

There are two basic systems of water law in the United States. California, Washington and the eastern states use the common law doctrine of riparian rights. The water poor western states use the statutory doctrine of prior appropriation. These doctrines are vastly different and important, both legally and economically. Under the riparian doctrine, the owner of land along a stream, river or lake has certain rights to the use of the water by virtue of his land ownership. The prior appropriation doctrine states that the first user of the water acquires a priority right. Land ownership along a watercourse is not necessary under the prior appropriation doctrine; the right to water is obtained by taking water and applying it to a beneficial use. Water rights may be lost by not continuing the use. In times of shortage later appropriators must cease using the water entirely in order to satisfy the needs of the first appropriator.

The riparian doctrine, used in Michigan, is considerably different from the western law. Under the riparian law, the use of water in a stream is part of the ownership of the land which borders a watercourse; this right of use cannot be lost by disuse. The riparian owner may use the water only on the riparian land and may not sell it to another. Riparian owners

are also restricted by two principal allocation theories: natural flow and reasonable use. The natural flow concept, which is not widely accepted, holds that no riparian shall diminish or impair the flow of a stream to the detriment of any other riparian user. The more common theory of reasonable use allows the riparian owner to use the water in a reasonable way, taking into consideration the needs and uses of other riparian land holders. This definition has led to some difficult problems such as what is reasonable use and which will be given the advantage - established uses or new uses. These difficulties have caused water problems to increase with water use and water demand.

The federal government has dominated the public development of water resources throughout our history. From the early beginnings of improving navigation for commerce and defense, the effort and the money which the federal government has put into water development projects, has been growing. Part of the reason has been the vacuum which the state and local authorities have left in these areas. Other obvious reasons are that water management projects help to develop the nation, they are very costly and it is doubtful that state or local government would be willing to finance many of them. The federal government has, through a series of laws and appropriations, become involved in a wide range of water management activities. The major justifications for federal water policies are several basic powers granted in the Constitution: the power over commerce on navigable streams, the power to appropriate funds for the general welfare, the proprietary power over federal land, the power to make treaties with foreign nations and the war power. These basic functions have given rise to the secondary functions of protecting wildlife and fish,

development of recreation, protection of the land and pollution control.

The chronological order of federal policies dealing with water resources illustrates the developing needs of the nation. The earliest federal policies were directed toward meeting the needs of a new undeveloped country. As the land was developed and the population increased, the initial policies were refined, expanded and joined by new policies that were directed at using and developing water resources more effectively, efficiently and equitably. The demand for water has increased the need for more supplies, better supply regulation and better allocation. The current problems of water resources have fostered the development of planning organizations and pollution control legislation.

All three levels of government have had responsibilities in the area of water management. The federal government has had to rely on its Constitutional powers to develop its water policies. These powers are limited, and they have been a limiting factor on federal involvement. The federal government has been active in the defined areas by direct involvement, but it has also played a role in stimulating and developing state and local programs by providing funds. The federal government should play a role in the water management process because of its orientation, its organization and its money. It should not, however, necessarily be dominant.

The evolution of water policies in the United States was not just federal but also state and local. States have basically limited themselves to regulatory programs with research, information and coordinating functions. Local governments, municipalities, counties and special districts, have carried the secondary share of the water management burden. They have been responsible for water supply, sewage treatment, local flood control and watershed improvement.

Circumstances have changed the needs of the country. The policies of water management have evolved slowly to meet modern needs. As new techniques of physical and political water management have developed, they have been blended with older techniques to solve existing problems. Older techniques are usually altered to fit new management situations. We should look at present policies in the same light; they should be viewed as being the present way of handling the existing situation and not as the final solution to the problem. As new knowledge, techniques and needs arise, water policies must be dynamic in order to efficiently and effectively manage water.

The changing American scene has caused changes in American water policies. In the earliest times the needs of the individual and his small settlements were adequately met by nature. These early beginnings set the earliest water rights laws. As towns, villages and cities grew, more stress was placed on the communities' needs for water. Communities, because of their concentrations of population and industrial activities, need water supplies, waste disposal and flood protection for both individuals and growing industries. With industry came the need for water transport and power. Physical improvements such as reservoirs, locks, levees and hydroelectric production and regulation can be provided only by large capital outlays - the kind that are difficult for profit making corporations, state or local governments to finance. The need to develop the country was an important impetus to reclamation and multi-purpose projects. The development of water management policies called for the development of administrative agencies. The financing and management of large water projects were handled mainly by the federal government, although local interest and local projects were developing.

As the problems of water management grew, the means of meeting these problems changed. The complexity and the tangle of water management projects called for planning authorities which were concerned with water systems. River valley authorities, like the Tennessee Valley Authority (TVA), were authorized to provide planning, coordination and multiple-purpose physical water management. River valley authorities have, in general, failed to achieve a satisfactory level of state, regional and local political and financial support. Interagency river basin committees were developed as a means of involving state, regional and local authorities with federal agencies to draw up and carry out comprehensive master water management plans. They have been plagued by overtones of national orientation and by a static plan that is partly out of date when it is published. The need for coordinated planning and action exists and should command higher priorities as water problems increase.

Interstate compacts are an approach to national, state and local cooperation which are designed to realize regional water objectives. The Great Lakes Basin Compact established the Great Lakes Commission to study and to make recommendations concerning water resource problems in the Great Lakes. Other interstate compacts, such as the Interstate Commission on the Delaware River Basin, have been implemented by joint state governmental agencies which are formed by parallel legislation in the affected states. The purpose is to bring about coordinated planning, development and operation within a water basin.

Watershed improvement and pollution control are two important areas of water management which need intergovernmental cooperation. Public Law 566 directs that federal cooperation be given to state and local authorities

to develop, maintain and to operate works of improvement in small watersheds. Under this law the states or their political subdivisions are the agents for carrying out the program with federal assistance. Public Law 660, the Federal Water-Pollution Control Act, calls for grants to states or their political subdivisions to prevent pollution. Legislation of this kind has responded to the need for state, regional and local involvement in water management programs.

Michigan Water Quality Standards

The development of Michigan's Water Quality Standards is an example of interaction and collaboration between the different levels of government to solve the problems of pollution. In the Water Quality Act of 1965 the federal government required the states "to establish water-quality standards applicable to interstate waters." These standards which are approved by the federal government act as an interstate basis for pollution control. The main difference between the standards and the basic water rights laws is that once the standards are violated immediate action can be taken. Under the water rights laws proof of damage is required before action can be taken. This is difficult to obtain and time consuming to litigate.

The federal government, by virtue of its right to control interstate waters, has forced the states to take up the pollution problem while leaving the responsibility for traditional state functions with the state. The federal government also provided funds, on a matching basis, to help local authorities provide treatment facilities.

The Federal Water Quality Act of 1965 provides for states to adopt

water quality criteria after holding public hearings. The federal act calls for standards which will protect the public health or welfare. It calls for the state authorities to consider the waters' use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial and other legitimate uses. The Michigan Statutes already contained the necessary authorization for the state to proceed in carrying out the directives of the federal act. The state went farther in deciding to set standards for intrastate waters as well.

Water Quality Standards[1] are set in terms of the physical, chemical and biological conditions of water. The condition of water is then tied to a given use. The uses which are designated for water are:

A. Water Supply

1. Domestic (such as drinking, culinary and food processing)
2. Industrial (such as cooling and manufacturing process)

B. Recreation

1. Total Body Contact (such as swimming, water skiing, and skin diving)
2. Partial Body Contact (such as fishing, hunting, trapping and boating)

C. Fish, Wildlife and other Aquatic Life (such as growth and propagation)

D. Agriculture (such as livestock watering, irrigation and spraying)

E. Commercial (such as navigation, hydroelectric and steam generated electrical power)

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[1]The Water Quality Standards included here are from the Michigan Water Resources Commission as approved by the Federal Government in 1968. They have been reduced for simplicity.

The physical, chemical and biological parameters of water are then set as the Water Quality Standard for a given use.

The coliform group is most important in water supply for domestic use and in total body contact recreation. For domestic water supply the monthly average of coliform organisms in 100 ml. samples (about 1/10 of a quart) shall not exceed 5000 nor shall 20% of the samples examined exceed 5000 nor exceed 20,000 in more than 5% of the samples. For total body contact recreation, the average of any series of ten consecutive samples shall not exceed 1000 nor shall 20% of the samples exceed 5000.

Coliform organisms may gain access to water from excretion of human beings, other warm blooded animals and land runoff. Fecal coliform count provides more meaningful information regarding the presence or absence of recent fecal contamination. A limit on fecal coliform of 100 per 100 ml. is suggested.

Oxygen is described in terms of milligrams per liter (mg/l) or parts per million. The amount of dissolved oxygen is most critical to waste assimilation and fish, wildlife and other aquatic life. The dissolved oxygen present for most uses at all times shall be sufficient in quantity to prevent nuisance. This, of course, means that aerobic conditions will be maintained. The critical problem with dissolved oxygen is in maintaining fish, wildlife and other aquatic life. Low flow time is a critical period to aquatic organisms which need dissolved oxygen. The water quality standard for dissolved oxygen then must consider the low flow time as being a limiting factor. The base period for low flow is described as the average low river flow of seven-day duration expected to occur once in ten years. The dissolved oxygen level must be maintained

during this time and should be kept as high as possible during times of lesser flow. Again the use must play a role in this standard. If the water is to maintain intolerant cold water species of fish such as trout, the D.O. must not be less than 6 p.p.m. If intolerant warm water species of fish such as blue gills and largemouth bass are to be maintained, the average daily D.O. must not be less than 5 p.p.m. and no single value shall be less than 4 p.p.m. If tolerant fish warm water species are to be maintained, the average daily D.O. must not be less than 4 p.p.m. and no single value shall be less than 3 p.p.m. When the flow is greater than the seven day low flow period, it is expected that the D.O. will be higher than these levels.

The temperature requirements for the different uses vary widely. Perhaps the most sensitive requirement is for fish, wildlife and other aquatic life.

	Ambient	Allowable Increase	Maximum Limit
Intolerant Fish - Cold Water Species	32° to natural maximum	10°	70°
Intolerant Fish - Warm Water Species	32° to 35° 36° to natural maximum	15° 10°	85°
Tolerant Fish - Warm Water Species	32° to 59° 60° to natural maximum	15° 10°	87°

For domestic and industrial water supply and commercial use, the maximum water temperature shall not be increased by more than 10° F. For all types of recreation, the water temperature shall be 90° F. maximum.

The rest of the standards are basically similar for all uses. There shall be no suspended, colloidal and settleable materials which will cause objectionable unnatural turbidity, color or deposits. There shall be no unnatural floating solids, residues or film of oil or gasoline. The

concentrations of taste and odor producing substances shall not be injurious to designated uses and the dissolved solids shall not exceed a monthly average of 500 p.p.m. or 750 p.p.m. at any one time. Toxic substances for water supply must conform to U. S. Public Health Service Standards and must not be toxic for fish, wildlife and other aquatic life. Nutrient materials from any source shall be limited to prevent the stimulation of unwanted weed growths which may be injurious to a designated use. The acidity of water shall be maintained within half a unit of the natural level for domestic supplies and between 6.5 and 8.8 (acidity is measured on a scale from one to fourteen with seven being neutral) for fish and wildlife. Radioactive materials are controlled and checked by the Atomic Energy Commission. Any reasonable suspicion of radioactivity should be reported to them immediately.[1]

Michigan standards for interstate waters were submitted and approved by the federal government along with a plan for implementation of the standards. State money as well as federal money has been designated to help local areas develop treatment facilities. Local governments, in conjunction with the states, have the added responsibility of designating the specific uses for a stream or a portion thereof. The specific designated use is vitally important because the use classification will determine the standard which will be followed. Local authorities and citizens should be vitally interested in the local stream use classifications.

The idea of standards has been criticized from the point of view

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[1]Michigan Water Resources Commission, Department of Conservation Water Quality Standards for Michigan Waters Revised June, 1967 (Lansing, Michigan, 1967).

that once they are adopted, they are hard to change and tend to create vested interests. Along with the enforcement of the standards through the courts, the Water Resources Commission now issues permits for water waste disposal use; in violation cases, these permits can be withdrawn.

The concept of a standards is an interesting one. Standards could be set at a number of different levels, which is the reason they have been tied to use. The range of water quality can be thought of as a continuum between natural conditions at the one end and a completely degraded situation at the other. Without the idea of use, no point on the continuum would be better than another. If a given use is to be economically and efficiently continued, however, a given minimum water quality is necessary. Most standards, as they are now conceived, are the basic minima necessary for a given use with an arbitrary increment for safety if exceptional conditions should occur.

In implementing the water quality standards, little effort has been generated in developing regional water management organizations. Significant diseconomies may occur if local authorities must individually provide treatment facilities. The most effective method of handling water quality problems is by handling them as part of a total system.

There are some important characteristics which water management institutions should have. The decision making process should be a continuous system, rather than static. As changes occur in the physical water system or as social, political or economic changes occur in the regional area, the decision making process should be able to evaluate the impact this will have on water management. Water management institutions should have political viability and fiscal responsibility. Water management institutions should

be politically broad so that they can consider inputs from various levels of government as well as from varied geographic areas. Water management institutions must have political decision making machinery if they are to effectively manage water resources.

The changes which have occurred in water policies have pointed to the need for regional and local involvement in water management. The need for responsible individual involvement is becoming evident. Citizens should be more involved in both the planning process and the decision making process. It is up to citizens to respond to the challenge. It is a responsibility that they must accept.

Citizen Action

Citizens can be effective in dealing with water resource problems just as they can be effective in helping to solve most environmental problems. Citizens, both privately and publicly, can effectively help to solve water resource problems.

Privately, citizens can be responsible landowners. Those individuals who own property close to or adjoining water have particular responsibilities. Individually owned property close to water was probably chosen for its aesthetic quality and recreational value. Individuals can do a great deal to protect this aspect of their property. Of prime importance is keeping nutrients from the water. This means septic tanks must be properly installed, in good working order and set back as far as possible (never less than 100 feet from the water). If the landowner must use fertilizer on his property, he should use as small a quantity as possible and make applications a number of times during the year. This prevents the washing of

excess fertilizer into adjoining waters. The individual landowner should try and maintain the banks of water property in natural cover in order to prevent erosion and/or siltation. Natural cover, such as trees, provides shade for the water and helps to keep it cool. This is particularly important in streams and small rivers. The landowner should also refrain from contaminating the water with pesticides or litter. All citizens can help to protect the aesthetic quality of our natural waters by refraining from littering.

Citizens can also be effective in helping to solve water problems by being publicly active. The political struggle resolves the conflict of values which are held by various factions of society concerning water problems. The "public interest" has been neglected in the area of water resources because the public has been under-represented in the political process. Individuals and groups should be able to express their values and value conflicts should be able to confront each other in the political process. Individuals and groups must be willing and able to express their values and institutional means for expression must be available if viable "public interest" decisions are to be made. Institutional arrangements for water resource planning and decision making should be evaluated in terms of how well they provide a form for the expression of citizen values.

Citizens, if they are going to effectively participate in the political struggle, must be basically and currently informed about water, local water problems, community political organizations, and the procedural steps for solving water problems. In order to be basically informed, citizens need to have a working knowledge of water from the physical, biological and social perspective. They need to understand the problems

so they can articulate their concern and so that they can ask the right kinds of questions of the right people to gain information about specific situations. Citizens must understand that each water problem or group of problems has its own significant individual characteristics. There are so many physical and social variables that no two situations are alike. Therefore basic knowledge must be coupled to specific knowledge about a given water problem in order for the citizen to understand a specific situation.

Citizens must understand the workings of government because they are not only the avenue to action, but they are also a prime source of information. Many politicians and public servants have noted the need for citizen participation. Often politicians actively seek to find the will of the people so that they can promote the types of programs which will give them the most support. Citizen support is vitally needed in most political situations. Citizens should work from the beginning with public officials so that they can understand what has been done, what is being done and what is planned.

Citizens must be willing to enter the political process. By bringing out conflicts of water uses into the political arena, compromise and alternative solutions can be generated.

The process of citizen action is up to the individual. A single individual can be the spark and the drive that starts an entire movement. In many instances single individuals have interested entire groups in a water problem and an action program. Citizens should be willing to work with and through interested groups. Group action multiplies the support which can be generated, and it opens up other points of view. Many water

problems break quickly and organized groups with an ongoing program can be organized to anticipate developing situations.

The mass media of television, radio and newspapers can be a valuable tool through which interested citizens and groups can generate public support. Letters to the editor or direct statements and interviews are important ways of generating interest and power. Often these media are used after the fact which speaks for the importance of sensing and working on problems as they are developing - not after decisions have been made. Viewing the problem first hand by bus tours, sponsoring public meetings, or by promoting adult education programs are all ways of generating citizen concern and support.

Citizens should be willing to enter into open public discussions of water problems. Hearings in particular should be used as an open forum for discussing views. Hearings are called for the purpose of sensing the feelings of the people. If they are not attended by all interested groups, the results can be slanted in favor of those which do attend and speak.

There are numerous documented cases of citizens who have been effective in dealing with water resource problems. Citizens who have been concerned about the public good, informed about water problems, and have worked with government officials have been effective in working toward the solution to these problems. They have played important roles in solving many different types of water resource problems. They have worked in a myriad of different ways, individually or as members of groups. They have helped to raise economic and political support to bring about solutions to water problems.

With the help and determination of citizens, intergovernmental agencies like the Huron River Watershed Council have been born and have

helped to solve water resource problems on a basin wide basis. The League of Women Voters, Sportsman's Clubs, Boy Scouts, The Izaak Walton League and others have lent their group support toward finding solutions to water problems. Even local groups such as the Lions Club, Kiwanis, Jaycees and others have found water resource problems which needed their attention. It is evident that if groups like this are to function, individuals - American Citizens - must be active.

In a recent survey of Michigan communities, individuals who are active in working toward the solutions of water resource problems were identified. From all over the state, individuals were recognized for their contribution in the field of water resources. From varied walks of life and in many different ways they made contributions. Just to list a few examples --

Mr. Norman Spring of Grand Haven, Michigan, a Junior High School Counselor, was concerned about the runoff from the use of D.D.T. to spray trees for Dutch Elm disease. Working with the support of the local Rod and Gun Club, he was able to bring about a change to a less persistent insecticide - methoxychlor.

In Grayling, Michigan, Mr. Derek E. McEvers, a funeral director and Mr. Kenneth Carlisle, a canoe livery operator, are both concerned and working on the problem of municipal pollution causing eutrophication of the Au Sable River. Working through the Au Sable River Watershed Study Council and other local committees, they are trying to stimulate concern and action on this problem.

In Wyoming, Michigan a general insurance agent, Mr. Jack Magnassum worked for a number of years to help his community solve its water supply

problem. Mr. Magnassum worked for the passage of a water bond issue in April of 1963 and in July, 1966 the city of Wyoming started using water from Lake Michigan.

Mrs. William Winter, a housewife in Holland, Michigan, has worked toward total body contact recreation for Lake Macatawa. Through the organization of the Inter-Municipality Lake Macatawa Committee, conferences with officials of the Water Resource Commission, hearings and other action, she and other citizens of the area are making progress on the problem.

These are only a few of the individuals who were identified and who have been active. Space limits including more, but the idea is clear. Concerned, motivated citizens can be effective in bringing about solutions to water resource problems. The knowledge is available, the means of solving the problems are available and active individuals have <u>proved</u> it can be done. The rest is up to <u>you</u>!

GLOSSARY

Aerobic Bacteria - bacteria which need free oxygen in order to live.

Ambient - completely surrounding.

Anaerobic Bacteria - bacteria which live in the absence of free oxygen.

Aquifer - a layer of permeable sand, gravel or rock through which water can pass.

Artesian - underground water that is trapped under pressure in a permeable layer which is between impermeable rock layers. An artesian well is one which taps artesian water.

Biochemical Oxygen Demand - the oxygen required by aerobic organisms in sewage for metabolism.

B.O.D. - Biochemical Oxygen Demand.

Brackish Water - slightly salty water

Capillary Action - the force that causes water to rise in soil against gravity.

Chlorination - the adding of chlorine to water to kill pathogenic organisms.

Coliform Bacteria - any of several bacilli found in the large intestine of man and warm blooded animals which in water indicate fecal pollution.

Condensation - the transformation of water vapor to liquid water.

Cone of Depression - a conical lowering of the water table surroumding a well caused by pumping.

Consumptive Use - the use of water in such a way that evaporation occurs reducing the supply of water present.

Corollary Pollutant - a substance which is not a pollutant itself but which causes conditions in water which are considered pollution.

Density - mass per unit volume.

Desalination - the processes of removing salt from water.

D. O. - Dissolved Oxygen.

Drainage Basin - the geographical area within which all the surface water flows into a single river or stream.

Effluent - outflow such as the effluent of a sewage treatment plant.

Erosion - the wearing down of the earth's surface often by water.

Eutrophication - a condition characterized by the dense growth of plants and animals in water supported by an accumulation of nutrient materials.

Evaporation - the transformation of water into vapor.

Evapotranspiration - the process of evaporation from the earth, plants and animals by which water is returned to the atmosphere.

Flood Plain - flat land on either side of a stream or river consisting of sediment laid down by the river or stream over time.

Fluoridation - the addition of fluorides to water supplies to reduce the incidence of tooth decay.

Fresh Water - water that is low in dissolved salts.

Ground Water - all subsurface water.

Hard Water - water containing dissolved mineral salts, mainly calcium which interfere with the action of soap.

Headwater - the beginning of a stream or river.

Humidity - the amount of water vapor in the atmosphere.

Hydrologic Cycle - the process by which water circulates from the oceans to the atmosphere, to the earth and back to the oceans.

Hydrology - the study of the water found on the surface, under the surface and in the atmosphere of the earth.

Infiltration - the movement of water through the surface of the earth into the porous openings in the soil.

Irrigation - the artificial application of water to land to promote the growth of plants.

Juvenile Water - water that has been trapped for centuries deep in the earth and cannot take part in the hydrologic cycle.

Leaching - the process by which water dissolves and carries away nutrient materials in the soil.

Low Flow Augmentation - methods used to retain water in underground or surface reservoirs so that it is available during low flow periods to maintain the natural flow.

Multiple-Purpose - water projects designed to serve more than one use such as a reservoir to provide water power, irrigation and recreation.

Oligotrophic - a condition characterized by sparse plant and animal life due to low amounts of nutrient materials.

Pathogenic Organisms - disease producing organisms.

Percolation - the passing of a liquid through a porous solid material.

Permeability - the ability of a solid to permit the passage of a liquid.

Photosynthesis - the process in green plants which in the presence of sunlight converts carbon dioxide and water into food and oxygen.

Physiological - pertaining to the functions or life processes of animals or plants.

Pollutant - any substance introduced into the environment which is potentially harmful or which may make the environment less suitable for human use.

Pollution - any impairment of water quality that makes the water less suitable for a desired use.

Porosity - the relationship between the amount of material and the spaces of soil or rock.

Potable - suitable for drinking.

p.p.m. - parts per million.

Precipitation - the products of condensation of water vapor from the atmosphere.

Primary Treatment - a term used in sewage treatment which denotes the removal of solids from the sewage by settling.

Putrefaction - the decomposition of organic matter that results in obnoxious odors and materials.

Respiration - the process in animals and plants whereby oxygen and food are converted into water and carbon dioxide with a release of energy.

Runoff - water which flows from the land in rivers and streams.

Salt Water - water containing a large amount of salt.

Sea Water - salt water found in the oceans and seas of the world.

Secondary Treatment - the second step in sewage treatment often meaning biological treatment.

Sediment - minute particles of dirt and rock carried by water.

Seepage - leakage or the process of leaking away.

Septic tank - a tank used for the decompositions of organic sewage by anaerobic bacteria.

Sludge - sediment deposited during sewage treatment.

Spring - an opening in the surface of the earth through which water flows.

Soft Water - water which is relatively free of minerals which interfere with the action of soap.

Surface Tension - the force existing on the surface of liquids which results from molecular attraction.

Synergistic - work together; such as when two pollutants are mixed together they become more toxic.

Tertiary Treatment - third order sewage treatment which may take any number of different forms.

Topography - the features of the surface of an area.

Transpiration - the evaporation of water from the leaves of plants.

Turbidity - cloudiness of water caused by suspended materials.

Watershed - an area from which water drains to a single point; the area contributing flow to a given place or a given point on a stream.

Water Table - the level of saturation in the soil.

Withdrawal Use - water that is taken from surface or underground supplies, used and then returned to the surface or underground supplies although not necessarily in the same place.

Zone of Aeration - the layer above the water table where the spaces between the soil particles are not filled with water.

Zone of Saturation - the layer below the water table in which the spaces between the particles are filled with water.

ANNOTATED BIBLIOGRAPHY

This bibliography lists and describes a limited number of books which deal with varied areas of water resources. These are only a select few of the many volumes, articles and other printed materials concerning water which are available to the public. The main purpose of this bibliography is to help the reader find specific material about water resources.

General Books on Water

1. Luna B. Leopold, Kenneth S. Davis and the Editors of Life. Water. New York: Time Inc., 1966.

An excellent, easy to understand and well written book which covers many aspects of water resources. The outstanding pictures, diagrams and illustrations deal with some of the properties of water that are difficult to describe with words. This work is particularly strong in the physical, chemical and geological characteristics of water resources. It is must reading for everyone interested in water resources.

2. United States Department of Agriculture. The Yearbook of Agriculture 1955: Water. Washington D.C.: U. S. Printing Office, 1955.

An extensive collection of articles by different authors that covers a wide range of different water resource topics. Many of the articles provide practical suggestions which individuals and groups will find helpful in dealing with water resource problems.

3. John Bardach. Downstream. New York: The University Library, 1964.

Written in an excellent narrative style, this book vividly describes the panorama of life which exists in proximity to water. It is a fascinating and in-depth look at the ecology of water. Man's interference with water habitats has caused many problems which water plants and water animals must face.

4. Luna B. Leopold and Walter B. Langbein. A Primer on Water. Washington D. C.: U. S. Government Printing Office, 1960.

A short easily understood work on water resource use and water resource problems. Contains some good diagrams.

5. Lorus Johnson Milne and Margery Milne. Water and Life. New York: Atheneum, 1965.

A popularly styled book that covers many interesting aspects of the relationship between man and water. Particular areas of interest are man's physiological need for water, how man has learned to use and control water and the role water has played in the development of civilization.

Hydrology

1. Oscar E. Meinzer (Editor). Hydrology. New York: McGraw-Hill Book Company, Inc., 1942.

A basic book in hydrology written by a number of experts. The elements of hydrology are well covered in a technical and comprehensive manner.

Floods

1. William G. Hoyt and Walter B. Langbein. Floods. Princeton, New Jersey: Princeton University Press, 1955.

A very comprehensive work on floods. It is easily understood and yet contains a great deal of technical information. It deals with the technical conditions which cause floods and includes many case histories of actual floods. The political and legal aspects of floods are covered along with a most interesting part which delves into man's adaptation to floods and how this has affected his progress with the problem. This book is important reading for anyone concerned with floods.

2. Luna B. Leopold and Thomas Maddock Jr. The Flood Control Controversy. New York: The Ronald Press, 1954.

An excellent summary of the physical and hydrologic problems which cause floods. Included is a comprehensive look at the physical management of flood plains and rivers.

Pollution

1. Louis Klein. River Pollution II: Causes and Effects. London: Butterworth and Co. Limited, 1962.

One of a series of books by Dr. Klein dealing with water

pollution. River Pollution II covers all the major aspects of water pollution. The historical perspective, the legal aspects, the nature, the effects and the causes of pollution, as well as the uses of river water are all included. Three sections of the book on the chemical aspects of pollution, fish and pollution, and the biological aspects of pollution were contributed by other authors. A very good volume for those directly concerned with water pollution problems.

2. Herbert A. Swenson and H. L. Baldwin. A Primer on Water Quality. Washington D. C.: U. S. Government Printing Office, 1965.

A good basic pamphlet on water quality. It deals with the basic problems of water pollution with a number of facts about the pollution situation in the United States.

3. Jack Edward McKee and Harold W. Wolf. Water Quality Criteria. Sacramento, California: State Water Quality Control Board, 1963.

A very comprehensive work on the different types of water pollutants. It covers most of the area of pollution with some excellent background information, a description of the reaction of pollutants in water and a discussion of the social control of pollution. This work is developed for California but should not be overlooked as a useful guide to water pollution.

Sewage and Water Treatment

1. Karl Imhoff and Gordon Maskew Fair. Sewage Treatment. New York: John Wiley and Sons, Inc., 1956.

A very good basic text on all the varied aspects of sewage treatment. It is basically a technical work and does not deal with the social problems of pollution.

2. Willem Rudolfs. Principles of Sewage Treatment. Washington D.C.: National Lime Association, 1955.

A very understandable summary of the basic principles and techniques of sewage treatment and the operation of sewage treatment facilities.

3. Edward Scott Hopkins and Elwood L. Bean. Water Purification Control. Baltimore: The Williams and Wilkins Company, 1966.

A technical and comprehensive summary of the principles and techniques of water purification.

Economics

1. Jack Hirshleifer, James C. DeHaven and Jerome W. Milliman. Water Supply. Chicago: The University of Chicago Press, 1960.

A controversial approach to the problems of water supply. It deals with many of the important economic issues which result from the increasing demand and use of water resources. The book is somewhat technical in many aspects but still is most complete. It deals with many of the social conditions which cause water problems and puts these in perspective through a number of case histories.

2. Allen V. Kneese. The Economics of Regional Water Quality Management. Baltimore: The Johns Hopkins Press, 1964.

This book contributes significantly to the development of a clear understanding of water quality management. It is directed at illustrating how rational decisions about water use and reuse can be made. Dr. Kneese brings together the economic, physical and hydrologic circumstances that exist in a watershed and shows how they affect water quality. He then develops a systematic approach to the management of a river so that the greatest overall net benefits will be realized. This book is an excellent summary of the application of some of the principles of economics to the problems of water resources.

Political

1. Jim Wright. The Coming Water Famine. New York: Coward-McCann, Inc., 1966.

Written by a congressman and a member of the House Public Works Committee. This book delves into the political problems which surround water resources. It discusses many areas of the country making the point that prime natural waters are fast disappearing and that the problem of water shortage is compounded by pollution. A good book from which to gain some perspective on the political problems of water resources.

2. Donald E. Carr. Death of the Sweet Waters. New York: W. W. Norton and Company, Inc., 1966.

Written in popular way, this book is intended to disturb complacency. The author probes at our ineptitude in dealing with water problems.

3. Frank Graham Jr. Disaster by Default. New York: M. Evans and Company, Inc., 1966.

A political look at the need for citizens to encourage public officials to challenge the problems of pollution. This book emphasizes how public apathy on the individual level reduces public action. It also summarizes the scope of federal and state law which exists for combating pollution and it presents some of the flagrant water pollution problems which have occurred in the United States.

Water Management

1. The Committee on Water, Division of Earth Sciences, National Academy of Sciences, National Research Council. Alternatives in Water Management. Washington D.C.: National Academy of Sciences - National Research Council, 1966.

This pamphlet examines some of the interactions between the knowledge concerning water resources and water use and the public policy concerned with water resource management. It looks at the economic, political, hydrologic, engineering, and planning inputs to public decision making in the area of water resources. It also makes some important points about how water management institutions can be more effective.

2. Allen V. Kneese. Approaches to Regional Water Quality Management. Washington D.C.: Resources for the Future, Inc., June, 1965.

This work is based on case histories of four different ways which have developed for managing river systems. The four systems mentioned are the Ruhr River of Germany, the English River Authorities, the French Basin Agencies and the Delaware River in America. The different management systems are compared as to their similarities and their differences.

Citizen Action

1. The League of Women Voters Education Fund. The Big Water Fight. Brattleboro, Vermont: The Stephen Green Press, 1966.

This book is dedicated to the problems and the methods of effective citizen action. Through the use of case histories it illuminates the trials and triumphs of citizen action on a variety of water problems such as water supply, water pollution and water

planning. It also has a section on how government works, and how citizens can be effective. It also contains addresses and organizational charts of governmental agencies.

2. Izaak Walton League of America. Clean Water: It's Up to You. Glenview, Illinois: Izaak Walton League of America, 1968.

This little pamphlet is full of information on how citizens can and should actively deal with water problems. It gives some background on pollution laws and how these can be enforced. It shows how citizens can relate to water problems. It discusses water standards and shows how citizens can be effective. Contains a number of citizen action check lists to help citizens be effective.

APPENDIX C

ACTIVITIES

THE UNIVERSITY OF MICHIGAN · SCHOOL OF NATURAL RESOURCES · ANN ARBOR, MICHIGAN

October 28, 1968

Dear Participant:

Enclosed are the activity and text materials for the short course on water resources. These basic materials are designed to inform you about water resources and to involve you in the water resource problems of your community.

You are asked to read the activity materials first. The reason for this is that you will need to understand what will be expected of you before you read the text. The text material is designed to give you a basic understanding of water resources. It contains a glossary of terms and an annotated bibliography. We hope that you will find all of the materials helpful. You will have three activities and an opinion questionnaire as part of the short course.

The suggested list of procedure is as follows. You may go at your own rate, but we strongly suggest you follow this order.

1. Read the activities
2. Read the text
3. Do Activity A
4. Mail Activity A to the University in the envelope provided
5. Do Activities B and C and send them to the University in the envelope provided.

You will receive your activities back just as quickly as we can process them. We will react to your activities and comment upon them.

We are looking forward to reading your first activity write-up. We wish you every success in this undertaking.

Sincerely,

William B. Stapp
Project Director

ACTIVITY A

FOR

THE UNIVERSITY OF MICHIGAN

SHORT COURSE IN WATER RESOURCES

FOR MICHIGAN RESIDENTS

ACTIVITY A: SELF GUIDED FIELD EXPERIENCE

STATEMENT: Activity A is designed to help you evaluate the water resources and the water resource problems of your community.

DIRECTIONS:

The following items are designed to direct your attention to water resources and water resource problems in your community. We suggest that you proceed through the following items in the order in which they are presented and check each one off as you finish it.

1) Read the check list carefully.

2) Plan your trip before you leave. Using a map of your community and your general knowledge of the area, plan your trip so that you have a good chance of viewing as many of the items listed as possible. Try to visit the major natural water area in your community, stopping at different places to view the situation. Try also to visit other rivers, streams or lakes in your community. Feel free to take others along when you go on your trip. The experience will be worthwhile for all.

3) Some of the questions on the list cannot be answered by the field trip experience. You are expected to phone your water treatment plant, sewage treatment plant, or other governmental officials to gain the needed information. This can most likely be carried out by two telephone calls.

4) Some questions on the check list may not pertain to your community - please leave these blank.

5) When you are finished with Activity A, please send it in the envelope provided to:

Dr. William B. Stapp
Correspondence Study Group
School of Natural Resources
University of Michigan
Ann Arbor, Michigan 48104

6) Go on to Activity B.

ACTIVITY A: CHECK LIST

1. Was there evidence of:

	Great Evidence	Some Evidence	Little Evidence	No Evidence
(a) Large man-made objects in the water or on the banks? (such as old tires, etc.)	___	___	___	___
(b) Small man-made objects in the water or on the banks? (such as bottles, cans, papers, etc.)	___	___	___	___
(c) Oil on the water?	___	___	___	___
(d) Silt in the water?	___	___	___	___
(e) Excessive plant growth?	___	___	___	___
(f) Slime on rocks or sticks in the water?	___	___	___	___
(g) Unnatural color to the water?	___	___	___	___
(h) Dead fish in the water?	___	___	___	___
(i) Noticeable odor?	___	___	___	___
(j) Erosion on the banks?	___	___	___	___
(k) Paths of compacted soil along the banks?	___	___	___	___
(l) Trash being dumped on the banks?	___	___	___	___

2. Make a general statement about the industrial development along the water in your community?

3. In your opinion were the industrial firms affecting the quality of the water in your community? Please explain briefly.

4. Make a general statement about the quality of private ownership of homes, cottages, docks and other shore developments along the water in your community.

5. Is access to the water difficult in your community? Explain briefly.

_____

_____

_____

_____

_____

6. Are there public recreation areas along the water in your community?

_____

_____

_____

_____

_____

7. Please check the following types of recreation which are possible in your community.

Fishing _____
Canoeing _____
Swimming _____
Water Skiing _____
Sightseeing _____
Hunting _____
Motor Boating _____
Sailing _____

8. Do you think more recreational areas adjacent to water are necessary in your community? Make a brief statement.

_____

_____

_____

_____

_____

9. Does your community have:

Combined storm and sanitary sewers?	Yes _____	No _____
Separate storm and sanitary sewers?	Yes _____	No _____
Sewers?	Yes _____	No _____
A Sewage Treatment Plant?	Yes _____	No _____
Septic tanks?	Yes _____	No _____

10. Is the sewage from your community treated in the following ways:

By a sewage treatment plant in another community?	Yes _____	No _____
Chlorinated?	Yes _____	No _____
Given Primary Treatment?	Yes _____	No _____
Given Secondary Treatment?	Yes _____	No _____
Given Tertiary Treatment?	Yes _____	No _____

11. Is there any noticeable difference between the water quality above and below your sewage treatment plant? Explain briefly.

_____

_____

_____

_____

_____

12. Where does your community obtain its drinking water?

_____

_____

_____

_____

_____

13. Does your community have a water supply treatment plant?

Yes _____ No _____

14. Is your community's water supply:

	Yes	No
Chlorinated	___	___
Softened	___	___
Fluoridated	___	___
Filtered	___	___
Aerated	___	___
Settled	___	___

15. How do you pay for sewage treatment in your community?

_____

_____

_____

_____

_____

16. How do you pay for water supply treatment in your community?

_____

_____

_____

_____

_____

17. List the names of some citizens' groups in your community which are concerned with water problems.

(a) _____

(b) _____

(c) _____

(d) _____

(e) _____

18. List governmental organizations concerned with water problems in your community.

(a) _____

(b) _____

(c) _____

(d) _____

(e) _____

19. Was there some condition regarding the river which particularly surprised you?

_____

_____

_____

_____

_____

20. Was the overall condition of the river water what you expected?

_____

_____

_____

_____

_____

21. Make a general statement of how well the lands adjacent to natural waters of your community are cared for.

_____

_____

_____

_____

_____

22. Make a brief general statement about water quality in your community.

ACTIVITIES B AND C

FOR

THE UNIVERSITY OF MICHIGAN

SHORT COURSE IN WATER RESOURCES

FOR MICHIGAN RESIDENTS

ACTIVITY B: INTERVIEW

DIRECTIONS:

1) You should select some problem area in the field of water resources which has local significance.

2) You should then interview one or more people who are in some way connected with this problem area.

3) You may conduct the interview in person or by phone. The interview should be structured in advance (knowledgeable questions should be prepared in advance) so that the interview will be directed toward the desired problem area. A part of the interview should be unstructured so that information which was not expected can be obtained.

   The types of people who might be interviewed would be:

   Government Officials
   Persons from the information media
   Private citizens with particular expertise or interest
   Members of an interest group
   Industry representatives

4) Write a short conclusion, with specific comments where appropriate, after the interview. The purpose of this short write-up is to draw out the major ideas gained from the interview and to act as a summary of the experience.

5) Go on to Activity C.

ACTIVITY C: PAPER

DIRECTIONS:

1) Write a 1250 to 1500 word paper about the local community water problem which you selected in Activity B.

2) Give special attention to the local aspects of the situation.

3) Please make use of the information in the text material, the information gained during the field experience and the information from the interview when you write your paper. Other sources of information may also be used.

4) The major purpose of this short paper is to draw your experiences and your thinking about some local water resource problem together.

5) As a part of your conclusion of this paper, please point out the role citizens should play in solving the specific water problem which you selected.

APPENDIX D

PRELIMINARY AND FINAL QUESTIONNAIRES

FIRST QUESTIONNAIRE FOR PARTICIPANTS

IN THE

UNIVERSITY OF MICHIGAN

SHORT COURSE

IN

WATER RESOURCES

For Michigan Residents

DIRECTIONS

PLEASE ANSWER ALL OF THE QUESTIONS TO THE BEST OF YOUR ABILITY. IF YOU DON'T KNOW THE ANSWER PLEASE MARK THE SPACE FOR DON'T KNOW OR LEAVE THE QUESTION BLANK.

PART A: PERSONAL INFORMATION

A-1 Name _____

A-2 Address _____

_____
zip code

A-3 Telephone Number _____

A-4 Age _____

A-5 Sex: Male _____ Female _____

A-6 Highest Level Obtained in School:

Grade School _____

High School _____

1-2 Years College _____

3-4 Years College _____

Graduated from College _____ Name of Degree _____

Attained Master's Degree _____ Name of Degree _____

Attained Doctor's Degree _____ Name of Degree _____

A-7 Type of business you are employed in (if any) (education, automobile):

_____

A-8 Your present job title (teacher, foreman):

_____

A-9 Type of business of your spouse (if any):

_____

A-10 Your spouse's present job title:

_____

A-11 Your average family income:

$	0 -	$ 5,000.00	_____
$ 5,001.00	-	$ 7,500.00	_____
$ 7,501.00	-	$10,000.00	_____
$10,001.00	-	$12,500.00	_____
$12,501.00	-	$15,000.00	_____
$15,001.00	-	$17,500.00	_____
$17,501.00	-	$20,000.00	_____
$20,001.00	-	up	_____

A-12 Number of hours you are employed per week:

30 or more _____
20 - 29 _____
10 - 19 _____
9 or less _____
None _____

A-13 Marital Status:

Single _____
Married _____
Widowed _____
Separated _____
Divorced _____

A-14 Number of children living at home and their ages:

_____

_____

_____

A-15 Which of the following best describes the type of area in which you live:

Inner City _____
Urban Residential _____
Suburban _____
Rural _____
Other (please describe) _____

A-16 Describe briefly why you are interested in conservation problems:

_____

_____

_____

_____

A-17 How did you hear about the short course?

____ Club bulletin or newsletter
____ Newspaper
____ Radio
____ Other - Please Note _____

A-18 Please list the citizen groups and the public service groups you are active in which are concerned with conservation problems:

_____

_____

_____

_____

_____

PART B: GENERAL KNOWLEDGE ABOUT WATER RESOURCES AND WATER RESOURCE PROBLEMS

DIRECTIONS: Check the answer which <u>best</u> completes the statement.

B-1 Leaching is the process by which water dissolves and carries away _____.

_____ A. pesticides
_____ B. iron
_____ C. calcium
_____ D. nutrient materials
_____ E. none of the above
_____ F. don't know

B-2 Ice is _____ liquid water.

_____ A. more dense than
_____ B. less dense than
_____ C. as dense as
_____ D. double the density of
_____ E. none of the above
_____ F. don't know

B-3 Water is chemically _____.

_____ A. not very stable
_____ B. stable
_____ C. very stable
_____ D. volatile
_____ E. none of the above
_____ F. don't know

B-4 In lakes, streams and rivers _____ can cause excessive plant growth.

_____ A. fish
_____ B. anaerobic bacteria
_____ C. nutrient materials
_____ D. calcium
_____ E. all of the above
_____ F. don't know

B-5 Water is an excellent _____.

_____ A. oxidizer
_____ B. solvent
_____ C. catalyst
_____ D. precipitate
_____ E. all of the above
_____ F. don't know

B-6 Water evaporates fastest in _____ climates.

_____ A. cold
_____ B. temperate
_____ C. warm
_____ D. cool
_____ E. none of the above
_____ F. don't know

B-7 Aquifers are underground _____.

_____ A. pipes
_____ B. water bearing strata
_____ C. sewers
_____ D. rivers
_____ E. none of the above
_____ F. don't know

B-8 Adequate ground cover over entire drainage areas can reduce _____.

_____ A. precipitation
_____ B. evaporation
_____ C. flood control
_____ D. flood intensity
_____ E. all of the above
_____ F. don't know

B-9 _____ can travel with underground water.

_____ A. Trash
_____ B. Fish
_____ C. Silt
_____ D. Green plants
_____ E. none of the above
_____ F. don't know

B-10 Water moves on the surface of the earth due to _____.

_____ A. the physical shape of the earth
_____ B. viscosity
_____ C. temperature
_____ D. gravity
_____ E. all of the above
_____ F. don't know

B-11 The earth's major source of evaporated water is _____.

_____ A. lakes and rivers
_____ B. plants and animals
_____ C. rain and snow
_____ D. oceans
_____ E. none of the above
_____ F. don't know

B-12 Fresh water normally contains _____.

_____ A. salt
_____ B. minerals
_____ C. oxygen
_____ D. carbon dioxide
_____ E. all of the above
_____ F. don't know

B-13 Water which has a large amount of dissolved calcium is referred to as _____.

_____ A. fresh water
_____ B. salt water
_____ C. hard water
_____ D. soft water
_____ E. none of the above
_____ F. don't know

B-14 Water holds heat _____.

_____ A. very well
_____ B. very little
_____ C. not at all
_____ D. well
_____ E. none of the above
_____ F. don't know

B-15 Man's development of the land affects _____ of water.

_____ A. surface runoff
_____ B. percolation
_____ C. evapotranspiration
_____ D. infiltration
_____ E. all of the above
_____ F. don't know

B-16 Industry can help reduce its need for water by _____.

_____ A. rationing
_____ B. pollution
_____ C. purification
_____ D. reuse
_____ E. all of the above
_____ F. don't know

B-17 The increasing standard of living _____ the demand for water.

_____ A. increases
_____ B. decreases
_____ C. does not affect
_____ D. greatly decreases
_____ E. none of the above
_____ F. don't know

B-18 The growth of urban centers has created difficult _____ water supply problems.

_____ A. international
_____ B. regional
_____ C. state
_____ D. national
_____ E. none of the above
_____ F. don't know

B-19 Watershed management techniques can be used to _____.

_____ A. control water flow
_____ B. increase water supplies
_____ C. prevent pollution
_____ D. prevent silting
_____ E. all of the above
_____ F. don't know

B-20 Water quality is _____ by use of water for cooling.

_____ A. not affected
_____ B. degraded
_____ C. increased
_____ D. greatly increased
_____ E. none of the above
_____ F. don't know

B-21 Irrigation _____ water supplies.

_____ A. reduces
_____ B. increases
_____ C. does not affect
_____ D. purifies
_____ E. none of the above
_____ F. don't know

B-22 Hydroelectric power generation _____ water quality.

_____ A. does not affect
_____ B. reduces
_____ C. increases
_____ D. greatly reduces
_____ E. none of the above
_____ F. don't know

B-23 Reservoirs can be used to _____.

_____ A. decrease siltation
_____ B. decrease pollution
_____ C. increase water supply
_____ D. prevent floods
_____ E. all of the above
_____ F. don't know

B-24 Maintenance of stream flow is most important for natural waste assimilation _____.

_____ A. during low flow periods
_____ B. at all times
_____ C. during the winter
_____ D. during the spring
_____ E. none of the above
_____ F. don't know

B-25 Assimilation of sewage in natural waters is caused by _____.

_____ A. oxygen
_____ B. carbon dioxide
_____ C. oxygen and carbon dioxide together
_____ D. living organisms
_____ E. none of the above
_____ F. don't know

B-26 Primary sewage treatment is a _____ process.

_____ A. bacterial
_____ B. chemical
_____ C. mechanical
_____ D. oxygen
_____ E. all of the above
_____ F. don't know

B-27 Water management has a responsibility for promoting _____.

_____ A. research
_____ B. planning
_____ C. education
_____ D. coordination
_____ E. all of the above
_____ F. don't know

B-28 The _____ doctrine is the basic water rights law of Michigan.

_____ A. prior appropriation
_____ B. common law
_____ C. statute doctrine
_____ D. riparian
_____ E. none of the above
_____ F. don't know

B-29 Anaerobic bacteria live where there is no free _____.

_____ A. carbon dioxide
_____ B. carbon
_____ C. oxygen
_____ D. calcium
_____ E. none of the above
_____ F. don't know

B-30 Water quality standards are concerned with _____.

_____ A. oxygen
_____ B. temperature
_____ C. pH (acidity)
_____ D. BOD (biochemical oxygen demand)
_____ E. all of the above
_____ F. don't know

B-31 Water quality standards are developed in terms of a given _____.

_____ A. level of quality
_____ B. average water flow
_____ C. low flow period
_____ D. use
_____ E. all of the above
_____ F. don't know

B-32 Most of the earth's fresh water supply is in the _____.

_____ A. ground
_____ B. polar icecaps
_____ C. ocean
_____ D. rivers, streams and lakes
_____ E. none of the above
_____ F. don't know

B-33 Water can be polluted by _____.

_____ A. organic materials
_____ B. pesticides
_____ C. pathogenic bacteria
_____ D. temperature
_____ E. all of the above
_____ F. don't know

B-34 Waste materials can be degraded by _____.

_____ A. chlorination
_____ B. transportation of wastes
_____ C. natural stream assimilation
_____ D. primary sewage treatment
_____ E. all of the above
_____ F. don't know

B-35 Aerobic assimilation of wastes takes place in the presence of _____.

_____ A. pathogenic bacteria
_____ B. coli organisms
_____ C. oxygen
_____ D. carbon dioxide
_____ E. all of the above
_____ F. don't know

B-36 Most of the water used by industry is used for _____.

_____ A. processing
_____ B. human consumption
_____ C. waste assimilation
_____ D. manufacturing
_____ E. none of the above
_____ F. don't know

B-37 _____ is the most consumptive use of water.

_____ A. Industry
_____ B. Electric power generation
_____ C. Urban water supply
_____ D. Irrigation
_____ E. none of the above
_____ F. don't know

B-38 Water demand can be politically controlled by _____.

_____ A. the riparian doctrine of water rights
_____ B. legislative action
_____ C. zoning
_____ D. easements
_____ E. all of the above
_____ F. don't know

B-39 The most economical means of providing additional water supply is _____.

_____ A. utilization of polar ice
_____ B. desalinization of sea water
_____ C. desalinization of brackish water
_____ D. storage of surface waters
_____ E. none of the above
_____ F. don't know

B-40 Water for low flow augmentation can be provided by _____.

_____ A. sewage treatment
_____ B. rationing
_____ C. watershed management
_____ D. natural assimilation
_____ E. all of the above
_____ F. don't know

B-41 Throughout the history of America the _____ dominated the development of water resources.

_____ A. states have
_____ B. urban areas have
_____ C. private interests have
_____ D. federal government has
_____ E. none of the above
_____ F. don't know

B-42 _____ can be compatible uses for water.

_____ A. hydroelectric water storage and flood control
_____ B. natural sewage assimilation and navigation
_____ C. fishing and water skiing
_____ D. agricultural irrigation and domestic water supply
_____ E. all of the above
_____ F. don't know

B-43 _____ have a responsibility for preventing erosion.

_____ A. Citizens
_____ B. Farmers
_____ C. Land developers
_____ D. Road construction companies
_____ E. all of the above
_____ F. don't know

PART C: KNOWLEDGE REGARDING COMMUNITY WATER RESOURCES AND COMMUNITY WATER PROBLEMS

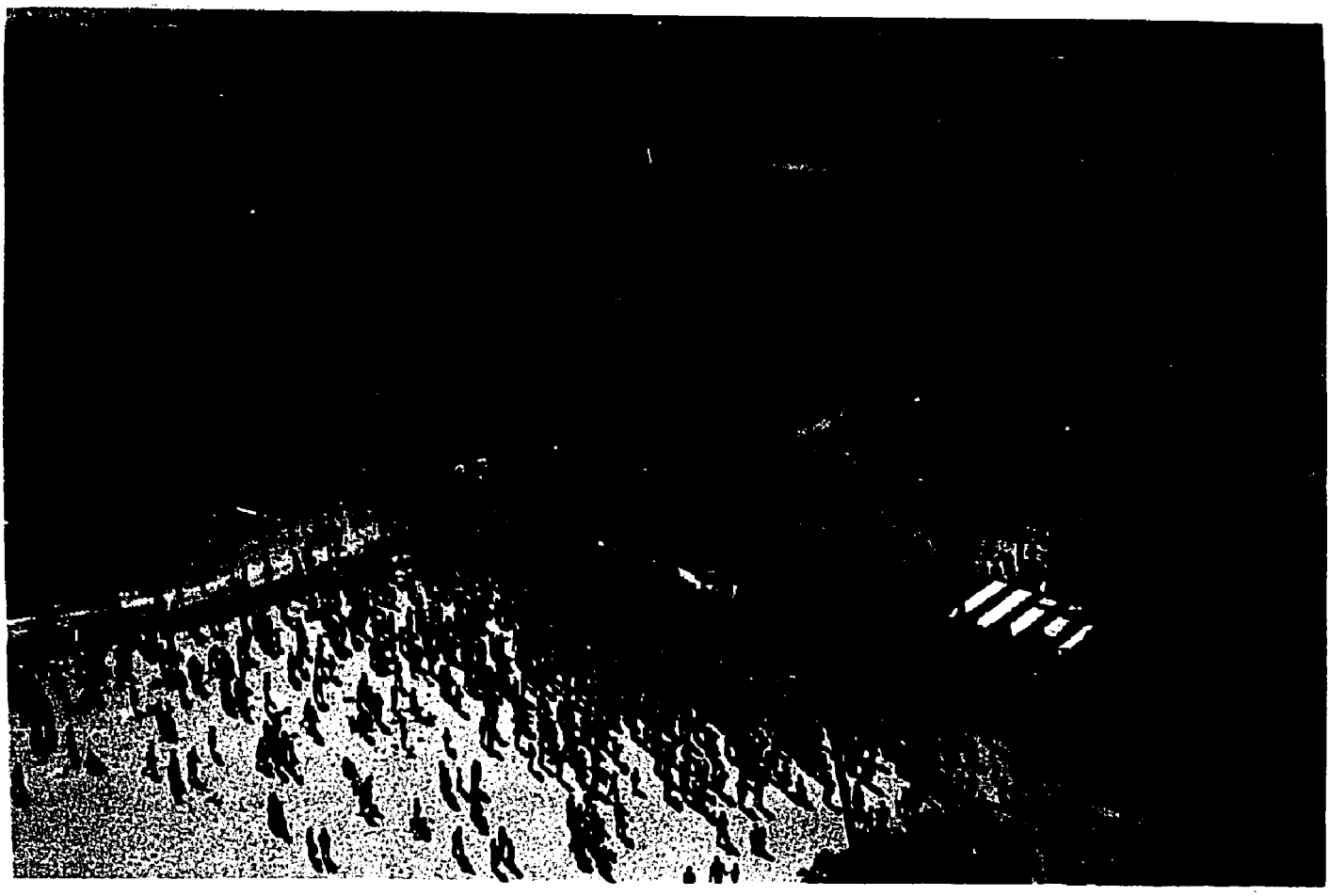
DIRECTIONS: Answer each question by placing a check mark in the appropriate column. If you do not know the answer, please mark the column titled "don't know."

		Yes	No	Don't Know
C-1	Part of your city's water supply comes from the Great Lakes.	___	___	___
C-2	Part of your city's water supply comes from the river in your community.	___	___	___
C-3	Part of your city's water supply comes from wells.	___	___	___
C-4	Your city buys some of its water from a neighboring community.	___	___	___
C-5	Your city has a water treatment plant.	___	___	___
C-6	Your city's water supply is chlorinated.	___	___	___
C-7	Your city's water supply is filtered.	___	___	___
C-8	Your city's water supply is fluoridated.	___	___	___
C-9	Part of the cost of your city's water supply is paid through some means other than the water bill such as a special bond issue or through the property tax.	___	___	___
C-10	Communities on your river upstream from your city put their sewage effluent in the river.	___	___	___
C-11	Agriculture upstream from your city contributes very few pollutants to your river.	___	___	___
C-12	Industrial pollution added to your river upstream from your city increases the cost of water supply treatment in your city.	___	___	___
C-13	Your city has combined storm and sanitary sewers.	___	___	___
C-14	Your city sends its sewage to another community for treatment.	___	___	___

		Yes	No	Don't Know
C-15	Your city has its own sewage treatment plant.	___	___	___
C-16	Your city's sewage is released directly into your local river.	___	___	___
C-17	Your city's sewage is chlorinated before it is released to the river.	___	___	___
C-18	Your city's sewage is given secondary treatment before it is released to the river.	___	___	___
C-19	Your city's sewage is given primary treatment before it is released to the river.	___	___	___
C-20	Your city's sewage is given tertiary treatment before it is released to the river.	___	___	___
C-21	Part of the cost of the treatment of your city's sewage is paid for through some means other than the water bill such as a special bond issue or through the property tax.	___	___	___
C-22	Public access to your local river for recreation is available within the city limits.	___	___	___
C-23	Floating oil is very evident on the surface of the river within the city limits.	___	___	___
C-24	The water of the river is usually very discolored within the city limits.	___	___	___
C-25	Public recreation land is available along the river within the city limits.	___	___	___
C-26	The river is unsuitable for canoes within the city limits.	___	___	___
C-27	The river within the city limits is used for commercial transportation.	___	___	___
C-28	The river is used for industrial cooling upstream from your city.	___	___	___
C-29	The river is used for industrial cooling within the city limits.	___	___	___

		Yes	No	Don't Know
C-30	Your local river is used for the production of hydroelectric power within the city limits.	___	___	___
C-31	Floods are a problem on the river within the city limits.	___	___	___
C-32	Your city government belongs to a River Watershed Council.	___	___	___
C-33	Your city government has one or more administrative departments concerned directly with water resources.	___	___	___
C-34	The city's public schools have a conservation education program which provides education experiences concerning local water resources.	___	___	___
C-35	The Health Department does not permit swimming in the river within the city limits.	___	___	___
C-36	The river within the city limits is suitable for trout.	___	___	___
C-37	The river within the city limits is suitable for bass and pike.	___	___	___
C-38	The river within the city limits is suitable for carp and bullheads.	___	___	___
C-39	Reservoirs play a role in maintaining the flow of the river within the city limits.	___	___	___
C-40	Waterfowl can nest along the banks of the river within the city limits.	___	___	___
C-41	The natural ability of the waters of the river to assimilate wastes is economically important to the citizens of the city.	___	___	___
C-42	Land developers are legally controlled from causing erosion that affects the quality of the river within the city limits.	___	___	___
C-43	Citizens are legally controlled from littering water areas within the city limits of your city.	___	___	___

PART D: AWARENESS AND CONCERN ABOUT WATER RESOURCES AND WATER RESOURCE PROBLEMS



D-1 List three aspects of this water resource picture which you consider good:

a. _____

_____

b. _____

_____

c. _____

_____

D-2 List three important water resource problems shown in this picture:

a. _____

_____

b. _____

_____

c. _____

_____

D-3 Which of the three problems listed in D-2 is the most important?

a. _____ b. _____ c. _____

D-4 How concerned would you be about the problem checked in D-3 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-5 Which of the three problems listed in D-2 is of second importance?

a. _____ b. _____ c. _____

D-6 How concerned would you be about the problem checked in D-5 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-7 Which of the problems listed in D-2 is of third importance?

a. _____ b. _____ C. _____

D-8 How concerned would you be about the problem checked in D-7 if this scene were in your community?

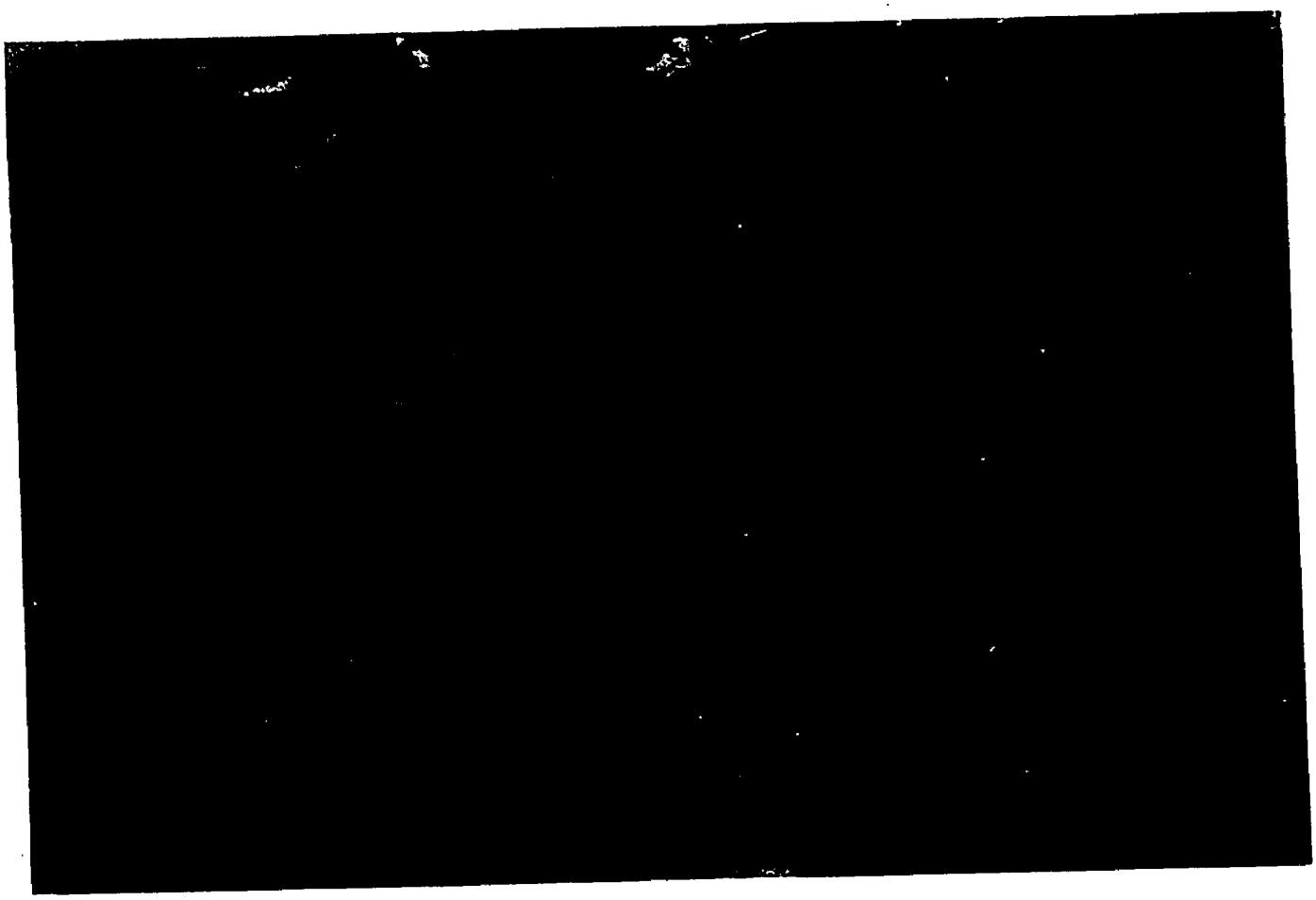
_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned



D-9 List three aspects of this water resource picture which you consider good:

a. _____

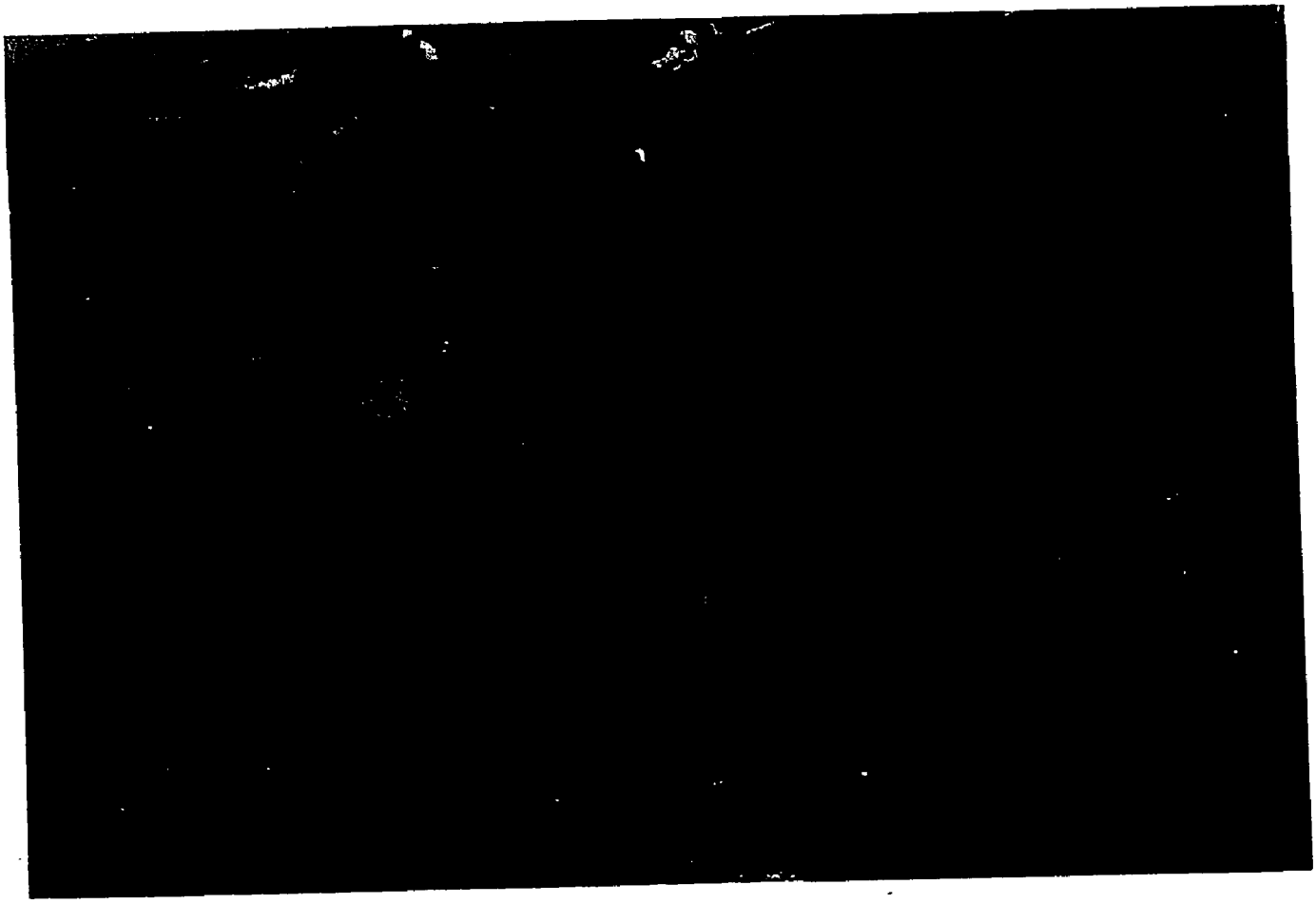
_____

b. _____

_____

c. _____

_____



D-9 List three aspects of this water resource picture which you consider good:

a. _____

_____

b. _____

_____

c. _____

_____

D-10 List three important water resource problems shown in this picture:

a. _____

_____

b. _____

_____

c. _____

_____

D-11 Which of the three problems listed in D-10 is the most important?

a. _____ b. _____ c. _____

D-12 How concerned would you be about the problem checked in D-11 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-13 Which of the three problems listed in D-10 is of second importance?

a. _____ b. _____ c. _____

D-14 How concerned would you be about the problem checked in D-13 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-15 Which of the problems listed in D-10 is of third importance?

a. _____ b. _____ c. _____

D-16 How concerned would you be about the problem checked in D-15 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned



D-17 List three aspects of this water resource picture which you consider good:

a. _____

_____

b. _____

_____

c. _____

_____

D-18 List three important water resource problems shown in this picture:

a. _____

_____

b. _____

_____

c. _____

_____

D-19 Which of the three problems listed in D-18 is the most important?

a. _____ b. _____ c. _____

D-20 How concerned would you be about the problem checked in D-19 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-21 Which of the three problems listed in D-18 is of second importance?

a. _____ b. _____ c. _____

D-22 How concerned would you be about the problem checked in D-21 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-23 Which of the problems listed in D-18 is of third importance?

a. _____ b. _____ c. _____

D-24 How concerned would you be about the problem checked in D-23 if this scene were in your community?

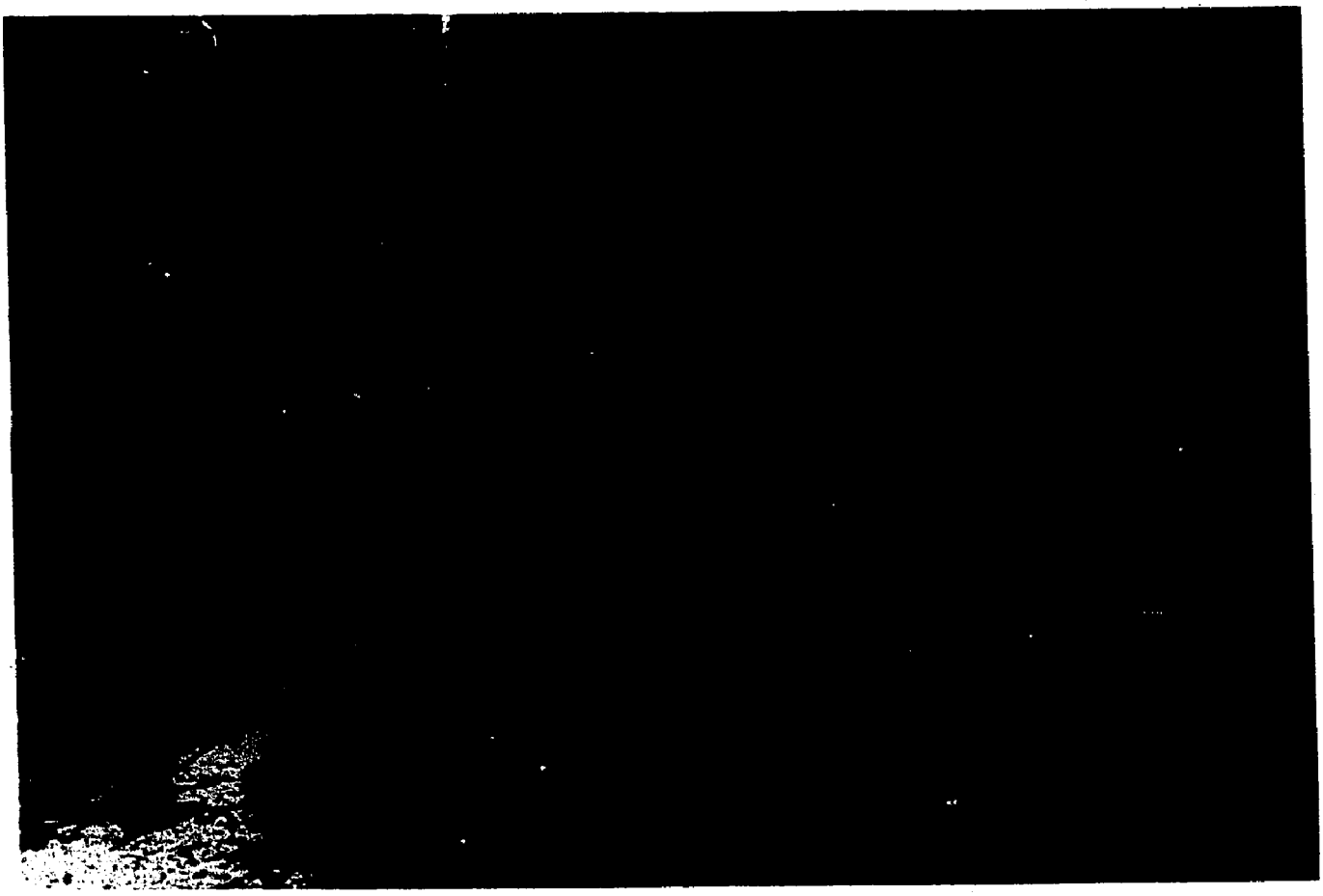
_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned



D-25 List three aspects of this water resource picture which you consider good:

a. _____

_____

b. _____

_____

c. _____

_____

D-26 List three important water resource problems shown in this picture:

a. _____

_____

b. _____

_____

c. _____

_____

D-27 Which of the three problems listed in D-26 is the most important?

a. _____ b. _____ c. _____

D-28 How concerned would you be about the problem checked in D-27 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-29 Which of the three problems listed in D-26 is of second importance?

a. _____ b. _____ c. _____

D-30 How concerned would you be about the problem checked in D-29 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

D-31 Which of the problems listed in D-26 is of third importance?

a. _____ b. _____ c. _____

D-32 How concerned would you be about the problem checked in D-31 if this scene were in your community?

_____ extremely concerned

_____ very concerned

_____ concerned

_____ slightly concerned

_____ not concerned

PART E: COLLECTION OF INFORMATION

E-1 How would you obtain information about water resources and water resource problems in your community?

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

E-2 List the public organizations you know of in your community which are involved in water resources and water resource problems.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

E-3 List the private organizations you know of in your community which are involved in water resources and water resource problems.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

SECOND QUESTIONNAIRE FOR PARTICIPANTS

IN THE

UNIVERSITY OF MICHIGAN

SHORT COURSE

IN

WATER RESOURCES

FOR

MICHIGAN RESIDENTS

PART A: PERSONAL INFORMATION

A-1 Name_____

A-2 Address_____

_____

APPENDIX E

OPINION QUESTIONNAIRE

THE UNIVERSITY OF MICHIGAN · SCHOOL OF NATURAL RESOURCES · ANN ARBOR, MICHIGAN

October 27, 1968

Dear Participant:

This opinion questionnaire is a vital part of the evaluation of the short course on water resources. The information from this questionnaire will play an important part in determining how University Conservation Correspondence courses will be developed. Please fill it out and return it as soon as possible in the envelope provided.

I would like to take this opportunity to thank you for your cooperation in this experimental project. I hope you have profited from your effort in this new type of educational experience.

Sincerely,

William B. Stapp
Project Director

Name _____

OPINION QUESTIONNAIRE

1. Approximately how many hours did you spend reading the text?

_____ Hours

2. How difficult do you consider the text?

_____ very difficult
_____ difficult
_____ about right
_____ easy
_____ very easy

3. Do you consider the text

_____ too long
_____ long
_____ about right
_____ short
_____ too short

4. Please make a brief statement about the completeness of the text.

_____

_____

_____

5. Please make a brief statement about the style of the text.

_____

_____

_____

6. Please make a brief statement about the interest level of the text.

_____

_____

_____

7. Please make any other comments you may consider important about the text.

_____

_____

_____

8. How did you like the activities which accompanied the unit?

_____

_____

_____

_____

_____

_____

9. Approximately how long did it take you to complete Activity A (the field experience)?

_____ Hours

10. Briefly describe how interesting you found Activity A.

_____

_____

_____

11. How difficult was Activity A?

_____ much too difficult
_____ too difficult
_____ about right
_____ too easy
_____ much too easy

12. Do you feel that Activity A was worthwhile?

_____ yes _____ no

13. Approximately how long did it take you to complete Activity B (the interview)?

_____ Hours

14. Briefly describe how interesting you found Activity B.

_____

_____

_____

15. How difficult was Activity B?

_____ much too difficult
_____ too difficult
_____ about right
_____ too easy
_____ much too easy

16. Approximately how long did it take you to complete Activity C (the paper)?

_____ Hours

17. Briefly describe how interesting you found Activity C?

_____

_____

_____

18. How difficult was Activity C?

_____ much too difficult
_____ too difficult
_____ about right
_____ too easy
_____ much too easy

19. How do you feel about the total short course?

_____

_____

_____

_____

20. Would you recommend this type of educational experience to your friends?

_____ yes _____ no

21. Do you feel the short course increased your interest in water resources?

_____ a great deal
_____ some
_____ a little
_____ not at all

22. Do you feel the short course increased your concern about water resources in your community?

_____ a great deal
_____ some
_____ a little
_____ not at all

23. Would you have liked to take the short course for college credit?

_____ yes _____ no

24. How much do you feel the short course increased your knowledge of water resources?

_____ a great deal
_____ some
_____ a little
_____ not at all

25. How much do you feel the short course increased your understanding of your community's water resources?

_____ a great deal
_____ some
_____ a little
_____ not at all

26. How much do you feel the short course increased your understanding of the political functioning of your community?

_____ a great deal
_____ some
_____ a little
_____ not at all

27. Do you feel the short course was a worthwhile educational experience.

_____ yes _____ no

28. Would you please make any suggestions you may have about how we could improve the short course.

_____

_____

_____

_____

29. Would you like to take a conservation correspondence course patterned along the lines of the short course which would cover the various areas of conservation?

_____ yes _____ no

APPENDIX F

LETTER TO NEWS MEDIA

U OF M OFFERS SHORT COURSE ON WATER RESOURCES

The School of Natural Resources of the University of Michigan is offering a short independent study course on water resources by correspondence for Michigan residents. For a limited time this non-credit course will be available at no cost to those who are interested in acquiring a fuller understanding of water resources and water resource problems.

The course is intended for citizens, students, teachers and other professionals who are interested in water resources. Even those who have had little or no professional training in the field of Conservation should find this course valuable. It is designed to help individuals understand how they can be effective in working toward the solution of water problems in their own community and state.

This course in water resources will take approximately 20 to 25 hours of the participant's time over a period of from three to five weeks. The participant will receive and may keep both the text and the activity materials. These materials are designed to help those who use them gain a better understanding of their community water resource situation as well as a better understanding of water resources in general.

The deadline for signing up for the short course on water resources is September 15, 1968. All work should be completed by October 20, 1968.

If you are interested in participating in the short course on water resources, please send your name, address and telephone number to:

Dr. William B. Stapp
Box A
School of Natural Resources
University of Michigan
Ann Arbor, Michigan
48104

APPENDIX G

LETTER TO EXPERIMENTAL GROUP

SCHOOL OF NATURAL RESOURCES THE UNIVERSITY OF MICHIGAN

DEPARTMENT OF RESOURCE PLANNING AND CONSERVATION ANN ARBOR, MICHIGAN 48104

September 18, 1968

To:

We wish to welcome you as a participant in the University of Michigan short course in water resources. Due to the magnitude of environmental problems in communities across our nation, a concerted effort has been made by the faculty and students of the School of Natural Resources in developing an independent study course in environmental conservation.

The total course consists of several units. The first unit that has been developed is on water resources. This unit is being offered to a limited number of citizens to assist our staff in evaluating the design and the content of the material. Your personal reaction to the water unit will be of vital importance to the success of our total project.

The procedural steps we would like you to follow are:

1) You will be asked to fill out a questionnaire at the University Extension Building concerning your level of understanding concerning water resources. The purpose of this questionnaire is to measure your growth in understanding as a result of this program.

2) Upon completion of the questionnaire a set of materials on water resources will be sent to you by mail. The materials will consist of both text and a list of activities. The activities are to be returned to the University in self addressed envelopes which will be provided. The material will be read by the staff and returned to you with comments.

3) After you have read the text and completed the activities you will be asked to return to the University Extension Building to fill out a second questionnaire.

If you would like some indication of your degree of achievement during the course, we will be happy to supply the desired information.

The first procedure for you is to fill out a questionnaire. This will be administered at the:

University of Michigan
Extension Service Building
412 Maynard
Ann Arbor, Michigan

Please come to the Extension Service Building (see enclosed marked map) for the first questionnaire which will take about an hour any day from September 23 (Monday) to September 27 (Friday) from 9:00 A.M. to 4:00 P.M. or from 6:00 P.M. to 8:00 P.M. A few days after completion of the questionnaire you will receive the text and the activity materials by mail.

Again let me thank you for your interest and your cooperation in helping us to evaluate the effectiveness of the water resources material.

Sincerely,

William B. Stapp
Project Director

APPENDIX H

LETTER TO CONTROL GROUP

SCHOOL OF NATURAL RESOURCES THE UNIVERSITY OF MICHIGAN

DEPARTMENT OF RESOURCE PLANNING AND CONSERVATION ANN ARBOR, MICHIGAN 48104

October 28, 1968

To:

As you know the short course on water resources is an experimental project. You have been chosen by a random selection process to be a member of our control group. I would like to stress to you the importance of this group to the success of our project. Without the data from the control group, our project will fail. The only difference between the control group and the rest of the participants is that you will take another evaluation procedure in five weeks and then you will receive the course materials. It is extremely important that you do not specifically try to learn about water resources in the interim but simply go about your normal routine. You will be given the course materials on the day you take the second evaluation procedure.

We hope you will participate as a member of our control group. You will receive the same complete course materials and interaction with the University as the other participants. The only alteration will be the difference in evaluation procedures.

Thank you very much for your consideration of this matter.

Sincerely,

William B. Stapp
Project Director

APPENDIX I

LETTERS CONCERNING THE WATER RESOURCES MATERIAL

HURON RIVER WATERSHED COUNCIL

415 WEST WASHINGTON ST. ANN ARBOR, MICHIGAN 48103 PHONE 665-0514

November 26, 1968

Dr. William B. Stapp
Resource Planning and Conservation Department
School of Natural Resources
The University of Michigan
Ann Arbor, Michigan 48104

Dear Dr. Stapp:

During the past few months the Watershed Council has had more calls from and interviews with citizens in the Ann Arbor area than ever before.

The interviews indicate an unusual depth of understanding of both the physical and the socio-political aspects of water resources problems. Most of the citizens were enrolled in Independent Studies in Water Resources offered by the School of Natural Resources.

One of the Council's major goals with respect to public education and citizen participation is to--

> "Conduct public education and citizen involvement programs, including those in cooperation with the schools, to aid in the long-range solution of water resource problems in the Huron River Watershed."

We would hope that the independent studies course would be made available to all citizens in the Huron River Watershed on a continuing basis. In fact, the Watershed Council could aid in the dissemination of information about the course and possibly in partial financial support of it.

A concerned and involved public will be our greatest future asset in work toward the solution of environmental problems. The Independent Studies in the Water Resources course is a significant step in the direction of meaningful citizen involvement, if it can be made available and if it can be continually updated and revised to deal with pertinent current problems.

Very truly yours,

Jerome K. Fulton
Executive Secretary

MRS. CARL S. COOK
603 CRESCENT DRIVE
HOLLAND, MICHIGAN

Mr. Nowak:

Drive the same route as in coming to our house but pass Thomas Ave., & turn left at Broadway to 26th Street. Turn right on 26th to Concord and left on Concord to Southgate. Right on Southgate to 774 - Kingsley's.

We are all looking forward to Tuesday. Nothing has happened to our garden Club in recent years to make the interest this study course is causing. EC.

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