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ALTERNATIVES FOR MANAGING WASTEWATER FOR CLEVELAND-AKRON METROP--ETC(U)
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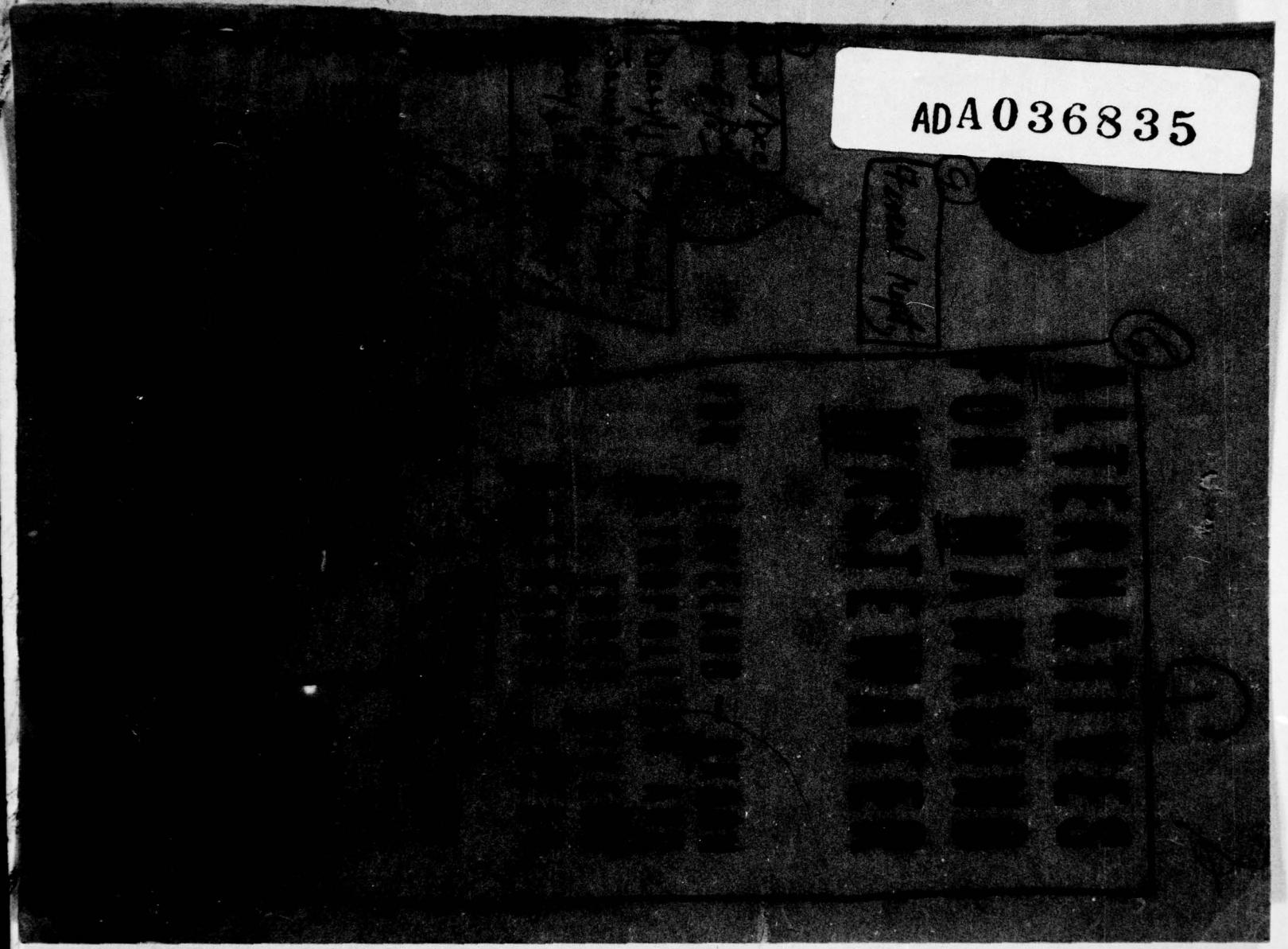

FINAL REPORT

on

IMPACT ASSESSMENT AND EVALUATION OF WASTEWATER MANAGEMENT ALTERNATIVES CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREAS

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

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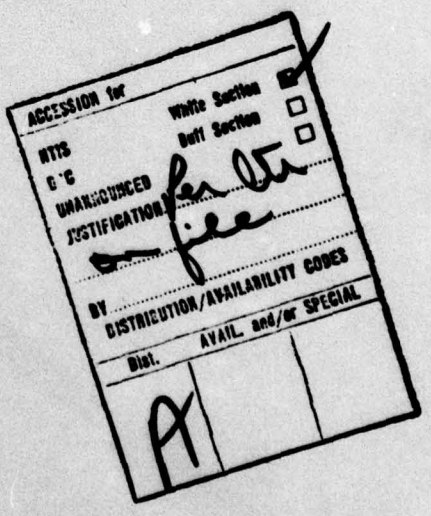

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APPENDIX III

Assessment and Evaluation of Wastewater Management Alternatives

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SUMMARY

Battelle-Columbus has assessed three alternatives developed by Havens and Emerson, Ltd., for wastewater management in the Cleveland-Akron metropolitan area. Each alternative was assessed with respect to its impacts on environmental quality, social well-being, regional development, and national economic development.

A two-step procedure was employed in the impact: (1) identification of impacts and (2) evaluation of impacts using an Impact Matrix. To insure that all major impacts were identified and evaluated, the assessment was comprehensive, systematic and interdisciplinary.

A two-step procedure was employed in the impact assessment: (1) identification of impacts and (2) evaluation of impacts using an Impact Matrix. To insure that all major impacts were identified and evaluated, the assessment was comprehensive, systematic and interdisciplinary.

Because of the feasibility nature of the study, the short time available, and the limited information available upon which to base the assessments, detailed analyses were not included in the study. This necessitated that the impact identifications and evaluations be qualitative in nature.

Three wastewater management alternatives selected for the impact assessment included one plan involving water based treatment, one plan involving land treatment, and one plan that included selected features of each. These wastewater treatments are defined as:

Water treatment. Use of biological or chemical process such as activated sludge, chemical coagulation, ion exchange in the treatment of wastewater.

Land Treatment. Use of the land as a primary mechanism for treatment of the wastewater.

Combination Treatment. Combines selected features of the water and land treatments.

To provide a summary of the numerous impacts that were identified and evaluated and also to be concise an Impact Matrix was selected. Overall results of the assessment are summarized in the matrix in Table S-1.

To interpret the results of the assessment, it is essential to understand the meaning of the entries in the matrix. Entries in each cell of the matrix were based on professional judgments of the interdisciplinary research team according to the following guidelines:

TABLE S-1. IMPACT MATRIX FOR THE THREE ALTERNATIVES EVALUATED

OBJECTIVES Indicators	Alternatives Water (W-1)	 Land (L-1)	 Combination (C-3)
ENVIRONMENTAL QUALITY			
Ecology			
Primary Productivity	+	+/-	+/-
Consumer Productivity	+/-	+/-	+/-
Biogeochemical Cycling	+	+	+
Species Diversity	+	+/-	+/-
Population Density/Distribution	+/-	+/-	+/-
SOCIAL WELL-BEING			
Hygienic			
Direct--Man	+/-	+/-	-
Indirect--Man	-	-	-
Aesthetic			
Land	+/-	-	-
Water	+/-	-	-
Biota	+	-	-
Air	-	-	-
Social Opportunities			
Recreation	+/-	-	-
Human Betterment	0	-	-
Life Style	+	-	-
Distribution	0	-	-
REGIONAL DEVELOPMENT			
Land Values	+	-	-
Water Treatment	+	+	+
Commercial Fishing	0	0	0
Economic Development	0	0	0
Income Redistribution	-	-	-
NATIONAL ECONOMIC DEVELOPMENT	-	-	-

+ Indicates that the major direction of the impacts represented by the indicator is positive or beneficial.

- Indicates that the major direction of the impacts represented by the indicator is adverse or negative.

0 Indicates that there is no major direction of the impacts represented by the indicator.

+/- Indicates that there are two significant directions of the impacts represented by the indicator, positive and negative.

It must be emphasized that these qualitative values (+, 0, -, +/-) indicate only a general direction of the impacts resulting from the alternatives considered. A negative (-) entry should be viewed as a "red flag" highlighting a possible problem or adverse impact that could result from implementation of the respective alternative. For this reason matrix entries cannot be compared between alternatives, within an alternative, between objectives or totaled to obtain a single index.

As shown in Table S-1, the water alternative is expected to produce both beneficial and adverse impacts but was primarily beneficial in nature. However, the land and the combination alternatives were significantly adverse in nature. It should be realized that this evaluation is specific to the alternatives given the research team and is not a general evaluation of all water, land or combination plans.

In any future study it is important to consider other land and combination alternatives in the basin with fewer basic negative impacts. For example, by selecting smaller sites dispersed throughout the basin it should be possible to minimize major nagative impacts. Also, any future study should attempt to seek a balance between the quality and quantity of water in the rivers and streams involved and not only one of these characteristics.

Battelle-Columbus believes that this study has permitted sufficient consideration of all factors related to land and water disposal, and combinations thereof, to permit subsequent identification and efficient evaluation of alternatives with much improved impact profiles.

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CHAPTER 1. INTRODUCTION

Man lives in a balanced system consisting of living and non living components. Any resource development by man must therefore be considered in the context of his surroundings, for a misallocation of one resource can have adverse effects on all of the other components in the system. It is important to consider the entire system in all of man's actions, even when they are directed at improving its quality, because an improvement realized in one area may prove to be detrimental in another.

In the past, consequences of man's actions that affected the quality, quantity, or distribution of the system's components were presented in dollar benefits and costs. This approach, while valid, does not adequately measure all the possible impacts. To alleviate this problem, the Water Resources Council suggested that four objectives be established to evaluate water resource projects. They are environmental quality, social well-being, regional development, and national economic development. Impacts evaluated with respect to these four objectives may or may not be expressed in dollar values. The Council further emphasized the expression of impacts in non dollar measurements does not in any way reduce the importance of the evaluation.

PURPOSE

The purpose of Battelle-Columbus' research for the Corps of Engineers, Buffalo District, was to assess alternatives developed by Havens and Emerson, Ltd., for the wastewater management in the Cleveland-Akron metropolitan area. Each alternative was assessed by determining its impacts on environmental quality, social well-being, regional development and national economic development. At the request of the Corps of Engineers major emphasis in this study was placed on the environmental and social well-being objectives; the other two objectives were treated in an overview framework. This study appears as Appendix III of the total report prepared by the Corps of Engineers on "Alternatives for Managing Wastewater for Cleveland-Akron Metropolitan and Three Rivers Watershed Areas".

IMPORTANT CONSIDERATIONS IN THE STUDY

This study is considered the first phase--feasibility--in the achievement of acceptable water quality in the Cleveland-Akron metropolitan area. Because of the nature of a feasibility study, the short time available, and the limited information available upon which to base the assessments, detailed analyses were not included. This necessitated that the impact

evaluations, determinations, and evaluations of change from a specified base be qualitative in nature. That is, the alternatives will be evaluated using

- Professional judgment
- Information contained in the literature and other reports
- Predictions based on past trends and interrelationships
- Knowledge of study area.

To analyze these qualitative impacts, Battelle-Columbus used a two-step procedure. The first step consisted of identifying the impact produced by each alternative with respect to each of the four objectives. This was then followed by a determination of the nature of the changes, beneficial or adverse. Also included in the second step is a transformation of the many changes or impacts into a single index of significance which is expressed in an Impact Matrix. This sytem provides a comprehensive and sytematic framework for analyzing the alternatives. To ensure a meaningful study, this analysis was conducted by an interdisciplinary research team consisting of ecologists, economists, social scientists, landscape architects, hydrologists, and engineers.

CHAPTER 2. FRAMEWORK FOR IMPACT ANALYSIS

STRUCTURE FOR IMPACT ANALYSIS

The objectives of environmental quality, social well-being, regional development, and national economic development provide the base for evaluating the impacts from each alternative. Because these objectives are often open to various interpretations resulting from their broad nature, for purposes of this study they have been defined by the Corps of Engineers as described below.*

Environmental Quality

Environmental quality involves the preservation or enhancement of the natural resources - land, water, air - that possess values which make them significant. In this study environmental quality is evaluated by ecological characteristics of the environment.

Ecology

Many of man's actions affect nature by altering the relationships that exist between the various organisms and their environment. These actions can cause either temporary or permanent changes in processes and components such as the growth, maintenance, and reproduction of organisms; the relationships that exist between organisms; and the entire ecosystem. By studying these changes it is possible to determine the impact and importance of ecological changes. Specifically, the ecological changes were evaluated by the following components:

(a) Primary Productivity

(b) Consumer Productivity

(c) Biogeochemical Cycling

(d) Species Diversity

(e) Population Density/Distribution

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* Department of the Army, Office of the Chief of Engineers, "Revised Guideline for the Assessment and Measurement of Impacts and Their Evaluation to the Objectives of the Wastewater Management Program", U.S. Army (June 18, 1971).

Social Well-Being

Social well-being involves the equitable distribution of income both real and psychic and how this distribution affects individuals or groups in society. In this study alternatives are evaluated in terms of their impact upon hygienic, aesthetic, and social opportunity characteristics. By determining these changes and evaluating their significance, it is possible to assess the social well-being objective.

Hygienic

The treatment and disposal of wastewater has impact on man's health. Because toxic compounds, infections, or irritating agents impact on the public health and general welfare of society, their consideration in an impact assessment is of utmost importance. This hygienic risk can be transferred to man through water directly or through other agents such as plants and animals. Therefore, the specific components considered in this study are:

(a) Direct Effects on Man

(b) Indirect Effects on Man

Aesthetics

Aesthetics pertains to the quality or condition of the environment as perceived by individuals in society. It includes the presence or absence of color, odor, taste, smell, and visual considerations. Individuals vary in their responses to these external stimuli in the environment, thus it is important to systematically analyze the individual parameters included in aesthetics in the comparison of alternatives. The specific parameters considered in this study are:

(a) Land

(b) Water

(c) Biota

(d) Air.

Social Opportunities

Many of man's actions affect other individuals in society by changing their necessities for human life, their emotional lives, or their general enjoyment of life. Because man is included in the environmental system, these changes must be considered in the alternative evaluation. Considered in this evaluation are changes to man's

(a) Recreation

(b) Human Betterment

(c) Life Style

(d) Distribution.

Regional Development

The development of water resources in a region, as was stated previously, affects the environment, ecology, and the social well-being (hygienics, aesthetics, social opportunities) of the region. In turn, these changes, affect the region's income, employment, and economic base. Although much criticism has been given to the use of dollar benefits and costs in alternative evaluation, in the context of coexistence with environmental and social well-being considerations, dollar aspects of regional development must be considered. Specific areas of consideration in this study are:

(a) Land Values

(b) Water Treatment Benefits

(c) Commercial Fishing

(d) Economic Development

(e) Income Redistribution.

National Economic Development

Resource development in a specific location of the United States can have direct spillover or influence on the Nation's goods and services and the national economic efficiency. These changes in national economic development are not merely economic transfers from one region to another, but are increases or decreases in the economic base of the country. Considerations of national economic development are important in making a decision on the allocation of general revenues for any resource development, and therefore, must be considered in alternative evaluation.

PROCEDURE FOR IMPACT ANALYSIS

The alternatives for wastewater management in the Cleveland area were evaluated in a feasibility framework. Therefore, the study is not intended to dwell on detail but to bring to the surface the expected

major impacts of each alternative. To ensure that all major impacts were identified and evaluated, a two step procedure which is comprehensive, systematic, and interdisciplinary was used for the impact assessment. These steps are;

Step 1 Identification of Impacts

Step 2 Evaluation of Impacts Using an Impact Matrix.

Determination of Impacts

The initial step for an impact assessment is an identification of changes that would be caused by the implementation of an alternative. These changes may take place in the amount of critical pollutants in the receiving streams, the aesthetic characteristics of a river valley, or the economic base of a region. To determine the changes produced by a specific alternative it is necessary to relate the alternative to base-line conditions which describe the present day quality in the area influenced by the alternative. By this comparison, it is possible to determine whether or not a change would occur. The changes are then translated into the indicators of environmental quality, social well-being, regional development, and national economic development.

These impacts occur in different geographic areas depending on the alternative considered and the specific objective evaluated. It is important to delineate the expected impact area to insure that all the major changes are evaluated and that time is not spent discussing minor considerations. In addition to the watersheds and Lake Erie, specific sites in the impact area that are also evaluated in this study are:

- Point sources of major pollution
- Zones of degradation
- Disposal sites for land and water
- Sites of treatment and transmission facilities.

Evaluation of Impacts Using an Impact Matrix

Each of the impacts defined in Step 1 were evaluated to find out the significance of the change. The significance is determined by knowledge of the changes:

- Magnitude
- Direction (positive or negative)

- Individuals or groups affected
- Importance in the entire system.

By following this procedure of impact identification and evaluation, the desired information needed for the assessment of alternatives is determined. However, because numerous changes occur for each of the objectives - environmental quality, social well-being, regional development, and national economic development - and therefore for each alternative, it is difficult to obtain a general overview of the alternative impact. To obtain this general overview--a primary goal of the feasibility study--Battelle-Columbus used an Impact Matrix.

Impact Matrix

The environmental Impact Matrix is a tool or method of transforming all the changes and their significance into several indices. These indices can then be easily used to evaluate completely each alternative. The matrix, Table 1, consists of a list of general indicators representing the four water resource objectives on the left side of the matrix and across the top is the list of the alternatives to be evaluated. Each cell in the matrix represents a "subtotal" impact and significance. The value placed in each of the cells in the matrix was determined by a judgment made by the research team. For the feasibility study this judgment approach does not appear to be present a serious limitation. This subtotal value is expressed in the matrix in the following ways:

+ Indicates that the major direction of the impacts represented by the indicator is positive or beneficial.

- Indicates that the major direction of the impacts represented by the indicator is adverse or negative.

0 Indicates that there is no major direction of the impacts represented by the indicator.

+/- Indicates that there are two significant directions of the impacts represented by the indicator, positive and negative.

It must be emphasized that these qualitative values (+, 0, -, +/-) indicate only a general direction of that indicator for the alternative considered. A negative (-) entry should be viewed as a "red flag" indicating possible problems or adverse impacts that could result from implementation of the respective alternative. For this reason matrix entries cannot be compared between alternatives, within an alternative, between objectives or totaled to obtain a single index. To make this type of comparison it would be necessary to weight each indicator and have quantitative as well as qualitative values in each cell.

TABLE 1. IMPACT MATRIX STRUCTURE

OBJECTIVES Indicators	Alternatives 1	 2	 3
Environmental Quality			
Ecology			
Social Well-Being			
Hygienic			
Aesthetic			
Social Opportunities			
Regional Development			
National Economic Development			

Specific Procedure for Impact Assessment

To provide a working framework for impact assessment the two steps can be subdivided into their various parts. They are listed below.

Step 1 Identification of Impact

(1) Define baseline for area considered in evaluation

(2) Identify potential problem

(3) Define major impacts

(4) Estimate the changes

(5) Translate the changes into specific indicators.

Step 2 Evaluation of Impact Using an Impact Matrix

(1) Determine the significance of each change

(2) Transform changes and significance into specific indicators

(3) Define a general direction for each indicator and express it in Impact Matrix.

CHAPTER 3. DESCRIPTION OF BASE INFORMATION

Information discussed in this chapter provided a description of existing conditions in the study area. This information was then used to determine what if any changes would result if any of the alternatives were implemented. Specific information on the water pollution and on the wastewater treatment provided by municipalities and industries in the study area is discussed in the body of the report and in an appendix.

The base line data that will be used in the impact analysis is discussed by using the general indicators of ecology, hygiene, aesthetics, social opportunities, and economics as a narrative framework. However, specific to each indicator the discussion will be related to the potential geographic impact areas. These potential impact areas in the Cleveland-Akron metropolitan area are listed below and shown in Figure 1.

- Three Rivers Watershed

  Rocky River
  Cuyahoga River
  Chagrin River

- Lake Erie

- Land Disposal Areas

  Richland County
  Ashland County
  Wayne County
  Stark County
  Columbiana County

In the determination of a base for impact evaluation it is important to select not only the areas for the investigation but also the base year to be used in the investigation. For purposes of this study, the base year of 1970 or as close to that year as possible was selected as the most appropriate base ; its recency and its use as a base for many reports on the study area were the deciding factors in its selection.

ECOLOGY

Discussion of Evaluation Procedure Used in the Base Analysis

It is the purpose of this study to identify various environmental impacts as indices for evaluating waste treatment alternatives for the Three

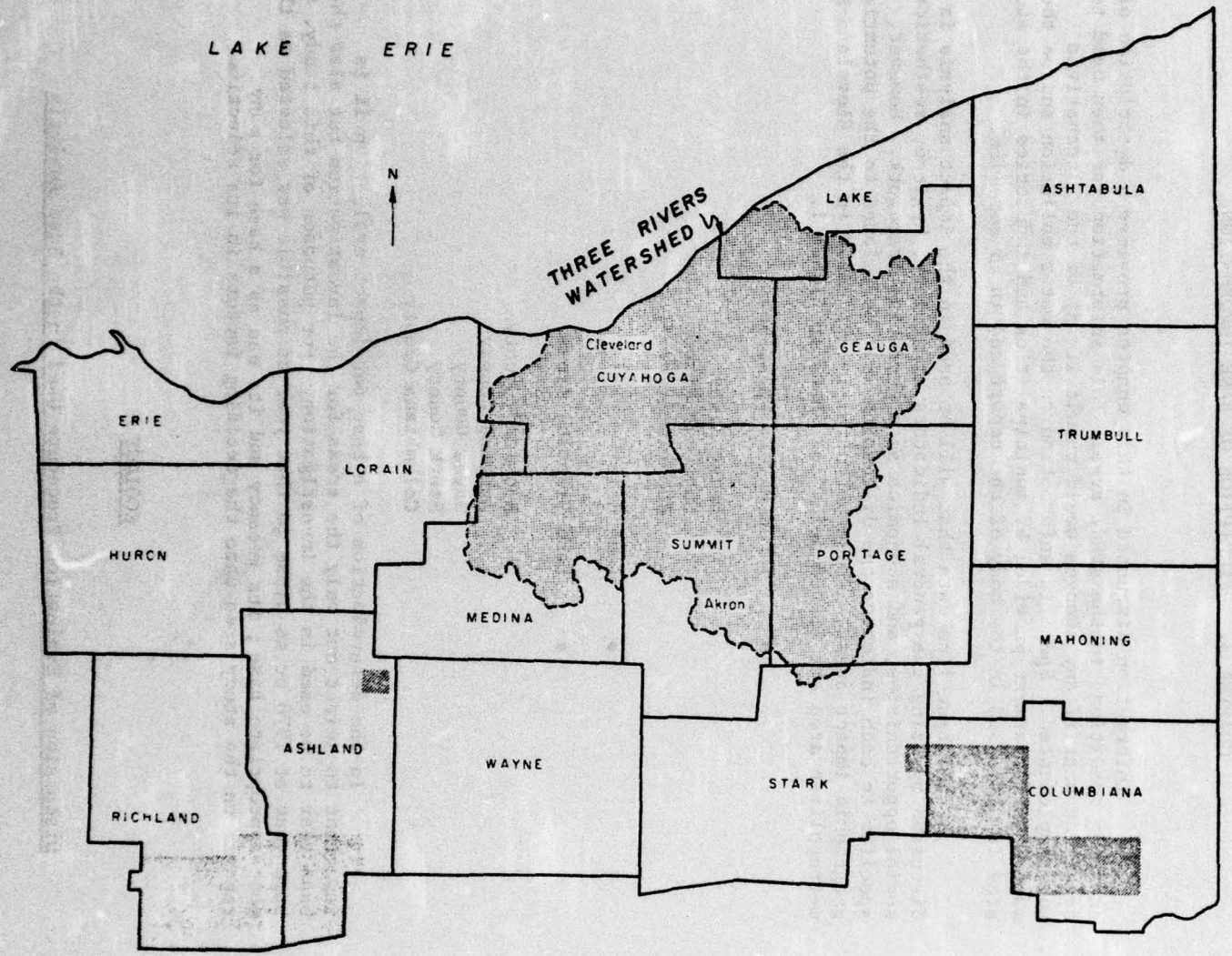

FIGURE 1. GENERAL LOCATION OF IMPACT AREAS

Rivers Basin and the land disposal areas. To the extent possible, data taken close to 1970 was utilized for the description of the current ecological conditions. Because ecological changes have been occurring so rapidly in the past several years in Lake Erie, it will be necessary to give a somewhat historical evaluation of the conditions prior to this recent period of rapid ecological change. The press has often referred to both the Cuyahoga River and Lake Erie as being dead. There is some validity for this statement at least relative to the lower reaches of the Cuyahoga River. Here the dissolved oxygen is quite low and in recent years this stretch of the stream has become devoid of animal life, with only a few species of algae being present. However, Lake Erie is not dead but is very much alive as an eutrophic (nutrient rich) lake. This lake is the most productive lake (i.e., commercial fish harvest) of the Great Lakes. Although there has been a significant shift in fish species, there is no reason to believe that it will not continue to be a highly productive lake if proper management is exercised.

An aquatic ecosystem, e.g., lake or river, is composed of three basic interrelated biotic components, namely, primary producers (plants), consumers (animals), and decomposers (microorganisms). There are, in addition, abiotic components, i.e., heat, light, mineral nutrients, dissolved oxygen, pH, etc., which limit and/or moderate an ecosystem. Under natural conditions an equilibrium level is established between these components for a given ecosystem, based on energy input, i.e., the rate of photosynthesis by the primary producers. In most lakes this energy would come primarily from algae; however, in some unique lakes, there can be a significant contribution by photosynthetic bacteria. In certain rivers, by comparison, a large portion of the energy may originate via photosynthesis of terrestrial plants. This energy enters the river as dead plant material, detritus. The primary productivity in rivers with a series of dams is similar to that of lakes, particularly during low flow conditions. There is little information on the relative importance of the algae-based vs. detritus-based food chain in the productivity of fish in a given river.

Modern man, in general, until recently has been altering the equilibrium of aquatic ecosystems through his zealous utilization of water for many purposes. This equilibrium change has resulted from (a) enhancing primary production, (b) overloading decomposition, (c) under and/or overharvesting of consumers, and (d) adversely altering the physical-chemical environment, e.g., heat, pH, and toxic chemicals. In addition, man has introduced low levels of exogenous chemicals into the environment which are concentrated through food chains to hazardous levels for the terminal consumer--noteworthy examples are mercury, DDT, and various radionuclides.

The principal chemical nutrients required for primary productivity are carbon dioxide, nitrates, and phosphates in an approximate ratio of 100:10:1 for a C:N:P atom ratio. Man has dumped into our aquatic ecosystems

surplus quantities of organic (BOD), nitrogenous and phosphate wastes, thus enhancing primary productivity by contribution to each of the three principal nutrients. As a result, we have a problem of algal blooms. Figures 2 and 3 illustrate the carbon and nitrogen cycles for the pathways by which BOD and nitrogenous wastes contribute to increased levels of CO_2 and NO_3. It should be noted that algal blooms are natural phenomena and become real problems when (bloom) primary productivity exceeds the assimilative capacity of the ecosystem, i.e., the decomposers cannot metabolize the excess algal biomass aerobically. This inability to metabolize aerobically causes the development of low oxygen and anerobic conditions in the bottom waters and/or sediment.

Microorganisms play a vital role in the recycling of elements in the biosphere (biogeochemical cycling). The major cycles include the previously mentioned carbon and nitrogen, as well as the sulfur and iron cycles illustrated in Figures 4 and 5. The overloading of these cycles results in ecological changes in the aquatic environment that are generally adverse to both consumers and producers. The following is only a partial listing of some of the more common micro-ecological processes in polluted aquatic ecosystems.

Input	Cycle	Output	Effect
BOD	Carbon	CH_4	Toxic
BOD	Carbon	oxygen uptake	Low O_2→anoxia
Nitrogenous materials	Nitrogen	NH_3	Toxic
N-BOD	Nitrogen/carbon	O_2 uptake	Low O_2→anoxia
-SH	Sulfur	H_2S	Toxic
SO_4, Fe	Sulfur/iron	FeS→H_2SO_4	Low pH (1-2)
Fe^{+++}	Iron	Fe^{++}---	Low O_2→anoxia
$FePO_4$	Iron/sulfur	PO_4 release	PO_4 ---- to algae

Another example of the importance of microorganisms in the aquatic ecosystem is the problem of mercury contamination of fish (see Figure 6). Mercury is commonly released to the environment in an inorganic form, usually a precipitated salt in the sediment, which is unavailable for uptake by most aquatic organisms. There are aerobic bacteria that will metabolize mercury into a soluble methylated form which can be accumulated through food chains leading to fish and then to man. There is some concern that there might be a continual problem for some time with mercury accumulation in fish, even if the input were to be reduced to zero. The continuation of the mercury problem is due to the present residual loading in the sediment.

The last major biotic component of aquatic ecosystems is the consumer group. Man historically has selectively harvested, sometimes excessively, certain species of fish. This practice can and has led to the demise of the desired harvested product. For example, the removal of

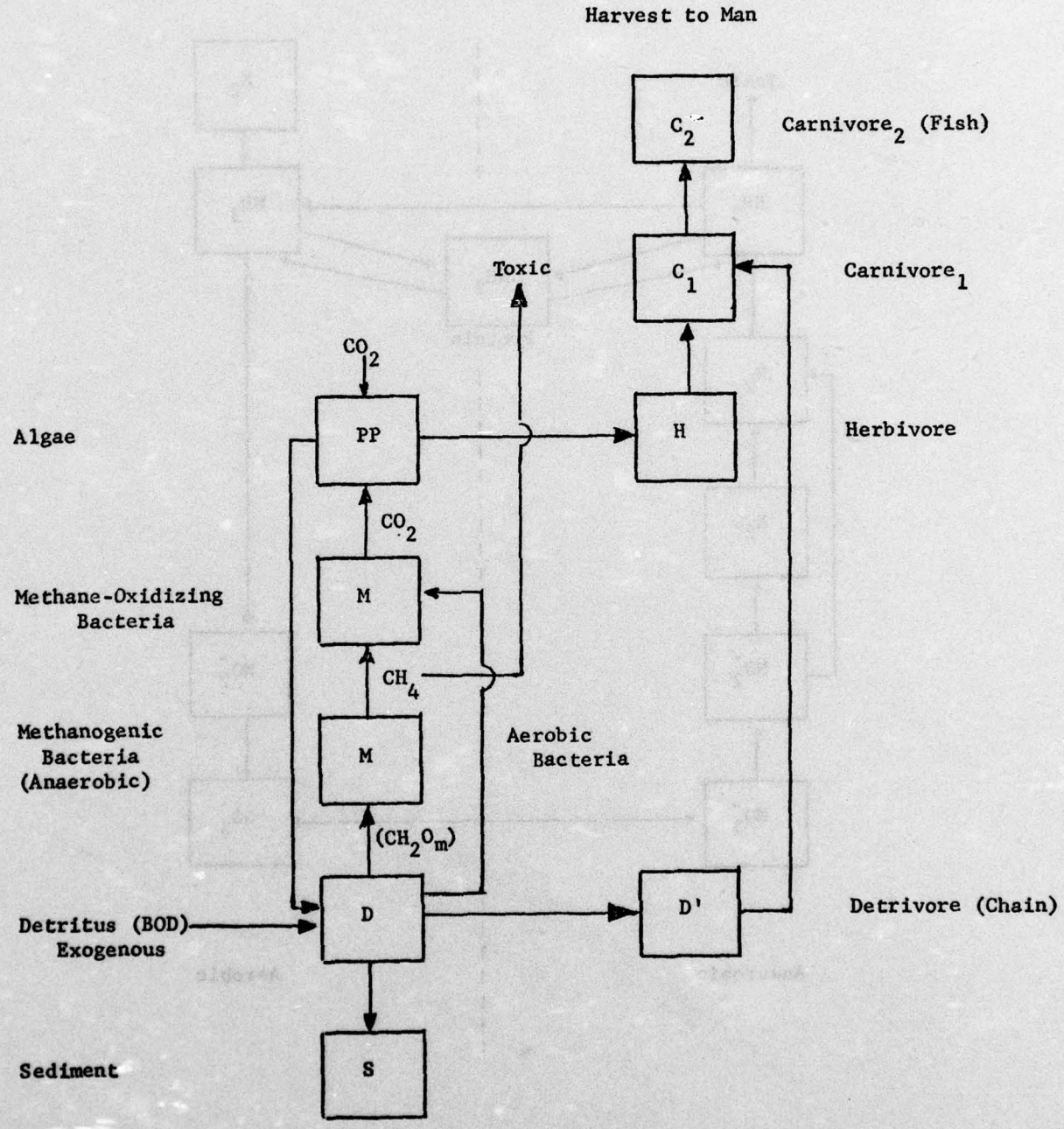

FIGURE 2. CARBON CYCLE IN AQUATIC ECOSYSTEMS

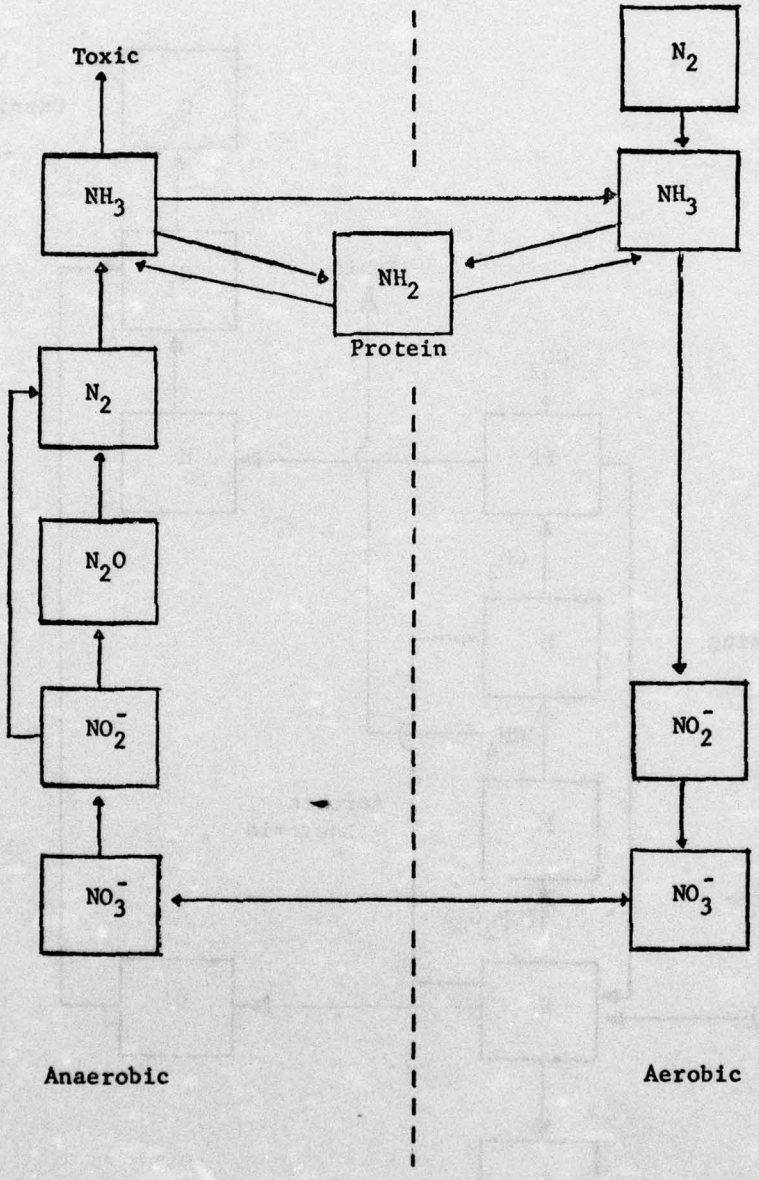

FIGURE 3. NITROGEN CYCLE IN AQUATIC ECOSYSTEMS

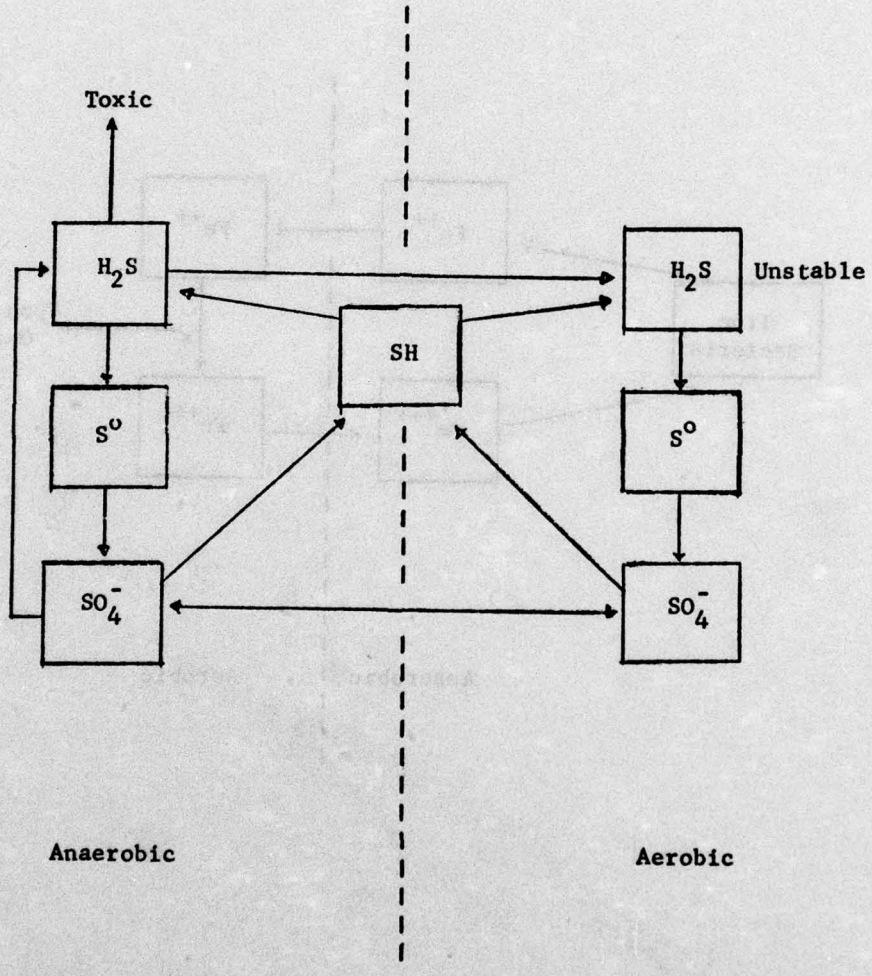

FIGURE 4. SULFUR CYCLE IN AQUATIC HABITATS

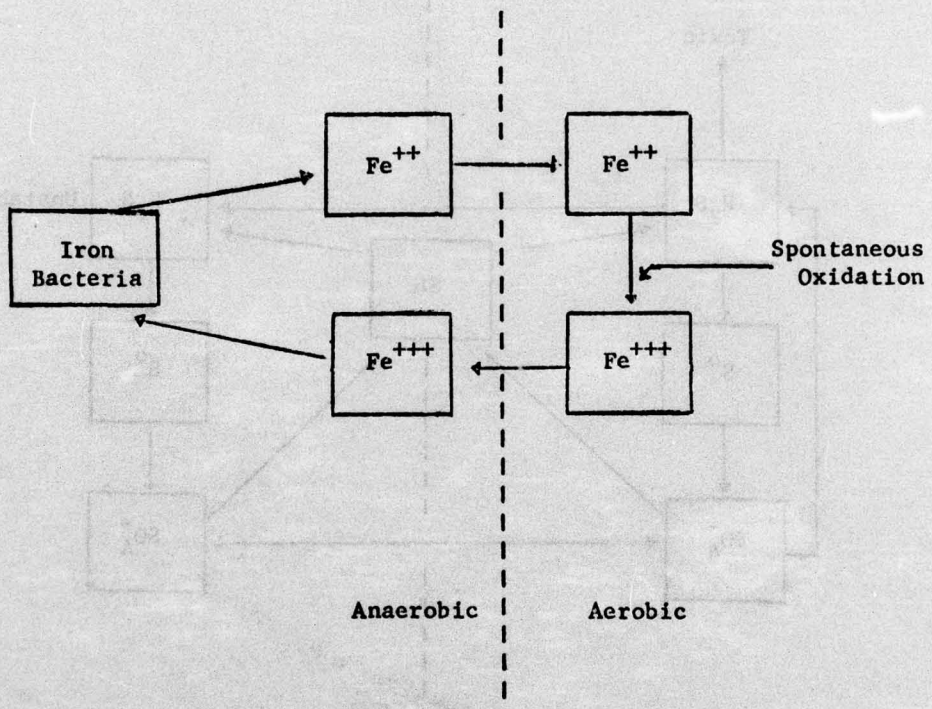

FIGURE 5. IRON CYCLE IN AQUATIC ECOSYSTEMS

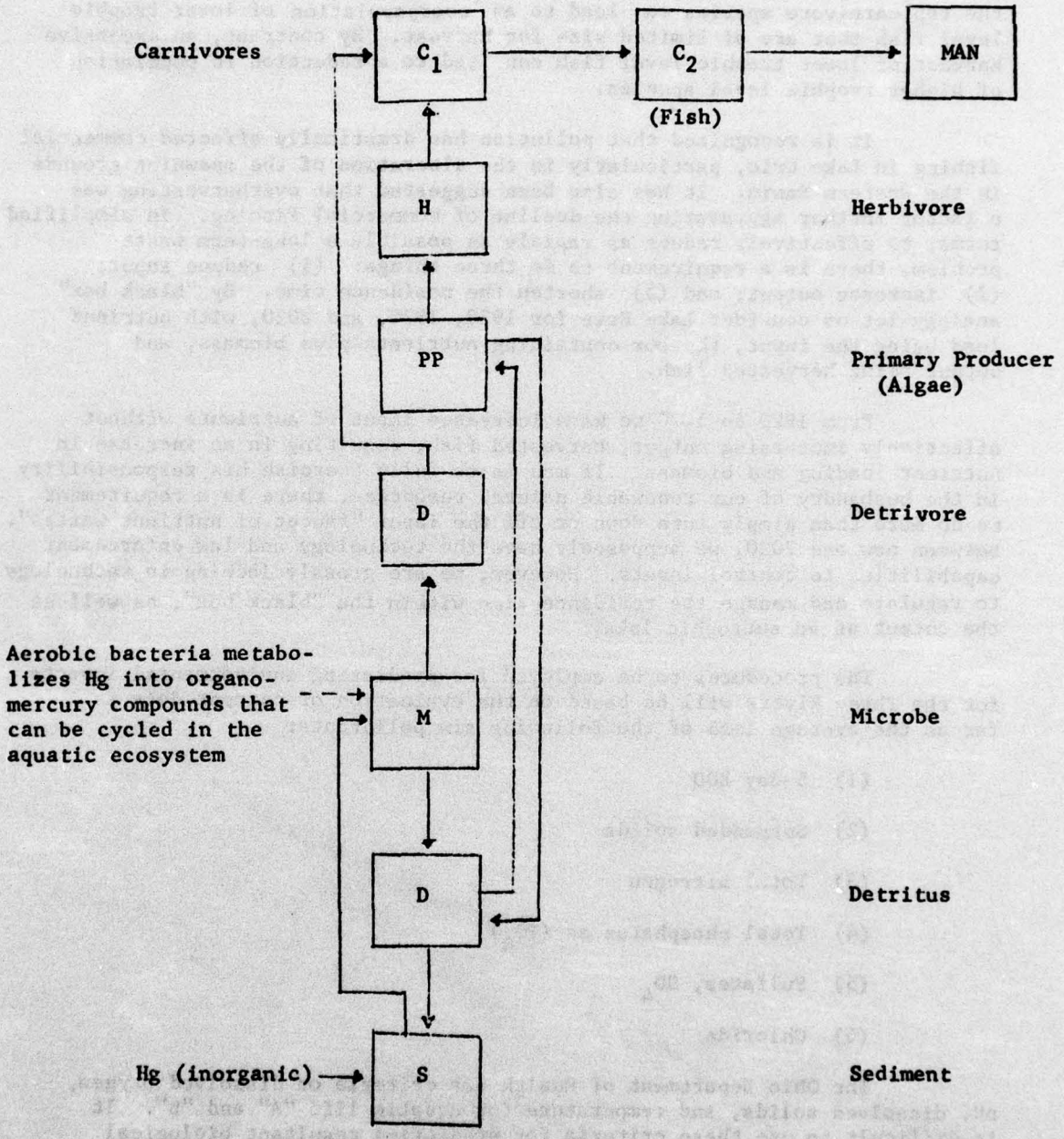

FIGURE 6. TRANSFER OF MERCURY IN AQUATIC ECOSYSTEMS

the top carnivore species can lead to an overpopulation of lower trophic level fish that are of limited size for harvest. By contrast, an excessive harvest of lower trophic level fish can lead to a reduction in population of higher trophic level species.

It is recognized that pollution has drastically affected commercial fishing in Lake Erie, particularly in the alteration of the spawning grounds in the Western Basin. It has also been suggested that overharvesting was a factor further aggravating the decline of commercial fishing. In simplified terms, to effectively reduce as rapidly as possible a long-term waste problem, there is a requirement to do three things: (1) reduce input; (2) increase output; and (3) shorten the residence time. By "black box" analogy let us consider Lake Erie for 1920, 1970, and 2020, with nutrient load being the input, the box containing nutrients plus biomass, and output being harvested fish.

From 1920 to 1970 we have increased input of nutrients without effectively increasing output, harvested fish, resulting in an increase in nutrient loading and biomass. If man is to fully exercise his responsibility in the husbandry of our renewable natural resources, there is a requirement to do more than simply turn down or off the input "faucet of nutrient wastes". Between now and 2020, we supposedly have the technology and law enforcement capabilities to control inputs. However, we are grossly lacking in technology to regulate and manage the residence time within the "black box", as well as the output of an eutrophic lake

The procedures to be employed for predicting environmental impacts for the Three Rivers will be based on the evaluation of current data as far as the average load of the following six pollutants:

(1) 5-day BOD

(2) Suspended solids

(3) Total nitrogen

(4) Total phosphates as (PO_4)

(5) Sulfates, SO_4

(6) Chloride.

The Ohio Department of Health has criteria on dissolved oxygen, pH, dissolved solids, and temperature for aquatic life "A" and "B". It is difficult to use these criteria for predicting resultant biological responses to pollutant loads. In these rivers there are several reaches with rapids and cataracts that contribute to the reaeration of the water, which results in the water having a higher dissolved oxygen content than would be expected under the present state of high BOD loading. In

the absence of state and federal regulatory criteria for the six above-mentioned pollutants, criteria were chosen for each of these pollutants on the basis of McKee and Wolf, Water Quality Criteria, 1963, and Water Quality Criteria, FWPCA, 1968. These criteria are given in Table 2. It should be emphasized that some of these concentration ranges are arbitrary and are used only for the purpose of identifying general levels of pollution in various reaches of the three rivers. It is believed that even though there might not be complete agreement on the criteria presented, at least they serve as a tool for relating the various pollutant loads in different streams.

Benthic Index

In addition, the benthic index, i.e., a modeified species diversity of benthic organisms, at selected sites was evaluated as the dependent variable using a multinegression analysis with the pollutant loads as dependent variables. A high benthic index is an excellent indicator of good water quality, as this illustrates that the water is capable of supporting a wide variety of aquatic life.

During 1969, Havens and Emerson*,** collected information on the benthic index, concurrently with pollutant concentration at various stations on the Chagrin and Rocky Rivers and main central tributaries to the Cuyahoga River. Initially plotting the benthic index, BI, as a function of the BOD concentration in the streams indicated a general linear relationship between BI and BOD when the BOD was below approximately 6. Following this preliminary plot, multiregression coefficients of all six pollutants were determined using a regression analysis computer program to establish their relationship to the benthic index. It was thought that if this relationship could be established, then the data on projected pollutant loads could be used for predicting the resultant benthic index that might be experienced with various waste treatment plants. The results of this regression analysis gave a multiple correlation coefficient of 0.85 for the combined data from sampling stations on the three rivers. With this correlation coefficient there is a good probability of predicting for these streams a benthic index, given the pollutant loading of BOD, suspended solids, total nitrogen, total phosphates (as PO_4), sulfates, and chlorides, and assuming that no other pollutants will be added.

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* Havens and Emerson, Ltd., Consulting Engineers, "Water Quality of the Rocky and Chagrin Rivers", prepared for the Three Rivers Watershed District, 1970.

** Havens and Emerson, Ltd., Consulting Engineers, "Study on Cuyahoga River Water Quality", prepared for Three Rivers Watershed District, 1968.

TABLE 2. BIOENVIRONMENTAL WATER QUALITY CRITERIA

Pollutant	Class, mg/l			
	Good I	Enriched II	Polluted III	Grossly Polluted IV
BOD	<3	3-6	6-10	>10
Suspended solids	<80	80-200	200-500	>500
Total N	<1	1-5	5-10	>10
Total PO_4	<0.1	0.1-1.0	1-5	>5
SO_4	<100	100-250	250-500	>500
Cl	<150	150-500	500-1000	>1000

Three Rivers Watershed

Rocky River

The extent of the pollution in the Rocky River is dependent on the specific location under investigation. Much of the East and West Branches of the river are in either a good or enriched classification. On the other hand, the main stream of the river varies in its pollution from polluted to grossly polluted, depending again on the location considered. Specifically, the average sulfate concentration in the Rocky River is in either the enriched or the good class, Table 3. The chloride content is in the good class with one exception--a location on the West Branch of the Rocky River is considered enriched. The suspended solids would also fall in the good class except at the one location classed as enriched. With BOD, 4 out of 13 sampling locations are in the grossly polluted class, two are in the polluted class, two are in the good class, and the remainder are in the enriched class. With total phosphates, 7 out of the 13 sampling locations indicate gross pollution. Three are in the polluted class and the remainder are in the enriched class. There is one sampling location indicating gross pollution in total nitrogen and five indicating a polluted situation. Two would be in the good class, with the remainder being in the enriched class. Figures 7, 8, and 9 illustrate the zones of pollution and gross pollution of BOD, total nitrogen, and total phosphate, respectively, on the Three Rivers. The location of the sampling stations listed on Table 3 are indicated on the above figures.

Cuyahoga River

The Cuyahoga River is arbitrarily divided into two regions, the Upper Cuyahoga River and the Lower Cuyahoga River. The Upper Cuyahoga is upstream of Lake Rockwell, approximately 60 miles upstream from the mouth of the river. In general, water quality in this reach is quite acceptable, as indicated by good small mouth bass fishing; however, quantitative data on various classes of pollutants in this reach of the stream are not presently available.

The Lower Cuyahoga River is well known as a polluted stream, both from municipal and industrial wastes being concentrated in the last 10-mile reach of the river before its discharge into Lake Erie. The sulfate and chlorides would be classed as enriched in the Lower Cuyahoga River excepting from Lake Rockwell to the Akron Sewage Treatment Plant where these pollutants would generally be in the good class, Table 4. The suspended solids are in the good class from Lake Rockwell to the last 10 miles of the river, where the suspended solids would be classified as

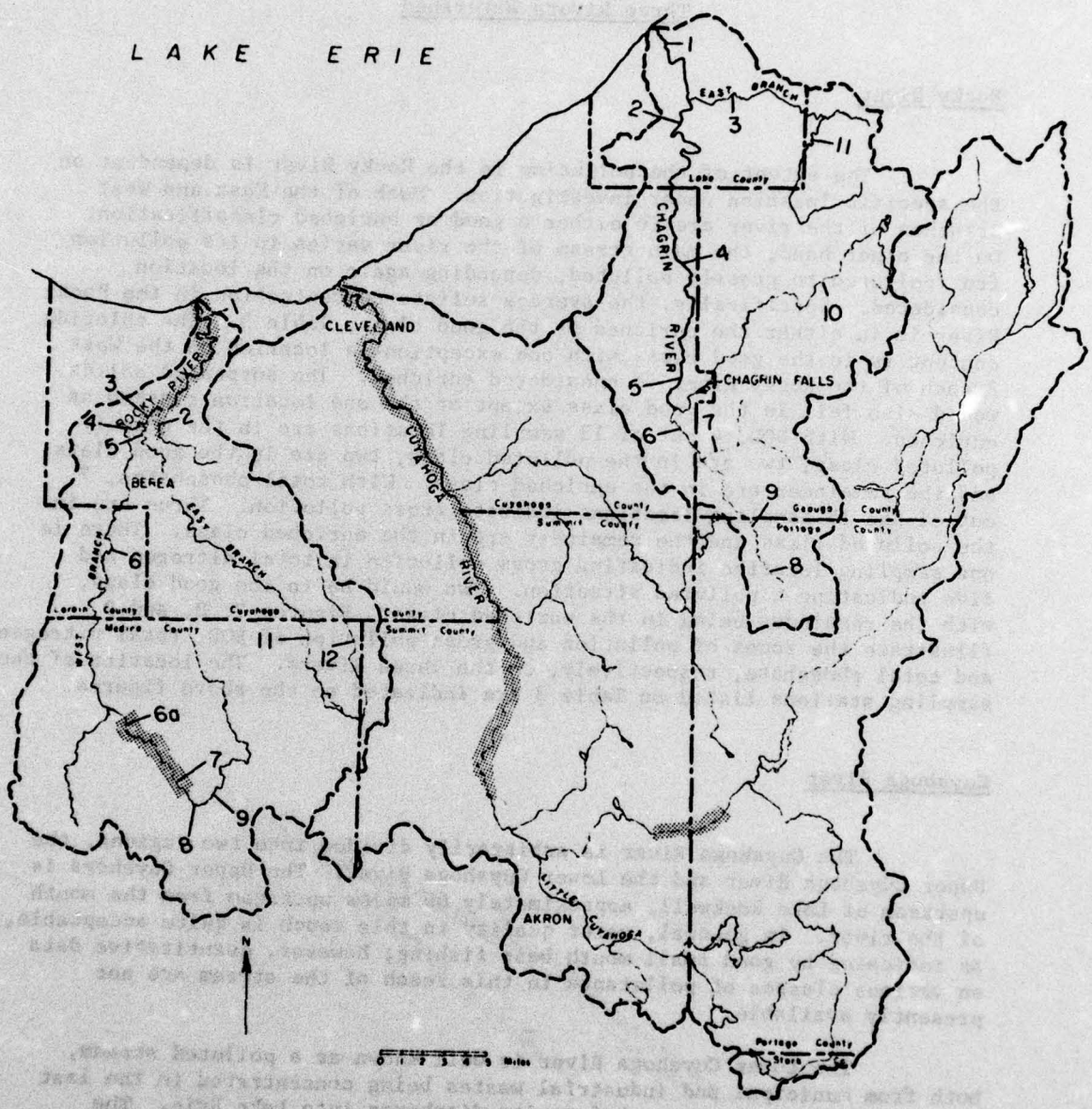

FIGURE 7. POLLUTED ZONES IN THE THREE RIVERS AREA AS INDICATED BY AVERAGE 5-DAY BOD LEVELS GREATER THAN 6 mg/l

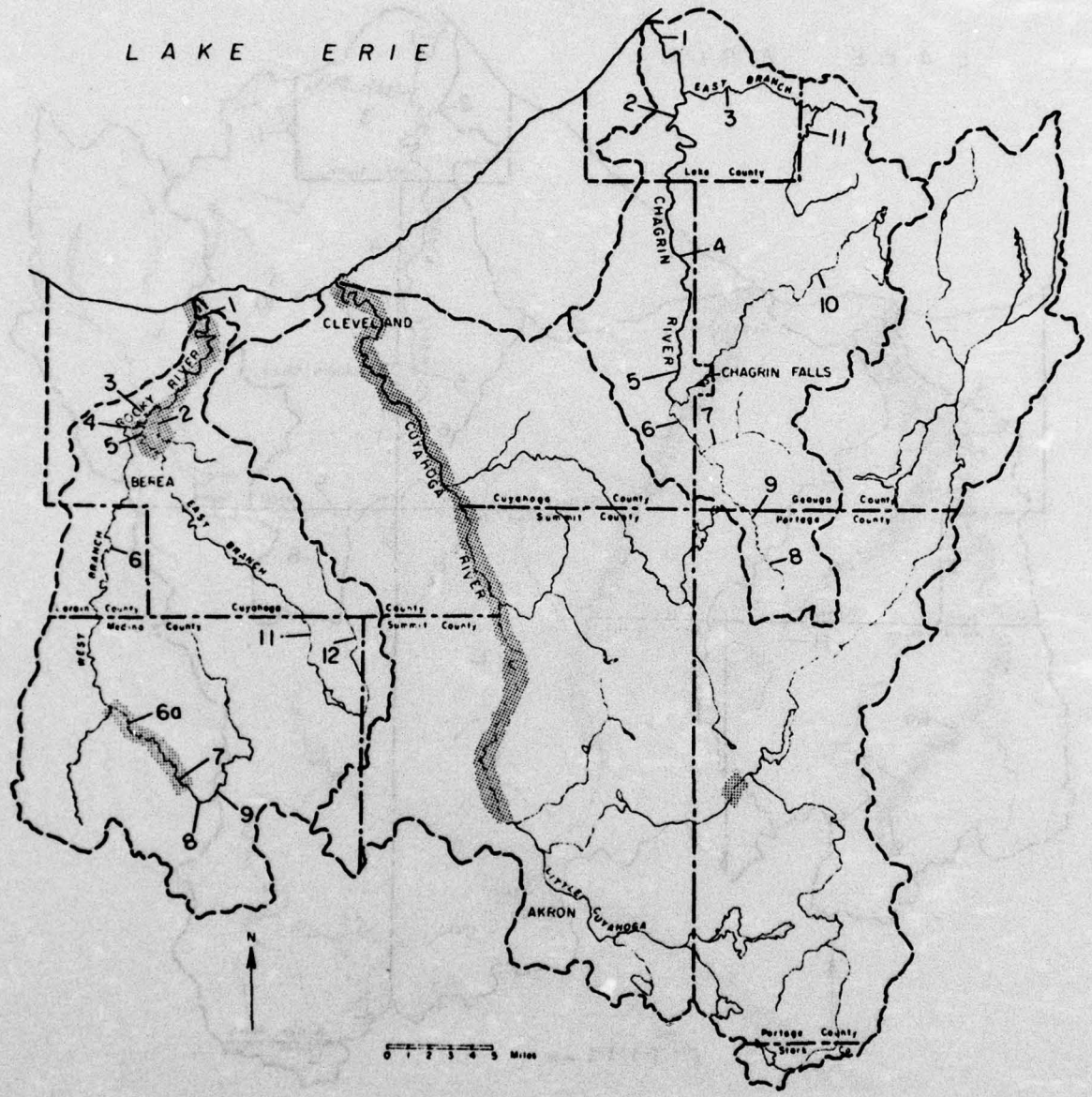

FIGURE 8. POLLUTED ZONES IN THE THREE RIVERS AREA AS INDICATED BY AVERAGE TOTAL NITROGEN LEVELS ABOVE 5 mg/l

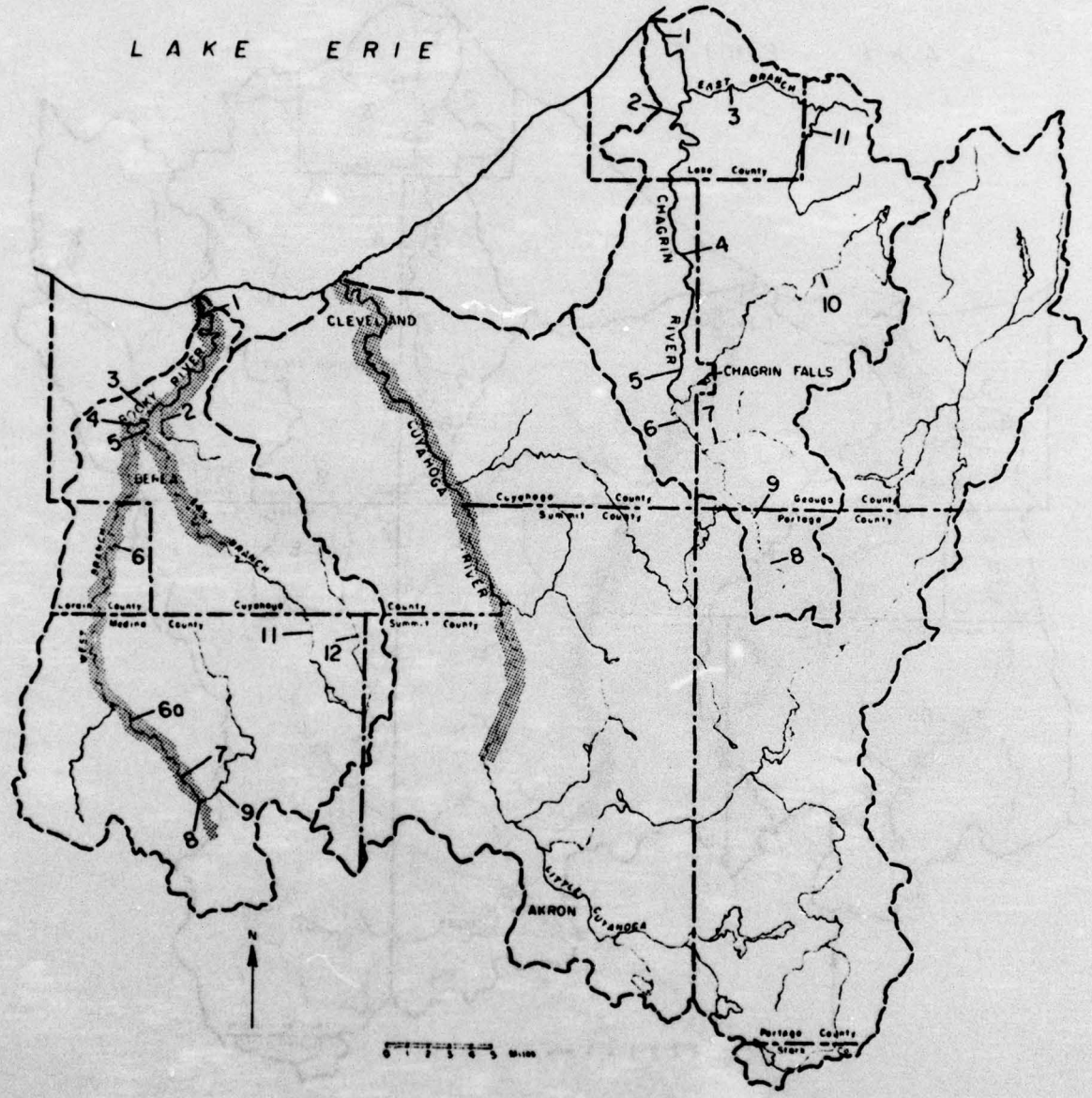

FIGURE 9. POLLUTED ZONES IN THE THREE RIVERS AREA AS INDICATED BY AVERAGE TOTAL PHOSPHATE LEVELS ABOVE 1 mg/l

TABLE 3. RELATIONSHIP OF POLLUTANTS TO BENTHIC INDEX FOR THE ROCKY RIVER

Sampling Station	Benthic Index	Average mg/l					
		BOD	Suspended Solids	Total N	Total PO_4	Total SO_4	Total Cl
1	1	6.7	65	7.87	9.27	97	65
2	2	9.2	39	53.8	13.5	90	70
3	5	6.2	88	5.23	5.15	80	59
4	6	4.6	44	4.17	3.76	111	102
5	6	5.2	47	6.32	8.07	127	97
6	9	4.0	49	2.25	5.23	120	93
6a	6	6.9	37	5.46	10.40	149	124
7	9	6.0	40	6.34	10.15	144	199
8	15	3.1	33	1.87	1.10	185	100
9	14	3.2	50	0.88	0.33	114	35
10	2	4.5	35	1.71	1.07	125	77
11	25	2.1	76	0.99	0.20	55	20
12	19	1.9	19	1.20	0.43	83	35

Source: Havens and Emerson, Ltd., 1970.

TABLE 4. POLLUTION IN MAIN STREAM CUYAHOGA RIVER, 1967

Sampling Station	River Mile	Benthic Index	Average mg/l					
			BOD_5	Suspended Solids	Total N	Total PO_4	Total SO_4	Total Cl
1	1.0	-	7.3	46	12.9	1.65	234	163
4	3.2	-	11.5	104	19.2	1.10	-	-
9	7.2	-	13.1	95	14.8	1.94	144	176
10A	8.3	-	10.7	493	20.4	5.7	248	181
10B	11.15	-	7.9	77	14.1	6.36	198	212
12	13.8	-	7.2	69	15.0	2.68	170	212
14	16.9	-	5.3	26	13.0	1.83	174	124
15	21.55	-	7.3	21	>3.1	1.51	160	232
16	24.8	-	8.0	78	13.7	1.30	145	290
17	27.8	-	9.6	22	12.0	1.30	162	207
18	30.4	-	10.5	25	12.2	1.73	125	195
19	34.6	-	10.6	27	9.6	2.07	138	239
20	36.7	-	9.2	28	11.5	1.98	160	235
21	38.6	-	12.2	39	11.8	3.07	186	249
22	39.3	-	2.4	5.4	5.1	0.34	118	135
23	41.6	-	2.5	38	≥6.4	0.34	87	90
24	44.2	-	2.5	6.4	7.2	0.48	90	86
25	46.7	-	3.6	11	≥4.1	0.6	93	108
26	49.4	-	9.6	15	≥3.1	0.72	178	106
27	51.4	-	8.2	24	≥4.9	0.39	76	43
28	54.2	-	3.0	20	≥4.5	0.93	80	33
29	56.1	-	2.1	7	≥5.1	0.51	72	33
30	59.1	-	2.2	9	0.9	0.50	38	24

Source: Havens and Emerson, Ltd., 1968.

polluted or enriched. With total nitrogen, the Cuyahoga River is enriched to polluted from Lake Rockwell to the Akron Sewage Treatment Plant, and in general is grossly polluted the rest of the way to Lake Erie. From Lake Rockwell to the Southerly Plant, the phosphates would be in an enriched class, and from the Southerly Plant to Lake Erie, they would be in the grossly polluted and polluted class. With BOD, there is a zone of pollution, starting approximately 10 miles downstream from Lake Rockwell. However, this recovers to the good class, with one exception, upstream from the Akron Sewage Treatment Plant. The river from the Akron Sewage Treatment Plant to the Southerly Plant would be classified either as polluted or grossly polluted. From the Southerly Sewage Treatment Plant to the mouth of the Cuyahoga River, the BOD would be in the grossly polluted class, except at the sampling station at the 1-mile mark, where it would be classified in the polluted class. The Lower Cuyahoga River is a polluted stream in BOD, total nitrogen, and total phosphates from the Akron Sewage Treatment Plant to Lake Erie, a distance of approximately 40 miles.

The above-described six pollutant loadings from municipal wastes are only a part of the total pollutant load on the Cuyahoga River. In addition there are also industrial loadings at Akron into the Little Cuyahoga River and at Cleveland into the last 10 miles of the Cuyahoga River. In this latter area there are additional oxygen-demanding materials added, and together with an increase in temperature, the dissolved oxygen drops off to less than 1 ppm. In this area there is a significant barrier limiting fish passage because of the low dissolved oxygen and high temperature. This barrier blocks the migration of any fish upstream or downstream. Langlois*, 1945, reported that early records showed that Walleyes "formerly ascended each spring .... the Sandusky River to the rapids at Fremont", and in the central basin "the Cuyahoga River to the rapids above Akron ....". Langlois also stated that the walleye runs were mostly destroyed by 1945 due to the construction of dams, siltation, and excessive pollution. These factors certainly were operative on the lower Cuyahoga River. As part of the U.S. Army Corps of Engineers Program for Total Waste Management in the Three Rivers District, it might be well to consider the installation of fish ladders to enable fish to bypass some of the dams on the Cuyahoga River. This action would be worthwhile if the total waste management is effective in upgrading the Cuyahoga River to its former fish spawning status.

Chagrin River

The Chagrin River appears to have good water quality. Both the SO_4 and chloride are in the good range at all the sampling stations, Table 5. The suspended solids levels at the sampling station near the mouth of the river are in the enriched class, while at the other sampling stations, they are classed in the good zone. There are only two cases in which

* Langlois, T. H., "Water, Fishes, and Croplant Management", Trans. 10th North American Wildlife Conference, (1945), pp 190-196.

TABLE 5. RELATIONSHIP OF POLLUTANTS TO BENTHIC INDEX FOR THE CHAGRIN RIVER, 1967-70

Sampling Station	Benthic Index	Average mg/l					
		BOD	Suspended Solids	Total N	Total PO_4	Total SO_4	Total Cl
1	4	5.4	147	0.84	0.60	65	34
2	9	4.0	23	0.89	0.63	59	54
3	20	3.2	42	0.82	0.25	72	23
4	15	3.5	40	0.90	0.69	51	31
5	8	3.6	50	1.18	0.91	45	29
6	19	3.4	36	0.98	0.81	45	24
7	21	3.8	17	0.59	0.33	25	14
8	3	1.7	51	1.32	0.99	41	10
9	31	3.9	40	0.76	0.28	36	20
10	23	2.8	52	0.61	0.49	25	15
11	18	2.6	27	0.35	0.25	58	15

Source: Havens and Emerson, Ltd., 1970.

the total nitrogen is classed in the enriched zone. However, the total phosphates at each of the sampling stations are classified in the enriched class. The BOD levels at most of the sampling stations are classed in the enriched zone. In general, there are indications that this so-called "clean river" has enrichment in phosphates and BOD. The Chagrin River is classed as a good fishing stream. The State of Ohio has established this river as a cold-water fishery stream; however, under conditions of low flow, temperature aspects of the water quality criteria are often exceeded in certain reaches. Any future reduction that would change or reduce this flow would tend to detract from this cold water fishery.

Both trout and coho salmon have been stocked in the Chagrin River. These stockings were conducted by the Division of Wildlife of the Ohio Department of Natural Resources. The Chagrin River stockings are as follows:

1968	30,800 coho salmon
1969	31,273 coho salmon
1970	12,060 rainbow trout
1970	40,180 coho salmon
1970	65,000 chinook salmon
1970	5,000 rainbow trout
1971	27,475 rainbow trout

These stockings were placed in the East Branch of the Chagrin River. There were return runs by coho up the river this past year from September through December. The Rocky River was not chosen because of the polluted conditions in the lower reaches of the river. The coho feeds primarily on alewife, shad, smelt, and emerald shiner. It is hoped that the salmon will fill the ecological niche left by the decline of cold water fish species, such as the sauger and blue pike. Marked coho salmon released in the Chagrin River have been caught in waters off Pennsylvania and New York, thus showing that the fish tend to move to the Eastern basin in the summer, where they are found commonly at a depth of 50 to 60 feet.

Lake Erie

Lake Erie has undergone significant changes in the last 20 years. The average individual living near Lake Erie is cognizant of the following: (a) a decline in the commercial fishery, (b) a decline of mayfiles, (c) an increase of algae washing up on the batching beaches, and

(d) mercury contamination in fish. There has also been an increase in the oxygen depletion in the bottom waters of the central basin of Lake Erie from July through September, followed by oxygen replenishment during the fall turnover time. The Central basin is deep enough to have thermal stratification, i.e., separation of epilimnion surface waters high in oxygen content and a cooler lower zone, the hypolimnion, near the bottom.

A problem exists in trying to identify a cause-and-effect relationship between the pollutants emanating from the three rivers and the aforementioned ecological changes. There has been much discussion of the causes of these various ecological changes, possibly interrelated. The decline of mayflies occurred from between the summer of 1953 through about 1958. The problem was first observed by Britt, in 1953, in the Western Basin of Lake Erie. Britt reported that there was a significant decline in population of the benthic mayfly in the sediment of the Western Basin of Lake Erie around the Bass Islands. The Western Basin is quite shallow, with an average depth of 24 feet, as compared with an average depth of 60 feet in the Central Basin. Under calm conditions, with very little mixing of oxygen from the surface waters to the bottom waters, the bottom will become quite low in oxygen, and it is thought that this action led to the decline in the mayfly population. The reason given for the low oxygen was due to the high organic content (BOD) in the sediment.

From the mid-1950's through 1960 there was a traumatic decline in the commercial fishery as far as the cold water species were concerned. During the summer these species normally spawned in the Western Basin and migrated to the Central Basin where they were commonly found in the cold waters of the hypolimnion. Various theories explaining this decline have been advanced, namely, (a) the pollutant load in the Western Basin had an adverse effect on the spawning grounds, (b) the advance of the low oxygen condition in the hypolimnion that started in the late 1950's forced the coldwater species out of its normal habitat, (c) overexploitation of the commercial fisheries. Figure 10 gives a food chain relationship of the coldwater fishery prior to 1950. Figure 11 gives the general food chain relationship in the hypolimnion in 1970, under low-oxygen conditions.

Commercial Fishing in Lake Erie

It has been often stated that the Lake Erie fishery is dead. Figure 12 shows the total commercial fish production from Lake Erie from 1920 through 1969. Although there is a great variability in catch from year to year, a general decline during the last 20 years in total production is not reflected in this graph. There has been a reduction during the 1960's in the U.S. commercial fishing catch compared with the Canadian fishery catch in Lake Erie (Table 6). Also, a significant decline of cold-water fish species, namely the blue pike and walleyes, occurred in the late 1950's. However, the total production for the entire Lake of all species has not shown a noticeable decline.

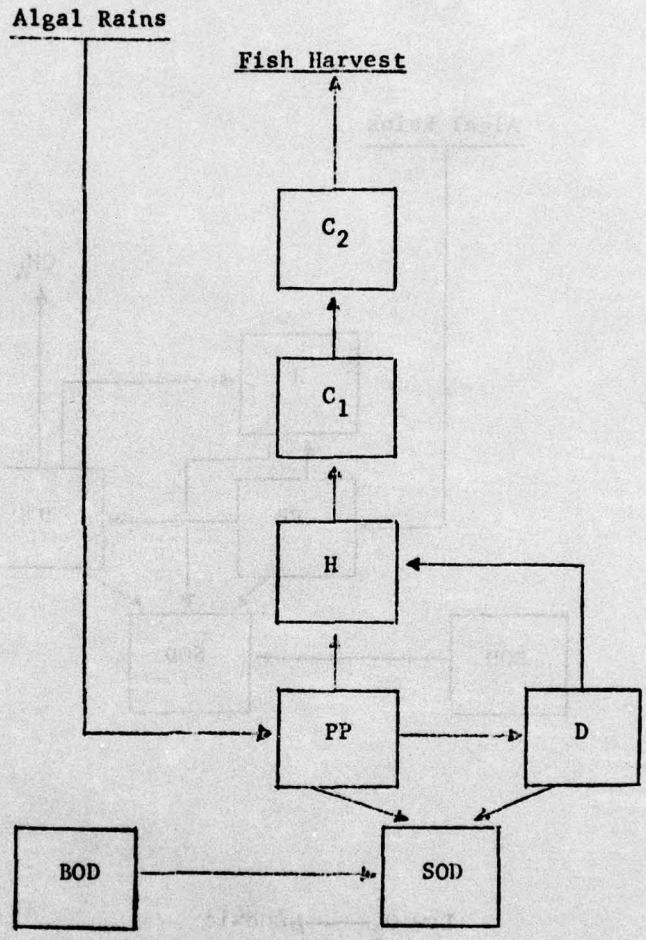

FIGURE 10. FOOD CHAIN RELATIONSHIP IN LAKE ERIE IN THE HYPOLIMNION PRIOR TO 1950

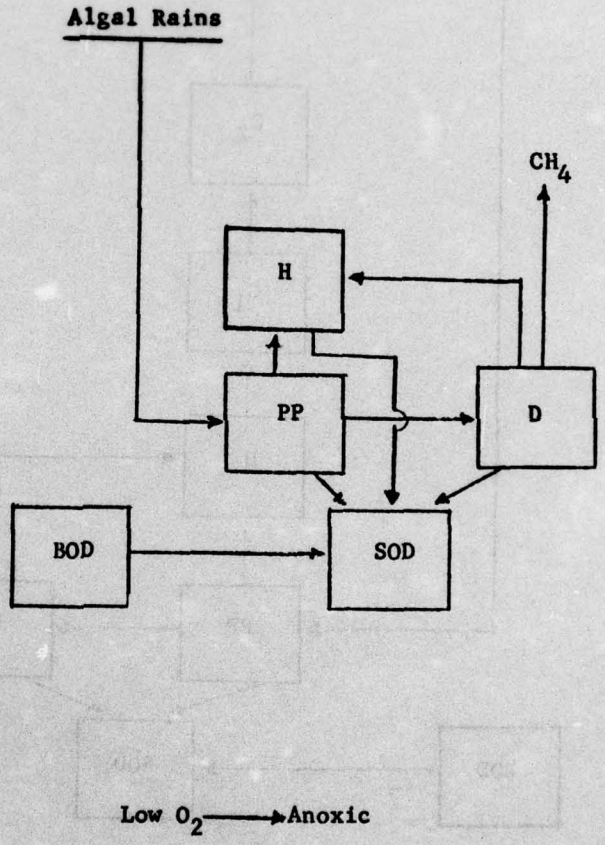

FIGURE 11. FOOD CHAIN RELATIONSHIP IN LAKE ERIE IN THE HYPOLIMNION, 1970

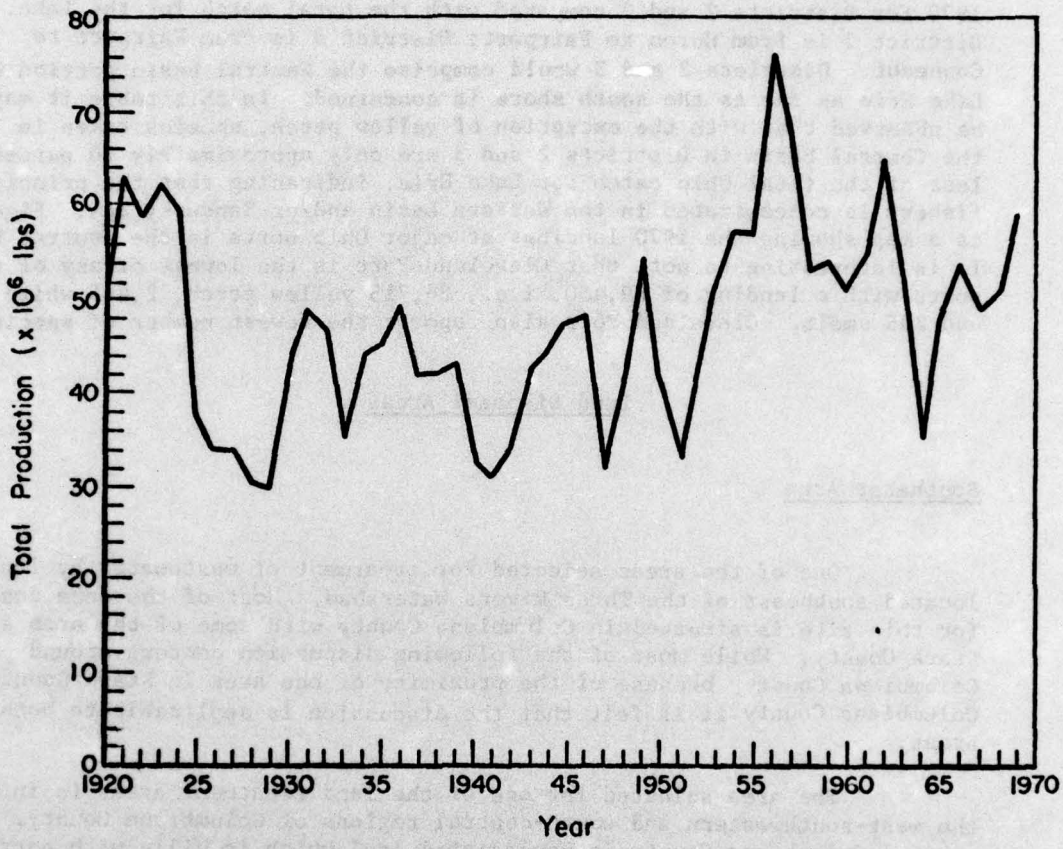

FIGURE 12. TOTAL COMMERCIAL FISH CATCH FROM LAKE ERIE, 1920-1969

TABLE 6. LAKE ERIE COMMERCIAL FISH CATCH

(In 10^3 pounds)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
U. S.	21,258	19,563	19,660	17,238	13,354	13,524	12,698	11,615	11,921	11,049
Canadian	29,219	35,698	44,465	35,301	25,381	35,096	41,426	37,770	39,415	48,026
Total	50,477	55,261	64,125	52,539	38,735	48,620	54,124	49,385	51,336	59,075

Table 7 shows the Lake Erie Ohio commercial fishery catch in 1970 for Districts 2 and 3 compared with the total catch for the Lake. District 2 is from Huron to Fairport; District 3 is from Fairport to Conneaut. Districts 2 and 3 would comprise the Central basin portion of Lake Erie as far as the south shore is concerned. In this table it may be observed that with the exception of yellow perch, species taken in the Central basin in Districts 2 and 3 are only approximately 10 percent or less of the total Ohio catch for Lake Erie, indicating that the principal fishery is concentrated in the Western basin and/or Sandusky Bay. Figure 13 is a map showing the 1970 landings at major Ohio ports in the Central basin. It is interesting to note that Cleveland Port is the lowest of any of the ports with a landing of 89,450, i.e., 86,715 yellow perch, 2,465 white bass, and 235 smelt. Cleveland Port also reports the fewest number of species (three).

Land Disposal Areas

Southeast Area

One of the areas selected for treatment of wastewater by land is located southeast of the Three Rivers Watershed. Most of the area considered for this site is situated in Columbiana County with some of the area also in Stark County. While most of the following discussion centers around Columbiana County, because of the proximity of the area in Stark County to Columbiana County it is felt that the discussion is applicable to both areas.

The area selected for one of the land treatment areas is in the west-southwestern and south-central regions of Columbiana County. South-central Columbiana County is unglaciated land which is hilly with narrow stream valleys. Its land cover is brushy to cutover woods, with abandoned strip mines contouring most ridges. The woods are interspersed with small marginal farms grazing a few head of cattle, with water from the West Fork of Little Beaver Creek presently being used for spray-irrigating potatoes and corn.

The west-southwest portion of Columbiana County selected for spray irrigation is practically divided in half between the watershed of the Muskingum River and the Ohio River. At the headwaters of the West Fork of Little Beaver Creek, the State of Ohio operates Gilford Lake State Park, while at the headwaters of Sandy Creek, the Ohio Division of Wildlife operates Zipernick Lake. Both lakes are actively utilized by sport fisherman. In addition, there are other small private lakes in the area for private clubs. Agriculture of the area would be suitable for spray irrigation because of the general rolling topography. The farms in the area are small, with strip cropping of corn, wheat, oats and hay crops. There are several farms with orchards (peach and apple), truck crops of strawberries and potatoes, as well as some elderberry plantations.

TABLE 7. OHIO COMMERCIAL FISH CATCH IN LAKE ERIE, 1970

(In pounds)

Species	District 2	District 3	Total
Buffalo	153	0	12,163
Bullhead	308	2	25,198
Carp	21,314	3	3,042,210
Catfish	16,130	75	526,718
Freshwater drum	165,995	546	1,037,682
Quillback	426	20	21,128
Smelt	259	0	259
Suckers	23,725	118	103,832
Walleye	467	0	10,258
White bass	188,518	808	1,091,864
Yellow perch	1,014,003	683,597	2,380,873
G. shad	0	0	4,909
Burbot	0	0	2
Goldfish	0	0	162,892
			8,419,988

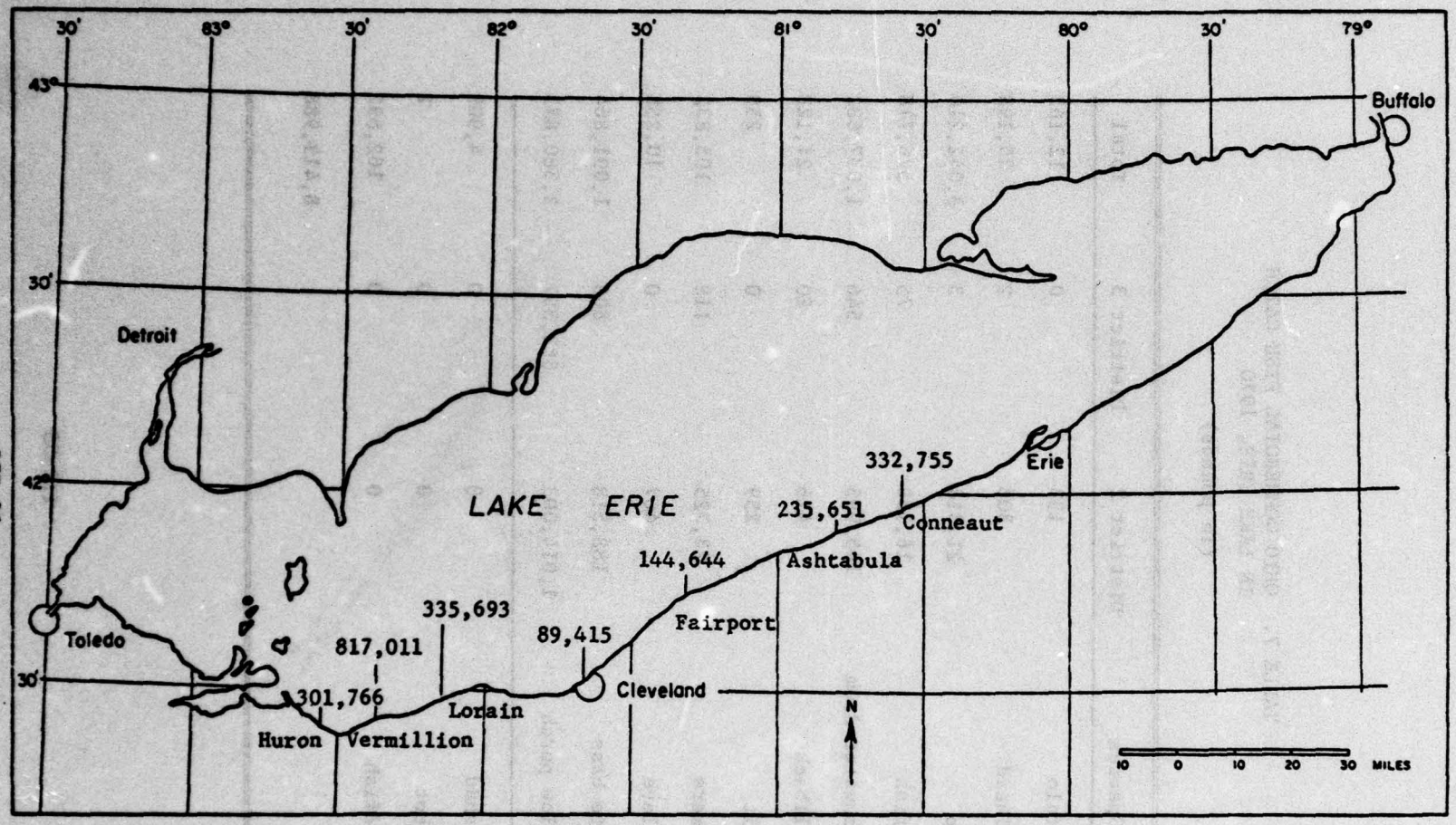

FIGURE 13. TOTAL COMMERCIAL FISH LANDINGS BY MAJOR OHIO PORTS IN THE CENTRAL BASIN OF LAKE ERIE - 1970

Source: Commercial Fish Landings, Lake Erie - 1970, Ohio Department of Natural Resources Division of Wildlife, Publication 200.

Southwest Area

The area selected for the southwestern land treatment area is in the the southern half of Ashland and Richland Counties. The land is glaciated hill land with wide rolling valleys, making possible several scenic vistas from the higher hills. The world famous Malabar Farm, of the late Louis Bromfield, is located in this region. Most of the hills and banks of the large streams are wooded. Corn is grown primarily on the flatter areas with strip cropping of grains and hay practiced on the low grade hills. There is grazing by both beef and dairy cattle on the steeper slopes. The area is in the Muskingum River watershed. A large percentage of the land is under state ownership and/or control, i.e., Muskingum Watershed Conservancy District Lakes and State Forest lands. There are several church camps and private recreational facilities in the area.

HYGIENE

Discussion of Evaluation Procedure Used in the Base Analysis

The effects of wastewater disposal practices on human health may be the result of direct personal contact with or ingestion of contaminated water, food, or soil, or they may be the result of indirect contact through plants, insects, or animals which carry pathogenic organisms or toxicants. There also may be indirect hygienic effects through nuisance organisms which multiply because of the wastewater disposal operations.

Direct Effects

Pathogens. The most commonly recognized pathogens are a relatively few varieties of bacteria and viruses. Those most important to a study of wastewater management in the United States are listed in Table 8.

Direct measure of the concentration of pathogenic bacteria and viruses in water is not generally feasible since very few of any given variety might be present and since, for each variety, a different test would be required. In order to resolve this problem, coliform bacteria which are not pathogenic and are discharged in large numbers (200 to 400 billion per person per day) by humans* are measured and the possible content of potentially pathogenic bacteria and viruses in any sample is inferred from this measure. Coliform bacteria occur in the intestinal tracts of all warm-blooded animals, but a high concentration of them in a stream or lake usually indicates fairly recent contamination by human feces. Escherichia coli is specific to warm-blooded animals and is often referred to as "fecal" coli. Bacteriological water quality measurements usually include counts of both total coliform and fecal coliform bacteria.

Use of the coliform tests to indicate the likelihood of the presence of viruses has been widely questioned. The practice is defended on the basis that viruses, like coliform bacteria, tend to die when not in a host organism, though the rate of population die off may be lower than for bacteria**, especially at low temperatures.*** An interesting

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* Phelps, Erle B., Steam Sanitation, John Wiley and Sons, Inc., New York, 1944.

** Krone, R. B., "The Movement of Disease Producing Organisms through Soils", in Wilson, C. W., and Beckett, F. E., editors, Municipal Sewage Effluent for Irrigation, proceedings of a symposium held at Louisiana Polytechnic Institute, July 30, 1968.

*** Le Gros, P. E., and Drobny, N. L., "Viruses in Polar Sanitation--A Literature Review", Technical Report R 505, Naval Facilities Engineering Command, U.S. Naval Engineering Laboratory, Port Hueneme, California December 1966.

TABLE 8. IMPORTANT PATHOGENIC BACTERIA AND VIRUSES*

Organism	Disease
Bacteria	
Salmonella	Salmonella gastroenteritis, typhoid fever
Shigella	Bacillary dysentery
Enteroviruses	
Poliovirus	Paralytic poliomyelitis, aseptic meningitis
Coxsackie, Group A	Herpangina, aseptic meningitis
Coxsackie, Group B	Pleuroclynia, aseptic meningitis
Infectious Heptitis	Infectious hepatitis
ECHO (enterie cythopathogenic human origin)	Aseptic meningitis, "summer rash, diarrheal disease
Adenovirus	Respiratory and eye infection

* Dunlop, Stuart G., "Survival of Pathogens and Related Disease Hazards", in Wilson, C. W., and Beckett, F. E., editors, Municipal Sewage Effluent for Irrigation, proceedings of a symposium held at Louisiana Polytechnic Institute, July 30, 1968.

Clarke, N.A., Berg, G., Kabler, P.W., and Chang, S.L., "Human Enteric Viruses in Water: Source, Survival, and Removability", in Eckenfelder, W.W., editor, Advances in Water Pollution Resource, proceedings of the International Conference held in London, September 1962, New York, the Macmillan Company, 1964.

observation is that the rate of die off is higher in moderately polluted water than in either very pure or grossly polluted waters. The use of the bacterial indicator is also defended on the basis that viral counts in sewage and polluted surface waters are much lower than bacterial counts. One investigation has resulted in calculations of coliform bacteria to enteric viruses ratios of 92,000:1 in sewage and 50,000:1 in polluted surface waters.* It is significant to add, however, that due to their relatively much smaller size, viruses are more likely than bacteria to be protected by suspended materials from disinfecting agents added to water.**

Aside from bacteria and viruses, there exist a number of other pathogenic organisms associated with fecal contamination which should be mentioned here. Most of them, fortunately, are relatively rare in the United States. Fungal forms include Vibrio and Leptospira, which causes cholera and leptospirosis, respectively. Isopora and Entamoeba are protozoans (one-celled animals) which cause coccidiosis and amoebic dysentery. The sporozoan parasite responsible for malaria is also among the protozoans though it is not transmitted by water, but rather, by the anopheline mosquito which breeds in water. Finally, large parasites include the flatworms (liver fluke and tapeworm) and the roundworms (ascaris).*** The round and flatworms are especially significant since they and their eggs are quite resistant to normal sewage treatment and disinfection.****

The only organisms regularly monitored in water quality measurements are the viruses and bacteria, and they are not measured directly, as has been noted earlier. The others may be measured directly, but they seldom are unless there is clinical evidence that they are infecting the human population. For a description of the water quality standards see the "Public Health Service Drinking Water Standards".*****

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* Clarke, et al., 1964.

** Culp, Russel L., "Virus and Bacteria Removal in Advanced Wastewater Treatment", Public Works, June, 1971.

*** Krone, 1968, National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, "Water Quality Criteria", April 1, 1968, Washington, D.C.

**** National Technical Advisory Committee to the Secretary of the Interior, 1968.

***** U. S. Department of Health, Education, and Welfare, Public Health Service, "Public Health Service Drinking Water Standards", 1962.

Toxicants. There are a fairly large number of chemical elements and compounds which have been shown to be toxic to man. Water quality standards for them are, in most cases somewhat arbitrary since the clinical effects of chronic low-level doses are not well known, individual susceptibility to the materials varies widely, combinations of two or more of them may have reinforcing or antagonistic effects on each other or combinations of them with other substances such as acids, bases, or surfactants may be more toxic than they would be alone. To further complicate the problem, most of these materials tend to accumulate in the tissues of animals and plants, an effect which is multiplied by the food chain so that animals at the top of the chain receive rather concentrated doses through the animals and plants they consume. Man is at the top of many food chains.

A thorough discussion of the effects of toxicants, recommended water quality standards, and the reasoning behind the standards can be found in the "Public Health Service Drinking Water Standards"* and in McKee and Wolf's Water Quality Criteria.** In order to minimize the possibility of clinical effects from toxic substances in water, the standards for the materials have been set much lower than the concentrations at which effects have ever been observed.

Indirect Effects

Indirect effects of wastewater disposal practices include disease caused in man through transmission of microorganisms or toxicants to him by way of animals, plants, or insects.

Generally, wastewater-related diseases passed to man by plants or animals result from microorganisms or parasites adhering to and coating the skin of the animals or surfaces of the plants. Most bacteria and viruses which cause diseases in man are too specific to survive in the body systems of animals, and they seldom progress beyond the roots in entering plants.*** An exception to this is malaria, but it is not prevalent in northern Ohio.

Indirect infection with microorganisms or parasites is not a problem in the present northern Ohio area since raw sewage and sludge are not widely disposed of on the surface of the soil.

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* U.S. Department of Health, Education, and Welfare, Public Health Service, 1962.

** McKee and Wolf, 1963.

*** National Technical Advisory Committee to the Secretary of the Interior, 1968.

Toxicants, on the other hand, tend to be concentrated in plant and animal tissues. The only toxicant which has been shown to approach or exceed safety limits in this fashion in northern Ohio has been mercury. This metal has been measured in fish in Lake Erie at levels clearly exceeding the 0.5 mg/kg safety limits accepted by the U.S. Food and Drug Administration.*

Samples of sediments taken from the Black River, Ohio, near the mouth and from Lake Erie near the Cleveland Easterly Sewage Treatment Plant outfall measured 8 and 4 mg/kg of mercury sediment, net weight, respectively. A sample from Euclid near sewer out falls measured 2 mg/kg. These concentrations were found even though dissolved concentrations in treatment plant effluents and polluted streams measured only 0.002 to 0.004 mg/l mercury. Fish pick up mercury from the bottom through direct ingestion and absorption through gills and possibly scales.*

Three Rivers Watershed

Rocky River Basin

Two communities in the Rocky River Basin depend upon surface water, other than Lake Erie, for water supply (Figure 14). Berea, which serves 19,000 people, has an intake in the lower portion of the East Branch. Its system needs water treatment improvements. Medina, serving 10,000 people, has a plant located on the West Branch just downstream of the confluence with the North Branch.

According to a study completed in 1970**, water quality at both intake stations meets all criteria except bacterial. In that study, samples taken in the vicinity of the Berea and Medina intakes, respectively, averaged 11,707 and 22,977 total coliform bacteria, far over the 5,000 limit specified by the Ohio water quality standards for the Rocky River in the two relevant stretches.

The Rocky River has already been developed for recreational purposes by the Cleveland Metropolitan Park District*** throughout the mainstream, and in the East Branch from its confluence with the mainstream to its confluence with Healey Creek, near Medina. The District

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* Federal Water Quality Administration and the Natural Field Investigations Center, 1970.

** State of Ohio, Department of Health, 1969.

*** Whitman, I. L., Davin, R. M., Goldstone, S. E., Dee, N. V., Molholm, L., Connell, K. R., and Milstead, R. J., "Evaluating Urban Core Usages of Waterways and Shorelines", prepared for the Office of Water Resources Research, U.S. Department of the Interior, April 30, 1971.

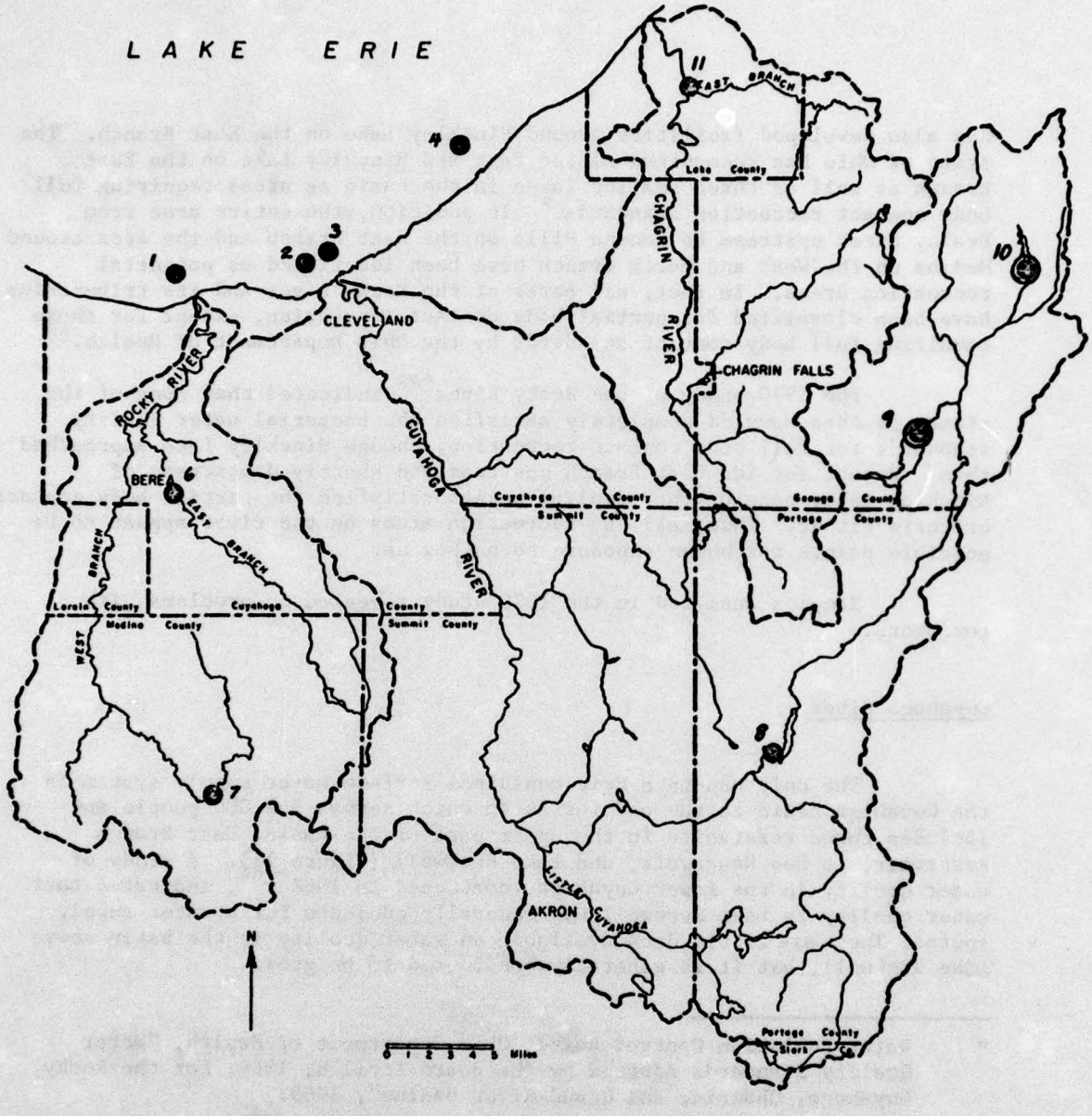

FIGURE 14. WATER SUPPLY INTAKES IN THREE RIVERS AREA

- • Water Supply Intake
- ⊙ Water Supply Storage
1. Cleveland - Crown
2. Cleveland - Division
3. Cleveland - Baldwin
4. Cleveland - Nottingham
5. Ohio Water Services - Mentor
6. Berea
7. Medina
8. Akron - Lake Rockwell
9. Akron - La Due Reservoir
10. Akron - East Branch Reservoir
11. Willoughby

has also developed facilities around Hinckley Lake on the East Branch. The state of Ohio has recognized Albion Park and Hinckley Lake on the East Branch as well as three smaller lakes in the basin as areas requiring full body contact recreation standards.* In addition, the entire area from Healey Creek upstream to Seneca Hills on the East Branch and the area around Medina on the West and North Branch have been identified as potential recreation areas. In fact, all parts of the Rocky River and its tributaries have been classified for partial body contact recreation, except for those requiring full body contact standards by the Ohio Department of Health.**

The 1970 study of the Rocky River*** indicated that none of the stream reaches sampled completely satisfied the bacterial water quality standards for full body contact recreation, though Hinckley Lake approached them. Except for the East Branch upstream and shortly downstream of Hinckley Lake, none of the sampling points satisfied the partial body contact criteria either. Thus, all the recreation areas on the river appear to be possible points for human exposure to pathogens.

Samples analyzed in the 1970 study revealed no problems with toxicants.

Cuyahoga River

The only non-Lake Erie municipal surface water supply system in the Cuyahoga basin is the one for Akron which serves 352,000 people and includes three reservoirs in the upper part of the basin, East Branch Reservoir, La Due Reservoir, and Lake Rockwell (Figure 14). A study of water quality in the Lower Cuyahoga, conducted in 1968****, indicated that water quality in Lake Rockwell was generally adequate for a water supply source. There are little data available on water quality in the basin above Lake Rockwell, but it is generally considered to be good.

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* Water Pollution Control Board, Ohio Department of Health, "Water Quality Standards Adopted by the Board April 8, 1969, for the Rocky, Cuyahoga, Chagrin, and Grand River Basins", 1969.

** Water Pollution Control Board, Ohio Department of Health, 1969.

*** Ohio Department of Natural Resources, "A Statewide Plan for Outdoor Recreation in Ohio, 1971-1977, Part I--Inventory and Resource Analysis, Section, Lakeshore Uplands Region", February, 1970.

**** Havens and Emerson, Ltd., 1968.

All waters in this part of the basin have been classified for use in full-body-contact water recreation. In the tributaries to many of streams in northeast Ohio, septic tank drainage creates a bacterial problem. This situation may exist in the upper Cuyahoga.

The Cleveland Metropolitan Park District has developed land along a portion of the Lower Cuyahoga, from the Cuyahoga-Summit County line downstream to, and including a portion of, Tinkers Creek. In addition, the Ohio Department of Natural Resources has identified the portion of the lower Cuyahoga, extending below the Cleveland parks to West Creek near Granger Road, and upstream of them to Yellow Creek, near Bath Road, as a potential recreational area. Identified also by the Department were several areas in the upper basin.**

The entire mainstem and many of the tributaries to the Cuyahoga downstream of Lake Rockwell are grossly polluted. Bacteria and various metals exceeded the drinking water and recreation standards in all samples, except at Lake Rockwell Dam. Clearly, all recreational areas along these polluted waters represent a serious health hazard, even though water contact recreation is not encouraged in them.

Chagrin River

Only Willoughby, serving 14,000 people, has a surface water supply in the Chagrin Basin (Figure 14). In the 1970 water quality study on the Rocky and Chagrin basins***, bacterial water quality at the sample stations nearest the Willoughby intake was not within water supply standards.

The Cleveland Metropolitan Park District has developed recreational areas near Gates Mills and in the Chagrin Falls areas. The Ohio Department of Natural Resources has indicated that almost the entire mainstem, part of the East Branch, and Silver Creek, tributary to the river northeast of Chagrin Falls, all have recreational potential.**** On the

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* Whitman, et al, 1971.

** Ohio Department of Natural Resources, 1970.

*** Havens and Emerson, Ltd., 1970.

**** Ohio Department of Natural Resources, 1970.

basis of the 1970 study*, only the East Branch in the area of the Geauga-Lake County and Kirtland Road is of full-body-contact water quality. The Aurora Branch and the mainstem upstream of the confluence with the Aurora Branch appeared to be acceptable for partial body contact recreation. Though the Ohio Water Pollution Control Board has classified the entire river and its tributaries for partial body contact recreation**, the mainstem below Chagrin Falls did not satisfy the bacteriological criteria at any of the four sample points distributed along its length. Since this is the stretch most developed and most identified for its recreational potential, it must be considered a health hazard under present conditions.

Lake Erie

Direct exposure of human beings to pathogens and toxicants in Lake Erie occurs through water supply systems taking water from the Lake or through recreation activities.

Five water supply intakes are located along the shoreline of Lake Erie in the immediate area of the Three Rivers Basins (Figure 14). From west to east, these are the Cleveland-Crown, Cleveland-Division, Cleveland-Baldwin, Cleveland Nottingham, and Ohio Water Service-Mentor intakes. The water intake cribs are located at varying distances offshore and in varying depths of water.*** Table 9 indicates their exact locations.

TABLE 9. LAKE ERIE WATER INTAKE CRIBS, THREE RIVERS AREA

Intake Name	Total Depth of Lake ft	Intake Depth ft	Distance From Shore, ft
Cleveland-Crown	44	19	12,000
Cleveland-Division	50	34	20,000
Cleveland-Baldwin	47	17	17,000
Cleveland-Nottinghma	49	38	18,000
Ohio Water Service-Mentor	17	14	2,000

* Havens and Emerson, Ltd., 1970.

** Water Pollution Control Board, 1969.

*** U.S. Department of the Interior and Ohio Department of Health, "Lake Erie Intake Water Quality Summary, 1968 and 1969"; 1969 and 1970.

According to analyses of intake water quality, the only standards for a drinking water source not met by all the stations all of the time is the bacterial limit at the Ohio Water Services-Mentor intake. This station is influenced by the discharge of Cleveland. All tests for toxicants in the water were negative or easily within acceptable limits. Since these five intakes serve 1,890,300 people, or about 78 percent of the population of the three rivers area (population 2,421,000 in 1970), it appears that most of the population is in little present danger of infection or poisoning from public water supplies.

Water contact recreation is possible in several places along the Cleveland area shore of Lake Erie. Of eight shoreline parks in the Three Rivers area of Lake Erie, the Federal Water Pollution Control Administration in 1968 rated one as generally safe on bacterial grounds, and seven as unsafe.* It is clear, therefore, that the bacterial water quality near the shore is far inferior to that farther out, as measured by the water intake data. The Ohio waters of Lake Erie are classified by the Ohio Water Pollution Control Board for full-body-contact recreation**, a classification not presently achieved.

Land Disposal Areas

Southeastern Area

Surface water resources in this area are of significance more for recreational purposes than for water supply. Only the communities of Salem City, Salineville Village, Wellsville City, and East Liverpool are dependent on surface water for water supplies. Salem City uses Salem Reservoir, located about 6 miles south of the city of the Middle Fork on the Little Beaver Creek. Wellsville Reservoir, west of Salineville, supplies that community. East Liverpool uses water from the Ohio River. The other communities utilize wells drilled primarily into the buried valley ground-water supplies, though some wells draw from underlying sandstone deposits.***

Under present conditions, ground water quality is not considered too serious a problem. Water shortage may become important if the communities draw upon the water table by overtaxing the aquifer capacity. Surface supplies are limited by the small size of the stream drainage areas, resulting in very low dry weather flows, and by water quality problems resulting from extensive coal mining and septic tank drainage.***

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* U. S. Department of the Interior, Federal Water Pollution Control Administration, Great Lakes Region, "Lake Erie Report", 1968.

** State of Ohio, Department of Health, 1969.

*** Columbiana County Regional Planning Commission, "General Development Plan, Columbiana County, Ohio Natural Resources Study", Report No. 4, 1968.

Recreational development of surface waters in Columbiana County is significant now and may be greatly increased in the future. At the present time, 3.3 percent of the total County area is recreational space. Of the 11,399 acres, 1,439 acres are water*.

Owing to the rolling to steeply sloping topography of the area, the southern half of which is unglaciated, and to the relatively undeveloped state of the watersheds, much of the area is considered potential recreational space. The Little Beaver Creek is being considered for inclusion in the national wild and scenic rivers system. This existing and potential recreational development makes body contact water recreation a large and growing consideration in water quality management. In recognition of this circumstance, the State water quality standards call for full-body water contact throughout the area.

Soils in the area are of variable composition. They are glacial till in origin in the glaciated portions, and in the unglaciated sections, they have formed from sandstones and shales. The former are more fertile than the latter, but drainage is not adequate in many places. Important to note is that in the unglaciated areas, the soils are thin in many cases, sometimes less than 4 feet thick, and they lie on steep slopes which make them susceptible to erosion.

Southwest Area

As in the case of Columbiana County and adjacent areas in southeast Stark and northwest Carroll Counties, surface water is little used for water supply in southern Richland and Ashland Counties. A very good buried valley system underlies the major streams in the area and, in fact, is interconnected across surface watershed boundaries.

The topography of the area is rolling to steeply sloping**, which makes it ideal for recreational development and also, fortunately, provides good sites for flood control reservoirs. Clear Fork, Charles Mill, Pleasant Hill, and Mohicanville Reservoirs are all major impoundments and are all in the immediate vicinity.***

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* Ohio Department of Natural Resources, 1970.

** State of Ohio, Department of Natural Resources, Division of Lands and Soil", Know Ohio's Soil Regions", map and text, revised 1962.

*** U.S. Army Corps of Engineers, Ohio River Division, "Water Resources Development" by the U.S. Army Corps of Engineers in Ohio", January, 1971. State of Ohio, Department of Natural Resources, Division of Water, 1968.

Water quality is generally good, hygienically, except for bacterial contamination. In a 1967 sampling program, the Ohio Department of Natural Resources found that on Black Fork about the confluence with Rocky Fork (just below Charles Mill Reservoir) and on Clear Fork below Pleasant Hill Reservoir, bacterial counts were well within the limits for full-body-contact water recreation.* In the report on that study, it was noted that Pleasant Hill Reservoir is used as a swimming area. It was the only major reservoir in the are at that time so used. State water quality standards specify that full-body-contact water recreation is to be accommodated in the streams throughout the area by January 1, 1972.

AESTHETICS

Clean, sparkling water has high aesthetic value. It is obviously more pleasing in color, odor, and taste than polluted water.

Related to these qualities are certain aesthetic values which arise from the presence of aquatic fauna and flora. The presence of fish, other animals and plants adds appreciably to stream and lake values. Polluted water which is lifeless, or nearly lifeless, has little appeal.

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* State of Ohio, Department of Natural Resources, Division of Water, 1968.

In determining aesthetic parameters for surface water, it is necessary to keep in mind that the waste treatment methods, and the physical design of water treatment processes, vary considerably. This study is designed to evaluate the various methods of wastewater treatment and the quality of the resulting water from an aesthetic viewpoint.

Individuals vary in their reaction to the physical environment. Therefore, it is difficult to determine precise and undeviating measurements of aesthetic quality.

For example, jazz music as opposed to a Beethoven symphony, a bold abstract painting compared to a detailed Norman Rockwell portrait, and the colonial home compared to a Frank Lloyd Wright house are just a few examples of areas where there could be disagreement about which was more aesthetically satisfying.

However, the aesthetic criteria for the purpose of the study and this report have been carefully selected and defined with a high sensitivity toward environmental and social values. The four broad aesthetic sectors selected are: land, water, biota, and air.

Discussion of Evaluation Procedure Used in the Base Analysis

Land

Natural Contour. The scenic quality of land, as it relates to topography, is largely proportional to the extent of relief and the degree of slope. A river situated on flat lands is less scenic than one nestled in a steep canyon. However, it is important to have both in a balanced system. Improving the water quality of a river already situated in a dramatic setting of gorges and water falls increases the aesthetic value of that area significantly.

Lakes and Streams--Their Alignment and Composition. The human eye and mind react favorably to a natural, meandering stream with tree-lined banks. When this condition is altered by straight, crude channelization, which destroys vegetative cover on both sides of the stream, the aesthetic rating lowers. On the other hand, a stream aligned by nature, with open space, trees, and grass on each side, ranks high aesthetically. At the same time, an artificially controlled stream, with well designed and maintained structures, may also be attractive. Least pleasing are those river fronts which have been usurped and crowded by dilapidated residential, commercial, and industrial buildings and aggravated by litter and debris dumped upon the banks.

It is not necessary in the latter half of the twentieth century for designers, engineers and builders to dominate and subdue nature. People have become aware that their lives are interwoven with the natural world and that a harmonious relationship is vital to their continued existence upon the planet.

Sewage disposal building, channel relocation, service roads and all structures constructed as part of this project should, to the fullest possible extent, be compatible and subordinated to nature; even though economics and function are of paramount importance in the design of man-made structures. To the degree feasible, low horizontal buildings should be used in lieu of narrow vertical structures, because the former type of building will generally "blend" better with the surrounding environment.

Graceful curving alignment for service roads and channels with a minimum of major cuts and fills will result in more pleasing aesthetics. The use of low earth mounds and landscape plantings can aid in subordinating man's activities. The more natural and less obstrusive the structures are made, whether buildings, streams, lagoons, or ponds, the higher will be their aesthetic rating.

Water

One of the country's most important natural resources is its rivers and streams. Unfortunately, this asset has often been overused and abused to the point of ugliness. Clear, free-flowing streams and rivers have too often been transformed into open sewers which support little or no life or have any real usefulness.

Few sights appeal to humans more than a stream or lake with the clean color of pure water. The muddy turbid water caused by soil erosion is certainly less aesthetically pleasing than clean water. However, the lowest ranking is for water impregnated with sewage, mining wastes and industrial effluents. This type of water is hygienically and aesthetically repulsive.

Although a breeze blowing off the ocean or large lake may have a pleasant smell, the lack of any odor from a body of water is most aesthetically acceptable. Rivers and lakes which receive large quantities of raw sewage or offensive industrial pollutants are likely to have a repulsive odor. Small streams receiving the primary treatment effluent from a sewage disposal plant may also have a negative aesthetic rating, particularly during still, humid weather.

While taste infers more of a hygienic consideration, it is nevertheless true that water for recreational activities, such as swimming and water skiing, is most pleasing when it is free of any taste.

During the Italian Renaissance, garden designers realized the importance of the sound of splashing, running water. The gurgling of a brook, the splash of a waterfall, the rush of whitewater, and the roar of the surf definitely add to the aesthetic quality of man's environment.

These important characteristics are grouped into two components for the impact analysis

- Physical characteristics (color, odor, taste, movement)
- Surface characteristics (oil, debris).

Biota

Living plants and animals create an infinite and changing variety of visual composition. Aesthetic qualities which relate to vegetation are height, density, type or species, color, and whether potentially harmful.

Height relates primarily to trees and the larger shrubs. Very tall, mature trees provide scenic qualities not often found in brush-stage or pole-stage forests. Extra large rhododendron would have more eye-appeal than smaller plants of the same species. Density is more often a negative factor. Very dense forests which are difficult to walk through are not nearly so attractive to most humans as an open parklike forest.

Dense shrub growth or even very dense grass may also make walking difficult. Many people associate dense forest and dense vegetation of any kind with dangerous animals and poisonous snakes and are ill at ease or outright frightened when in such cover.

Although personal preference and prejudice would be involved, certain types or species of vegetation are more attractive than others. A mixed hardwood-coniferous forest might provide the greatest contrast in color and form for the average eye. Yet some may prefer a pure stand of conifers, while others may prefer a stand of mixed hardwoods with no conifers. Most everyone prefers trees to lesser vegetation.

Flowering shrubs may have more eye-appeal than nonflowering species. Ferns may be more attractive than grass and one kind of grass may be greener than another kind. Thus, aesthetic appeal is definitely related to vegetation type and species. Color can be an extremely important aesthetic characteristic in the case of vegetation. Brightly colored flowers are an obvious attraction, whether they are low-growing annuals, shrubs, vines or trees. Foliage color may have significance, too, particularly during the fall when the foliage of hardwoods takes on temporary brilliance.

The presence of extensive green coloration in vegetation is also important. This restful color signifies a productive soil and a well watered earth to the average person and he responds favorably to the verdant scene.

The presence of animals around a body of water provides very positive aesthetic values. If deer were present in the project areas, for example, they would have great appeal. However, smaller animals--squirrels, rabbits, water fowl, songbirds, etc., add measurably to the total aesthetic and recreational experience, also.

Air

The air pollution caused by motor vehicles, industrial (and residential) emissions, and power generation create many problems in society. One of these concerns the aesthetics of the area. Aesthetic problems created by the air pollutants of carbon monoxide, sulfur oxides, hydrocarbons, particulate matter, and photochemical oxidants are low visibility, odor, taste, and irritation of eye and throat. There is also an effect on the vegetation of an area because of these air pollutants.

Three Rivers Watershed and Lake Erie

Land

Natural Contour. The natural topography of the Three Rivers Basin consists of two geological sectors. Along the shores of Lake Erie exists a narrow flat plain, while the rest of the basin is made up of a gently rolling plateau. Sectors of each of the three major rivers in the basin flow through gorges that have been cut through the sandstone, shale, and clay of the area. These gorges, which wind through the basin, when combined with the flat plan and plateau provide a picturesque topographic composite for the Cleveland urban setting. Also, situated in these gorges are rock out-croppings which provide natural waterfalls and rapids.*

* Ohio Department of Health, 1968.

In the Chagrin and Rocky Rivers Basins and in parts of the Upper Cuyahoga, land adjacent to the river has been preserved in its natural setting of trees and vegetation. This refreshing and somewhat inspiring composite of land topography does not exist in the Lower Cuyahoga. The valley, which becomes wider as the river approaches Lake Erie, is heavily industrialized. In this Lower Cuyahoga Basin, there is adequate relief to provide for an aesthetically pleasing setting; however, the industrial development overshadows any desirable environment.

The topography of Lake Erie shoreline adjacent to the Three Rivers area consists, generally, of high clay banks with narrow beaches. Near the shoreline of these beaches, the mud and high organic matter which exists in the center of the Lake is replaced by sand and gravel.*

Lakes and Streams - Their Alignment and Composition. In the Rocky River, Chagrin, and Upper Cuyahoga, a natural backdrop exists adjacent to the water. Low density development, vegetation, and trees--hemlock, yellow birch, sycamore, maple--and open space park land provide a pleasant feeling of being close to nature. The winding nature of these streams combined with the frequent rapids and falls adds to the aura of a natural setting. In the Rocky River Basin, East Branch, the Cleveland Metropolitan Park District has purchased and developed a park system adjacent to the river. Atmosphere of a bubbling meandering river, when combined with the natural park setting, presents an appealing environment.

The Cuyahoga River from Akron to Lake Erie paints a different picture. The water is slow moving, winding occasionally on its way to the Lake. The stream is tree lined in places and although polluted is somewhat pleasing.

As the river enters the Cleveland area, the land use adjacent to the River and the navigation channel changes to industrial. This use continues until the river reaches Lake Erie. The industrial area of the lower Cuyahoga and of parts of Akron provides a typical urban setting for a polluted river.

The land use adjacent to Lake Erie restricts a majority of the Cleveland population from using the Lake. In the city the port occupies the principal shoreline, while in the suburbs, residential development occupies the waterfront. The 1960 distribution of land uses for the area is given in Table 10.

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* Federal Water Pollution Control Administration, 1968.

TABLE 10. CLEVELAND LAND USE ON LAKE ERIE*

	Percent
Recreation - Public	15.4
Recreation Restricted	15.8
Recreation Commercial	1.6
Residential	46.2
Commercial and Port Facilities	5.8
Institutional	6.4
Utilities	6.2
Vacant	2.1

* Regional Planning Commission, Cleveland, Cuyahoga County, "Lake Front Study", July, 1962.

The lack of large park lands adjacent to the lake does not provide the composition of land uses that should be present in an urban area with such a water resource.

Water

Physical Characteristics. Water pollution in a river directly influences the color, odor, and taste of the water, while the topography and man-made structures influence the water's movement. Because there are many reaches of the streams in the Three Rivers Watershed that are polluted and therefore possess aesthetically unpalatable feelings, it is difficult to list all of them in this feasibility study. Some of the major problem areas with respect to color, odor, and taste are:

- Lakefront (Lake Erie)

  Mixture of the blue waters of the Lake with the often chocolate colored waters of the Cuyahoga is aesthetically offensive. Soil erosion and algae blooms all along the lakefront also contribute to the aesthetic problem.

* Havens and Emerson, Ltd., 1968.

** Havens and Emerson, Ltd., 1970.

*** Federal Water Pollution Control Administration, 1968.

**** Ohio Department of Health, 1968.

- Lower Cuyahoga

  River is dark brown color and almost septic as it flows through the industrial complex in the Cleveland Flats.

- Akron, Kent, Ravenna

  River dark gray, odorous, and septic in bank zones.

- Tributaries to Cuyahoga

  Algae and color problems exist in

  - Tinkers' Creek
  - Brandywine Creek
  - Chippewa Creek

- Rocky

  Algae blooms and high sediments exist in the East and West Branches and the main stream. Occasionally, odor problems interfere with the usage of the park which is adjacent to the river.

In the Rocky, Chagrin, and Upper Cuyahoga, the water movement is through numerous waterfalls, rapids, and small pools. This composite of rapids and pools gives a refreshing appearance to the stream. In the main stream of the Cuyahoga, the water is slower moving and greater in depth. This difference in river flows provides the necessary comparison to make the area - except for the pollution - aesthetically acceptable.

Surface Characteristics. The rubbish, dead fish, oil, and natural debris which are present in the rivers of the United States present a repelling picture to society. Some of these aesthetic problems are not directly the cause of water pollution. They result from natural conditions and from misuse of the river by individuals because the water is already polluted. However, in some cases, this debris exists in areas where the water is clean.

Some of the major problem areas are: * - ****

- Lakefront (Lake Erie)

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* Havens and Emerson, Ltd., 1968.

** Havens and Emerson, Ltd., 1970.

*** Federal Water Pollution Control Administration, 1968.

**** Ohio Department of Health, 1968.

- Cuyahoga-Akron, Kent, Ravenna, Cleveland
- Rocky - East and West Branch
- Chagrin (headwaters)
- Upper Cuyahoga

Biota

Many of the areas that are adjacent to the Rocky, Chagrin, and Upper Cuyahoga are abundant in animals and possess numerous types of vegetation. The existence of this biota results from the conservation goals of the Cleveland Metropolitan Park District which has many undeveloped park lands adjacent to these streams and the low population density adjacent to many of these streams.

Air

Cleveland metropolitan area represents one of the major air pollution problems in Ohio, although it enjoys a flushing of pollutants onto the Lake. This is primarily because of the extensive industrial development in the flats area.

Land Disposal Areas

Land

In the southeast disposal area, primarily Columbiana County, the topography varys greatly in relief from the northern border with Mahoning County and the southern border with West Virginia, and Jefferson and Carroll Counties. The northern section consists of an undulating to rolling topography, while the southern section is made up of rugged steep slopes.* This change in relief occurs because of the change in geology from a glacial plain to part of the Allegheny Plateau. The difference in relief in many areas varies as much as 265 to 390 feet as measured from the valley bottom to the ridge line.

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* State of Ohio , 1962.

Most of Columbiana County is in the Little Beaver Watershed which flows southeast into Pennsylvania and finally empties into the Ohio River. The river for the most part flows through gorges that are too narrow for agriculture, industry or urbanization. Another watershed that is of some importance to the neighboring counties to the west is the Sand Creek River Basin. The headwaters of this river originate in the east-central portion of the county and flow southwest finally emptying into the Muskingum River.

Sections of Columbiana County have been developed for strip mining. This activity has produced spoil slopes and lack of vegetation, resulting in an increase in runoff and siltation in the mined areas and those areas downstream from the mining operations.

The Little Beaver River in Columbiana County for the most part is situated in an aesthetically pleasing setting. Because the slopes of the river valley are steep much of the high residential, industrial, and commercial development normally pr sent in a river valley is not present here. This leaves the river in its natural setting, which, because of its topography and tree-lined valley bottoms, presents an appealing picture. This river is being considered as a scenic river under the Wild River's Act.*

In the southwest disposal area in Richland and Ashland Counties the topography is predominantly undulating to rolling in nature.** However, in the extreme southern section of Ashland County, the topography changes to one of steep rugged slopes. The southern sections of these counties are in the Mohican River Basin which flows into Walhonding River and finally into the Muskingum River.***

The Mohican River flows in a well-known scenic valley in both Ashland and Richland Counties. After the river leaves the Pleasant Hill Reservoir, it winds its way unto the northern section of the Mohican State Forest. This river and reservoir are situated in an aesthetically pleasing setting.

Water

The water quality in the southeast disposal area is generally in good condition. However, in the strip mining areas there is a water quality problem. The runoff and mine drainage from the active and inactive mines creates acid conditions in the streams - color changes in the stream and stream bed.

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* Columbiana County Regional Planning Commission, 1968.

** State of Ohio, 1962.

*** Ohio Department of Health, Division of Engineering, "Report and Recommendations on Water Quality for Muskingum River Basin", October, 1968.

Another pollution problem resulting from the strip mining, is the increase in sediment in the streams resulting primarily from the surface runoff. Although dead fish and algae are not major problems, some aesthetic problems do exist because of rubbish, debris, and landfills present in areas adjacent to the streams.

In the southwest area water quality is not considered a problem other than some bacterial contamination. The reservoirs and streams in this area are used extensively for swimming, fishing, and boating. Rapids and swiftly moving streams provide excellent areas for canoeing and are aesthetically pleasing.

Biota

In Columbiana County much of the undeveloped area is in forest cover. The three predominant forest covers in the area are beech and maple (North); beech, maple, and oak (Central); and oak and hickory (South). Because the Little Beaver and its tributaries drain these forested areas, numerous biota - animals and vegetation - exist in the areas adjacent to these streams.*

In the southern section of Ashland County is located the Mohican and Memorial State Forest which includes over 4000 acres. The Mohican River flows through the northern section of the Mohican forest and, therefore, the land adjacent to the river, at least in this large area, possesses numerous animals and a wide variety of vegetation.

Air

There are no major air pollution problems occurring in either the southeast or the southwest land disposal areas. This is probably due to the lack of industrial development in these areas.

SOCIAL WELL-BEING

Each proposed alternative is evaluated as to the effects, or impacts, it will have on the social well-being of the persons in the community. The evaluation is based upon the contents of the proposed alternative and the resulting changes in pollutants and changes in treatment facilities. For the purpose of the evaluation of these proposed alternatives, the concept of "social well-being" is broken down into several rather broad categories: (1) Recreation, (2) Human Betterment, (3) Life Style, and (4) Distribution.

The category Recreation includes the effects the alternative will have on present recreational facilities--increase or decrease in the number of facilities available, whether or not there are changes in the type of user of the facilities--and the effects that creation of new recreational opportunities may have.

Human Betterment includes those aspects of human life making up the daily-life activities - education, housing, the immediate community, and historical/cultural activities. The category Life Style includes the impacts resulting in land-use changes, in relocation of individuals, and in the general amenities of life. Each alternative is also to be evaluated on the basis of what changes, if any, will be caused in the Distribution of benefits or usage in each of these aspects of human life.

For a complete evaluation of these proposed alternatives and the impacts they will have on the social well-being of the affected community, the ideal situation would allow for detailed analysis of the community as it exists now by making use of existing available data. The analysis of the community as it exists now could then be compared with a description of the community after the proposed alternative had been effected. A thorough description of the community and the probably resultant impacts experienced by the community can be given only after a complete analysis of the proposed alternative is made and a complete picture of the present social community is obtained. Time has not allowed for thoroughness in either aspect in this study. Therefore, description of social well-being impacts is based upon a fairly general knowledge of the community, and emphasis is placed upon encouragement for a much more detailed study of social impacts, because of their importance, in the survey scope study.

Three Rivers Watershed and Lake Erie

Recreation

Water based recreation includes a wide range of activities both active and passive in their use of water. Active recreation refers to the direct usage of the water for recreation such as boating, fishing, and swimming while passive recreation concerns the use of water as a setting for land based activities, such as hiking, picnicking, and camping. A

brief inventory of the general demand for these recreational activities in the Cleveland area is given in Table 11. By comparing the demand and the supply, both now and projected for the area, a list of the recreation needs has been completed, and is given in Table 12. A recreation distribution problem which is not shown in Table 12 also exists in the Great Lakes Region. Many of the existing recreation areas are located outside the major populated areas of the region, and therefore are not readily accessible to the majority of society.

Active. Existing active recreation--boating, fishing, swimming--in the Three Rivers Watershed is illustrated in Figure 15. Boating in the watershed is limited for reasons other than water pollution. The Lower Cuyahoga is used for commercial navigation and therefore presents a hazard to any boating in the area. Boating on Lake Erie can also be hazardous because of its frequent storms and its shallow depth. The Rocky and the Chagrin Rivers are too shallow to allow any boating other than at their mouth where marina's do exist. Other than near these marinas, the only other major boating exists on the main stream of the Cuyahoga. The canoeing that takes place in this area does not seem to be greatly hampered by the polluted water.

Wastewater pollution in the watershed has adversely affected the fishing in many areas. The fishing in the mainstream of the Rocky, and the Cuyahoga from Akron to Lake Erie has been almost completely eliminated by the wastewater pollution. While the pollution has not eliminated the fishing in Lake Erie, it has changed the species of fish available from prime game fish of cisco, blue pike, and walleye to less desirable fish of yellow perch, smelt, and carp. This change has reduced the number of sport fishermen on the Lake.**

Another type of water pollution, siltation from runoff, has also restricted the fishing in the Basin. Because of this increase in sediments in many of the Rocky, Chagrin, and Upper Cuyahoga upstream reaches, the natural breeding grounds for the sport fish are being adversely affected and in some cases eliminated.*

Although wastewater pollution has affected some of the fishing areas in the Basin, there are many areas in the Basin where good fishing does exist, primarily through stocking efforts. The areas where fishing still exists are the Chagrin, Upper Cuyahoga, East and West Branch of the Rocky, parts of Lake Erie, and in many inland lakes in the Basin. In these waters, trout, bass, coho salmon, and other game fish can be caught.

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* Great Lakes Framework Study, Fish, Appendix No 8, Preliminary draft, April, 1971.

** Federal Water Pollution Control Administration, 1968.

TABLE 11. ANNUAL DEMAND FOR RECREATION DAYS BY TYPE OF RECREATION

(Millions)

	1970	2020
Active	87.6	321.8
Passive	104.9	293.7
Cleveland Area* Total	192.5	615.5
Total Great Lakes Area	637.1	1,865

* This area refers to subarea 4.3 in the Great Lakes study, which includes a little more area than the Three Rivers area.

Source: Great Lakes Basin Framework Study, "Outdoor Recreation", Appendix 21, Preliminary Draft, February, 1971.

TABLE 12. ESTIMATED NEEDS IN CLEVELAND AREA BY TYPE OF RECREATION

(Acres)

	1970	2020
Active	53,070	356,660
Passive	1,040	6,720
Total Cleveland Area* Needs	54,110	363,380

* This area refers to Subarea 4.3 in the Great Lakes study, which includes a little more area than the Three Rivers area.

Source: Great Lakes Basin Framework Study, "Outdoor Recreation", Appendix 21, Preliminary Draft, February, 1971.

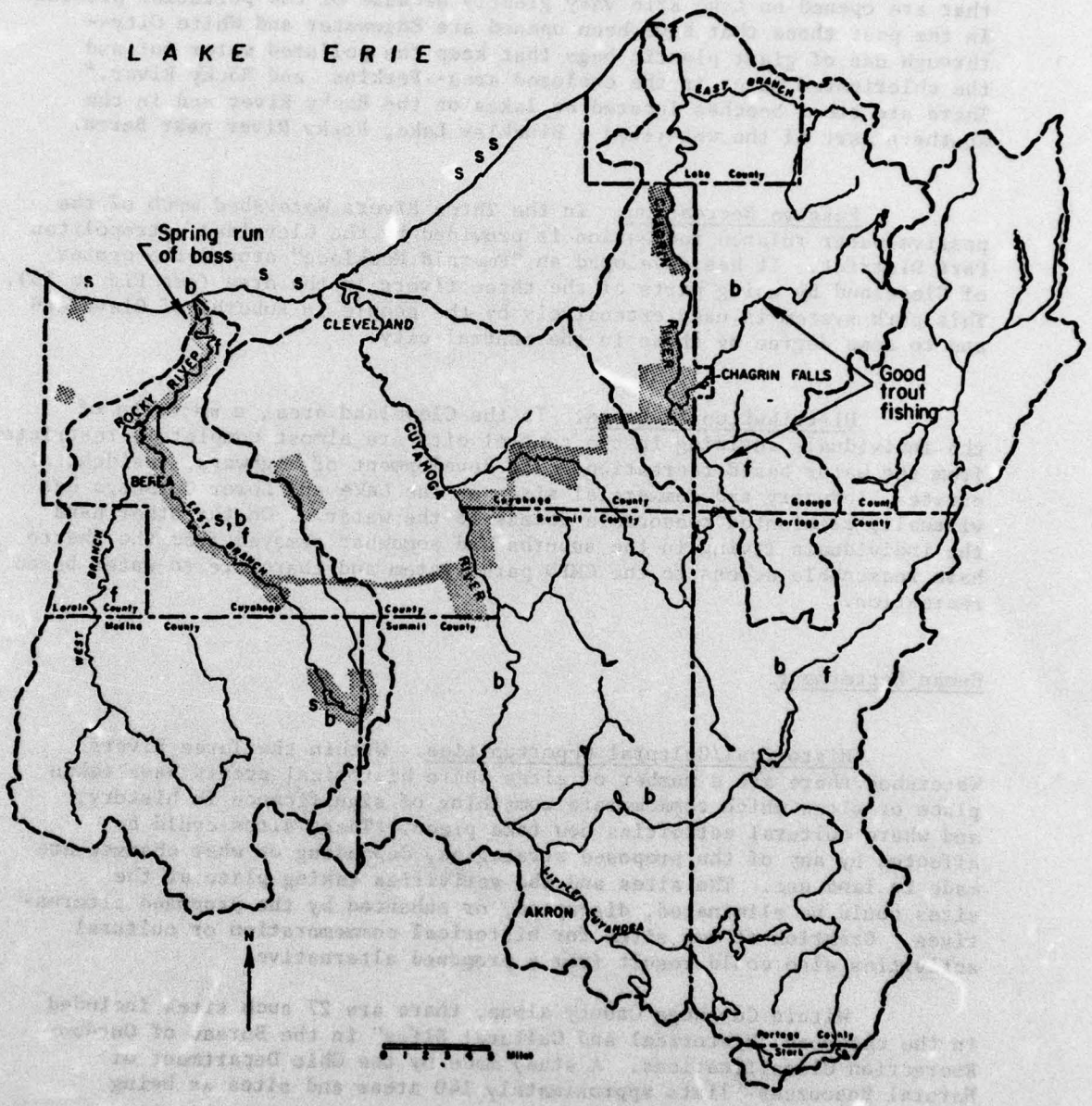

FIGURE 15, WATER-BASED RECREATION IN THREE RIVERS BASIN

s - swimming area
f - fishing
b - boating
▒ - Cleveland Metropolitan Park System

In addition to the restriction of fishing in the Three Rivers area, wastewater pollution has affected the swimming in the area. Beaches that are opened on Lake Erie vary greatly because of the pollution problem. In the past those that have been opened are Edgewater and White City--through use of giant plastic bags that keep the polluted water out and the chlorinated water in the enclosed area--Perkins and Rocky River.* There are other beaches located on lakes on the Rocky River and in the southern part of the watershed - Hinckley Lake, Rocky River near Berea.

Passive Recreation. In the Three Rivers Watershed much of the passive water related recreation is provided by the Cleveland Metropolitan Part District. It has developed an "Emerald Necklace" around the center of Cleveland by using parts of the three rivers in the area (see Figure 15). This park system is used extensively by the people in suburbs of Cleveland and to some degree by those in the central city.

Distribution of Usage. In the Cleveland area, a majority of the individuals residing in the central city are almost completely restricted from the water based recreation. The development of highways, residential estates, industry and commercial sites on the Lake and Lower Cuyahoga has virtually eliminated reasonable access to the water.* On the other hand the individuals living in the suburbs and somewhat removed from the ghetto have reasonable access to the CMPD park system and therefore to water based recreation.

Human Betterment

Historical/Cultural Opportunities. Within the Three Rivers Watershed there are a number of sites where historical events have taken place or sites which commemorate something of significance in history, and where cultural activities now take place. These sites could be affected by any of the proposed strategies, depending on what changes are made in land use. The sites and the activities taking place at the sites could be eliminated, disrupted, or enhanced by the proposed alternatives. Creation of new sites for historical commemoration or cultural activities also could result from a proposed alternative.

Within Cuyahoga County alone, there are 27 such sites included in the category "Historical and Cultural Sites" in the Buresu of Outdoor Recreation Classifications. A study made by the Ohio Department of Natural Resources** lists approximately 140 areas and sites as being

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* Whitman, et al., 1971.

** Ohio Department of Natural Resources, 1970.

noteworthy historical and cultural areas in Cuyahoga County. The evaluation of the proposed strategies should take into consideration the impact or effect the strategy will have on these historical and cultural sites.

Housing. It is difficult to give a fully adequate picture of the housing situation (in relation to water resources) existing in the Three Rivers Watershed without going into detail. Generally, though, it can be said that, in the Cleveland area, it appears that there is a positive correlation between value of residential land and proximity to open space (parks) and water (mainly the three rivers and Lake Erie). It also can be said that the people having greater access to most of the parks and rivers (and the benefits offered thereby) are those with moderate to high incomes. This is true of the Cleveland suburban areas and the residential areas along the Lake Erie shoreline.

The inner-city residents of Cleveland appear to have the least amount of access to water-based activities and parks.

Education. There are several educational programs in the Cleveland area which utilize the water resources in the area. There is, however, a large variance in the class of persons making use of these programs. Generally, participants include those from middle- or higher-income classes, with very few participants from the inner-city or lower-income classes.

Water-related educational programs are offered at the Cleveland Health Museum, the Aquarium, and the Cleveland Museum of Natural Science. The Supplementary Education Center, operated by the Cleveland Board of Education, has a science program devoted to the study of oceanography. The Supervisor of Science Programs in the Cleveland Board of Education is responsible for training teachers to do experiments related to environment. It appears that the Cleveland Educational System is not making full use of the opportunities provided by the presence of its water resources.* Improving the quality of the water in this area, therefore, will probably not affect the educational use made of this resource; other factors would have more influence, such as an increase in the amount of funds made available for utilization of the water resources educationally.

Life Style

The factors related to life style that seem relevant to consider in this evaluation are changes in land use, the relocation of individuals, and changes, mainly improvements, in the general amenities of life.

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* Whitman, et al., 1971.

Land Use Changes. Some of the proposed alternatives may result in changes in the water treatment facilities, either by the building of new facilities, additions to old ones, or elimination of old facilities. Each of the changes is likely to result in a change in land use. This should be considered when the land use will be changed in a predominantly residential area to water treatment facility use. It can be expected that if the water treatment plant is built in a residential area and is not planned and maintained in such a way as to have little effect on nearby neighbors, nearby residents will probably have objections to locating the plant in their area.

Relocation of Individuals. It should also be recognized that some of the proposed alternatives may require some people to relocate their homes and/or businesses. The number of people who would be affected by such a requirement and to what degree they would be affected should be given serious study before any alternative is accepted. An attempt should be made to determine what effects such relocation would have on a neighborhood and the life patterns of its occupants.

Amenities. In this category, the general pleasant or agreeable effects that the proposed alternative will have on the lives of those individuals affected are taken into consideration. Each proposed alternative is evaluated as to the overall benefits it will contribute to the members of the community.

Distribution

As each of the alternatives is evaluated as to the effects it will have on recreation, housing, and education, it is also evaluated on the basis of the effects it will have on various types of classes of users. It will be noted whether the alternative will have greater impact effect, either positive or negative, on one particular group of users versus another.

Land Disposal Areas

Southeast Area

Located in Columbiana County is Little Beaver Creek. A segment of the North and Middle Forks of the Little Beaver from a point near Negly and Elkton downstream to a point near East Liverpool has been designated by the National Wild and Scenic Rivers Act for potential addition to the national wild and scenic rivers system.

Much of Columbiana County contains areas of recreational, scenic, historic and educational interest. There are two state parks, two wildlife areas, and a state forest in the county. Nine areas in the county have been identified by the Ohio Department of Natural Resources as having potential for recreational development. These are a part of a statewide plan for outdoor recreation. There are two north-south highways (one in the center of the County, the other in the eastern part) which have been recognized and named state "scenic highways". Of historic interest in the County, there are six covered bridges; and located near East Liverpool is the site which marks the beginning point of the U. S. Public Land Survey. This site is listed in the National Register of Historic Places. Located throughout the County are nine camps for children, either scout or church camps. The County also contains a marsh and a swamp which have been identified by the Ohio Biological Survey as being worthy of preservation for nature study and trails.

Specifically, in Columbiana County there are 11, 399 acres of land and water devoted to recreation, which amounts to 3.3 percent of the total County area. A little over 60 percent of this land is in public ownership, while the rest is private. Administrating 6,216 acres of this land is the State of Ohio. Also included in recreation activity but not included in the above figures is 2,479 acres of streams or rivers that is devoted to boating recreation. These 9 rivers are not designated as parks or developed recreation. Some of the major areas where all forms of active and passive recreation occur are listed below.*

- Guilford State Park
- Highland Town Wildlife Refuge
- Yellow Creek State Forest
- Zepernick Lake Wildlife Area.

Southeast Area

The section of Ashland County in which the spray irrigation is proposed to be located is generally hilly (with fairly steep slopes) and wooded. The towns of Loudonville, Forrysville, and Mohicanville are located in this section. The area offers many recreational opportunities: many campsites, several canoe liveries, boat clubs, horse liveries, Mohican State Forest, Mohican State Park, and Pleasant Hill Reservoir. There are also three scenic highways located in this section.

Part of Pleasant Hill Reservoir is located in Richland County. Richland County also offers many recreational opportunities, including a number of campsites, a marina, riding trails, two ski areas also offering other winter sports (including a toboggan run), and a 25 mile

* Ohio Department of Natural Resources, 1970.

bicycle trail. There are two scenic highways located through the area. The towns of Bellville and Butler are located here. The remainder of the area is forested or used for agricultural purposes. One area in this county is eligible for registration as a National Natural Landmark - Clearfork Gorge.

Specifically, in these two counties Ashland and Richland, there are 12,589 and 10,692 acres devoted to both active and passive recreation, respectively. Of this land, 69 and 50 percent are devoted to public recreation, respectively. Not included in these totals are the acres devoted to boating activity for which the area is not designated as a park or developed area. In Ashland County this accounts for 692 acres and in Richland County it accounts for 389 acres.

ECONOMICS

The economic analysis of the impact of the alternatives is developed for several selected categories. These categories were selected for two reasons. First, because they represent the categories of most significant potential for economic impact. Second, unless one delineates certain categories to be considered for analysis, economic consequences can be drawn from virtually every activity. Thus land values, water treatment benefits, commercial fishing, regional and national economic development, and income redistribution have been selected as the categories for analysis.

This section presents background or base information for the analysis. Unfortunately both time and information limitations preclude greater detail in data. In general, however, the appropriate data are available and can, given more time, be collected for a more thorough analysis.

Because of the general nature of this section, it is not divided into the geographic areas of the Three Rivers area and the land disposal area. It is felt that such a division would destroy the continuity of the general presentation.

Land Values

Perhaps the greatest economic impact of the proposed wastewater management alternatives will be on land values. The base data on land values for the relevant area are available but not conveniently located in a single place. There is some fairly accurate information available on the values of agricultural property. Because a significant portion of the impact of the proposed land disposal plans is likely to occur in agricultural areas, the base values for these properties for several counties and townships are presented in Table 13.

The source of this information is the Office of the Division of County Affairs of the Ohio State Department of Taxation. The land values per acre for a township are determined by multiplying the current assessed value of the land times the "sales ratio". The "sales ratio" obtained from the Division of County Affairs is determined by dividing the assessed value of an average acre of land for a county by the current realized sales prices of a sample of the land.

Clearly there is much opportunity for bias in such an estimate, including problems of inferring the average market price of the land from a sample consisting of the sales for a recent time period. In addition, the average assessed value is likely to be quite different from the value of currently assessed property.

In the absence of additional time for further refinements, the land value estimates by county and by township are presented in Table 13.

TABLE 13. AVERAGE PER ACRE LAND VALUE ESTIMATES

County	Township	Dollars per Acre	
		Assessed Value	Market Value
Ashland:			
	Mifflin	36	152
	Vermillion	43	181
	Mohican	47	198
	Green	37	156
	Lake	38	160
	Hanover	26	110
Columbiana:			
	Knox	72	258
	Butler	61	219
	Putery	98	351
	Salem	54	194
	Fairfield	62	222
	Unity	54	194
	West	45	161
	Hanover	39	140
	Center	34	122
	Elkrun	21	75
	Middleton	27	97
	Franklin	22	79
	Wayne	23	82
	Madison	22	79
	St. Clair	43	154
	Washington	15	54
	Yellow Creek	20	72
	Liverpool	39	140

TABLE 13. (Continued)

County	Township	Dollar per Acre Assessed Value	Dollar per Acre Market Value
Geauga:			
	Chardon	101	401
	Montville	51	202
	Chester	--	--
	Munson	56	222
	Claridon	72	286
	Huntsburg	51	--
	Russell	--	--
	Newbury	125	496
	Burton	72	285
	Middle Fields	52	206
	Bain Bridge	106	421
	Auburn	77	306
	Troy	63	250
	Parkman	55	218
Lake:			
	No data		
Lorain:			
	Eaton	115	583
	Columbia	108	548
	Grafton	61	310
Richland:			
	Mifflin	61	257
	Washington	59	249
	Monroe	43	181
	Worthington	30	127
Summit:			
	Northfield	311	1111
	Macedonia	--	--
	Twinsburg	226	795
	Richfield	174	621
	Boston	158	564
	Hudson	240	857
	Bath	277	989
	Northampton	269	961
	Stow	--	--
	Copley	211	754
	Portage	--	--
	Tallmadge	--	--
	Coventry	291	1039
	Springfield	245	875

These township areas represent the major areas to be affected by the proposed plans. No data were available for estimates within Cuyahoga, Medina, or Lake Counties.

These data can be used to estimate the acquisition costs of the land. They can be used to determine the potential increases or decreases in land values as the land is changed from one agricultural use to another. Generally, the data are applicable to such a wide area that it will not be convenient to use them for specific estimates of changes in land values for different points within the watershed, but they could be effectively used to assess land-value changes, especially for the land plan and the combination plan where the most significant effects on land are likely to occur.

To obtain comparable data for industrial, commercial, and residential property would require much more extensive work and must be classified outside the scope of this project. While some impact is undoubtedly to be expected on the industrial and commerical property, the major land impact other than on agricultural land would be expected to be on residential property, especially where these properties are adjacent to or nearby a portion of the treatment facility.

One major factor which will have a significant effect on the net impact of any program is the nature of acquisition of land for land disposal sites. The land for the lagoons must be purchased from the present owner and therefore become public property, not subject to taxation and not available for any type of use other than storage of wastes. The impact on tax revenues would be considerable and could be measured. Similarly, the lands adjacent to phased out plants will return to tax rolls if they are not kept in the public sector for recreation.

The land to be used for irrigation purposes, it would appear, would have to be acquired by the public sector - either the Federal Government or state government. If so, this would remove the property from the tax rolls. This would have an even more impressive effect on revenues from property taxes. Aside from the objections of local residents to moving from property long held in families, one must also consider the effects of what might be done with the property as held by the public sector. If it were farmed in some way, and were substantially more productive than adjacent nonirrigated properties, it could have unfortunate consequences on these farmers. They might find themselves unable to effectively compete with "public" farmlands and thus be driven out of farming. Furthermore, one might wonder how these new "highly productive" lands would be utilized. If used to produce foods presently in surplus, the lands could compete with lands all over the nation for productivity. Unfortunately, it may be necessary to grow nonrow crops on the irrigated land. This would restrict the options for growing crops considerably. If, in the final analysis, the lands were acquired by the public sector and had to be held idle, it would be difficult to impute any positive value to the lands.

Suppose, however, the lands were not acquired by the public sector but were simply leased. Then one must wonder how farmers who refuse to leave their land would fare having adjacent properties being "reclaimed" and their own property not "reclaimed". It is also of some consequence whether or not the lands can be farmed at all during the process of irrigation.

In sum, it is not difficult to forsee an increase in productivity of agricultural lands irrigated with wastewater, but it is difficult to forsee how this increment to productivity is going to have anything but unfortunate consequences for the farmers in the area.

Land Value Impact Analysis

Table 13 provides land values per acre for much of the land to be affected by the proposed plans. To analyze impact one might simply consider the economic impact of doubling productivity in irrigated land. This might be expected to result in a significant increase in the value of the property (providing the land is marketable), perhaps as much as doubling the value. Then one must consider to whom this value is to accrue.

One can also determine how much might have to be paid to acquire the property. This might provide an estimate of the budgetary magnitude of the project. Even in the case of outright acquisition of property one must be concerned with the issue of whether one pays a price reflecting the potential of the land, or simply the price at which the present owner is willing to sell. If the present owner is less wealthy, he may be willing to sell at a relatively low price. Later, the more productive land might be acquired by a wealthier person. The net effect is an exchange of productive assets from the less wealthy to the more wealthy person. While it is, perhaps, difficult to argue that such a transfer is inherently not desirable, our entire democratic philosophy of income redistribution to produce a more equalitarian populace rests on redistribution favoring the poor and disfavoring the more wealthy.

Water Treatment Benefits

One of the major benefits expected to accrue from rationalizing the treatment facilities to the regional level is in the form of reduced per unit costs of treating wastewater. This is expected primarily on the basis of economies of scale. The treatment of larger quantities of water using larger facilities should reduce per-unit treatment costs because (1) capital and administrative costs should be reduced and (2) higher quality labor should be available for work in the fewer treatment plants.

The analysis of the per unit costs of existing and projected treatment costs is not undertaken in this report because it requires detail for which there is neither time to draw up the plans nor time for the analysis.

There will also be impact on the cost of treating water for public consumption. To the extent that intake waters are less polluted after the waste treatment system is constructed, the cost of treatment appears likely to fall.* Data on per-unit treatment costs can be obtained from technical data on the types of wastes, the amounts of wastes treated, and the degree of concentration of the wastes per unit of water. Water treatment costs would appear to be likely to change, but one cannot determine whether or not the price to be charged for water will change because this is primarily a political matter for each municipality.

Commercial Fishing

The impact of alternative plans upon the commercial fish catch for the Three Rivers basin, the State of Ohio and the nation as a whole must, in part be dependent upon the value of the fish caught from Lake Erie. The values of the catch for the last 10 years and the tonnage of the catch indicate that while the value of the catch for Ohio has been declining, that is not the case when the Canadian catch is taken into account. In addition the tonnage caught by Ohio industry has continuously declined, but the tonnage caught by the combined Ohio and Canadian Industry has remained fairly steady. Table 6 indicates the changes in the composition of the fish population which have taken place as the Lake has become more polluted.

Even if the tonnage were to remain the same, a reversion to the level of pollution which obtained in 1940, for example, would significantly change the composition of the catch, assuming the higher priced fish were introduced and were able to survive. The higher grade mix would result in an increase in the total dollar value of the catch. Such an outcome might have favorable effects on the revenues earned by the industry and might provide the incentive for additional investment in capital equipment to upgrade the productivity of the average fisherman. As explained below, the Canadians already have a considerable head start in the mechanization of their industry.

Under the very best of circumstances it would be difficult to foresee a benefit to the region from commercial fishing which would exceed 2 or 3 million dollars per year (see Table 7 and Figures 13 and 16).

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* Meredith and Ewing, "Systems Approach to the Evaluation of Benefits from Improved Great Lakes Water Quality", Procedures of 12th Conference Great Lakes Research, 1969, pp. 843-870, International Association of Great Lakes Research.

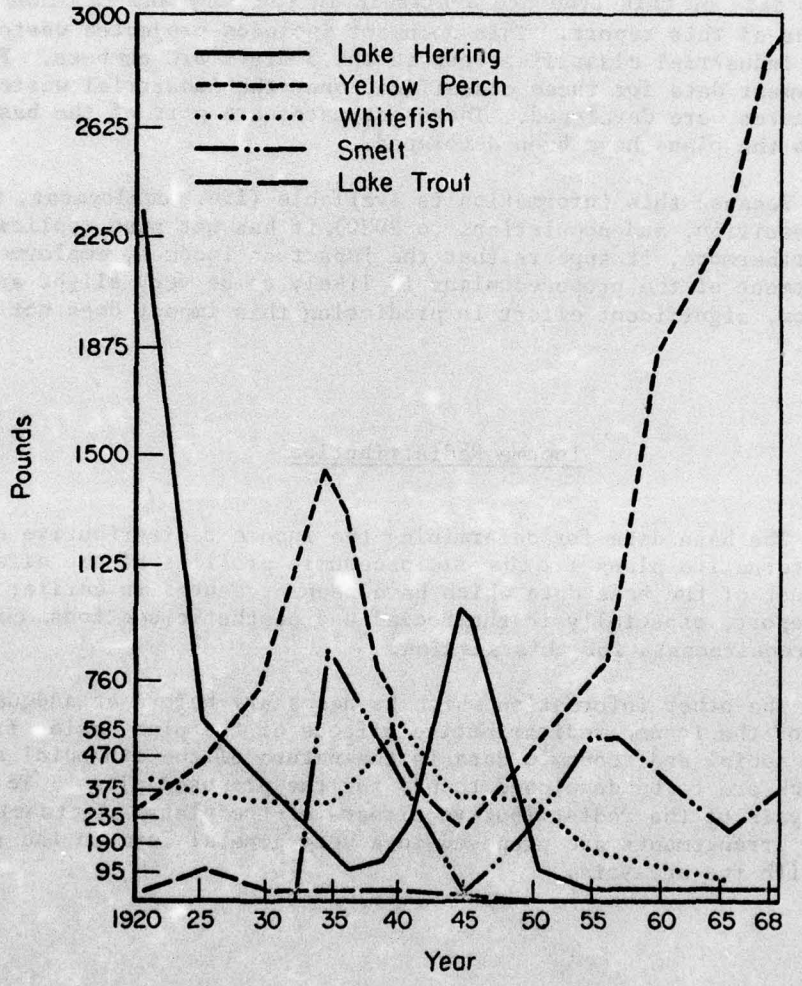

FIGURE 16. COMMERCIAL FISH PRODUCTION OF SELECTED SPECIES IN THE LOWER GREAT LAKES 1920-1968 (TENS OF THOUSANDS OF POUNDS)*

* Lower Great Lakes provides a proxy for the imposition of Lake Erie because the Ontario commercial catch is less than 5 percent of the total Lake Erie catch.

Economic Development

The major indicators of economic development, income investment, and employment are quite readily documented for the present time. Some base data of this type are available in the body and in other appendicies of this report. This document includes projected waste loads for industrial classifications to the 3 digit SIC numbers. From the employment data for these classifications, the industrial waste load estimates were developed. These estimates are part of the base upon which the plans have been developed.

Because this information is available (i.e., employment, industrial composition, and populations to 2020), it has not been replicated here. Furthermore, it appears that the impact on incomes, employment, and investment of the proposed plans is likely to be very slight and for that reason, significant effort in predicting this impact does not seem warranted.

Income Redistribution

The base data for determining the income redistributive effects of the alternative plans are the socioeconomic profiles of the affected areas. Most of the base data which have been presented in earlier sections of this report, especially in the Social and Aesthetic sections, constitute the data requirements for this section.

The other information which is necessary before an adequate analysis of the income redistributive effects of the plan, aside from the basic social and economic data, is the nature of the financial arrangements which are to be developed to pay for the proposed plans. To permit some analysis of the redistributive effects of the plans, alternative financial arrangements are proposed in a very general form in the section dealing with the analysis.

CHAPTER 4. ASSESSMENT OF IMPACTS

In the development of a feasible wastewater treatment plan for the Cleveland Metropolitan area, it is desirable to start with general alternatives and work toward a single plan that can be implemented while achieving water quality objectives. To avoid possible exclusion of any feasible alternative, the Corps of Engineers selected three general areas for developing engineering feasible alternatives. They are (1) water-based treatment of waste, (2) land-based treatment of waste, and (3) combination of water-based and land-based waste treatment.

The objective of the water-based alternative is to apply existing treatment--biological or chemical--processes to control the water pollution problem. This alternative would be restricted to using unit processes such as activated sludge, chemical coagulation, distillation, ion exchange, and microstraining in treatment of the wastewater. In the land alternative, the primary mechanism for wastewater management is the land itself. Spray irrigation and percolation fields are the principal components of the waste management system. The final alternative--combination approach--combines selected features of both the land and water alternatives to treat the wastewater. Using these three areas as general guidelines, Havens and Emerson, Ltd., developed three specific alternatives (W-1, L-1, C-3) to treat the wastewater in the Cleveland-Akron metropolitan areas.

In this feasilbility study, each of thses three specific alternatives were evaluated on the goal of water quality improvement and their impacts on the environment and society. Specifically, in this chapter the impact from three general wastewater treatment alternatives is discussed in the framework of the four water management objectives of:

- Environmental Quality
- Social Well-Being
- Regional Development
- National Economic Development

As was stated in Chapter 2, a two-step procedure is necessary to assess adequately the variou wastewater treatment alternatives: determination of change and evaluation of change. It should be noted that the two-step procedure was followed by Battelle-Columbus in making the evaluation but, for reasons of brevity, the steps are combined for discussion purposes in this Chapter.

To perform a complete impact analysis of an alternative. it is necessary that the alternative be specified in detail. However, the scope of this feasibility study did not permit sufficient time and information exchange on each alternative to permit complete evaluations. Consequently, sections of the impact analysis are discussed in an overview fashion while others are portrayed in more detail. A description of the information on which the impact assessments were based is

given in Table 14. In those cases with detailed information available (as noted in Table 14), impact assessments were performed by comparing 1970 base data with projected levels for 2020 from each plan.

TABLE 14. DEPTH OF SUBSYSTEM INFORMATION AVAILABLE ON ALTERNATIVES

Subsystems	Alternatives		
	Water (W-1)	Land (L-1)	Combination (C-3)
Collection + Transmission	D*	D	D
Waste Treatment			
Municipal	D	D	D
Industrial	G**	G	G
Storm Water Runoff	G	G	G
Sludge Treatment and Disposal			
Storm and Municipal	D	D	D
Industrial	G	G	G

* D = Detailed information consisting of 1970 base data and projected 2020 values for each plan.

** G = General or incomplete information.

GENERAL IMPACTS FROM ALL ALTERNATIVES

In evaluating each of the three alternatives, it was evident that there were impacts common to all alternatives which could not be discussed adequately in this report. Time and the limited amount of information available were the prime reasons for not including a detailed evaluation on these subjects. However, it is believed that because of their importance in wastewater management in the area, they should be mentioned briefly. These considerations are:

- Reliability of wastewater treatment systems
- Spray irrigation systems
- Industrial waste treatment

Reliability of Wastewater Treatment Systems

In the evaluation of waste treatment alternatives, it is important to consider the possibility that the proposed system may fail, and the consequences of such a failure on the environment and society. This failure can occur in two ways: (1) complete failure of a component and (2) continual underdesign operation.

Regionalization of treatment operations in both land and water require the concentration of all wastewater in relatively few locations. Because of the large volume of waste at these locations, a pipe breakage or treatment failure is a major problem which can have major severe consequences. In designing a regional system, therefore, it is important to include some backup system to minimize the environmental or social problems resulting from such a failure.

A second problem to be considered concerns the operating efficiency of large regional waste treatment operations. In the past there has been much argument for regional systems. It is commonly assumed that with regional systems better trained personnel could be hired and that this would result in better waste treatment. However, to date regional plants have provided the least efficient operations. It has been estimated that large treatment plants operate about 45 percent* of the time below the designed efficiency. If this is true, then the estimates of greater than 90 percent removal of pollutants stated in the alternatives would not be true 100 percent of the time but only about 55 percent of the time.

It is important to determine whether these estimates are correct, and if they are the resultant consequences. For clearly, if the removal efficiency of pollutants in 2020 is similar to the present efficiency, substantial sums will have been spent to achieve little.

Spray Irrigation Systems

The waste management system proposed to treat the wastewater from Cleveland-Akron metropolitan area was evaluated both for locational considerations and for technical feasibility. It is believed that the land areas considered for wastewater treatment are not suited for the intended purpose because of their excessive slopes. Although the soil is acceptable from a permeability criterion, spray irrigation fields are not realistic in the defined areas. The slopes in this area would accelerate erosion and restrict

- Type of crop grown
- Use of underdrains
- Harvesting of crops.

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* Dr. Roger Schull, Environmental Protection Agency, personal communication, 6/16/71.

Because this analysis is based on only one field investigation and other general background information on the area, further detailed investigations are necessary.

Industrial Waste Treatment

The general waste treatment proposal--for all alternatives--of segregation of industrial wastes is good in concept and must be used to obtain the desired treatment efficiency in the rest of the system. On the other hand, the proposal to put industrial sludge and other liquid wastes in underground caverns is not considered to be a solution in the long range to the industrial waste problem. "Out of sight out of mind" is not a treatment but a storage of the waste. It is believed that society cannot solve its waste problems by burying them, and, therefore, Battelle-Columbus feels that this is not a long range treatment alternative.

WATER BASED ALTERNATIVE

The water based alternative (W-1) consists of regional treatment plants located throughout the basin and on Lake Erie. Some of these locations are Akron, Medina, Chagrin Falls, Cleveland Southerly, Easterly, Westerly, and Rocky River. Each of these plants will provide tertiary treatment of wastes--pretreatment, primary sedimentation, biological secondary, nutrient removal, disinfection. All the combined overflows and storm water runoff in the Cleveland-Akron metropolitan area will be collected and treated in holding ponds in Lake Erie. The sludges generated from these waste treatment operations will be disposed of by land fill, either with or without prior incineration to reduce volume.

Expected Changes

The implementation of the water alternative would have both beneficial and adverse impacts on the environment and society. Some of the major changes are listed in Table 15. These and other changes are discussed below.

TABLE 15. EXPECTED CHANGES FROM THE WATER BASED ALTERNATIVE

Location	Expected Changes
Rocky River	• Improved quality--from a polluted river to enriched river
	• East Branch could become an intermittent stream because of basin transfer of wastes
Cuyahoga River	• Improved quality--from a polluted river to an enriched river
	• Lower Cuyahoga suitable for fish runs
Chagrin River	• Quality remains essentially unchanged
	• Increased temperatures because of storm water transfers out of basin
Lake Erie	• Improvement in quality primarily along shoreline
	• Holding basins--algae and hygienic problems
Air	• Air pollution from sludge incineration
	• Transfer of heavy metals from sludge incineration
General (Treatment Facilities)	• New and expanded treatment facilities
	• Old facilities phased out

Environmental Quality

Ecological Impacts

Primary Productivity. The principal pollutants affecting prime productivity are nitrogen and phosphates. With the water based plan there should be an improvement of algal problems in the Rocky and Cuyahoga

Rivers. In the Chagrin River there will be a slight increase in both total nitrogen and phosphate levels which should not adversely affect the river ecosystem. However, when one considers the recommended level for phosphates of less than 0.1 mg/l to limit algal growth, the projected phosphates concentration resulting from the water based plan for the year 2020 of 1.5 mg/l could contribute to algal bloom conditions. Increased algal growth could become a potential problem in both the Chagrin River and East Branch of the Rocky River with significant removal of water from these streams. With a reduction of total phosphates from 880,000 lb/day in 1970 to 10,200 lb/day in 2020 entering Lake Erie from the Three Rivers Watershed, there should be a significant reduction in algae problems in the nearshore area (see Table 16). Because of the high concentration of phosphates in the Lake and the phenomenon of recycling the phosphates from the bottom sediment, it is predicted that there will not be a significant improvement in algal blooms in the Central Basin.

Consumer Productivity. Consumer productivity tends to be principally inversely related to the BOD and suspended solids level. With the water treatment plan, in both the Cuyahoga and Rocky Rivers there should be a significant improvement in both the benthic and the fish species. The Chagrin River essentially should remain unchanged. With the projected reduction of BOD and suspended solids, the Cuyahoga River and Rocky River should be satisfactory for fish spawning, subject to the dissipation of the residual BOD in the bottom sediment. Both these streams may require the reintroduction of fish species owing to the length of time they have been polluted. This is particularly true for the walleye. There should be significant improvement of both fish and bottom organisms in the nearshore waters of Lake Erie. A problem will develop, however, in the East Branch of the Rocky River and the Chagrin River with the removal of water from these watersheds. In the Chagrin River there will be warmer water under lower flow conditions, which will adversely affect the cold water fishery in this stream, i.e., salmon and trout. In the East Branch of the Rocky River there will be a development of a pond type fish population rather than coho salmon.

Biogeochemical Cycling. With the reduction in BOD and nitrogen loading, there will be an improvement in the chemical environmental conditions for aquatic life. The production of toxic wastes, such as methane, H_2S, and ammonia, should be minimal in the Cuyahoga and Rocky Rivers as well as in the nearshore waters of Lake Erie. The Chagrin River should remain relatively unchanged. The increased sulfate loading may be a problem as far as the sulfur microorganisms are concerned. However, this cannot be evaluated at this time.

Species Diversity. Species diversity of benthic and fish species for the Cuyahoga and Rocky Rivers should significantly improve. The Chagrin River should remain relatively unchanged. There are indications that with good upstream waters, benthic species diversity can

TABLE 16. PROJECTED POLLUTANT GROSS LOAD TO LAKE ERIE AND CONCENTRATION OF POLLUTANTS IN THE THREE RIVERS - WATER ALTERNATIVE

		BOD	SS	Cl	N	PO_4	SO_4
Lake Erie lb/D	2020	28,800	11,500	779,200	11,800	10,200	664,100
	1970 Base	118,000	140,000	510,000	43,000	880,000	439,000
Chagrin River mg/l	2020	4	~2*	136	2	1.5	114
	1970 Base	3.8	47	40	1	0.8	60
Cuyahoga River mg/l	2020	4	~2*	136	2	1.5	114
	1970 Base	11	87	230	16.5	3.8	202
Rocky River mg/l	2020	4	~2*	136	2	1.5	114
	1970 Base	6.4	63	111	6.6	8.7	135
Good Criteria (See Table 2)		<3	<80	<150	<1.0	<0.1	<100

* Under low-flow conditions; during high flow level will increase to an average maximum approaching 1970 values because of erosion, etc.

recover in a 2-year period after reestablishment of good stream water quality conditions. However, species diversity in the fish may be dependent upon man's reintroduction of species that have been destroyed from the whole river basin. There should be an improvement in the benthic organisms nearshore in Lake Erie adjacent to the mouth of the Cuyahoga River.

Population Density and Distribution. With the water treatment plan there should be significant increase in the total population of fish, particularly in the lower Cuyahoga River as well as in the Rocky River. The fish population in the Chagrin River could be adversely affected by the projected low flow conditions. In the nearshore waters of Lake Erie there should be a significant improvement in fishing with reestablishment of commercial fish species spawning in the Rocky River and Cuyahoga River.

Social Well-Being

Hygienic Impacts

Direct Effects. As of 1970, bacteria and very likely viruses are problems in virtually every stretch of every stream and along the lake shore. This plan would eliminate this problem through the following steps:

(1) Many small sewage treatment plants, some poorly managed, would be eliminated.

(2) Discharges from overflowing septic tanks and from areas where septic tanks are too crowded or where soils are not favorable for them would be eliminated by new sewer systems. Some exceptions to this, however, are noted below.

(3) Combined sewage discharges would be eliminated by collection and holding facilities, and the collected wastes would be treated before release to Lake Erie.

The plan does present some possible hygienic problems, nevertheless. An obvious one, of course, is the possibility of a disasterous malfunction or breakdown of one of the major sewage treatment plants. Others are somewhat less obvious.

The offshore holding basins for the collected storm and combined sewage discharges would contain high concentrations of bacteria and viruses after a storm. While most of these would die off in 1 to 3

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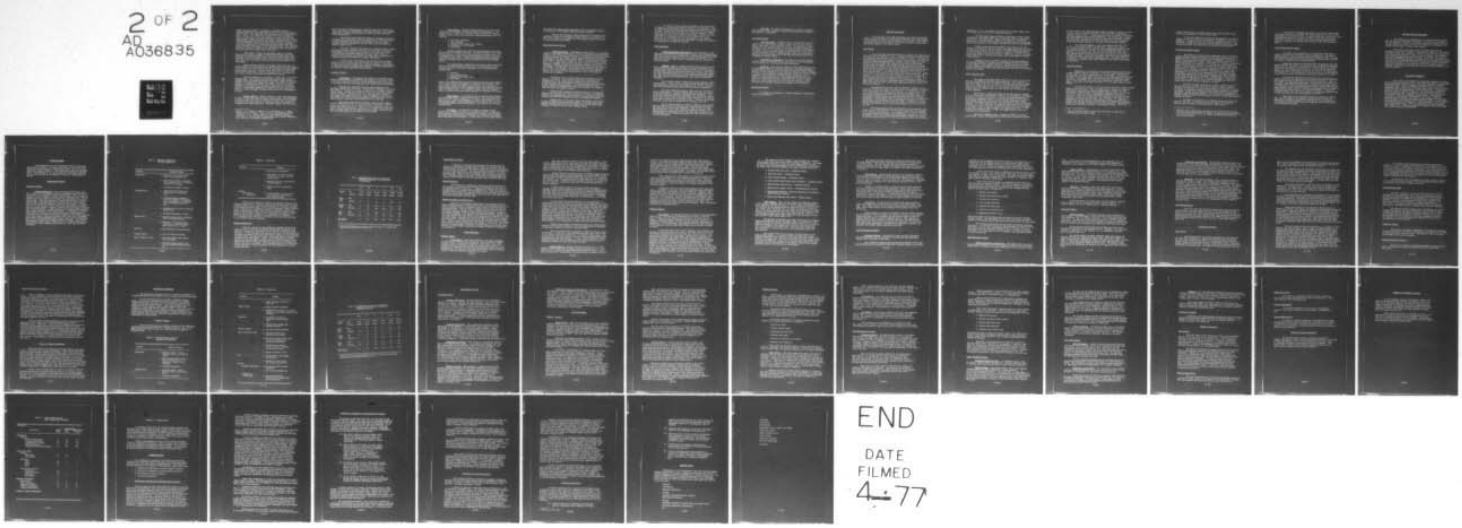

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weeks, some would remain.* In addition, roundworms (ascaris) would be prevalent if any significant portion of the human population harbored them. These organisms and their eggs are quite long-lived in water. While it is assumed that the public will not be permitted access to these basins, if a storm should occur with winds and waves large enough to cause overflow of the basins, nearshore waters used for drinking water supplies and full body contact recreation could be seriously contaminated. The fact that the people would be accustomed to safe water, especially for recreational purposes, might cause them to expose themselves unknowingly to the contaminated water. The risk would be greater, therefore, after such an overflow than when the nearshore waters are known to be unsafe most of the time.

Even without a storm, the roundworms would be a problem. These forms are quite resistant to disinfection treatment and would, therefore, be released normally into the Lake with the treated water. The hazard would be especially great since the nearshore water would look, smell, and taste clean, and bacteriological tests would be very encouraging.

There are large portions of the Upper Rocky, the upper and middle Cuyahoga, and the Chagrin River Basins which are not to be sewered. This is based upon expected future use of these lands for recreational or agricultural purposes. Eventual sewer construction in these areas would result should more intensive development occur, but perhaps not do so until a severe septic tank drainage problem existed.

Poisonous materials are currently a problem only in the Lower Cuyahoga Basin. The industries located there would, under the plan, eliminate these constituents from their discharges through treatment or through concentration and underground storage. The former is a sound approach, but underground storage, even though it may be safe where underground water supplies are concerned, represents only a temporary solution. Furthermore, malfunction or failure of such a system would result in direct discharges of concentrated poisons into the streams or the Lake.

Indirect Effects. Improved control of septic tank discharges, as stated in this plan, would eliminate stagnant pools of polluted water in ditches, which under present conditions are ideal areas for breeding of mosquitos and flies which can be annoying and can carry dangerous organisms to the human population. This gain, however, would be offset

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* Clarke, N. A., Berge, G., Kabler, P. W., and Chang, S. L., "Human Enteric Viruses in Water: Source, Survival, and Removability", in Eckenfelder, W. W., editor, Advances in Water Pollution Research, Proceedings of the International Conference held in London, September, 1962, New York, the Macmillan Company, 1964.

by the creation of stagnant pools in the East Branch of the Rocky River, which would become an intermittent stream under the plan. The combined sewage and storm water holding basins in Lake Erie would also offer pest breeding places.

The mercury problem would be reduced by elimination of mercury discharges from industries in the Three Rivers area. With elimination of these discharges, the mercury now contained in river and lake sediments would be dissipated in time and fish in the area would no longer be exposed to it.

The mercury problem still might not be entirely solved, however, Secondary wastewater treatment systems are not efficient in removing heavy metals and the large scale of plants in this plan might result in significant concentrated discharges of them. There is also a possibility that mercury vaporized by high temperature incineration of sludges could enter terrestrial and aquatic food chains.

A rather ironic circumstance could develop from any program which would open up large areas of lake and river bottom to fish where no fish can live at the present time. Mercury contained in the sediments in these areas would be ingested and absorbed by the fish, resulting in an increased (though temporary) mercury hazard.

Aesthetic Impacts

Land Effects. The improved water quality in the Three Rivers Basin resulting from this alternative could improve the aesthetic composition of the rivers and Lake Erie. Major improvements would take place in the Rocky River and in the Cuyahoga River between Akron and Cleveland.

However, this alternative has some adverse impacts on the aesthetic composition in the basin. The transfer of wastewater out of the East Branch of the Rocky could cause the East Branch to become an intermittent stream. Because this stream is located in a park which provides natural landscape of vegetation and trees, the composition setting of this river would change drastically. Also influencing the importance of this change is the fact that the elimination of flow would occur in the summer and early fall when the park usage will be at its peak.

The natural composition of Lake Erie--water and open space--would be changed by the use of holding basins for storm water. Because of the urban setting, it is felt that these basins themselves would not greatly affect the composition. However, it is expected that algae would appear in these basins and the combined effect of algae and basin would have an adverse effect on the composition of the Lake.

Water Effects. Physical characteristics of the water could change both beneficially and adversely from this alternative. It is expected that, in general, all stated problem areas would be improved greatly in their color, odor, and taste. Major improvements would take place at:

- Lake Front (Lake Erie)
- Lower Cuyahoga
- Cuyahoga River--Akron, Kent, Ravenna
- Tributaries to the Cuyahoga
- Rocky River.

However, changes in the flow of the East Branch of the Rocky River could cause aesthetic problems. The pools remaining in the stream bed when there is no flow in the river would become stagnant and cause a noticeable odor. Other odor and color problems could be caused by the storm water holding basins. Instead of having algae blooms dispersed along the shoreline, they would be concentrated in six large holding basins.

The improved water conditions in the basin's rivers would also affect the surface conditions of the river. It is expected that oil and dead fish will be virtually eliminated from the following major problem areas:

- Lakefront
- Lower Cuyahoga River
- Cuyahoga River--Akron Area
- Rocky River.

However, the rubbish problem along the shorelines and the natural debris in the river would not be changed by the improved water quality. As a case in point, rubbish is dumped along the banks of the Chagrin and Upper Cuyahoga basins which are considered some of the best water quality areas in northeast Ohio. It is possible, though, that with cleaner waters a stronger enforcement against dumping will alleviate the problem.

Biota Effects. It is expected that the natural biota--vegetation and animals--will be enhanced in the Basin. This improvement would result from the expected development of new park lands adjacent to the improved water areas. These developments would probably take place along the Cuyahoga--between Akron and Cleveland--, the Chagrin, and the Upper Cuyahoga Rivers.

Air Effects. The disposal of sludge as proposed in this alternative is expected to cause an air pollution problem. Sludge from large treatment plants which is incinerated at regional plants throughout the region would possibly cause an increase in the amount of particulate matter released to the atmosphere. At this time, it is not clear whether

this additional burning would appreciably affect the aesthetic quality of the air, or if air quality standards would be followed.

However, this increased burning combined with the normal slow compliance to quality requirements by public agencies is expected to cause some changes in air quality near the treatment plants in the form of increased particulate matter.

Social Opportunity Impacts

Recreation Effects. Improvement in water quality in the Cuyahoga and Rocky Rivers and the shoreline of Lake Erie could have some beneficial effects on the recreation in the Basin. It is expected that while the Upper Cuyahoga maintains its fishery, new and improved fisheries will become established in the main stream and West Branch of the Rocky River and the Cuyahoga River from Akron to Cleveland, and to a limited extent, in Lake Erie. These changes would increase the sport fishing in the Three Rivers Watershed. However, fishing will be adversely affected and possibly eliminated in the East Branch of the Rocky River, because of the stream's flow change. Flow changes in the Chagrin River would also cause this river to lose its cold water fishery status (trout and coho salmon). Because this fishery has been established for years, this change in status would be adverse.

Boating will not be greatly affected by any changes in water quality in the Basin. There should be some small increases in the Cuyahoga River in the expected park system but also some possible boating decreases due to the hazards on Lake Erie that would be created by the storm water holding basins. It is also believed that boat marinas could not be established on these holding basins for aesthetic (odor and color) and hygienic reasons.

Swimming should improve in the Basin because of the improved water in Lake Erie along the shoreline and in the rivers. Although the potential for swimming would increase markedly, the problems of adequate access to the Lake would dampen the extent of swimming improvements.

Another effect of the water quality improvement is the change in land use adjacent to the improved streams. It is anticipated that passive recreation areas will be developed along the main stem of the Cuyahoga, the Chagrin, and the Upper Cuyahoga Rivers.

The effect of water quality improvement on the distribution of usage of recreation facilities is expected to be negligible. That is, the group of individuals using the existing facilities would remain the same. However, the low-income group which does not have adequate access to any facilities would probably perceive a change in access. They might feel that this is another establishment restriction of the poor--namely, clean water for the rich and nothing for the poor. Therefore, it is believed that this improvement in water quality while not directly influencing the distribution of usage may influence it indirectly in the negative direction.

Human Betterment

Historical/Cultural Opportunities. The only aspect of the water based alternative that would effect changes to historical/cultural opportunities would be the construction of new regional treatment plants. Until more specific locations of the new plants are defined, it is impossible to predict what specific historical/cultural opportunities would be changed.

Housing. There are several important impacts that the water based alternative would have on housing in the area considered. The construction of the new regional treatment plants and the elimination of many smaller plants would involve changes in land use. The value of the homes immediately adjacent to the new plants would decrease, while the effect that the smaller plants being phased out would have depends upon that replaces the treatment plants, e.g., parks or industrial activities.

Air pollution caused by sludge burning will adversely affect housing nearby. If air quality standards are not adhered to by the plant burning the sludge, it can be assumed that, for this alternative, less water pollution is being substituted with more air pollution.

The water alternative leaves a large area near the Chagrin River without sewers. It can be assumed that in the near future this area will probably be developed, most likely with residences. This leaves the possibility that such development will overtax the capacity of the area's septic tanks and result in the pollution of the Chagrin River which at present is an unpolluted river. Overtaxed septic tanks would also create an odor problem for the housing in the area.

The six holding ponds to be built in Lake Erie will possibly have an adverse affect on lakeshore homes and apartment buildings if the ponds have an unattractive appearance. When the lake is viewed from a high level (e.g., from a high-rise apartment building), the holding ponds will change the view of the lake, even if they are somewhat attractive, thus, probably decreasing the value presently placed on those apartments.

Education. No change is anticipated as a result of improving water quality. Other factors, in addition to improved water quality, would have to be introduced.

Life Style Impacts

Land Use Changes. Changes in land use would result from the construction of new regional treatment plants, and from the closing down of many smaller plants presently in use. The importance of these changes cannot be assessed until the particular changes in land use are known. That is, it is necessary to know whether the land preempted for construction of treatment plants is presently vacant or in use as a park, residential area, or industrial area. Also, it is important to know what use would be made of the land made available because of the termination of smaller plants.

Relocation of Individuals. The construction of new regional treatment plants and additions to existing plants involves some relocation of individuals, of their homes and/or businesses.

Amenities. There will be a change in the general amenity value of the community because of the fact that most of the Cleveland-Akron metropolitan area will be served by sewers and adequate sewage treatment. However, if some improvement in water quality comes about only as a result of increase in air pollution (sludge burning), there is no benefit to the community. One problem area is solved by the introduction of or increase in another problem area. The water-based alternative would result in cleaner water and more attractive water (removal of color, smell, etc.) which would make using the water and facilities nearby the water a more pleasant experience for members of the community.

Distribution Impacts

No changes in distribution of either beneficial or detrimental effects are anticipated.

Regional Development

As is the case in any impact analysis, the causal relationships between the construction of a water quality management system and changes in the economic activities are very difficult to establish. Nevertheless, the characteristics of the plans are defined well enough to permit some speculation regarding the economic impact.

Land Impacts

One of the major areas identified as a potential for impact by the alternative being developed is land. To whatever extent the prices of land are changed by the alternative, economic impact will result. The impact of the water-based plan on land values is most likely to occur along the Rocky River and perhaps somewhat along the Chagrin. Because there is little activity in terms of additional treatment facilities or interceptor systems along the Chagrin, even though one might anticipate an increase in the prices of the land in that area, the increases are not going to be due to the installation of the planned interceptor system and industrial waste treatment system. The Rocky River system may enjoy increases in land values adjacent to the planned public lands next to the river. Some of this may be attributable to the installation of the interceptor systems because it is anticipated that this system will result in a cleanup of the River, including the area where the River empties into the Lake. This area is presently serving as a marina and if the River were cleaned up appreciably, there could be a measurable impact on reduced maintenance for water craft which are kept in the inlet, thus increasing the value of the area for recreation.

One negative factor which must be considered, however, is the potential problems which might be brought about by the decrease in the flow of the Rocky River as a result of the diversion of a significant portion of its flow through the interceptor systems of the Cuyahoga basin. The lower flow characteristics of the river may have deleterious effects on the adjacent property because the remaining pollution may be more concentrated or a river without water for certain periods may be aesthetically displeasing. The East Branch of the Rocky River is expected to run dry during certain periods of time during the summer. Clearly this is going to have a detrimental effect on land values adjacent to this protion of the river.

The Cuyahoga between Akron and Lake Erie will be improved to the extent that the land bordering the river may be used either for parklands or for residential development. If development along the river proceeds into areas where presently there is no development, the values of the land are likely to rise. The only problems which might mitigate this finding is that the areas along the river may now presently be slated for industrial

development. If so, the values of the land may be somewhat higher than if the land were to be used for residential purposes.

The land values along the Lake Erie shoreline are quite likely to improve if the planned system has a significant impact on the population levels in the Lake itself. However, the values of the property which will be in view of the proposed holding basins may, in fact, decline because the aesthetics of the view of the lake will have been interrupted.

Finally, there may be some changes in the value of the land adjacent to proposed new treatment plants and proposed expansions of plants. It seems quite possible that the values of the land immediately adjacent to a new treatment plant are quite likely to decline. It should also be pointed out, however, that the closing of a number of plants in "desirable" areas (especially in the Rocky River Basin) will induce positive changes in land values.

Considering both the possible negative and positive impacts of the proposed program on the values of land suggests that the net impact on land values is quite possibly positive. The main potential for error in this judgment would appear to be the possibility that the unsightly offshore holding basins would significantly reduce the value of the property within view of them.

Water Treatment Costs

The impact of the water-based alternative on the costs of treatment can be considered under three main categories. First, there is a potential impact on the cost of treating wastes generated within the basin. This can be broken down into the costs of treating municipal wastes and storm water runoff, and the costs of treating industrial wastes. The second change in treatment costs is in the charges for treating water for drinking purposes.

The costs of treating the wastes for the Basin and for dealing with the storm runoff are difficult to deal with in the absence of estimates of costs for the other alternatives. To treat the problem properly one would have to establish the costs of treating the wastes and the costs of the untreated wastes plus the costs of the present storm water runoff. This would be compared with the costs less the benefits of the alternatives proposed. If it were found that the proposed plans produced a net reduction in the overall cost of treatment of wastes from the Basin, then the impact of the plan in terms of waste treatment costs would be positive. At the current level of detail there is simply not enough detail to draw any conclusions on this question.

The cost of industrial waste treatment is likely to increase significantly. Under the proposed plan, industries are required to remove

certain effluents and treat discharges without relying on the public sector to assist them in defraying the costs. This could have a significant impact on industry costs. In some cases the costs of treating the effluents may induce marginal firms to cease operations. For the most part, however, the more likely outcome would be that the firms would undertake cleaning up the effluent, and pass the cost of the cleanup on to the consumer of the product through increases in the prices of the products produced.

The potential changes in costs from improved water for users in the area are quite likely to be very small. There will probably be a reduced requirement for chemicals for treatment purposes but because a significant portion of the water for public consumption comes from Lake Erie at the present time, the major benefit will be in the form of the improved quality of the Lake Erie water. The quality of the water is already quite good. The best to be expected would be a minor improvement in quality at the intake for the treatment plants. This will result in a reduction in treatment costs simply because of the reduced requirements for chemicals.

Commercial Fishing

Improvement in the quality of the waters discharged into the Lake is quite likely to improve the quality of the Lake itself, especially the Central basin, but only if associated with other changes. If this were the case, then one might expect the quality of the fish caught from the Lake to improve. The composition of the fish population would probably change. Thus, to the extent that the returns from fishing are a function of the quality of the fish in the lake, the returns to the fishing industry should improve.

The majority of the U. S. fish catch from Lake Erie consists of those caught by Ohio Fishermen.* Thus, one might expect a significant impact on the fishing industry in the region surrounding and including the Three Rivers basin. Unfortunately, other evidence suggests this is not the case. The fishing industry in Ohio is antiquated, inefficient, and poorly structured. Labor has so many alternative employments that wages to draw them into fishing must be quite high. The industry in Ohio compares very unfavorably on every count with the industry in Canada. It seems very unlikely that the Ohio industry would be capable of reaping any measurable benefits from improved composition of the fish population. The majority of the benefits are likely to accrue to the Canadian industry. Thus, the

* The United States' catch is only about one fourth as large as the Canadian catch in dollar terms.

fishing industry does not appear likely to enjoy any favorable impact either at the regional or at the national level.

It has been suggested that the poor performance of the fishing industry in Ohio is not due to the decline in the quality of the fish population Instead, this factor was merely a permissive factor. This contention is supported by the fact that the Canadian industry has shown considerable growth and technological change during the same period.*

Economic Development Impacts

The effects of a regional water management system in promoting regional economic development should occur through the effects of the planned system on incomes, investments, and/or employment. There do not appear to be significant regional economic consequences either for or against implementing such a system. The growth in the region is a function of the capital base of the region, and a system for carrying wastes to central treatment places and also to divert and hold storm runoff would appear to be an addition to the capital base of the region. Even if it were possible to implement the program immediately (i.e., within say, 1 year), it would be extremely difficult to attribute any change in the development of the region to the implementation of the water and sewer system simply because the system would represent a very small increment to the total capital stock of the Basin. Implementing within a year would provide the maximum potential for measuring impact. Clearly such an occurrence is infeasible. As the plan is developed over time, the impact thus lessened would be impossible to detect.

The major advantage generated by the plan would be incentive for new industry to develop. While the existence of waste treatment facilities is important in the decision by industry to locate in a particular place, the decision is based on either having the system or not having the system. In the case of the Three Rivers Basin, there are facilities available, although perhaps inadequate. But the effect of development of adequate sewage treatment facilities would be reduced by requiring industrial treatment of wastes.

The added attractiveness of the area may induce more persons to move into the area. This could provide a plus factor for industrial location simply because of the availability of labor inputs.

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* Donald W. Lewis, "Some Factors Associated with the Decline of the Lake Erie Commercial Fishing Industry in Ohio", Procedures from 12th Conference of Great Lakes Research, 1969, pp. 834-842, International Association Great Lakes Research.

The problem of estimating the impact on the regional development is further complicated by the fact that one must project the effect of the development of the system to 2020. It seems unlikely that the plan will have any measurable effects in the economic growth of the region beyond what would have occured in the absence of such an investment simply because there is a potential for too many other factors to have more significant effects.

Income Redistribution Impacts

The impact of the proposed plan on the income redistribution within the region could potentially be quite significant. The impacts depend, however, on the alternative forms of financing the plan. Because the financing methods have not been developed, Battelle-Columbus has taken the liberty of speculating on financing sources.

Assume the financing of the system were to take place with funds generated within the region. The assumption that the funds are generated from outside the region is discussed in the section dealing with national impacts and income redistribution effects. If the funds are generated within the region, income may be distributed in favor of the less wealthy individuals only if the development of the system entails the availability of facilities or water uses for the poor which previously did not exist.

The facilities available to the central-city residents are at present limited, and the existing parks and swimming beaches are used fully even though they may be dangerous to the health of the users. There do not appear to be significant advantages to be gained for recreation to the central-city poor from the proposed plan. Because the areas most likely to be affected are the areas along the Rocky River, and the areas near the Lower Cuyahoga, there would be a regional income redistribution in favor of individuals residing in these or the adjacent parklands. It should be stressed, however, that these would receive the income redistribution only if they did not pay for all the financing by themselves.

There would be an unfavorable distribution toward the individuals who live along the East Branch of the Rocky River and also an unfavorable distribution toward the individuals who live in areas near the existing treatment plants (because of expansion of these facilities) or near proposed new plants.

National Economic Development

The impacts of the proposed plan for national economic development are virtually impossible to determine. The fact that the impacts for the region are so difficult to perceive and measure suggests that the national impacts are likely to be even more difficult to determine. No attempt has been made to evaluate these impacts.

There may be some implications for income redistribution nationally if one were to assume the plan would be financed by the Federal Government rather than regionally. In such a case there would undoubtedly be an income redistribution in favor of those residing in the Cleveland-Akron area vis a vis the nation as a whole. If, however, the national interest in cleaning up Lake Erie were great enough, the income redistribution favoring the Cleveland-Akron area would be an acceptable redistribution. The region contained within the Basin is undoubtedly a relatively affluent region and, therefore, if the plan were financed from general federal revenues, redistribution would probably favor more affluent members of the national community.

LAND BASED ALTERNATIVE

Use of land as the mechanism for wastewater treatment is defined as the land based alternative (L-1). The wastes generated in the Cleveland-Akron metropolitan area are transmitted to lagoons and then to spray irrigation fields. Water is collected from these fields by the use of underdrains and then returned to the Three Rivers Basin. The size of each lagoon and field is approximately 17 and 156 square miles, respectively, and their location is shown in Figure 1. The information provided by Havens and Emerson, Ltd., indicated that the entire area at these locations would be used for irrigation and percolation. Consequently, no mixture of land uses was investigated in this study. Because of potential hygienic hazards, any mixture of land treatment and other land uses would have to be studied in detail before developed. In this alternative the storm water is distributed to three percolation fields located in the Three Rivers Basin. Their size ranges from one half to greater than 1 square mile. Sludges are handled by spreading them on the irrigation fields along with the wastewater.

Expected Changes

The implementation of the land based alternative would have some beneficial impacts in the Three Rivers Basin, but it would have significant adverse impacts on land disposal areas. Some of the major changes are listed in Table 17. These and other changes are discussed below. This appraisal is, of course, based on these chosen locations and the results should not be construed to apply to land disposal in general.

Environmental Quality

Ecological Impacts

Primary Productivity. With an increased water input to the soil, there will be a release of calcium and magnesium from the soil by the process of ion exchange by sodium and potassium. This could pose a problem of nutrient uptake by certain crops on selected soils. Battelle-Columbus is not in a position to evaluate this phenomenon in the feasibility study. There will, however, be significant leaching of nitrate from the soil. With additional nitrate being applied via the liquid wastes, there should be sufficient nitrate for plant growth. A problem may exist in the springtime when liquid wastes are added to the fields from the storage lagoons. Normally, after a period of storage, the wastes will be high in ammonia. A high concentration of ammonia will adversely affect seed germination of most crop species. If the quantity of wastewater added to the soil is not closely controlled, adverse anaerobic conditions will be caused by either water logging or high organic retention on the soil surface. The latter condition will contribute to increased water runoff, thus accelerating soil erosion, especially in rolling land such as the sites selected for land treatment of wastes. This erosion will adversely affect crops. However, most of the above problems can be alleviated by proper management and selection of land sites for spray irrigation.

TABLE 17. EXPECTED CHANGES FROM THE LAND ALTERNATIVE

Location	Expected Changes
Rocky River	• Improved quality--from a polluted to an enriched river
	• East Branch becomes an intermittent stream because of wastewater transfer out of Basin
	• Increased phosphates in river
Cuyahoga River	• Improved quality--from a polluted river to an enriched river
	• Flooding potential problem at high flow--almost all of Basin's return wastewater is discharged into river between Akron and Kent
	• Increased flow in river at low and medium flows
	• Increased phosphates in river
Chagrin River	• Reduced quality--from an enriched river to a polluted river
	• Reduction in river flow from collection of runoff and wastewater transfer out of Basin
Lake Erie	• Improved quality along shoreline
Storage Lagoons	• Odor and hygienic problems
Spray Irrigation Areas	• Excessive slopes cause sedimentation problems
	• Excessive slopes restrict type of crops and harvesting feasibility

TABLE 17. (Continued)

Location	Changes
	• Relocation of individuals
	• Elimination of numerous scenic, historical, cultural, and recreation areas
	• Hygienic problems--contamination of surface water
	• Change in entire ecosystem of areas
(Other) Transmission Facilities	• Increase demand for electricity to transfer and return wastewater ($1x10^6$ hp/day)

There will be significant leaching of phosphates from the soils receiving liquid wastes. Leached phosphates and nitrates could contribute to algal problems in the local lakes and streams if a significant portion of the percolated water escapes to the natural drainage in spray irrigation areas. There will be a significant increase in phosphate loadings in the Rocky and Cuyahoga Rivers, which could contribute to increased algal growth in these rivers. There will be a significant reduction in both phosphate and nitrogen loadings to Lake Erie, Table 18. Therefore, it is anticipated that there will be a reduction in algal bloom problems in the nearshore waters of Lake Erie.

Consumer Productivity

With the reduction in BOD loading and suspended solids in the water returned to the Rocky and Cuyahoga Rivers after irrigation there should be a significant improvement in the benthic and fish species productivity. On the other hand, the reduction in flow in the East Branch of the Rocky and Chagrin Rivers would have adverse impacts on the productivity in these rivers. The nearshore waters of Lake Erie should be improved for both benthic and fish species. Because of the topography of the area selected for the land waste treatment, there will be an increase in soil erosion which will contribute to increased siltation in the streams and lakes in the natural watershed. This increased siltation will contribute to the reduction of benthic populations and fish spawning in the local streams and lakes.

TABLE 18. PROJECTED POLLUTANT GROSS LOAD TO LAKE ERIE AND CONCENTRATION OF POLLUTANTS IN THE THREE RIVERS - LAND ALTERNATIVE

		BOD	SS	Cl	N	PO_4	SO_4
Lake Erie lb/D	2020	9,700	57,600	865,700	12,900	82,000	737,900
	1970 Base	118,000	140,000	510,000	43,000	880,000	439,000
Chagrin River mg/l	2020	--	--	--	--	--	--
	1970 Base	3.8	47	40	1	0.8	60
Cuyahoga River mg/l	2020	2	~5*	178	<4	13	149
	1970 Base	11	87	230	16.5	3.8	202
Rocky River mg/l	2020	2	~5*	178	<4	13	149
	1970 Base	6.4	63	111	6.6	8.7	135
Good Criteria (See Table 2)		<3	<80	<150	<1.0	<0.1	<100

* Under low-flow conditions; during high flow level will increase to an average maximum approaching 1970 values because of erosion, etc.

Biogeochemical Cycling

A reduction in BOD and total nitrogen loads should result in significant improvement of chemical water quality in the Rocky and the Cuyahoga Rivers and the nearshore waters of Lake Erie as far as the production of methane and ammonia. The land treatment plan should contribute to an overall improvement in the low dissolved oxygen problem in the Lower Cuyahoga River. There will be an increased load of sulfate entering Lake Erie. Battelle-Columbus is not able at this time to determine what the resultant effect might be with this increased load of sulfate (Table 18).

Species Diversity

There should be a significant increase in species diversity of both benthic and fish species in the Rocky and Cuyahoga Rivers as well as the nearshore waters of Lake Erie. A reduction of species could occur in the East Branch of the Rocky and the Chagrin Rivers. There will also be a problem with the reduction of species diversity in the streams that naturally drain the proposed plan treatment sites, due to the fact that they will be receiving an increased siltation load.

Population Density and Distribution

Because of the increased stream flow in the Cuyahoga and Rocky Rivers resulting from the return waters from the land treatment area, there will be increased levels of suspended solids, while a new stream level is being established. This will have a temporary adverse effect on the fish and benthic species. However, after a relatively short period of time, a more normal suspended solid load should become reestablished. Because of the decreased loading of BOD material, and suspended sediment loadings, with the land treatment the water quality conditions should be improved to a level that could support populations of sport and commercial fish in the Cuyahoga and Rocky Rivers. This will also be true for the nearshore waters at Lake Erie. However, sport fishing in the East Branch of the Rocky and the Chagrin Rivers would be adversely affected by the changes in river flow. Due to the projected increased level of siltation, those streams in the natural watershed of the land treatment areas may also undergo a reduction in population of fish species.

Social Well-Being

Hygienic Impacts

Direct Effects. With this alternative, all sewage discharges to rivers and Lake Erie would be eliminated. There would be no sewage treatment plants, and with some exceptions, noted below, septic-tank discharges would be eliminated through the construction of sewers. Collection of all combined wastes and storm waters would end this source of contamination. The effect on the rivers and Lake Erie should be virtual absence of hygienic organisms associated with sewage.

Some direct hygienic threats would still exist, however. First of all, large portions of the Upper Rocky, the Upper and Middle Cuyahoga, and the Chagrin River Basins, which are expected to be reserved for agricultural or recreational use, are not included in the sewer plans. If these areas should develop more intensively, they might very well not be sewered before a serious septic tank drainage problem resulted.

Second, disposal of collected storm and combined sewage discharges would present some possible hygienic problems. If the percolation basins should overflow or should develop leakage into the rivers, it is possible that bacteria, viruses, and roundworms or their eggs could be carried with the escaping water. Overflows would be unlikely, however, and even a few feet of filtration through soil would serve to prevent escape of most disease organisms.

A third concern would be, of course, failure of pumps or breakage of pipes used to transport raw sewage to the land disposal sites. Since the entire load of wastes would have to be disposed of through only two pipes, and since the pipe contents would have to be kept under pressure, any serious malfunction would almost certainly result in discharge of a large volume of untreated sewage onto the land adjacent to the pipeline or into the rivers.

A fourth potential hazard would exist in the possibility of contamination of surface waters in and around the irrigation areas. Since these areas would be large, they would present serious drainage difficulties in the event of severe storms. With the soil already saturated with water, almost all intense rainfall would runoff on the surface, carrying with it residual bacteria, viruses, and roundworms or their eggs. Even long detention time and disinfection in the aerated and storage lagoons would fail to kill all pathogenic bacteria and viruses in undiluted sewage. Ground water supplies would be safe, fortunately, since those areas used for treatment are generally 100 or more feet below the soil surface in buried valleys. Historical records indicate very little tendency for these supplies to be contaminated by surface water pollution of any kind.

Finally, the proximity of population centers and transportation arteries to the proposed irrigation areas would make aerosol transmission of pathogenic bacteria and viruses a potential threat.

Since industries would be required to eliminate hazardous wastes by treatment or concentration and underground storage, these should cease to be a threat to the human population. It should be noted, however, that the systems for deep well injection of wastes involve pumping concentrated toxicants under very high pressure. If such a system should fail, these concentrated poisons would be released to the land and surface waters in substantial amounts in a very short period of time.

Indirect Effects. Indirect transfer of pathogens to the human population from sewage would be reduced by this plan in so far as it is a present threat in areas now inadequately served by septic tanks. Sewers would eliminate most accumulations of polluted water in ditches where they

now serve as breeding places for mosquitos and flies, which serve as vectors. The storm and combined sewage disposal areas, the aerated and storage lagoons, and the sewage irrigation sites would provide, however, ideal breeding places for these pests. Under this alternative, the East Branch of the Rocky River would become an intermittent stream resulting in stagnant pools during periods of low or no flow which would provide additional pest breeding places. On balance, the new hazard would be much greater than the hazard under existing circumstances.

Human consumption of crops raised in the sewage-irrigated fields would not be anticipated, but, if eventually practiced, it would offer little pathological threat so long as all foods were cooked. Bacteria and viruses would not be present inside these plants, and cooking would inactivate bacteria, viruses, roundworms, or encysted flatworms on their exterior surfaces.

Elimination of mercury-containing discharges to the rivers and lakes, as provided in this plan, would be followed by gradual dissipation of existing mercury accumulations in bottom sediments. Together, these effects would reduce the exposure of fish to mercury compounds and would, therefore, reduce the threat of human consumption of contaminated fish or water fowl. It is possible, however, that improvement of general water quality in Lake Erie and the rivers would make areas now grossly polluted accessible to fish which cannot currently survive in the areas, thus exposing the fish to additional mercury-laden sediments. This, fortunately, would be only a temporary effect.

Aesthetic Impacts

Land Effects. The proposed system of transfer of Cleveland-Akron's wastewater out of the Basin for treatment and its return to the basin after treatment has some aesthetically beneficial but mostly adverse impacts. Beneficial impacts stem from the improved water quality in the Cuyahoga River and Lake Erie, and the resulting aesthetic improvement in composition. On the other hand, this proposed transfer return system has adverse impacts in both the Three Rivers Basin and at the land treatment locations.

In the Three Rivers Basin the East Branch of the Rocky River is expected to become an intermittent stream. This flow change results from the transfer of wastewater out of the Rocky Basin with no return of the treated water back into the East Branch. Because of its location in the Cleveland park system, this change would have adverse consequences on the rivers' aesthetic composition. It is also estimated that unfavorable aesthetic conditions would be created in the Cuyahoga River Basin between Akron and Cleveland. A problem is created by the discharge of large volumes of return flow into the river in the Akron-Kent area. The additional flow would probably cause flooding conditions at medium to high flows, which would disrupt the scenic value of the river valley. At flows less than those causing flooding conditions; however, the increased river flow would increase the river's velocity. This in turn would increase the scenic value of the river.

The suggested land-use changes in the southeast and southwest land treatment areas would affect their aesthetic composition. The change in the natural landscape of trees and steep sloping valleys to spray irrigated fields and sludge lagoons would be aesthetically objectionable. The scenic areas directly affected by the spray irrigation fields are

- Guilford Lake State Park - Columbiana County
- Watercress Marsh - Columbiana County
- Center Township Swamp - Columbiana County
- Little Beaver Creek (Scenic River Proposed) - Columbiana County
- Zepernick Lake Wildlife area - Columbiana County
- Mohican River (Scenic Valley) - Ashland/Richland Counties
- Pleasant Hill Reservoir (Corps of Engineers Flood Control) - Ashland/Richland Counties
- Mohican and Memorial State Forest - Ashland County.

Water Effects. There are both adverse and beneficial impacts on the physical characteristics of color, odor, taste, and movement of water resulting from this alternative. The existing color problems would be eliminated on the Cuyahoga River and along the shores of Lake Erie. But, because this alternative does not reduce the nutrients in the wastewater, the streams receiving the return flows, Rocky and Cuyahoga, would increase their potential for algae blooms beyond present conditions. It is also expected that these blooms would occur along the shores of Lake Erie, but to a lesser extent than in 1970.

The transfer of wastewater and storm runoff outside the Chagrin Basin would reduce the flow in the Chagrin River. Because much of the adjacent land use has and will continue to have septic tanks, the reduced flow in the Chagrin, below Chagrin Falls will most likely change the flow from enriched to a polluted class. Along with this change will come an increase in algae production and the corresponding color and odor problems.

Odor problems will also be present in areas adjacent to the large storage lagoons. It is expected that the lagoons will become anaerobic during the winter months, and after the ice cover is gone, will produce a noticeable odor. This odor will remain until the lagoons return to an aerobic condition. Because of the size of these lagoons and wind direction, this odor problem would be noticeable in many of the adjacent population centers, and therefore is objectionable.

The pleasing aesthetic feeling of seeing and hearing water rush over small dams and rapids would be partially eliminated in the East Branch of the Rocky River. This change would take place because at times the stream is expected to be dry. Because this impact would take place in a known recreation area which has high usage, the aesthetic loss would be perceived to be major.

Biota Effects. Improved water quality in the Cuyahoga is expected to precipitate the development of additional parks adjacent to the river. These new parks will probably follow the Cleveland Metropolitan Park District trend for large conservation areas with ample trees and vegetation. Additions of these parks will increase or at least preserve the natural biota in the Three Rivers Basin.

However, the adverse effects to the biota in the areas considered for spray irrigation and lagoons are significant. Forest cover exists in much of the undeveloped land in Columbiana County and in large state forests in Ashland County. These areas provide a natural habitat for numerous animals and a diverse vegetation. To change these areas into spray irrigation fields would eliminate all animals, trees, and other vegetation in the area. This drastic change in land use would cause a negative impact on aesthetics.

Air Effects. The construction of these large spray irrigation fields and lagoons would possibly have an effect on the meteorology of the area. This change would be in the form of increased fog in the area, which might cause a safety problem on the highways (Ohio Turnpike) that exist in the area.

Another change that must be considered in the air quality component is the increased electricity required to transport the water to and from the Three Rivers Basin. It is estimated that the power required to make this transfer would be about 1 million horsepower per day. This increase in demand for electricity would not in itself necessitate increased electric power generation, but it would be a step in that direction. If fossil fuel were used in this generation, it would cause a significant increase in air pollution and possibly thermal pollution in the area.

Social Opportunity Impacts

Recreation Effects. Improvement in water quality in the Rocky and Cuyahoga Rivers, and the shoreline of Lake Erie has some beneficial effects on the recreation in the Basin.

New or improved fisheries will probably be established in the Cuyahoga and Rocky and the shoreline of Lake Erie. However, because of the water

transfers out of the Chagrin and the East Branch of the Rocky River, it is anticipated that the Chagrin would lose its cold-water fishery status (trout) and that the fishing in the East Branch of the Rocky would be occasional at best. Boating and swimming in the Three Rivers Basin would not change appreciably from the evaluation given for the water alternative.

Passive recreation will be stimulated by the improved water quality in the Basin's rivers. It is expected that parks will be developed along the Cuyahoga and other rivers in the basin. The extent of the park development along the Cuyahoga is dependent on the frequency of flooding in this Basin from the wastewater return flows.

Most of the positive impacts on recreation in this Basin are small and almost completely negated by the adverse impacts to be caused by the proposed spray irrigation fields. All boating, fishing, swimming and passive recreation areas would be eliminated by the irrigation fields. Some of the major areas to be lost are

- Mohican River System
- Mohican and Memorial State Forest
- Pleasant Hill Reservoir
- Little Beaver Watershed
- Guilford Lake State Park
- Lepernick Lake Wildlife Area
- Highlandtown Wildlife Area.

These areas supply the recreation needs for these five and the adjacent counties of Ohio. The loss amounts to over 11,000 acres which is over 60 percent of the existing public recreation--active and passive--in these areas.

Rural America would suffer the most from the proposed land-based alternative. For not only would many of the individuals be forced to vacate their homes, but also those remaining would have lost almost all of the recreation facilities presently available to them. The gain in improved recreation in the Basin would be at the expense of the individuals outside of the Cleveland area.

Human Betterment Impacts

Historical/Cultural Opportunities. The storage lagoons and spray irrigation areas proposed in the land alternative would have a significant adverse effect on historical/cultural opportunities and activities in these

areas. If the value of such opportunities is not completely lost, the attraction of such areas will certainly be significantly diminished. Included in this category are five covered bridges in Columbiana County.

Housing Effects. Implementation of the land based alternative would possibly result in flooding conditions in the Cuyahoga River. These high flows could have adverse effects on homes or property located near the Cuyahoga River. The three percolation basins proposed for the Cleveland area are likely to have bad odors; therefore, housing nearby these basins will be adversely affected. Odor problems would also exist near the storage lagoons used prior to spray irrigation. This would have also adverse effects on the adjacent housing.

Education. Columbiana County has a marsh and a swamp which have high potential for development for educational purposes. If spray irrigation is introduced to these portions of the County, the value of the marsh and swamp will be completely lost. Also, Columbiana County has two State Parks, two wildlife areas, a State Forest, and a scenic highway, all of which would be adversely affected by the introduction of spray irrigation in the County.

In Ashland County, two State Parks, two State Forests, and three scenic highways would be adversely affected by spray irrigation. In Richland County, two scenic highways would be adversely affected.

Life Style Impacts

Land Use Changes. The potential problem in the Cuyahoga River could result in land use changes. Land on the river banks, previously used for residential, park, or industrial purposes, could be changed to use for river flow. The three percolation basins proposed for the Cleveland metropolitan area would also adversely affect whatever development surrounds them and will inhibit future development that might have taken place near them.

This alternative proposes that all treatment facilities now in existence be phased out of the treatment system. Therefore, this land would be open for other kinds of development, but it is impossible to predict what use will be made of it.

The storage lagoons and spray irrigation areas would replace the existing land uses of recreation and agriculture. There are a number of towns, large and small--Loudenville, Canton, Alliance, Lisbon, East Liverpool--which, if left alone, would develop or grow into the areas proposed to be used for storage lagoons and spray irrigation areas. The growth of these towns would be restricted by the presence of the lagoons and spray irrigation areas.

Relocation of Individuals. The potential flooding problem in the Cuyahoga River could cause some homes and businesses to be relocated. The construction of the percolation basins and the storage lagoons and the creation of the spray irrigation areas could also result in all homes, farms, and businesses having to be removed or deserted and relocated elsewhere. The population density of the rural areas is not so great as in part of the Cleveland area; however, the problems created by relocation are just as great for rural people as for urban residents.

Amenities. The negative changes of this alternative appear to outweigh the positive changes. The treatment system proposed by this alternative results in a high amount of phosphates remaining in the water; therefore, algae growth in the rivers would still be a problem. The quality of the Chagrin River may be reduced as a result of low flow and possible problems caused by septic tanks. The percolation basins, storage lagoons, and spray irrigation areas all have strong negative points about them. They will cause a major relocation program, will be aesthetically unpleasant, and will have, in general, negative effects on those areas surrounding them. The only positive change caused by this plan is that the Cleveland-Akron metropolitan area will not have to contend with the problems of sewage treatment facilities in their own area. The implications of this change are discussed below.

Distribution Impacts

Residents of the Cleveland-Akron metropolitan area would benefit from having more adequate sewage treatment at the great expense of the people in the rural areas whose lives would be greatly affected and not to any benefit of their own. The Cleveland-Akron area would benefit also from having new land made available (created by the closing of many sewage treatment facilities), while the rural area will lose a very large amount of their land.

Regional Development

Land Impacts

This alternative has the greatest potential for land impacts of the three major alternatives. Considering first the Rocky River Basin, the land values along the East Branch of the Rocky River are likely to change because this branch will become an intermittent stream. Land along the West Branch is also likely to change because of the increased flow into the stream in the Medina area. The effects are uncertain owing to the fact

that it is not clear whether or not the branch can contain the additional flow. But the potential for the destruction of significant portions of the adjacent land simply because of flooding may occur.

The Cuyahoga River may also have a significantly increased flow, and appears to have even greater potential for overflowing its banks as a result of the large discharge into it. Flow changes may also occur in the Chagrin Basin because of the transfer of wastewater out of the basin and the collection of storm water runoff. The resulting low flow may affect the use of the river as a trout stream and thus may have impact on those persons who might live there for that reason. To that extent, the land values for the nearby property may change.

The proposed alternative would not reduce the phosphates in the Cuyahoga and the Rocky Rivers. In fact, they would be enhanced by this alternative. The algae blooms resulting in the rivers and Lake Erie, although reduced, would also cause a significant impact on the values of land adjacent to the problem areas.

The acquisition and development of percolation basins throughout the Three Rivers Basin would require the displacement of a portion of the Cleveland population. This land would have to be acquired by the public sector and may be quite costly because it is so near the metropolitan area. Individuals residing near these basins may notice displeasing odors, and, as a result, the price of land near the basin may decline.

Another major feature of the land plan involves the use of lagoons for storage. The lagoons will require the displacement of portions of the county's population and the acquisition of large parcels of land which will be removed from tax rolls. The land to be acquired for the eastern lagoon will result in the removal of a large parcel of land which could potentially serve either as suburbs to the Canton-Alliance axis or as truck-farming areas for the same axis. Land values near the lagoon would be unfavorably affected because few would wish to live near them. In addition, unpleasant odors would detract from the desirability of living nearby.

The final feature of the land alternative as it impacts on land values is the spray irrigation areas. First, the land will have to be acquired from private owners. This is likely to prove difficult without offering quite large sums of money for the land. Second, the existing productivity of the land will be destroyed. The land to be acquired is broadly classified as either recreational land, farm land, or strip-mining land. In addition, the land represents income to the state and to the counties in the form of revenues on property taxes or property based taxation. By removing the land from productive use, one must also consider the impact on incomes for the affected areas. If the land acquisition results in no returns to the present owners other than sales, all their incomes will be lost from the federal income tax rolls, and in some cases income taxes will be lost by the State of Ohio.

It is possible that the land will be used for agricultural purposes. If so, the complications discussed in the introduction to this section will apply. Furthermore, because of the steep slopes, the uses of the land are limited to nonrow crop farming. Thus, the potential and existing truck-farming capabilities of the area under consideration will be lost. Furthermore, unless the land is acquired at present prices, there is a good possibility that the price of the land will more than double as it becomes a potential for truck farming.

If the stated areas are acquired for spray irrigation, there is little chance that property values in the surrounding areas and within the adjacent towns will do anything except fall.

Water Treatment Costs

The water treatment costs for the land alternative are also considered in three categories. The costs of treating wastes within the basin are practically impossible to determine for this alternative because detailed cost estimates of the alternative are presently not available. However, it can be stated that the waste treatment costs will be greater for this alternative as compared with the water alternative. This increase would result from the additional pumping that would be required to collect, transfer, and return the wastewater.

The industrial waste treatment costs and benefits are similar to those discussed for the water alternative. Costs related to water treatment for domestic consumption in Cleveland should also be similar to those discussed for the water alternative. However, many of the water supplied for the communities in the spray irrigation areas will be eliminated. This would necessitate an increase in costs to find and develop other water supplies.

Commercial Fishing

There may be some minimal improvement in the quality or quantity of fish in Lake Erie as a result of this plan but the effects on the commercial fishing industry should be small. The reason for this is the same as discussed for the water alternative.

Economic Development Impacts

There is little reason to attribute measurable economic development to the region as a result of implementation of the land based alternative.

Income Redistribution Impacts

There is potential in this alternative for income redistribution effects to be quite different from the effects in the water alternative because the acquisition of lands for lagoons and spray irrigation areas would deny the present residents of the farm lands to be acquired of their livelihood. The benefits of the alternative would accrue primarily to city residents. As a result, there would be a redistribution away from farm owners, who in this area tend to be relatively poor, in favor of city or suburban residents who tend to be relatively less poor. Furthermore, some of the impact of the waste treatment facilities would fall outside the watershed. This permits the city residents to "export" their problems and forces rural persons to bear some of the sacrifices of waste management. It might be theoretically possible to compensate an individual for the cost of forcing him to move, and change his occupation, but this plan does not appear prepared to do this.

Another regional income distribution problem is generated by the acquisition of the lands both in Richland-Ashland counties and in Columbiana County. These areas (especially the Columbiana County area) may be viewed as an alternative site for the disposal of wastes by nearby towns, and appropriating them for Cleveland prevents their use by the local citizenry for their waste disposal sites. It seems quite possible that the Youngstown-Alliance-Canton complex must view the Columbiana County region both as potential area for expansion as recreation areas and as potential area for their waste disposal. It would be difficult to convince them that it was to their advantage to allow Cleveland to appropriate the area for its use.

National Economic Development

National impacts of the land based alternative appear to be quite similar to the impacts of the water alternative. There are two additional notes which might be made regarding the national impact of the land alternative, however. First, it may be against the national interest to utilize part of the land in Columbiana County because at one point in time the land had been considered both as a national recreation area and as a potential wild river area. The use of the land for spray irrigation would preclude its use for either of these options. While these options may not be presently active, they do indicate that this land has some national priority above the average run-of-the-mill farmland area. Thus, the use of this land for spray irrigation might have an unfavorable national impact on this basis.

Second, unless the same amount of water is returned to Lake Erie after passing through the spray irrigation system as is presently flowing into the lake, the internationally established flow into the Lake might be disrupted. If it is required to replace the water lost by using other water sources, there may be significant objections from the other states or watershed districts.

COMBINATION ALTERNATIVE

The combination alternative (C-3) for wastewater management for the Cleveland area includes aspects of both the water and land alternatives.

In the northern section of the Basin regional treatment plants using tertiary treatment are proposed, while in the southern section of the Basin, the wastes are to be treated by using storage lagoons and spray irrigation fields. These land treatment areas are located in the same general areas as those proposed in the land alternative, except that they are smaller in size. Storm water is to be treated by holding basins in the northern section and separate land facilities are used in the southern section. Sludges generated by the waste treatment facilities are landfilled either with or without prior incineration to reduce volume.

Expected Changes

As in the other two waste treatment alternatives the combination alternative will have both benefical and adverse impacts. Some of the major changes are listed in Table 19. These and other changes are discussed below.

TABLE 19. EXPECTED CHANGES FROM THE COMBINATION ALTERNATIVE

Location	Expected Changes
Rocky River	• Improved quality - from a polluted river to an enriched river
	• East Branch becomes an intermittent stream because of wastewater transfer out of the Basin
	• Increased phosphates
Cuyahoga River	• Improved quality - from a polluted river to an enriched river
	• Increased phosphates

TABLE 19. (Continued)

Location	Changes
	• Lower Cuyahoga suitable for fish runs
Chagrin River	• Quality remains unchanged
	• Temperature increases in the river because of storm water transfers out of Basins.
Lake Erie	• Improvement in quality, primarily along the shoreline
	• Holding basins--algae and hygienic problems
Storage Lagoons	• Odor and hygienic problems
Spray Irrigation areas	• Excessive slopes cause sedimentation problems
	• Excessive slopes restrict the type of crops grown and harvesting feasibility
	• Elimination of numerous scenic, histroic, cultural, and recreation areas
	• Change ecosystem of area
Air	• Air pollutants from sludge incineration
	• Transfer of heavy metals from sludge inceneration
General	
Treatment Facilities	• New and expanded treatment facilities
	• Old facilities phased out
Transmission Facilities	• Increased demand for electricity to transfer and return wastewater

TABLE 20. PROJECTED POLLUTANT GROSS LOAD TO LAKE ERIE AND CONCENTRATION OF POLLUTANTS IN THE THREE RIVERS - COMBINATION ALTERNATIVE

		BOD	SS	Cl	N	PO_4	SO_4
Lake Erie lb/D	2020	22,900	24,900	805,400	12,100	22,500	685,400
	1970 Base	118,000	140,000	510,000	43.000	880,000	439,000
Chagrin River mg/l	2020	4	~2*	136	2	1.5	114
	1970 Base	3.8	47	40	1	0.8	60
Cuyahoga River mg/l	2020	2	~5*	178	<4	13	149
	1970 Base	11	87	230	16.5	3.8	202
Rocky River mg/l	2020	2	5*	178	<4	13	149
	1970 Base	6.4	63	111	6.6	8.7	135
Good Criteria (See Table 2)		<3	<80	<150	<1.0	<0.1	<100

* Under low-flow conditions; during high flow level will increase to an average maximum approaching 1970 values because of erosion, etc.

Environmental Quality

Ecological Impact

Primary Productivity. The land treatment for the combination plan will be similar to that for the land-based plan, only the acreage requirements will be reduced. Assuming the same irrigation loading per unit of land areas, similar problems of erosion will exist as discussed with the land-based treatment plan. In this treatment plan there will be a significant increase in phosphate loadings into the Cuyahoga and Rocky Rivers; therefore, potential problems with algae might occur during low flow conditions. Although the total nitrogen levels will be reduced in the Cuyahoga and Rocky Rivers, there may be sufficient nitrogen to enhance algal growth. It is anticipated that with the combination plan, there should be an improvement in the algal bloom problems in the nearshore waters of Lake Erie.

Consumer Productivity. With a significant reduction in the BOD loading in the Cuyahoga and Rocky Rivers, there should be a marked improvement in the growth of both fish and bottom organisms. There should also be an improvement in the productivity of fish and benthic species in the nearshore waters of Lake Erie. However, there could be a problem with reduction in productivity of fish and benthic organisms in the localized streams owing to siltation from runoff from the land treatment areas. The consumer productivity is also adversely affected by the flow changes in the East East Branch of the Rocky and the Chargin River.

Biogeochemical Cycling. There should be a significant improvement in the chemical water quality, i.e., reduction of methane, H_2S , and NH_3, particularly with the decrease of BOD and nitrogen loadings in the Rocky and Cuyahoga Rivers and the nearshore waters of Lake Erie. The level of total nitrogen in the Chagrin River will increase, but probably not to a detrimental level. There will be a decreased loading of sulfate in the Cuyahoga River, little change in the Rocky River, and an increase in the Chagrin River. It is thought that these changes will not significantly alter the aquatic ecosystems of these rivers. There will be an increased load of sulfate entering Lake Erie. Battelle-Columbus is not able at this time to determine what the resultant effect might be with this increased load of sulfate (Table 20).

Species Diversity. There should be a marked increase in the species diversity particularly in the benthic population in the Rocky and Cuyahoga Rivers owing to the improvement of BOD loadings and the reduction of suspended solids. In addition there should be an improvement in the fish species diversity owing to the improvement of the potential spawning grounds of the river. There should also be an improved species diversity in the bottom organisms in Lake Erie immediately adjacent to the discharge of the Cuyahoga and Rocky Rivers. However, there should be reductions in species diversity in the Chagrin River and East Branch of the Rocky River.

Population Density and Distribution. With reduction of BOD and suspended solids loadings to the Rocky and Cuyahoga Rivers, there should be a return to a water quality that could support sport and commercial fish species. There will be a requirement of restocking the rivers in order to obtain maximum population levels. The Chagrin River will probably remain relatively unchanged. There should also be a significant improvement in the fishing in the nearshore waters of Lake Erie owing to the significant reduction in BOD and suspended solids (Table 20). Owing to the projected increased level of siltation, those streams in the natural watershed of the land treatment areas may undergo a reduction in population of fish species.

Social Well-Being

Hygienic Impacts

Direct Effects. Under this alternative many small wastewater treatment plants, some of which are not efficiently operated, would be abandoned, and their sewage loads would be handled in larger plants or through a land disposal system. This alternative should eliminate most sources of hygienic bacteria, viruses, and other sewage-related pathogens which now contaminate the surface waters of the Three Rivers area. There would be, however, some very significant hygienic hazards created by the plan.

Among the most dangerous problems would be possible failure of one of the large sewage treatment plants, failure of the pumps in the land disposal system, or rupture of one of the major interceptors or land disposal pipes. Any of these events would result in the disasterous release of large volumes of raw sewage onto the surrounding land or into the surface waters.

The offshore holding basins for combined sewage and storm water discharges would have some contamination potential. These basins would contain large numbers of bacteria, viruses, and other organisms which would be released if a severe storm should cause an overflow or spill. The sudden load of organisms in the nearshore waters would result in infection of water contact recreationists, accustomed to safe clean water, and in contamination of drinking water supplies drawn from the Lake. In addition, parasitic round worms, especially ascaris and their eggs, are very resistant to long periods in water and to disinfection. There is, therefore, a strong possibility that they would be released in a viable state from the basins under normal operating conditions. This would be especially serious since all usual indicators of water quality, including appearance, smell, taste, and bacterial counts, would suggest that the waters were of excellent recreational quality.

This alternative would result in sewering all of the presently serious septic tank drainage areas; however, there are large land areas which would be omitted in the sewer program. These are located in the upper Rocky, the upper and middle Cuyahoga, and the Chagrin River Basins, which are expected to remain in agricultural or recreational use. Should intensive development take place instead, some serious septic tank contamination problems would occur prior to the installation of sewers.

The sewage irrigation areas would pose a serious threat to hygienic water quality in the streams and reservoirs near them. Intense rain on the already saturated soils would result in large amounts of contaminated surface runoff. Fortunately, the very important water supplies in the buried valleys underlying both land disposal sites would be safe due to their depths. There is very little historical evidence of serious contamination of these supplies by polluted surface waters.

Bacteria and viruses could be spread from the sewage irrigation areas through an aerosol effect on windy days. Nearby communities and highways make this a serious problem.

The plan would require industries to dispose of poisonous wastes through treatment or underground storage. This would certainly improve the quality of the Lower Cuyahoga River. The subsurface storage alternative, however, requires concentration of wastes and injection under very high pressures. If an injection system should fail, large volumes of highly concentrated toxicants could be released to the surrounding land and surface waters.

Indirect Effects. Sewering of present areas of septic tank drainage would eliminate many of the polluted, stagnant pools of water in ditches which now serve as breeding places for mosquitos, flies, and other insect pests and vectors. At the same time, however, the plan would create combined sewage and storm water discharge storage basins, aerated and storage lagoons for raw sewage, and sewage irrigation areas which would, together, negate this benefit. The alternative would also remove a large portion of the flow from the flow from the East Branch of the Rocky River, reducing the stream to intermittent flow. During low- or no-flow conditions, pools of stagnant water would be left in the stream channel and would provide additional pest breeding areas.

The mercury problem would be generally reduced by this plan, though it would not disappear entirely. Elimination of industrial mercury discharges would be followed by gradual dispersion of mercury now deposited in lake and river sediments, thus reducing exposure levels for fish. Discharges of effluent from the large wastewater treatment plants would contain mercury, however, since these plants would not be efficient in removing heavy metals. There is also some possibility that high-temperature incineration of sewage plant sludges would vaporize mercury and release it to the atmosphere where it might be introduced to terrestrial and aquatic food chains.

Aesthetic Impacts

Land Effects. The improved or unchanged water quality in the Rocky, Cuyahoga, and Chagrin Rivers and near the shoreline of Lake Erie would improve the aesthetic settings of these rivers. In the Cuyahoga Basin, the improved water quality would probably initiate the purchase and development of park lands adjacent to the river. However, the reduced flow in the East Branch of the Rocky would reduce the value of this existing scenic location.

The natural composition of Lake Erie water and open space would be changed by the use of holding basins for storm water. Because it is anticipated that these basins will produce color, odor, and algae problems, these holding basins would have adverse aesthetic impacts on the composition of the Lake.

The natural composition of the areas suggested for spray irrigation and lagoons would alter or eliminate

- Watercrest marsh
- Center township swamp
- Guilford Lake State Park
- Mohican River Basin
- Mohican and Memorial State Forests
- Pleasant Hill Reservoir.

These areas are presently known as scenic locations and are used for recreation, both active and passive. Therefore, the change in land use would affect the aesthetic composition of the areas unfavorably.

Water Effects. The major beneficial change in the physical characteristics of the rivers in the Three Rivers Watershed is the reduction in color and odor problems in the Cuyahoga River from Kent to Cleveland. Because the return flows from the irrigation fields contain nutrients, the Rocky and the Cuyahoga will increase their potential for algae blooms. There will be a reduction in algal blooms in the lakeshore area, but not a complete elimination of them. Because algal blooms would be still present in the Lake and also in the storm-water holding basins, a major aesthetic problem is expected.

Because of the size of these storage lagoons it is expected that they could go anerobic over the winter and possibly at other times. The odor resulting from this change would be noticeable in the adjacent towns and rural areas. Consequently, the impact is judged to be aesthetically objectionable.

Water surface problems of oil, dead fish, and some floating debris would be reduced by the improvement in water quality. However, the rubbish along the river banks and the natural debris floating in the river would probably not be directly influenced by this water quality improvement.

Biota Effects. It is expected that the biota in the Three Rivers area would be improved by the acquisition of new park land. However, the changing of land use in Ashland, Columbiana, and Richland counties from forest cover to irrigation and crops would cause a serious aesthetic consequence. At the present time, a balanced composition of crops, vegetation, forest cover, and animals exists in these counties. By changing these natural conditions, this aesthetically desirable system would be eliminated.

Air Effects. The burning of sludge in the quantities suggested could produce an air pollution problem near the wastewater treatment plants. The increase in particulate matter would be noticeable and possibly aesthetically unacceptable only if air quality standards were not adhered to.

The transmission of the wastewater to and from the treatment areas (spray irrigation fields) will require additional electricity. This additional electricity might create an air or water pollution problem.

Social Opportunity Impacts

Recreation Effects. The improved water quality in the Three Rivers Basin will improve its recreation potential. It is expected that the Upper Cuyahoga will maintain its fishery and the Rocky, the shoreline of Lake Erie, and the Cuyahoga will develop new or improve existing fisheries. However, the East Branch of the Rocky will suffer a decrease in its fishery owing its change to an intermittent stream. A change in the cold-water fishery of the Chagrin River is expected with the transfer of storm water out of the basin. This loss would be significant to the fishermen in the area.

Boating will not be greatly affected by the improvement in water quality. It is expected that some increase in canoeing will take place on the Cuyahoga with the further development of the Cleveland Park System. On the other hand, the storm water holding basins in Lake Erie could possibly present hazzards to the recreational boating that now takes place on the lake.

Recovery of the water quality in the basin will improve the conditions for swimming in Lake Erie. The extent of this increased recreation potential is dependent on access acquisition. At the present time, only a small increase in recreational activity would result from the water quality changes.

Passive recreation in the Cleveland area will also increase because of the improved water quality. It is anticipated that passive recreation areas will be developed along the Cuyahoga River.

These positive results of this combination alternative are overshadowed by the adverse conditions created in the land disposal areas. Although the areas designated for land use changes are smaller for this alternative than for the land alternative, the impacts are not significantly different.

Major active and passive recreation areas are either reduced or eliminated by this alternative. Some of these major areas where boating, swimming, fishing, and passive activities presently occur are:

- Mohican River System
- Mohican and Memorial State Forests
- Guilford Lake State Park
- Pleasant Hill Reservoir
- Zepernick Lake Wildlife Area.

By eliminating these and other recreational areas, over 7,000 acres of existing recreational development would be lost to spray irrigation fields. These losses account for over one-half of the area's public recreation resources.

The effect on the distribution of recreation activity in the Three Rivers area is expected to be negligible. Inner-city residents are presently cut off from the recreational opportunities and there is no elimination of this barrier by the alternative. In the areas proposed for waste treatment, the distribution effect is adverse. The individuals living in these rural communities will lose their recreational opportunities, and residents of Cleveland will gain some.

Human Betterment Impacts

Historical/Cultural Effects. In Columbiana County, there are several covered bridges whose historic value and attraction would be adversely affected by the presence of spray irrigation activities.

Housing Effects. Any housing located close to new regional treatment plants or close to additions to plants presently in use will be adversely affected. The value placed on these homes will be lowered because of their close proximity to the plants, especially if the plants have bad odors and if sludge is burned at the plant, causing an air pollution problem. The small treatment plants being phased out may have adverse effects on nearby housing, depending on what replaces the plants.

An area near the Chagrin River will not be provided with sewers in this plan, but will be served by septic tanks. Since this area has high potential for development in the near future, it is anticipated that the use of septic tanks may not be adequate for the area, thus resulting in pollution of the Chagrin River.

The holding ponds to be located in Lake Erie will probably have an adverse effect on lakeshore homes and apartment buildings if the ponds have an unattractive appearance. When the Lake is viewed from a high level (e.g., from a high-rise apartment building), the holding ponds, even if they are somewhat attractive, would change the view of the Lake, thus decreasing the value presently placed on those apartments.

The storage lagoons and spray irrigation areas proposed for rural areas in counties outside of the Cleveland-Akron metropolitan area would have little but adverse effects on housing. The storing lagoons could emit bad odors and the spray irrigation fields would be perceived as areas next to which living would be undesirable.

Education Effects. The marsh and swamp areas in Columbiana County which have been identified as having high potential for educational purposes would be completely disrupted if spray irrigation is introduced there. In Ashland and Richland Counties, a state forest and two scenic highways would be adversely affected by the spray irrigation.

Life Style Impacts

Land Use Changes. Changes in land use would result from the construction of new treatment plants, from additions to existing ones, and from the closing of some small plants. Land needed for new construction and additions would have to be taken from other uses (e.g., residential, industrial, parks). The land on which the terminated plants are located would be available for many uses. The resulting changes would depend on what use is made of the newly available land, and what presently surrounds this area.

The land alternative would replace the existing land uses of agriculture and recreation with storage lagoons and spray irrigation fields. The development of nearby towns would be greatly restricted by the areas taken up by the storage lagoons and for spray irrigation.

Relocation of Individuals. The construction of new regional treatment plants and additions to existing plants would result in some relocation of individuals, of their homes and/or businesses.

The storage lagoons and the spray irrigation areas would cause all homes, farms, and businesses in the areas affected to be deserted or relocated elsewhere. This would affect a large number of rural residents and is likely to create considerable dissatisfaction and many problems for the people involved.

Amenities. The Cleveland-Akron metropolitan area would benefit from more adequate sewage treatment and better water quality; however, there is likely to be an increase in air pollution, caused by the burning of sludge. Algae growth in Lake Erie, not to mention algae growth in the holding ponds, is likely to be a problem.

The storage lagoons and spray irrigation areas have strong negative points about them. They would create a major relocation problem, would be aesthetically unpleasant, and would have, in general, negative effects on those areas surrounding them.

Distribution Impacts

Residents of the Cleveland-Akron metropolitan area would benefit from having more adequate sewage treatment at the great expenses of the people in the rural areas whose lives would be greatly affected, without any benefits for themselves.

Regional Development

Land Impacts

The land impact of this alternative will be more significant than for either the water or land alternatives. Unfortunately, this alternative includes many of the problems of the other alternatives with few if any of the possible benefits. The impact on Lake Erie shoreland would be significant because of the holding basins and the algae problems. Because of the phosphate increases, algae could occur not only in these basins, but also around them.

The land to be utilized for lagoons and the spray irrigation areas is considerably reduced from the proposed areas in the land alternative. However, it is believed that this reduced impact still have a considerable effect on land values. Furthermore, the smaller spray irrigation fields are still located in areas which have land use related disadvantages. The proposed areas would still utilize land which represents one of the major areas available for the truck farming industry serving the Youngstown-Alliance-Canton area. It also represents one of the major growth areas for the Youngstown-Alliance-Canton complex. Finally, as stated previously, these cities may wish to use this land for their own waste disposal or recreation activities.

Water Treatment Costs

The costs of treating water--either waste treatment, industrial treatment, or storm runoff--do not appear to be significantly different from the treatment costs arrived at for the other alternatives.

Commercial Fishing

The impacts on commercial fishing from this alternative are similar to those discussed for the other two alternatives. Therefore, they will not be discussed here.

Economic Development

The economic development for the region will probably proceed at the same rate whether this alternative is implemented or not.

Income Redistribution

As stated in the land alternative, the acquisition of lands for lagoons and spray irrigation would pose a hardship on the residents of the lands to be acquired. The benefits would accrue to the city residents (Cleveland) while the impacts would be realized by individuals outside of the watershed.

National Economic Development

The national impacts from the combination alternative combines the impacts of both the water and land alternatives. As in both of those alternatives, there is a redistribution of income in favor of Cleveland residents at the expense of the rural community. This adverse impact results from the financing approach and the use of rural land as a disposal area for urban residents.

SUMMARY OF ASSESSMENT OF IMPACTS

In the preceding section of this Chapter, impacts were assessed for the wastewater treatment alternatives of water and land, and a combination thereof. To stress the important water resource objectives of environmental quality, social well-being, regional development and national economic development and at the same time to bring to the surface the major impacts, an Impact Matrix was used (see Table 21).

Before using this table it is important to refer to the discussion in Chapter 2, which gives the interpretation of the table and the assumptions made in its development. These values are only a "red flag" indication of the direction and not the magnitude of impact and should be used as such.

TABLE 21. IMPACT MATRIX FOR THE THREE ALTERNATIVES EVALUATED

OBJECTIVES Indicators	Alternatives Water (W-1)	Land (L-1)	Combination (C-3)
ENVIRONMENT			
Ecology			
Primary Productivity	+	+/-	+/-
Consumer Productivity	+/-	+/-	+/-
Biogeochemical Cycling	+	+	+
Species Diversity	+	+/-	+/-
Population Density/Distribution	+/-	+/-	+/-
SOCIAL WELL-BEING			
Hygenic			
Direct-Man	+/-	+/-	-
Indirect-Man	-	-	-
Aesthetic			
Land	+/-	-	-
Water	+/-	-	-
Biota	+	-	-
Air	-	-	-
Social Opportunities			
Recreation	+/-	-	-
Human Betterment	0	-	-
Life Style	+	-	-
Distribution	0	-	-
REGIONAL DEVELOPMENT			
Land Values	+	-	-
Water Treatment	+	+	+
Commercial Fishing	0	0	0
Economic Development	0	0	0
Income Redistribution	-	-	-
NATIONAL ECONOMIC DEVELOPMENT	-	-	-

CHAPTER 5. RESEARCH NEEDS

In conducting this study, the Battelle-Columbus research team has identified a large number of areas in which research efforts would be desirable before a plan for wastewater management in the Three Rivers area can be formulated with confidence. The rather negative evaluation made of the three alternatives discussed in this report testify to the difficulties of attempting to design an effective scheme in the absence of the information which these studies would generate.

Clearly, the generation and use of data requires personnel trained in appropriate disciplines. Without entering into a discussion of how many people in each discipline will be needed, a list of disciplines which should be represented has been prepared. The following discussion addresses both information needs and personnel needs.

INFORMATION NEEDS

It is impossible to categorize the research needs we have identified into absolutely discrete divisions, but unless some attempt is made to do so, the list will be incomprehensible. Data needs are therefore discussed in the context of the following overall study areas.

- Engineering, Hydrological, and Meteorological Research
- Ecological, Biochemical, and Physiological Research
- Sociologic and Economic Research
- Institutional Research.

Engineering, Hydrological, and Meteorological Research

There are some very basic data needed for routine calculations which are not now available. Flow in the Rocky and Chagrin River Basins has not been regularly monitored, except at or near the river mouths. Water quality parameters have also not been measured consistently. Quality data are especially scarce in the portion of the Cuyahoga basin upstream of Lake Rockwell Dam. Of major importance are the total quantity and quality inputs into Lake Erie, which at the present time have not been determined. Use of those data on water flow and quality which are available is greatly hindered by the fact that the quality data are not related to direct measures of flow taken at the same time and place. A regional water quality monitoring network could be used to obtain this information and be an input source to a model of the area.

Present wastewater treatment plants are notoriously unreliable, sensitive as they are to sewage content, concentration, and volume. It is very important, especially if regional consolidation of treatment facilities is anticipated, that systems of very high reliability to designed and tested. Reliability of other types of systems to be used in wastewater management, such as pumps, interceptor gates, and irrigation nozzles must also be tested and, where necessary, improved.

Before any alternative can be prepared, the cost and effectiveness of various wastewater treatment, storage, transportation, and disposal methods must be clearly and accurately described as they apply to the specific conditions of the Three Rivers area.

If spray irrigation of sewage is to be considered as a treatment and/or disposal alternative, there are several kinds of information which will be required. First of all, a great deal needs to be learned about the ability of various types of soils to absorb sewage. How much of various pollutants will be absorbed by the soil particles? What changes will occur in the pollutants and in the soil structure as the irrigation process is continued? Will pollutants eventually washout into streams, lakes, or underground water supplies? Will continuous or batch spraying produce the best results? Second, if an underground tiling system is to be installed and used to return treated water to streams in the Three Rivers area, how should the system be designed and operated to achieve the best results? Finally what effects will the procedure have on underground water supplies? Where do supplies used by individual residences, industries, and communities originate, and how are they interconnected? If contamination should occur, to what geographic areas and geological strata might it spread?

If wastewater is to be transported from one basin to another for treatment and disposal, the capacity of the channels receiving the treated water will become a critical consideration. If a significant amount of water is to be added to the flow in a channel on a constant basis, what physical effects will it eventually have on the channel itself?

Large scale transportation of water and wastewater will require large amounts of energy. Critical questions are how much power and from where? What will be the cost of obtaining it? What environmental impacts will result from developing it.

Wastewater reclamation and reuse have been much discussed as a means of reducing industrial and municipal waste discharges. Before it is included as an integral part of a plan, its feasibility and cost must be evaluated under the specific circumstances present in the Three Rivers area, especially the Lower Cuyahoga Basin.

An entirely different kind of engineering problem is presented by the scarcity of beach areas around Lake Erie. In order for the full benefit of improvement of water quality in the lake to be realized, new beach areas will have to be located and opened to the public or created artificially. Data on engineering problems, techniques, and costs related to such a program need to be developed.

Meteorological data are needed to determine the likely fate of incinerator discharges of particulates, metals, and other waste products.

Ecological, Biochemical, and Physiological Research

The ecology of the land, the rivers, and the lakes in the Three Rivers area is complex. Too often, we find ourselves attempting to improve ecological conditions without really understanding what our activities will accomplish and what they will not accomplish. It is very important that the efforts made in this study to explain and predict the ecological responses to proposed wastewater management plans be continued and expanded before any alternative is implemented. Some specific informational needs are as follows:

(1) What toxic substances are now present in the Three Rivers aquatic ecosystem? What acute, chronic, and biomagnification effects are occurring? What eventually happens to these substances?

(2) Exactly what are the effects of other common water pollutants on these aquatic ecosystems? Of particular interest are the relationships between phosphorus, nitrogen, and carbon compounds, and the stimulation of algal blooms. Effects of temperature, light, and dissolved oxygen concentration must also be more carefully and thoroughly investigated.

(3) Of special concern are the relationships between toxic substances, nutrients, and other pollutants, and the ecosystems of Lake Erie, itself. It appears that chemical interactions taking place on the lake bottom under anaerobic and aerobic conditions may be critical to the ecology of the lake as a whole.

(4) If the anerobic conditions of much of the lake bottom are cyclic, how can the cycle be interrupted? Should the sludge be removed, or should other means be used to alleviate the anerobic conditions?

A special category of ecologic problems may result if large volumes of return water from spray irrigation treatment areas are discharged into streams in the Three Rivers area. This return water will probably contain very little biochemical oxygen demand, but it will likely still contain substantial amounts of phosphates and nitrates. Will it result in algal problems in the rivers? What will its effects be on Lake Erie and on instream impoundments?

The alternatives evaluated in this study have included the construction and operation of very large stabilization ponds in Lake Erie for combined storm runoff and sanitary wastes. Also, included have been large aeration and storage lagoons for raw sewage. It is unclear what

the ecological behavior of these ponds and lagoons would be under the climatic conditions of northern Ohio and with the pollutants they would receive. If algal blooms and anaerobic conditions would be likely, how might they be prevented?

Little is known about the probable ecological effects of irrigating land with wastewater. Information on these effects will be required before possible insect and rodent vector problems and the long range waste treatment effectiveness of the soil can be evaluated adequately.

Beyond the research needs in general ecology noted above, there are questions of direct consequence to human health. One nagging unknown is the kind and concentration of viruses in water. An accurate but easily measured indicator test of their presence is needed. The potential longevity of viruses in water may mean that water which is considered bacteriologically safe is, in fact, dangerous.

While there is little doubt that water absolutely devoid of toxicants would be best for human use, the economic cost of achieving such quality may be higher than society can bear, even if technical means of achieving it can be devised. It is necessary, therefore, that better information be developed on the acute and chronic human responses to known toxicants. Safety standards now accepted by the state and federal water quality control agencies are, at best, conservative estimates, and at worst, little better than educated guesses.

Sociologic and Economic Research

The anticipated effects of wastewater management programs on society should be the primary consideration in designing and evaluating any plan. In order to estimate these effects with confidence, some important information gaps must be filled.

Cleanup of pollution in Lake Erie and its tributaries is widely considered a worthwhile goal. One reason frequently given is improvement of the recreational potential of the Lake and the streams. As indicated in this study, there is reason for some serious doubt that recreational benefits would be substantial. Before enormous expenditures are made to carry out an effective water quality improvement program, a careful and thorough analysis of probable recreational benefits should be made. Since the high bluffs surrounding much of the Lake and bordering many of the stretches of rivers in the Three Rivers area prevent public recreational use of much of the water, an evaluation should be made of the benefits of opening up new beach areas or of creating artificial beaches along the rivers, impoundments, and Lake Erie.

Related to the recreational benefits evaluation is the need for a study of access to present and potential water recreation areas for inner city residents, especially those unable to afford the expense of transportation over significant distances. As indicated in a recent Battelle-Columbus study*, it appears that the bulk of the urban population cannot presently use existing water-recreation sites. What effects might low-cost or free public transportation have on this problem? Are there other ways that inner-city residents might be given access to the water recreation areas?

Implementation of any wastewater management alternative will necessitate construction of new or enlarged facilities, including such items as pipelines, pump stations, treatment plants, stablization ponds, lagoons, spray irrigation areas, and incinerators. Most of these facilities are considered undesirable from an aesthetic point of view, and this results in reduction of property values, loss in commercial activities, and reduction of human well-being in surrounding areas. Absolute and relative psychological and economic costs of various kinds of wastewater management facilities need to be quantified, and ideas for reducing this effect need to be developed. As specific plans are drawn up, thorough site analyses of property uses and values, residential and commercial locations, valuable historic, cultural, recreational, and natural resources, and other similar factors should be conducted. The costs of alternative sites and facilities should be compared before a definite plan is selected.

Finally, the public and private investment costs of implementing a proposed plan should be evaluated, and schemes for financing the plan should be developed. In adopting a financial scheme, consideration should be given to the resultant incidence of costs upon respective groups of people and interests. Care should be taken to prevent the assessment of unnecessarily burdensome financial loads to anyone, and the distribution of costs should be made as nearly as possible proportional to the distribution of benefits.

Institutional Research

Successful implementation of any wastewater management plan is dependent upon a design which takes advantage of and works through existing or probable laws, agencies, and administrative powers. It is, therefore, absolutely essential that complete and accurate information on these "institutional arrangements" be gathered and interpreted very early in the planning program and that this information be continually updated. Among the important types of information to look for are the following:

(1) Identification of all significant international, federal, interstate, state, regional, and local

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* Whitman, et al, 1971.

agencies and organizations, both public and private, which exercise or could exercise water and land management authority in the geographic area of interest

(2) Inventory and evaluation of the legal and assumed powers of these agencies and organizations

(3) Existing policies, policy trends, and development plans regarding such items as cost sharing, intergovernmental cooperation, resource use and development, fiscal priorities, and interbasin transfer of water

(4) Identification of important individuals and organizations which should be intimately involved in the planning process

(5) Taxing and spending powers and limitations of agencies and organizations which might be expected to bear the capital, operating, and maintenance costs of implementing a wastewater management plan.

PERSONNEL NEEDS

Following is a list of disciplines which the Battelle-Columbus research team believes would be necessary and advisable to include in further planning for wastewater management in the Three Rivers area. The extent of commitment and the timing of participation by individuals representing the respective disciplines will vary, so that some might best be retained on a full-time basis while others might serve only on a part-time level.

Agronomy

Biochemistry

Chemical engineering

Ecology

Economics (especially public finance)

Environmental Planning

Geology

Hydrology engineering (surface water and ground water)

Landscape architecture (aesthetics)

Law

Limnology

Meteorology

Microbiology

Physiology (plant, animal, and human)

Political science

Public administration

Public health

Recreation planning

Sanitary engineering

Sociology.