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APPENDIX G

WATER USE AND STREAM QUALITY

COMPREHENSIVE PLANNING STUDY

OF THE

GRAND RIVER BASIN, MICHIGAN

Prepared by the

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region

Chicago, Illinois

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SUMMARY

Background

Appendix G, "Water Use and Stream Water Quality" has been prepared pursuant to a request by the U. S. Army Corps of Engineers in a letter dated May 22, 1963. Appendix G is one of several similar documents to be prepared by a variety of agencies who are participating in a "Comprehensive Planning Study of the Grand River Basin, Michigan." The study, under the chairmanship of the U. S. Army Corps of Engineers District, Detroit, Michigan deals with the best use of the water and related resources of the Grand River Basin. The following paragraphs summarize the contents of Appendix G.

Pollution in the Grand River

The waters of the Grand River are degraded in quality particularly below Jackson and Lansing, and at its mouth near Grand Haven. This degradation in quality is evidenced by low dissolved oxygen levels, and other biological, chemical, microbiological and physical parameters analyzed by both Federal and state pollution control agencies.

Pollution of the waters of the Grand River is further evidenced by the impairment of water uses. Whole and partial body contact recreation is potentially hazardous due to high coliform bacteria and fecal streptococcus bacterial densities below Jackson, Lansing and at Grand Haven. The fishery of certain sectors of the Grand River is harmed by low dissolved oxygen levels and high stream temperatures. Esthetic enjoyment is impaired by the unsightly appearance of the Grand River at Jackson and certain other areas.

Sources of Pollution

Municipal waste treatment plants of the Grand River Basin serve a population (1962) of 540,000. The combined effluents from these municipal treatment facilities discharge a total of 17,000 pounds of 5-day biochemical oxygen demand (BOD_5) daily to the waters of the Grand River Basin. These wastes are equivalent in oxygen-consuming power to the untreated wastes of over 100,000 persons. Other municipal waste sources include the overflows from combined sewer systems.

Industrial wastes discharging directly to the waters of the Grand River Basin put an additional 21,000 pounds of BOD_5 into the streams daily. These wastes are equivalent in oxygen-consuming power to the untreated wastes of over 126,000 persons.

In addition to the organic waste load discharged from industries and municipalities, thermal discharges also have a significant bearing on water quality. For example, cooling water discharges from steam electric generating stations at Lansing produce adverse effects on desirable water uses.

Future Conditions

Growth projections indicate that the 1960 Grand River Basin population of 949,000 may increase more than two-fold by 2020. Industrial activity is expected to double by 1980 and to continue to expand in the decades that follow. Water demands and waste flows will increase at a more moderate pace due to increased water reuse and other efficiencies. These and other related factors indicate that the waste load received by all municipal sewerage systems in the Basin will increase to about 2,500,000 Population Equivalent (PE) by 2020. By comparison, the present estimated waste load received by all municipal sewerage systems of the Grand River Basin is approximately 540,000 PE.

Needed Water Quality Improvement Measures

A number of pollution control measures are presently needed to bring the quality of the Grand River up to the Standards for Michigan Intrastate Waters established by the Michigan Water Resources Commission. These measures, partially shown in Tables 5-4 and 5-5, include secondary waste treatment for all major municipal waste sources and equivalent treatment for all significant industrial waste sources. Based on studies conducted by the Federal Water Pollution Administration (FWPCA), it appears that advanced waste treatment beyond secondary will be required at Lansing and Jackson, Michigan. Future growth of population and industrial activity and projected increases in waste discharges in the Grand River Basin will require expanded and improved waste treatment processes. By 1980 approximately 46,000 acre-feet of storage above Lansing would be needed for water quality control even with a BOD_5 (5-day 20°C biochemical oxygen demand) reduction of 90% of the untreated wastes. Even if a level of 95% reduction of BOD_5 were achieved at Lansing by the year 2020, 304,000 acre-feet would be required for water quality control purposes alone.

In addition, the recommendations of the Four-State Federal Enforcement Conference on the Pollution of Lake Michigan and its Tributaries require that all communities provide at least 80% phosphorus removal.

Needed Water Supply Measures

It has been estimated that by 2020 Lansing, Michigan will require 46,000 acre-feet of storage of municipal water supply purposes. One alternative to such storage would be to obtain water for this purpose from one of the Great Lakes.

A number of recommended actions for water quality control are given in Section 5. The economics of alternative methods of providing water supply and pollution control are presented in Section 6. Advanced waste treatment has been evaluated as an alternative to these large volumes of storage.

Benefits

Implementation of the recommendations contained in this appendix will result in substantial improvement in the quality of the waters of the Grand River Basin and the adjacent waters of Lake Michigan. The program objectives, however, are more specific and have been developed to provide water of satisfactory quality for both present and planned uses. The waters of Lake Michigan serve many States and of National importance, all will share in the benefits resulting from the enhancement and protection of these waters for both present and future needs.

Owners of the property adjacent to or near polluted water will derive increased esthetic enjoyment and enhanced property values from the elimination of the unsightly conditions resulting from water pollution, including nuisance algal blooms stimulated by over-fertilization. Residents of the Basin will benefit from the assurance of a safer, more palatable water supplied to their homes, industries and public buildings.

Michigan residents and visitors from out-of-state who use the area's streams and lakes for swimming, water skiing, boating and other water-oriented recreation will be protected against infectious diseases which can be spread as a result of water pollution. The sport fisherman will find additional fishing areas to challenge his skill, and improved fishing as a benefit of enhanced water quality.

As a return to their investment in improved water quality, industry will share in the benefits through assurance of consistency in the quality of process water it needs for many of its products and other water uses.

In addition to these immediate and direct benefits, the preservation and protection of the quality of the waters of Lake Michigan and the Great Lakes is an important benefit which is essential to the Nation's continued growth and prosperity.

SECTION 1

INTRODUCTION

Authorization

The Secretary of Health, Education, and Welfare was informed by the Secretary of the Army in a letter dated December 4, 1962 of the comprehensive water and related land resource investigations to be conducted in the Grand River Basin, Michigan. In response the Secretary of the Department of Health, Education and Welfare appointed a representative and an alternate to the Coordinating Committee of the Grand River Basin Comprehensive Study by a letter dated December 20, 1962. The District Engineer, U. S. Army Engineer District, Detroit, Michigan in a letter dated May 22, 1963 specifically requested the assistance of the Department of Health, Education, and Welfare. The Department was requested to study and to prepare a report concerning the water supply and waste water disposal aspects in the Grand River Basin, Michigan.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et.seq.). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

Purpose and Scope

This report presents an action program of water pollution control geared to provide high quality waters in the Grand River Basin, Michigan through abatement of existing pollution, and to provide continuing control of pollution through actions scheduled in anticipation of future problems. This report and resulting program have been developed from information on present water quality, water uses and trends in water usage, present and anticipated future waste loads, the existing and projected population and economic growth, and other relevant facts. The information was gathered by the Great Lakes-Illinois River Basins (GLIRB) Project, Federal Water Pollution Control Administration, Department of the Interior, during its comprehensive study of the Lake Michigan Basin. The preparation of this appendix is a joint planning effort conducted by the Lake Michigan Basin Office and the Planning Branch, Great Lakes Region, Federal Water Pollution Control Administration.

The area (See Figure 1-1) within the scope of this appendix includes the Grand River and the entire watershed tributary to the Grand River. Water quality conditions in the adjacent water of Lake Michigan at the mouth of the Grand River are also considered.

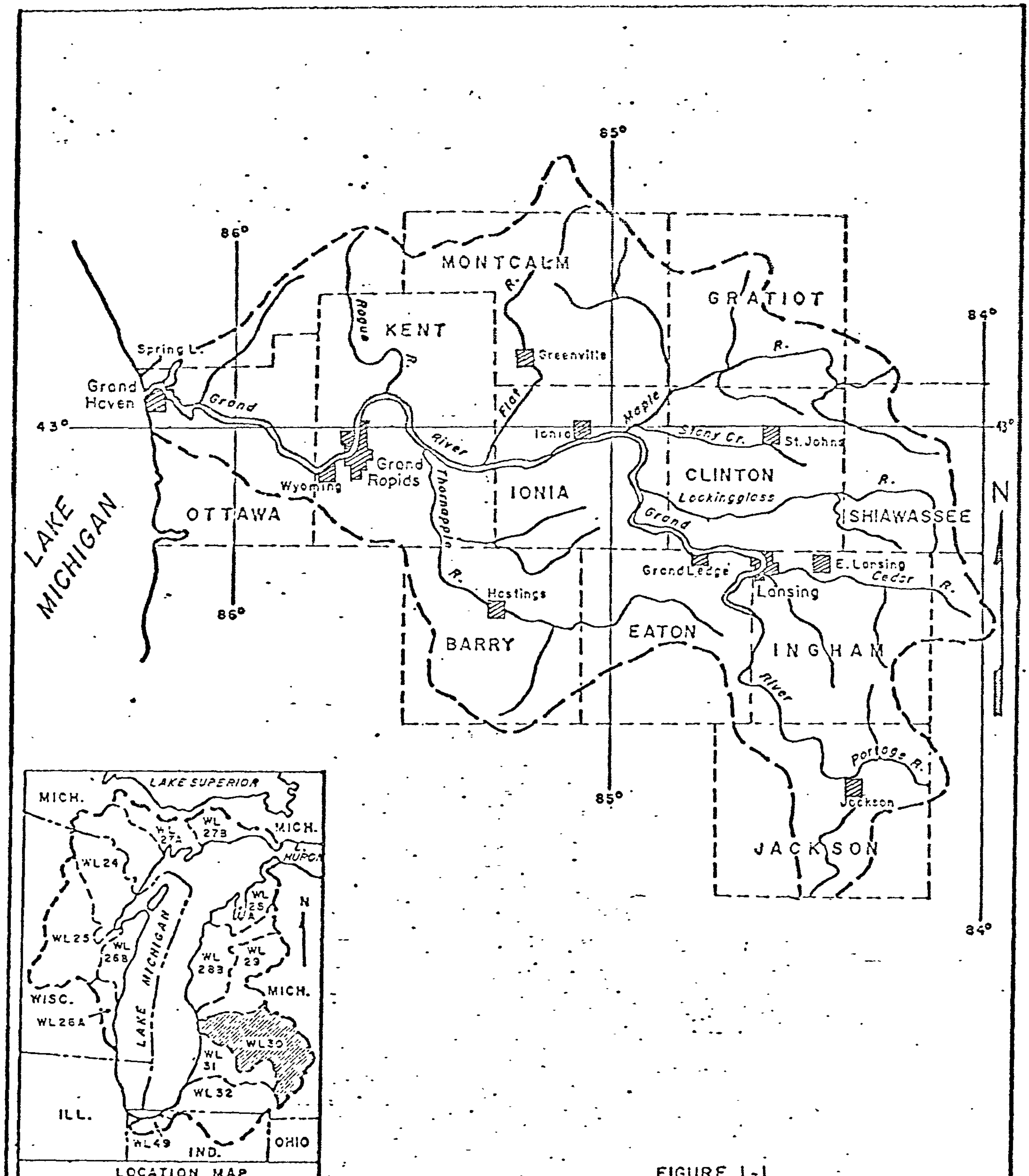


FIGURE 1-1

CHICAGO PROGRAM OFFICE

GRAND RIVER BASIN - MICHIGAN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION CHICAGO, ILLINOIS

SECTION 2

DESCRIPTION OF AREA

Location

The Grand River Basin is located in the south-central part of the lower peninsula of Michigan. The Basin contains a drainage area of 5572 square miles. It is approximately 135 miles long and 70 miles at its maximum upstream width. All or part of 19 counties are contained within the area.

Hydrology

The Grand River originates in the northeast corner of Hillsdale County some 15 miles south of Jackson, Michigan. Six major tributaries are the principal contributors to runoff in the Basin. The Flat, Rogue and Maple Rivers enter the main stream from the north, the Thornapple River from the south, and the Lookingglass and Cedar Rivers from the east. These six streams together with the Portage River near Jackson comprise a total of some 3,200 square miles of drainage area. The remaining drainage area is accounted for by about 30 minor tributary creeks, ranging in size from 65 square miles down to 2 square miles.

Table 2-1

Drainage Areas - Grand River Basin

River	Drainage Area (Square Miles)
Portage	186
Cedar	463
Lookingglass	312
Maple	775
Flat	562
Thornapple	845
Rogue	255
Other Tributaries	2,174
Grand River Total	5,572

Streamflows at specific gage locations are given in Table 2-2.

TABLE 2-2

GRAND RIVER FLOW DATA

Location	Drainage Area Above (Sq. Mi.)	Station Years of Record	Average Dis-charge (cfs)	Instantaneous Flows From Station Years of Record		Years of Record Used to Compute Low Flow	7 Day Avg. 1 in 10 Years (cfs)
				Minimum Flow (cfs)	Maximum Flow (cfs)		
Grand River at Jackson, Michigan	174	29	113	9.2*	1,070	1935-64	20
Grand River at Eaton Rapids, Michigan	661	14	407	14.0	3,360	1950-64	73
Cedar River at East Lansing, Michigan	355	34	197	3.0	5,920	-	-
Grand River at Lansing, Michigan	1,230	35	803	2.8*	24,500	1901-06, 1935-64	75
Lookingglass River at Eagle, Michigan	281	20	160	11	2,860	-	-
Maple River at Maple Rapids, Michigan	434	20	227	4.6	6,500	-	-
Grand River at Ionia, Michigan	2,840	13	1,576	105*	21,500	1951-64	175
Flat River at Smyrna, Michigan	528	14	385	7.4*	2,500	-	-
Thornapple River at Caledonia, Michigan	773	20	482	-	6,290	-	-
Rogue River at Rockford, Michigan	234	12	202	30	2,640	-	-
Grand River at Grand Rapids, Michigan	4,900	38	3,370	381	54,000	-	-

*Regulation by upstream control structures.

Topography and Soils

The surface of the Basin is covered with glacial deposits with bedrock outcropping at only two or three locations. The glacial debris consists primarily of sands and gravels on the terminal moraines, the outwash plains and the till plains. Clay, fine sand, silt and finely ground lime are found in the old glacial lake beds. The loamy sands, clays and muck soils are prominent throughout the valley and, because of their fertility and favorable texture, produce high yields of crops.

Climate

The average annual temperature in the watershed is about 49°F. Mean monthly temperatures range from a low of approximately 25°F in January to 72°F in July. Mean monthly precipitation ranges from a low of 1.9 inches in December to a high of 4 inches in June, with an average annual precipitation of 32.9 inches.

Population

The Grand River Basin had a 1960 population of about 950,000. This estimate is based on an analysis of basin population by minor civil subdivisions. The population of the Basin has grown at a faster rate than the Nation since 1940, increasing by more than 300,000 in that period. In 1960, 67 percent of the Basin's population was municipal. The major cities in the Basin include: Grand Rapids (173,300), Lansing (107,800), Jackson (50,700), and Wyoming (45,800). Table 2-3 shows the 1960 total and municipal population of the Basin and the projected populations for the years 1980 and 2020.

Table 2-3

Present and Projected Populations
Grand River Basin

1960		1980		2020	
Total	Municipal	Total	Municipal	Total	Municipal
950,000	640,000	1,300,000	940,000	2,300,000	2,000,000

Economy

The Grand River includes all or major parts of eleven Michigan Counties.(Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa and Shiawassee). Manufacturing is the predominant economic activity in this eleven county area which approximates the Basin. In 1963, value added by manufacture totalled $1.7 billion. Major industries in the area include transportation equipment, fabricated metals and furniture and fixtures. Table 2-4 shows trends in value added and manufacturing employment.

Table 2-4

Value Added by Manufacture
(In 1957-1959 Constant Dollars) and Manufacturing
Employment for the Eleven County Area

	1947	1954	1958	1963
VAM($1000s)	840,000	1,250,000	1,140,000	1,680,000
Mfg. Employment	121,622	127,865	113,954	130,056

Projections of population, manufacturing employment and productivity increases indicate that industrial activity in the Basin may be expected to increase six to seven-fold by the year 2020.

Agriculture is diversified in the Basin with dairying, livestock raising and cash grain farming, all relatively important.

SECTION 3

WATER USES AND WATER QUALITY REQUIREMENTS

Water Quality Standards

The water uses to be protected by water quality standards in the Grand River Basin have been determined by the Michigan Water Resources Commission. Their inclusion in this appendix is in recognition of the primacy of the State's interest in and control of the quality of intrastate waters. This inclusion does not constitute endorsement of these standards or water uses by the Federal Water Pollution Control Administration. The standards are shown in Table 3-1.

Water Supply

(1) All existing public water supply intakes in normal daily use will be protected for Domestic Water Supply at the point of intake. The following waters will be protected for Domestic Water Supply:

Grand River at Grand Rapids
Rogue River at Rockford

(2) All public waters will be protected for Industrial Water Supply.

Recreation

(1) All natural lakes will be protected for Total Body Contact. The following impoundments will be protected for Total Body Contact:

Name	Water Impounded or Used for Total Body Contact	County	Area to be Protected
Ada Lake	Thornapple River	Kent	From head of Ada Dam.
Cascade Lake	Thornapple River	Kent	Upstream to headwaters of Cascade Lake (48th Street).
Fallasberg Dam	Flat River	Kent	-
Grand River	Grand River	Ottawa	Eastmanville downstream to 160th Ave.
Grand River	Grand River	Kent	Plainfield Road bridge downstream to lower limits of Comstock Riverside Park.

Name	Water Impounded or Used for Total Body Contact	County	Area to be Protected
Ionia Recreation Area	Sessions Creek	Ionia	T6N, R3W, NW 1/4 Sec. 3 downstream to dam.
Lake Geneva	Lookingglass River (not impounded)	Clinton	-
Lake LeAnn	Grand River	Hillsdale	-
Lake Victoria	Alder Creek	Clinton	-
Manitoon Lake	Unnamed Creek	Shiawassee	-
Moore's Park Impoundment	Grand River	Ingham	Waverly Rd. downstream to dam.
Sleepy Hollow Reservoir	Maple River	Clinton	Jason Rd. downstream to dam.
Springbrook Lake	Springbrook Ck.	Shiawassee	-
Thornapple Lake	Thornapple River	Barry	-
Webber Dam Impoundment	Grand River	Goodwin Rd. downstream to dam.	

There are certain waters which, due to physical hazards, have not been designated for total body contact. If these waters in the future become suitable for this use through removal of these hazards the waters will be reconsidered for total body contact use.

(2) All public waters will be protected for Partial Body Contact.

Fish, Wildlife and Other Aquatic Life

All waters designated under the authority of P.A. 26 of 1967 by the Director of the Michigan Department of Conservation will be protected for Intolerant Fish, cold water species. (trout)

The Grand River will be protected for anadromous fish migration from its mouth upstream to the 6th Avenue dam at Grand Rapids.

All public waters will be protected for Intolerant Fish, warm water species except the following which will be protected for Tolerant Fish:

Deer Creek - Grand Trunk and Western Railroad bridge in Coopersville downstream to confluence with the Grand River.

Grand River - Jackson wastewater treatment plant downstream to U.S. 127 expressway bridge.

Grand River - Moore's Park dam downstream to upper dam in Grand Ledge.

Plastic Creek - 28th St. bridge in Grand Rapids downstream to confluence with the Grand River.

Red Cedar River - Harrison Rd. bridge downstream to confluence with the Grand River.

Agricultural

All public waters will be protected for Agricultural.

The above designated uses are not intended to be applicable to drainage ditches. However, Act 245 of the Public Acts of 1929, as amended, prohibits unlawful pollution of any waters of the State of Michigan.

It has been and continues to be the policy of the Water Resources Commission to abate existing pollution and prevent the occurrence of future pollution of all waters of the state including drainage ditches.

There are stretches of streams within the Grand River drainage area where natural water quality may at times be lower than certain parameters of water quality standards specified for a designated use. However, it is intended that the water quality for a designated use be maintained except in those instances where because of natural conditions the quality is lowered.

The water quality standards for the designated use areas shall not apply during periods of authorized dredging for navigation purposes and during such periods of time when the after-effects of dredging degrade water quality in areas affected by dredging. (Water quality standards for the designated use shall apply in areas utilized for the disposal of spoil from dredging operation.)

Where the waters of the Grand River Basin are classified under more than one designated water use, it is intended that the most restrictive individual standards of the designated water uses shall be adhered to.

The use designations adopted by the Commission are in all cases minimal and are not to be interpreted as a license to cause injuries declared to be unlawful by Act 245, P.A. 1929, as amended, or to do any other unlawful act.

COMMISSION OBJECTIVE:

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS, OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED, OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTRASTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

TABLE 3-1

WATER

PARAMETERS / WATER USES	1 COLIFORM GROUP (organisms/100ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A WATER SUPPLY (1.) DOMESTIC. Such as drinking, culinary and food processing.	The monthly geometric average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium-6: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-8
(2) INDUSTRIAL. Such as cooling and manufacturing process.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	Present at all times in sufficient quantities to prevent nuisance	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
B RECREATION (1) TOTAL BODY CONTACT. Such as swimming, water skiing and skin diving.	The geometric average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 100	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
(2.) PARTIAL BODY CONTACT. Such as fishing, hunting, trapping and boating.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
C FISH, WILDLIFE AND OTHER AQUATIC LIFE such as (growth and propagation)	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	At the average low flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained in rivers capable of supporting <u>Intolerant fish, cold-water species (trout, salmon)</u> - Not less than 6 at any time. <u>Intolerant fish, warm-water species (bass, pike, panfish)</u> - Average daily DO not less than 5, nor shall any single value be less than 4. <u>Tolerant fish (carp, bullheads)</u> - Average daily DO not less than 4, nor shall any single value be less than 3. <u>Principal anadromous fish migrations in warm-water rivers</u> - Not less than 5 during migrations. At greater flows the DO shall be in excess of these values. For lakes see discussion, page 26	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D AGRICULTURAL Such as livestock watering, irrigation and spraying.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	Not less than 3 at any time	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use
E COMMERCIAL AND OTHER Such as navigation, hydroelectric and steam generated electric power and uses not included elsewhere in these [illegible]	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	Average daily not less than 2.5, nor any single value less than 2	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use

QUALITY STANDARDS

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
Total Dissolved Solids: Shall not exceed 500 as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 75, nor shall any single value exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample	The maximum natural water temperature shall not be increased by more than 10°F	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Standards to be established when information becomes available on deleterious effects	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	In rivers capable of supporting / Ambient / Allowable increase / Maximum limit: Intolerant fish, cold-water species (trout): 32° to nat max / 10° / 70° Intolerant fish, warm-water species (bass): 32° to 35° / 15°; 36° to nat max. / 10° / 85° Tolerant fish, warm-water species (carp): 32° to 59° / 15°; 60° to nat max / 10° / 87° For anadromous fish migrations and inland lakes see discussion, page 29	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0)	Standards to be established when information becomes available on deleterious effects
...ess than 700 dissolved ...inerals. Maximum ...ercentage of sodium ...0% as determined by the ...ormula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ ...hen the bases are expressed as milliequivalents per liter	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council
...imited to concentra...ons less than those ...hich are or may become ...njurious to the ...esignated use	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects

Present and Future Water Uses

Municipal Water Supply

In 1963 there were 54 communities in the Grand River Basin served by community water supply systems. These facilities served an estimated population of 534,000 and supplied water at the average rate of 89 million gallons per day (mgd). Of this total, approximately 45 mgd were supplied for domestic, public and commercial uses and 43 mgd were supplied for industrial use. Table 3-2 summarizes municipal water use data for the Grand River Basin.

TABLE 3-2

Total Water Intake - Municipal Water Systems, Grand River Basin (1963)

Source	Population Served	Water Intake(mgd)
Surface Water	214,000	35
Ground Water	320,000	54
	534,000	89

Municipal water demands for the major water service areas and projections to the years 1980 and 2020 are presented in Table 3-3. The projections are based upon considerations of population growth, anticipated industrial expansion and projected industrial water use efficiency.

TABLE 3-3

Municipal Water Demands 1963 and Projections to 1980 and 2020 (MGD)

Service Area	Source of Water***	Population Served(1963)	1963 Demand (MGD)	1980 Demand (MGD)	2020 Demand (MGD)
Grand Rapids*	G,S,Lake Michigan & Grand R.	252,000	40.7	68	131
Lansing**	G	127,000	22.4	40	112
Jackson	G	55,000	10.5	16	30
Grand Haven	G	11,000	3.3	5	11
Greenville	G	7,450	1.4	2	4
Hastings	G	7,320	0.8	1	3
Ionia	G	6,700	1.0	2	3
St. Johns	G	5,900	1.0	2	3
Grand Ledge	G	5,770	0.6	1	2
All Others	-	58,000	7.3	28	61
Basin Total		534,000	89	165	360

* Includes Wyoming, Grandville, and East Grand Rapids.
** Includes East Lansing and Lansing Township.
*** S = surface water source, G = ground water source.

Self-supplied Industrial Water

Based on data provided by the U. S. Bureau of the Census in a special tabulation for the FWPCA, it has been determined that the major demand for self-supplied industrial water in the Basin in the Grand Rapids, Lansing, and Jackson areas as shown in Table 3-4. Projections contained in Table 3-4 were developed following consideration of anticipated increases in industrial output and water use efficiency.

TABLE 3-4

Self-Supplied Industrial Water Demands
1959 and Projections to 1980 and 2020

Service Area	1959 Demand(mgd)	1980 Demand(mgd)	2020 Demand(mgd)
Grand Rapids	5	8	14
Lansing	2	3	6
Jackson	6	9	14

The study area abounds with natural resources capable of satisfying the needs of residents for water-oriented outdoor recreation. There are many lakes in the study area which provide excellent recreational potential. The eastern shore of Lake Michigan around Grand Haven offers a great opportunity for water-oriented recreation. However, a number of the streams and stream sectors within the study area are degraded in water quality to the point that they are not available for most recreational pursuits.

The Bureau of Outdoor Recreation has identified areas of serious water recreation impairment due to water pollution. In general, the impaired areas are the harbor water at Grand Haven, the downstream end of the Portage River, and the Grand River below Jackson, Lansing, and Grand Rapids.

The State of Michigan has identified potential parks and camp grounds and is contemplating the construction of reservoirs for recreational purposes. The need to control water pollution at all such facilities is paramount since such pollution could well jeopardize the very water uses for which the facilities are being planned.

Irrigation

The soils in the Basin which require irrigation are located, for the greater part, adjacent to Lake Michigan.

In the Upper Grand River Basin, above Ionia, specialized crops such as mint account for the greatest acreage receiving irrigation. These are followed by potatoes, field crops, cucumbers, pickles, and melons. Non-agricultural irrigation (golf courses, cemeteries, parks, etc.) accounted for 740 of the 4800 acres irrigated in this part of the Basin. The overall results of Michigan Water Resources Commission irrigation surveys indicate that there were 23% more irrigation systems and 28% more acres irrigated in the Upper Grand River Basin during 1960-61 than there were in 1957-58.

In the Lower Grand River Basin truck crops accounted for about 35% of the agricultural irrigated acres with raspberries, blueberries, flowers and nurseries also having significant acreage in irrigation. Of the estimated total of 6500 acres receiving irrigation, cemeteries, parks and golf courses accounted for about 800 acres.

The 1959 water usage for irrigation in the Grand River Basin was estimated to average 3.5 mgd during the growing season. It is anticipated that this usage will increase threefold by 1980. However, even with such an increase the demand on existing water resources will be minor compared to the total water usage in the Basin.

Fish and Aquatic Life

There are about 260 miles of main stream channels in the Upper Grand River Basin above Ionia. This includes the Grand, Maple, Lookingglass, Cedar, and Portage Rivers. This system offers many opportunities for fishing and duck hunting. A number of reservoirs at power dams furnish expanded fishing and hunting opportunities.

In the Grand River Basin there are 12 State Game Project Areas where public hunting and fishing opportunities are provided. Fishing opportunities exist at the Grand Haven State Park. Public fishing sites are available at 48 lakes and streams in the Basin with an area of about 2,100 acres and frontage of about 21,600 ft. Over 250,000 fish, including trout, bass, pike and bluegills were planted during 1962 in 10 of the 19 counties of the Basin.

Wildlife and Stock Watering

The 1959 agricultural water use for stock watering in the Grand River Basin was about 3.5 mgd. Projections of this usage indicate that the demand will increase 1½ times by 1980. The use of water for wildlife and stock watering does not play a significant role in the water supply problems of the Basin.

Hydropower

As of 1965 there were 12 hydroelectric power plants in the Basin, with a total installed capacity of 13,500 kilowatts (KW) and a total average annual generation of 46,400 megawatt hours (MWH). Five of the plants are located on Thornapple River, two are located on the Flat River, one is located on Spring Brook and four are located on the main stem of the Grand River. Five potential hydroelectric sites on the Grand River have been identified by the Federal Power Commission. The sites are located at Grand Rapids, Saranac, Portland, McGee and Danby and would have a total potential capacity of 18,700 KW and a total average annual generation of 65,400 MWH.

The use of water for hydroelectric power generation is not considered to be a major use in the Basin. However, water quality problems may develop from the operation of such plants, particularly below dams during off-peak power demands when water releases may be drastically reduced. This can be seen in reviewing Table 2-2.

Commercial Shipping

Grand Haven is one of Lake Michigan's major commercial harbors currently handling in excess of 2½ million tons of commerce annually. Harbor vessel traffic has averaged 2.9 million tons for the period 1955-64, while during 1964 the traffic was 2.6 million tons. The harbor is located at the mouth of the Grand River. A shallow-draft barge channel extends about 15 miles up the Grand River serving commercial sand and gravel deposits, located near the channel's upper end.

Cooling Water

As of 1965 the Federal Power Commission reported that there are 14 thermal electric power plants in the Basin. Table 3-5 summarizes data relating to capacity and cooling water intake, when operating at capacity, at each of the 10 steam plants. There are also 4 internal combustion plants in the Basin with an installed capacity of 28,800 KW.

TABLE 3-5

Water Intake-Steam Power Plants
Grand River Basin

Location	Installed Capacity(KW)	Est. Cooling Water Intake(mgd)
Grand Haven	20,000	27
Grand Rapids	20,000	27
Grand Rapids	4,050	6
Grand Rapids	1,250	2
Lansing	81,500	110
Lansing	262,000	353
East Lansing	6,000	8
East Lansing	6,000	8
Eaton Rapids	1,250	2

The use of water for cooling purposes in steam power plants is considered to be significant in the study area with a high level of such use at Lansing. Most cooling waters are returned to streams 12-13°F warmer than at intake. Stream temperatures as high as 90°F have been recorded below the power stations at Lansing.

Waste Assimilation

Use of streams in the Grand River Basin for waste assimilation is one of the predominant present day uses, and in several locations it is the cause of extreme water quality problems as discussed in Sections 4 and 6.

Esthetics

The use of water for esthetic enjoyment is an intangible benefit which is directly related to the availability of clean water. It is a very important factor in determining the recreational potential of the Grand River Basin. Camping, picnicking, and sightseeing are more enjoyable when accompanied by pleasing lakes and streams of high quality water. Pollution robs the water of its esthetic value for such water related activities. Since this Basin will be called upon to provide recreation for many people living both within and outside the Basin, it is very important that the waters of the area be kept esthetically pleasing.

Beyond its importance to recreation the maintenance of an esthetically pleasing habitat for the present and future millions of residents of the Basin is essential to the economic and social well being of the area.

SECTION 4

PRESENT WATER QUALITY AND PROBLEMS

General

The information and interpretations presented in this discussion are based on data collected by the GLIRB Project during its water quality studies of the Lake Michigan Basin (1962-1964). The GLIRB Project studies have been supplemented by data obtained from other Federal agencies, the State of Michigan and local agencies. Two programs of study were carried out by the GLIRB Project with respect to water quality in the Grand River Basin. The first consisted of weekly sampling of the river mouth to determine average annual loadings discharged to the Lake and water quality variability. The second consisted of intensive studies of two stream stretches of the Grand River to determine the effect of organic wastes on stream oxygen resources.

Summary

The chemical, bacteriological and radiochemical data presented in subsequent pages form the basis for the following conclusions with respect to water quality effects:

1. The Grand River for a 25 mile stretch below Jackson is polluted. The principal waste source causing pollution is the effluent from the Jackson sewage treatment plant.

2. The Grand River for a 25 mile stretch below Lansing is polluted. The principal waste sources causing pollution are the effluent from the Lansing and East Lansing sewage treatment plants. Cooling water discharges from Thermal-electric power plants in Lansing intensify the adverse effects on water quality.

Grand River Mouth Sampling

Physical and Chemical Findings

During the period from March 1963 through April 1964, the GLIRB Project collected samples at the mouth of the Grand River to determine loadings of various substances being carried into Lake Michigan. The analytical results of this sampling are shown below in Table 4-1. Of all the chemical parameters reported, the two nutrients, total phosphorus and ammonia nitrogen, are most illustrative of the waste inputs discharged to Lake Michigan by the Grand River.

Considering all Lake Michigan tributaries, the Grand River is one of the greatest contributors of phosphorus and ammonia nitrogen with inputs of 1777 and 6970 pounds per day, respectively. In general, the chemical parameters for given streams in the Lake Michigan Basin follow definite patterns. In the Grand River phosphorus and ammonia nitrogen concentrations are high and a pattern of high values is also seen for the other chemical parameters as shown in Table 4-1. The Grand River is also one of the major contributors of dissolved substances to the Lake.

Table 4-1

Water Quality - Grand River at Mouth
March 1963 - April 1964

Parameter	No. of Samples	Concentration (mg/l) Average	Concentration (mg/l) Range	Loading (lbs/day)
Total				
Phosphorus (P)	52	0.17	0.04-0.36	1777
Ammonia Nitrogen (NH_3-N)	52	0.68	0.05-1.5	6970
Nitrate Nitrogen (NO_3-N)	51	0.72	0.04-2.4	
Organic Nitrogen (Org-N)	52	0.77		
Total Dissolved Solids	51	350	275-570	
Total Suspended Solids	44	24	6-84	
Sulfates (SO_4)	52	74	56-100	
Chlorides (Cl)	52	42	19-67	
Silicon Dioxide (SiO_2)	52	5.3	2.5-17	
Calcium (Ca)	52	72	51-85	
Magnesium (Mg)	52	26	16-30	
Sodium (Na)	52	28	7.1-43	
Potassium (K)	52	2.8	2.1-3.9	
Alkyl Benzene Sulfonate (ABS)	52	0.28	0.11-0.73	
Copper (Cu)	52	0.14		
Cadmium (Cd)	52	*		
Nickel (Ni)	52	0.04		
Zinc (Zn)	52	*		
Chromium (Cr)	52	0.04		
Lead (Pb)	52	0.11		

* Not Detectable at Test Sensitivity.

The maximum phenol concentration on the eastern side of Lake Michigan was 7.2 micrograms per liter (ug/l) close to the mouth of the Grand River. BOD_5 values as high as 8.6 mg/l were recorded near the mouth. An average total chromium concentration of 0.04 mg/l was found at the mouth of the Grand River. This concentration is only slightly less than the Public Health Service Drinking Water Standards(22) mandatory limit of 0.05 mg/l for hexavalent chromium.

Radiochemical Findings

The analytical results from 1963 sampling in the Grand River at the mouth are shown below in Table 4-2.

Table 4-2

Radioactivity
Grand River at Mouth
1963 Average

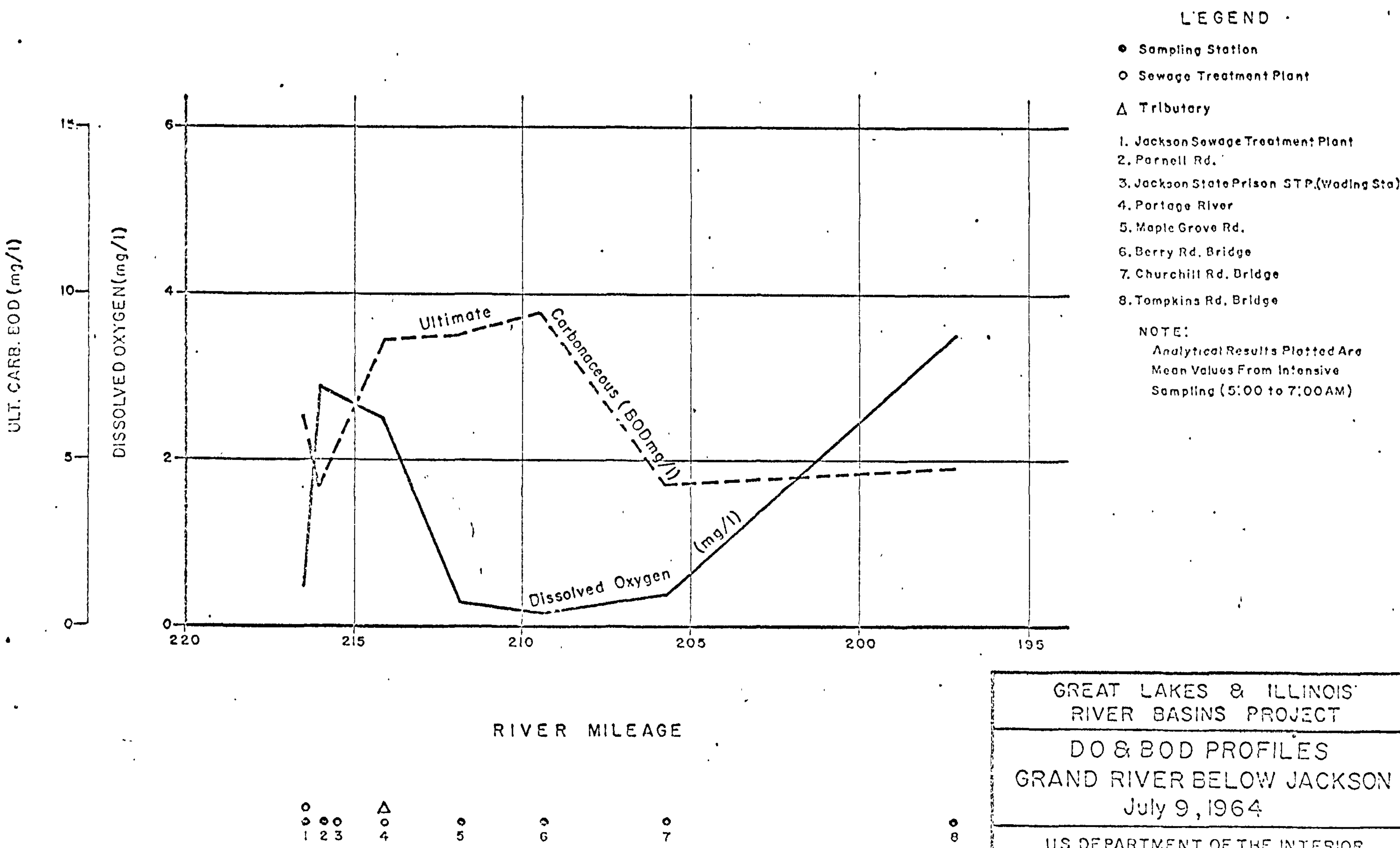
Portion	Gross Alpha Concentration (pc/l)	Gross Beta Concentration (pc/l)
Suspended Solids	<1	4
Dissolved Solids	<1	12
Total Solids	<1	16

In relation to the Public Health Service Drinking Water Standards, the concentrations reported above meet the Standards. However, a specific determination of the Strontium -90 concentration would be necessary in order to verify that the concentration was equal to or less than 10 picocuries per liter (pc/l). Past experience with similar waters shows that a very small portion of the gross beta activity is from Strontium -90.

Grand River Intensive Studies

Physical and Chemical Findings

The effects of organic loadings on the oxygen resources of the Grand River below Jackson and Lansing are indicated in the profiles of the dissolved oxygen (DO) and biochemical oxygen demand (BOD) shown in Figures 4-1 and 4-2.

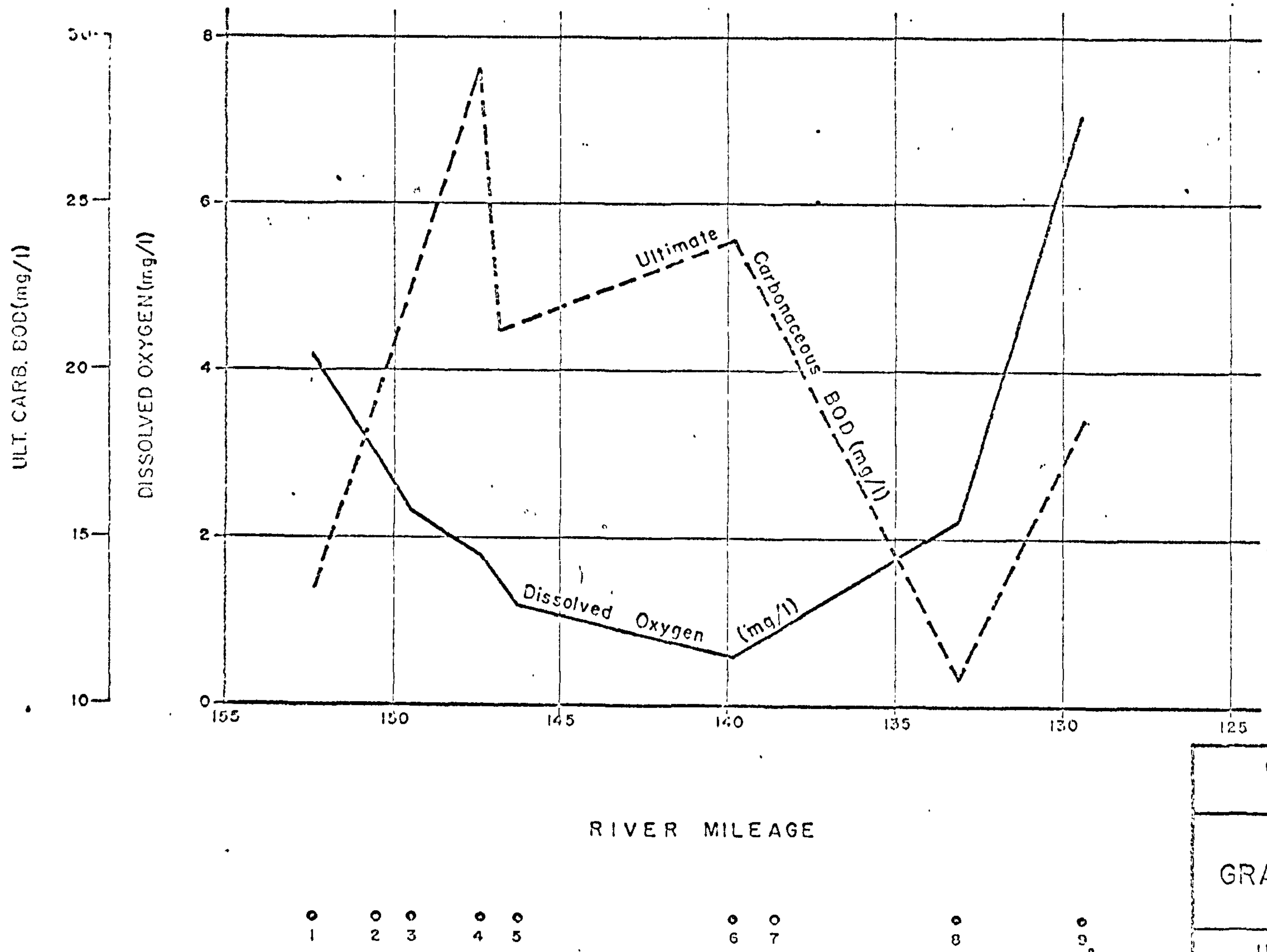


GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT

DO & BOD PROFILES
GRAND RIVER BELOW JACKSON
July 9, 1964

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

FIGURE 4-1



LEGEND

- Sampling Station
- Sewage Treatment Plant

1. Grand River Ave.
2. Lansing Sewage Treatment Plant
3. North Waverly Rd.
4. Wading Station
5. Canal Rd. Bridge
6. Highway M-100
7. Grand Ledge Sewage Treatment Plant
8. Jones Rd. Bridge
9. Turner Rd. Bridge

NOTE:
Analytical Results Plotted Are Mean Values From Intensive Sampling (5:00 to 7:00 AM)

GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

DO & BOD PROFILES
GRAND RIVER-BELOW LANSING
July 15, 1964.

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

FIGURE 4-2

In Figure 4-1 the apparent effects of effluent aeration at the Jackson sewage treatment plant are shown with a rise in the stream DO from about 0.4 mg/l to 3 mg/l in a distance of about 0.5 mile below the plant discharge. The stream DO concentration then decreases rapidly to a low of about 0.2 mg/l at a point about 7 miles below the plant discharge. The highest DO concentration in the study reach, 3.5 mg/l, was found at a point about 19 miles below the Jackson plant discharge. Desirable fish and aquatic life cannot survive under such degraded oxygen conditions.

In Figure 4-2 the high BOD levels, reaching a maximum of 29 mg/l about 3 miles below the Lansing Sewage Treatment Plant discharge, result in DO levels below 3 mg/l for a 19 mile stretch below the Lansing plant. The minimum DO, about 0.6 mg/l, occurs about 10.5 miles below the Lansing plant. As was the case below Jackson, desirable fish and aquatic life cannot survive below Lansing due to the degraded oxygen conditions. The stream is also unsuitable for other beneficial uses.

Further demand on the oxygen resources of the Grand River below Lansing results from the thermal discharges of the steam electric generating stations at Lansing. Increases in stream temperatures below the stations result in a higher rate of biological activity and a more rapid uptake of dissolved oxygen. The increased temperatures also limit the total amount of dissolved oxygen available for waste assimilation due to a lowering of oxygen saturation values. As discussed in Chapter 5 the stream temperatures below Lansing, under certain conditions, can easily rise above 100°F. These temperatures, in themselves, impair water uses at Lansing.

The Grand River in the stream reaches below Jackson and Lansing was also found to be esthetically unpleasing and objectionable for recreational uses such as boating, water skiing, and similar aquatic sports. The organic loadings causing these polluted conditions originate from the discharges of municipal sewage treatment plants. The major municipal waste discharges are listed in Table 5-1.

Microbiological Findings

Limited microbiological studies were conducted in conjunction with the intensive DO - BOD studies below Jackson and Lansing. Analyses for both total coliform and fecal streptococcus organisms were made.

Below Jackson, 11 samples were collected at eight stations and analyzed for coliform and fecal streptococci. Total coliform organisms reached a maximum density of 230,000 per 100 ml. At a point about 1.5 miles below the Jackson sewage treatment plant discharge and 0.5 mile below the Prison plant discharge. The maximum fecal streptococcus density was 6400 organisms per 100 ml. About 0.5 mile below the Jackson plant discharge, the maximum densities were found in samples collected October 14, 1964.

Below Lansing 17 samples were collected at eight stations. Total coliform organisms reached a maximum density of 930,000 per 100 ml during the May 13, 1964 sampling, at a point approximately 1 mile below the Lansing sewage treatment plant discharge. The maximum fecal streptococcus density was found at a point about 5.5 miles below the Grand Ledge sewage treatment plant discharge, reaching 12,000 organisms per 100 ml during the October 14, 1966 sampling.

The bacterial densities reported above indicate a high degree of pollution most likely resulting from the discharge of wastes from the municipal sewage treatment plants at Jackson, the State Prison, Lansing and Grand Ledge. The densities are of such magnitude as to seriously impair beneficial water uses such as partial body-contact recreation and municipal and industrial water supply. The densities present a definite hazard to the health of humans coming in contact with the waters effected.

SECTION 5

WATER QUALITY CONTROL
(WASTE SOURCES AND CONTROL MEASURES)

General

The problems of water quality control in the Grand River Basin are complex. Solutions to these problems will of necessity involve a comprehensive program which includes construction of new sewerage facilities; and continuous and intensive monitoring of operating procedures, treatment plant efficiency, and water quality conditions to determine necessary additional construction and operation needs as they arise. In addition, some combination of advanced waste treatment and flow regulation may be required to attain the desired water quality below Jackson and Lansing. The following paragraphs present information on waste sources, projected waste loads and water quality improvement measures which should be employed.

Waste Sources

The Grand River and the streams tributary to it receive an estimated organic waste load of 32,000 pounds of 5-day biochemical oxygen demand (BOD_5) per day. Approximately 15,000 pounds are from industries with separate discharges. The most significant waste loads in terms of water use impairment are discharged at Jackson and Lansing.

The following paragraphs summarize the major waste sources in the Basin. Consequences of these discharges were discussed in Section 4.

Municipal

Approximately 540,000 people were served by 47 municipal sewerage systems in the Grand River Basin in 1962.

Of the 47 municipal sewerage systems 18 provide minor or no treatment. Of the remaining 29 systems, 9 provide only primary treatment, (sedimentation and sludge disposal) and 20 provide secondary treatment (primary treatment plus filtration or activated sludge). Major municipal sewerage facilities having connected populations of 5,000 or more are listed in Table 5-1, and their locations are shown on Figure 1-1.

TABLE 5-1

MUNICIPAL WASTE INVENTORY OF MAJOR COMMUNITIES
GRAND RIVER BASIN

Community	Receiving Stream	Miles Above Mouth of Grand River	Treat-ment	Population Connected	Population Equivalent Estimated Waste Untreated	Population Equivalent Estimated Waste Treated	%BOD5 Reduction
Jackson	Grand River	216.4	Secondary	51,000	53,000	3,690	93
Jackson State Prison	Grand River	214.2	Secondary	6,500	11,400	1,600	86
East Lansing	Cedar River	160.0	Secondary	35,000	50,000	5,000	90
Lansing	Grand River	150.5	Secondary	130,000	170,000	17,000	90
Grand Ledge	Grand River	138.6	Primary	5,100	6,600	4,300	35
Saint Johns	Stony Creek	121.3	Secondary	5,600	7,300	1,415	81
Hastings	Thornapple River	102.8	Primary	6,350	8,250	5,350	35
Greenville	Flat River	98.1	Primary	7,400	9,600	6,250	35
Ionia Ionia State Reformatory	Grand River	89.2	Primary	6,600	8,600	5,600	35
Grand Rapids	Grand River	40.6	Secondary	220,000	285,000	28,500	90
Grandville	Grand River	34.3	Secondary	8,000	4,800	500	90
Wyoming	Grand River	-	Secondary	56,000	36,000	6,900	81
Grand Haven	Grand River	1.0	Primary	11,000	14,300	9,300	35

TABLE 5-2

MAJOR INDUSTRIAL WASTE DISCHARGES
GRAND RIVER BASIN

Company Location	Receiving Stream	Miles Above Mouth of Grand River	Treatment	Waste Discharge Flow MGD	Waste Discharge BOD_5 lbs/day	Waste Discharge Susp. Solids lbs/day	Estimated Treatment Efficiency BOD Removal
Wolverine World Wide Rockford	Rogue River	56.2	Primary & Aeration	0.58	2,150	750	70
Packaging Corp. of America Grand Rapids	Grand River	40.6	None	2.5	3,180	6,700	0
Eagle Ottawa Leather Company Grand Haven	Grand River	1.0	Screening	1.4	15,000	23,000	5

Industrial

Industries with separate outfalls discharge approximately 21,000 pounds of BOD_5 daily to the streams of the Grand River Basin. Major industrial waste sources in the Grand River Basin are listed in Table 5-2.

Combined Sewers

It has been estimated that a quantity, equivalent to 3 to 5 percent of all untreated waste-water flow in combined sewer systems, is annually discharged to streams by overflows. A far greater percentage of the solids are discharged to streams from overflows due to the fact that the sludge deposited in the sewers is flushed out by the storm flow.

Of the 47 communities with public sewer systems in the Area only about 8 have completely separate sewer systems. The types of sewer systems of the major municipal waste source are listed in Table 5-3.

TABLE 5-3
Types of Municipal Sewer Systems
Major Municipal Waste Sources
Grand River Basin

Municipality	Type of Sewer System
Jackson	Combined
East Lansing	Separate and Combined
Lansing	Separate and Combined
Grand Ledge	Separate and Combined
Saint Johns	Separate and Combined
Hastings	Combined
Greenville	Combined
Ionia	Separate and Combined
Grand Rapids	Separate and Combined
Grand Haven	Combined

Steam Power Plants

Thermal discharges from two steam generating stations at Lansing, Michigan are particularly significant from a water quality standpoint. The temperatures of 90°F reported by the Michigan Water Resources Commission were measured prior to the installation of additional generating capacity at Lansing. Unless control measures are taken, the temperature standards for fish and aquatic life will not be maintained.

Agriculture and Land Runoff

Fertilizer

Estimates of fertilizer use in the Grand River Basin are that approximately 8,000 tons of nitrogen and 5,000 tons of phosphorus are being used annually. The applications of these are projected to increase four and two-fold, respectively, by 2020.

During 1963 - 1964 the FWPCA conducted a rural land runoff sampling study to assess the relative amounts of phosphorus and other substances transported to streams by rural runoff in the Lake Michigan Watershed. Based upon the results of this study, it is estimated that there is an annual total soluble phosphorus runoff from rural land of about 310,000 pounds per year in the Grand River Basin. Estimates of the total amount of phosphorus discharged to Lake Michigan from the Grand River Basin are discussed on page of this report.

Insecticides and Herbicides

Pesticide contamination of streams is a matter of growing concern. Agricultural activity is considered to be the major source of the pesticides which have been found in water. Insecticides used in the Grand River Basin include D.D.T., Diazinon, Guthion, Malathion, Parathion, Sevin, Thiodan, and Toxaphene. Unfortunately, there is little or no information available as to the amounts that are used in the Basin.

Ships and Boats

Commercial Shipping

The large number of vessels plying Grand Haven Harbor represents a considerable potential for pollution of the Harbor waters. Among the possible sources of pollution are cargo spillage, dunnage, bilge waste, ballast water, fuel spills, garbage and sanitary wastes. Uncontrolled discharges of these wastes can result in serious pollution problems to beaches, shore property, recreational waters, fish and aquatic life, and municipal and industrial water supplies.

Commercial shipping has increased significantly since the opening of the St. Lawrence Seaway in 1959. While all new vessels built since 1952 specifically for use on the Great Lakes have been equipped with waste treatment facilities, ocean-going ships generally have no provisions for waste treatment. The majority of these ocean-going vessels are designed to discharge sanitary wastes from multiple outlets.

The U. S. Public Health Service has established regulations governing vessel waste discharges in the Great Lakes based upon their legal responsibility for the interstate control of communicable diseases. Restricted areas have been established in which the discharge of sewage, or ballast or bilge water, from vessels is prohibited. Restricted areas include the water within a three mile radius of domestic water intakes. Additional controls were recommended by the conferees to the Four State-Federal Lake Michigan Enforcement Conference.

Recreational Boats

In addition to commercial traffic, Grand Haven Harbor is also an important recreational boating center. About 4,000 recreational craft annually are passed through the Spring Bridge which joins Ferrysburg and Spring Lake. There are numerous marinas and boat clubs along the lower part of the Grand River. Many of the larger recreational craft are equipped with galley and toilet facilities which may discharge untreated or inadequately treated wastes to the Harbor or Lake waters. Oil and gasoline wastes, as well as garbage and sewage from onboard cooking and toilet facilities, are the major potential sources of pollution. The State of Michigan has recently adopted rules and regulations to control pollution from this source.

Dredging

Maintenance dredging is done by the U. S. Army Corps of Engineers to maintain authorized navigation depths in Grand Haven Harbor. Dredged materials are disposed of in the deep waters of Lake Michigan.

Water quality surveys made in 1967 by the FWPCA showed significant evidence of pollution material in the bottom deposits of Grand Haven Harbor. Transfer of this pollutional material to Lake Michigan via the dredging process creates an additional zone of pollution in the Lake.

Through a joint statement announced March 1, 1967, the Department of the Army and the Department of the Interior agreed on a program and plan for attacking the problem of the disposition of polluted material dredged from harbors in the Great Lakes. It was agreed that, in order to maintain navigation, the Corps of Engineers would proceed with dredging in calendar year 1967 on 64 channel and harbor projects in the Great Lakes. The Corps also initiated a two-year pilot program early in 1967 to develop alternative disposal methods which would lead to a permanent plan of action.

Transport to Streams and Lakes from Rural Lands

The amount of soluble phosphorus reaching streams from land runoff, in the Grand River Basin, as estimated from samples taken on eight pilot watersheds, as previously discussed, is about 310,000 pounds annually or approximately 0.1 pounds per acre of watershed. Although there are many factors which affect phosphorus contributions from rural areas, including methods of applying fertilizers, quantities applied, type of soil, topography, rainfall, land use practices and soil cover, it is believed that the results obtained are reasonably representative of the Grand River Basin.

Municipal Sources

Domestic sewage is relatively rich in phosphorus compounds. Most of this phosphorus comes from human excreta and synthetic detergents. The amount of phosphorus released by human metabolic processes is a function of protein intake and for the average person in the United States, this release is considered to be about 1.5 grams per day. Synthetic detergent formulations contain large amounts of phosphorus. It is estimated that 2.5 grams of phosphorus per capita-day are discharged to sewer systems as a result of the use of synthetic detergents.

When the above per capita figures for phosphorus from human excreta and detergents are expanded to cover the entire sewered population of the Grand River Basin the quantity becomes quite large. Data from waste inventories show that 540,000 people are served by sewer systems in the Basin. It is estimated that a total of approximately 1,100,000 pounds of soluble phosphorus from humans and detergents are discharged to the waters of the Basin each year.

Tributary Mouth Sampling

In addition to the land runoff sampling from the eight small subbasins discussed above, sampling stations were established at the mouth of the Grand River. These stations were sampled intermittently for one year during the same period in which the land runoff stations were sampled.

Sampling at the mouth made it possible to estimate the total phosphorus load reaching Lake Michigan from the Grand River. It was determined that a total of approximately 700,000 pounds of phosphorus is discharged to the Lake annually. This is 14% of the total phosphorus input to the Lake and is therefore a significance source of this critical pollutant.

Municipal Waste Treatment Needs

The immediate goal in the treatment of municipal wastes is the provision of biological (secondary) treatment at each waste treatment plant. Such treatment is the minimum considered adequate in terms of present technology. This need is especially important in those areas where consideration is being given to low-flow augmentation to assist in maintaining water quality standards. Augmentation cannot be considered as a substitute for secondary treatment. Adequate effluent disinfection is also considered to be a necessity in the Grand River Basin particularly where recreational use of the receiving waters is prevalent. There is also a present need to increase total phosphorus removal to at least 80% as recommended by the Four State-Federal Enforcement Conference on the Pollution of Lake Michigan and its Tributary Basin.

There are 47 municipal sewerage facilities in the Grand River Basin. Of these, 20 provide secondary biological waste treatment. Municipal waste treatment construction needs for the major communities of the Grand River Basin are shown on Table 5-4. These needs are based on waste flow and waste load projections to the year 1980.

Industrial Waste Treatment Needs

Minimum treatment needs for major industries with separate outfalls are listed in Table 5-5. In developing this list it was considered that the equivalent of secondary waste treatment as described in the preceding section would be the minimum degree of treatment required.

Combined Sewer Overflow Control

The need for solutions to the problems caused by overflows from combined sewer systems is pressing and is receiving much current attention. The Water Quality Act of 1965 established a four-year program of grants and contract authority to demonstrate new or improved methods to eradicate the problems of combined sewer overflows.

While economically feasible methods for solving the problems are being developed, existing combined sewer systems should be patrolled and overflow regulating structures should be adjusted to convey the maximum practicable amount of combined flows to and through waste treatment facilities. Combined sewers should be prohibited in all newly developed urban areas and should be separated in coordination with urban renewal projects.

TABLE 5-4

MUNICIPAL WASTE TREATMENT CONSTRUCTION NEEDS (MAJOR COMMUNITIES)
GRAND RIVER BASIN - MICHIGAN

Community	Present Status	Population Connected	Needs
Jackson	Sec. Tr.	51,000	Advanced Waste Treatment*
Jackson State Prison	Sec. Tr.	6,000	Advanced Waste Treatment*
East Lansing	Sec. Tr.	35,000	Expansion, Chlorination, Phosphorus Removal
Lansing	Sec. Tr.	130,000	Further Evaluation Pending Completion of Expanded Facilities
Grand Ledge	Pri. Tr.	5,100	Secondary Treatment, Phosphorus Removal
Saint Johns	Sec. Tr.	5,600	Phosphorus Removal
Hastings	Pri. Tr.	6,350	Secondary Treatment, Phosphorus Removal
Greenville	Pri. Tr.	7,400	Secondary Treatment, Phosphorus Removal
Ionia	Pri. Tr.	6,600	Secondary Treatment, Chlorination, Phosphorus Removal
Grand Rapids	Sec. Tr.	220,000	Expansion, Chlorination, Phosphorus Removal
Grand Haven	Pri. Tr.	11,000	Secondary Treatment, Phosphorus Removal

*Advanced waste treatment - chemical precipitation, filtration, adsorption or other unit treatment processes, singly or in combination following conventional secondary waste treatment to provide a treated waste effluent of extremely high quality. It is assumed that the advanced waste treatment process adopted will remove the required 80% of total phosphorus.

TABLE 5-5

WASTE TREATMENT NEEDS FOR MAJOR INDUSTRIAL WASTE SOURCES
GRAND RIVER BASIN

		Treatment Facilities	
Company	Location	Present	Recommended Minimum
Wolverine World Wide	Rockford	Primary & Aeration	Secondary
Packaging Corporation of America	Grand Rapids	None	Secondary
Eagle Ottawa Leather Company	Grand Haven	Screening	Secondary

Plant Operation

Proper plant operation must follow proper plant design in order to efficiently reach the goals of water pollution control. The importance and value of proper plant operation must be emphasized at all levels of public authority. Effective operation can be encouraged by means of a routine inspection program. Inspections should be conducted by the appropriate State agencies on at least an annual basis for the small and medium-sized plants, and at least, bi-annually for the larger plants.

The Michigan Department of Health, administers a mandatory sewage treatment plant operators' certification program. State-sponsored operator training programs are also a useful tool for elevating the level of overall plant performance. Today, with increasing activity in the field of water pollution control at the Federal, State and local levels, operator training courses should be conducted at least annually. The Michigan program, consisting of annual training on a regional basis, compares favorably with the training programs sponsored by other states.

Monthly operation reports should continue to be submitted to the Michigan Water Resources Commission from each municipal and industrial waste treatment facility. These reports should contain sufficient information to describe waste treatment efficiency and the quality and quantity of the effluent discharged to the waters of the Basin.

Monitoring

The maintenance of desirable water quality on a continuing basis calls for a routine monitoring program covering the significant water quality parameters at strategic points.

The overall monitoring program should be geared to provide an adequate picture of all wastes being discharged to the waters of the Basin and adjacent waters of Lake Michigan and serve to indicate trends in water quality or the need for additional water quality improvement measures.

As part of an overall monitoring program efforts are needed to assess the potential problems associated with agricultural practices in the Grand River Basin. There is a lack of reliable information concerning land use practices and the quantities of pesticides and fertilizers applied within the Basin. Reliable data concerning application rates on a yearly basis in each county would be very helpful in identifying potential water quality problem areas.

State Water Pollution Control Program

The Federal Water Pollution Control Act recognizes the primary responsibility of the States in the control and prevention of water pollution. The effectiveness of a State program, however, is dependent upon adequate funds and personnel with which to accomplish this mission.

The State of Michigan has achieved commendable success in the control of water pollution with the staff and funds available. However, even though much has been accomplished by the State in controlling conditions, much remains yet to be done. In 1964, the Public Administration Service prepared a survey report for the Public Health Service concerning the budgeting and staffing of State programs. This report contains suggested guidelines for use in evaluating the adequacy of State water pollution control programs. This report suggests a minimum total staff level of 110 persons and a desirable total staff level of 171.

In view of the water pollution control problems still existing in the Basin consideration should be given to an accelerated program to match the needs for clean water for all legitimate uses. An accelerated State water pollution control program utilizing fully the resources and programs of the Federal Water Pollution Control Administration will ensure the earliest possible accomplishment of our common goal - more effective use of our water resources.

Streamflow Augmentation Requirements

Based on consideration of the location of principal municipal and industrial waste discharges in the Grand River Basin and the quantitative and qualitative characteristics of the receiving waters, two reaches of the main stem of the Grand River below Jackson and Lansing were selected for waste assimilation studies.

Waste assimilation studies were conducted to determine the total streamflow required to meet a range of water quality goals in the Grand River below Jackson and Lansing. During 1964 intensive stream investigations were conducted on these reaches during May, July and October.

A computer program was utilized to develop a mathematical model which reproduced the stream conditions observed during these intensive sampling periods. Using projected flow and quality data for the waste inputs within the study reaches of the stream, the model was used to compute the total streamflows required for flow regulation for water quality control. It has been assumed that a 90% BOD_5 removal will be provided ~~by 1980 and a 95% BOD_5 removal will be provided by 2020~~ for both municipal and industrial waste discharges.

The State of Michigan has set a minimum standard of 4.0 mg/l of dissolved oxygen below both Lansing and Jackson. The maintenance of this standard for dissolved oxygen in conjuction with the other water quality standards listed in Section 3 will assure the absence of nuisance odor conditions; permit recreational use involving partial body contact; support pollution tolerant fish such as carp and other aquatic life; and in general, provide for the esthetic enjoyment of clean surface waters. Streamflow requirements to maintain the required DO level are shown by month in Table 5-6.

The estimated ranges of total streamflow required to maintain a DO concentration of 4.0 mg/l below Jackson are 53 to 510 cfs in 1980 and 103 to 860 cfs in 2020. Below lansing the streamflows required to maintain a DO of 4 mg/l are 55 to 480 cfs in 1980 and 160 to 1760 cfs in 2020. Ranges in streamflow requirements are primarily due to the wide variation in stream temperatures over the year.

The ability of existing streamflows to meet the above demands can be assessed by comparing the estimated maximum required flows in 1980 and 2020 with the 7 day once-in-10-year low flows as shown in Table 2-2. The comparison indicates that existing low flows will not be adequate to assimilate the treated waste discharges at Jackson and Lansing in 1980 and 2020. Thus, it is concluded that some combination of streamflow regulation and advanced waste treatment, beyond 90% BOD_5 removal, will be required to achieve the water quality goal of 4 mg/l DO below Jackson and below Lansing.

TABLE 5-6

Average Monthly Streamflow Necessary to Maintain
Stated Minimum Dissolved Oxygen Levels in the Grand River, Michigan*
(DO goal 4 mg/1)

	Below Jackson cfs			Below Lansing cfs			
Year	1966	1980	2020	1966	1980	2020	
Month							Temp. °C
April	57	76	155	53	85	250	6
May	126	169	317	114	185	520	14
June	195	274	480	172	290	780	18
July	250	362	630	218	360	1020	20
August	345	510	860	290	480	1760	22
September	195	274	480	172	290	780	18
October	157	212	385	140	230	630	16
November	91	123	238	85	110	390	11
December	57	76	155	53	85	250	6
January	42	53	103	25	55	160	0
February	45	58	112	30	60	180	1
March	45	58	112	30	60	180	1

*Note: Streamflows are exclusive of municipal, industrial and institutional waste discharges.

SECTION 6

ALTERNATIVES

General

Benefits to be derived from water supply and water quality control are determined on the basis of the least costly alternate single-purpose project which would provide an adequate water supply or result in meeting a given water quality level. Alternatives considered in the case of water supply include storage reservoirs in the Grand River Basin itself, transportation of water from outside the Basin and expansion of existing well supplies. Water quality control alternatives include storage reservoirs in the Grand River Basin itself, transportation of water from outside the Basin and higher degrees of waste treatment.

Reservoir Sites

Approximately 75 possible Grand River Basin reservoit sites have been identified by the U. S. Army Corps of Engineers. These sites have been depicted by means of colored overlays on Michigán Department of Conservation County maps. A set of these overlay maps was used to obtain pertinent information, such as the location, storage volume and drainage area of each of the proposed sites. This information permitted tentative selections of reservoir sites which could be used for the purpose of water supply storage for water quality control to serve the control areas previously outlined. At the writing of this appendix no final decision had been made as to which reservoir projects would actually be constructed.

Possible reservoir sites are shown schematically on Figure 6-1 and described in Tables 6-1 and 6-2. These possible sites were selected from the overlay maps on the basis of size and location. In estimating the storage that could be obtained for the purposes of water supply or water quality control, the average annual flow was utilized. A factor of 0.7 cfs per square mile (Lansing Gage) was used to estimate the average discharge at the various sites. If the estimated average annual volume of flow was less than the storage available at a site then the lower volume figure was used to determine the storage available for water supply or water quality control.

Water Supply

Data on municipal and municipally supplied industrial water use was presented in Section 3. Based on projected water needs given in that section and comments obtained from the U. S. Geological

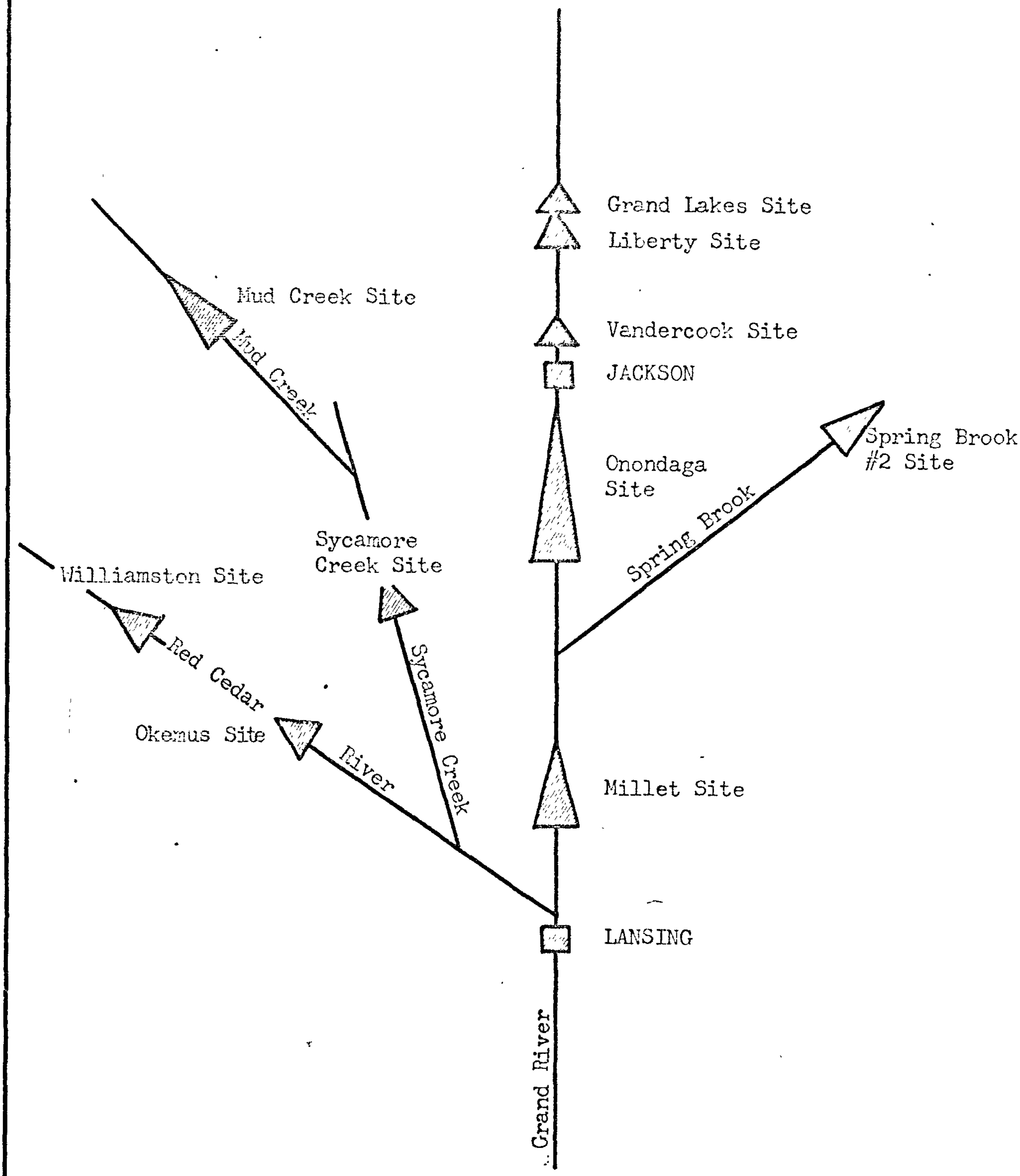


FIGURE 6-1

CHICAGO PROGRAM OFFICE

POSSIBLE RESERVOIR SITES
LANSING & JACKSON, MICH.

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION CHICAGO, ILLINOIS

Survey, it appears that ground sources of municipal water supply will become insufficient to meet the demands of 2020 the water demand at that city will reach about 120 mgd. Some 90 mgd of this amount will be supplied from ground water sources. Considering a single-purpose reservoir as a possible water supply source, a storage volume of approximately 46,000 acre feet would be required to augment the well supply. This includes a 20% allowance for storage losses and is over and above storage requirements for water quality control which are discussed below.

Development of the Williamston site on the Red Cedar River as a single-purpose water supply reservoir would cost approximately $10,200,000.

One alternative to construction of a reservoir as described above would be to obtain water from one of the Great Lakes, i.e., either Lake Michigan or Lake Huron. A connection with Lake Michigan would require the construction of a 60 inch diameter pipeline 80 miles in length and 9 pumping stations. The construction of such a project would cost about $30,000,000. This is based on a cost of $60 per lineal foot of pipe and $52,000 per pumping station.

Water Quality

Flow requirements given in Table 5-6 were used to determine the storage volume needs for water quality control in the Grand River. It should be noted here that these flow requirements were determined by means of a mathematical model which among other things was based upon existing stream geometry, i.e., existing depths and widths.

Jackson

Approximately 108,000 acre feet of storage will be required by 1980 to meet water quality needs in the Grand River below Jackson. As can be seen from Table 6-1 this is considerably greater than the storage available in the Grand River Basin above Jackson. Although 16,000 acre feet could be used for water quality storage if all available storage were devoted to this single-purpose, advanced waste treatment, resulting in an effluent which is essentially stable appears to be the most feasible alternative.

The method of treatment considered here for both Jackson and Lansing consists of chemical coagulation and sedimentation using 300 mg/l of hydrated lime and 50 mg/l of ferrous sulfate plus filtration through sand at 4 gallons per minute per square foot plus aeration of the final effluent and pH adjustment before final discharge. This degree of treatment would provide about 93 percent reduction in BOD and would be utilized during periods of low stream flow when needed to maintain the required 4 mg/l of dissolved oxygen in the river.

It is interesting to note that the City of Jackson has proceeded on its own initiative with encouragement from the Michigan Water Resources Commission to study treatment methods to further reduce oxygen-demand in their present activated sludge effluent. Jackson has received a Demonstration Grant from the Federal Water Pollution Control Administration to aid in carrying on this study.

The alternative of importing water from the Great Lakes for augmentation is not considered advisable. This is due to the fact that local interests have already recognized the need for higher degrees of treatment and are working toward that end. Further, it is the Federal Water Pollution Control Administration's opinion that the importation of high quality water for the primary purpose of diluting waste treatment plant effluents is not in best interests of the general public in this instance.

Lansing

Storage requirements for water quality control below Lansing are approximately 46,000 acre feet in the period up to 1980 and an additional 74,000 acre feet in the period 1980 to 2000. In the period 2000 to 2020, an additional 184,000 acre feet would be required. This assumes a 90% reduction of BOD_5 in the untreated raw waste. ~~by 1980 and a 95% reduction by 2020.~~ It appears that sufficient storage and flows in the Grand River Basin are available to meet the storage demands up to 1980. Meeting the need for the 1980 to 2020 period may be impracticable, since a large percentage of the storage available above Lansing would be needed for this single-purpose (See Figure 6-1 and Tables 6-2 and 6-3). The cost of providing the required storage would be approximately $46,000,000.

Because this method of solving the water quality problems below Lansing is probably unacceptable, advanced waste treatment has been evaluated as an alternative means of meeting water quality standards.

<u>Summary</u>

The annual costs of each of the alternative methods of meeting the water supply and water quality problems of the Grand River Basin are shown in Table 6-3.

SUMMARY OF ALTERNATIVES

Type of Problem	Location	Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O&M Cost	Total Annual Cost
Water Supply								
	Lansing	Storage Reservoir (46,000 acre feet)	2000	$10,000,000	$2,600,000 (4-5/8%)	$134,000 (50 yrs. at 4-5/8%)	$46,000	$180,000
	Lansing	Pipeline to Lake Michigan	2000	$30,000,000	$6,900,000 (5%)	$378,000 (50 yrs. at 5%)	$252,000	$630,000
Water Quality Control								
	Jackson	Advanced Waste Treatment	Present 1995	$1,600,000 $2,200,000	$2,200,000 (5%)	$120,000 (50 yrs. at 5%)	$210,000	$330,000
	Jackson	Storage Reservoir	Storage for water quality control is not considered a feasible alternative at Jackson.					
	Lansing	Storage Reservoir (Williamston 46,000 acre feet)	Present	$10,200,000	$10,200,000 (4-5/8%)	$530,000 (50 yrs. at 4-5/8%)	$46,000	$580,000

SUMMARY OF ALTERNATIVES

Type of Problem	Location	Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O&M Cost	Total Annual Cost
	Lansing	Storage Reservoirs (Millet, Mud Creek and Okemus) (74,000 acre feet)	1980	$16,200,000	$10,300,000 (4-5/8%)	$530,000 (50 yrs. at 4-5/8%)	$74,000	$600,000
		Storage Reservoir (Onondaga 221,000 acre feet)	2000	$25,000,000	$6,400,000 (4-5/8%)	$330,000 (50 yrs. at 4-5/8%)	$190,000	$520,000
	Lansing	Advanced Waste Treatment	Present 1995	$3,400,000 $5,600,000	$5,000,000 (5%)	$270,000 (50 yrs. at ~~4-5/8%~~ 5%)	$160,000	$430,000