A WATER POLLUTION INVESTIGATION

OF THE

DETROIT RIVER

AND THE

MICHIGAN WATERS OF LAKE ERIE

SECTION VI

PRESENTATION OF RESULTS

MICHIGAN WATERS OF LAKE ERIE

U.S. Department of Health, Education, and Welfare
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LAKE ERIE

DESCRIPTION OF WATER QUALITY - LAKE ERIE

The Michigan waters of Lake Erie represent approximately 1 percent of its total surface area. This complicates a description of water quality. It will be approached by presentation of a series of maps on which quality contours of various measures of water quality are shown. Narrative interpretation will follow to evaluate the graphical presentation. Sampling stations in Lake Erie, along its bathing beaches and on its tributaries, are shown in Figure 2-I. Tables 1-VI through 3-VI summarize average sampling results and Tables 4-VI through 6-VI summarize maximum results found during the survey in Lake Erie, its bathing beaches and tributaries respectively.

Bacteriological

Figure 1-VI depicts geometric mean coliform values in the Lake as contours. Figure 2-VI shows maximum coliform concentrations found at different locations in Lake Erie during the survey. The majority of the Michigan Lake waters have average coliform concentrations under 500 organisms per 100 ml. Two areas of high concentration are evident from study of Figure 1-VI. The first extends below the mouth of the Detroit River south to just above Stony Point while the other radiates out into the lake a short distance from the Raisin River. These two tributaries to the Lake exert separate influences upon these areas and do not appear to be associated with each other. An area of geometric mean coliform concentration above the International Joint Commission objective of 2,400 organisms per 100 ml extended down into Lake Erie for a distance of 2 to 3 miles. Geometric mean coliform concentrations greater than 5,000 organisms per 100 ml were observed at the mouth of the Detroit River as it entered Lake Erie.

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TABLE 1-VI. SUMMARY OF AVERAGE RESULTS IN MICHIGAN LAKE ERIE

Station	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Geometric Mean Coliform org/100ml	Geometric Mean Fecal Strep org/100ml	Geometric Mean Fecal Coli org/100ml	Phosphates mg/l	Nitrates mg/l	Nitrites mg/l	Ammonia Nitrogen mg/l	Organic Nitrogen mg/l
L2	8.07	2	14	79	2,000	16	360	.17	.15	.003	09	.13
L3	8.12	2	25	79	6,000	23	1,620	.35	.12			
L4	8.08	3	44	85	3,500	12	550					
L5	7.95	2	18	79	3,700	15	670	.32	.24	.003	34	.12
L6	8.14	1	20	79	1,600	80	320		.24			
L7	8.13	1	19	80	1,900						.34	.18
L8	8.22	2	24	82	640			.20	.15	.003	24	.12
L9	8.25	2	18	119	330			.12	.12	.002	39	.14
L10	8.44	2	21	83	130			.22	.26			
L11	8.36	6	22	80	69			.14	.10	.002	.05	.08
L12	8.33	1	25	79	200			.24	.39	.003	.13	.23
L14	8.46	4	25	81	160	5	21	.13	.53	.001	.18	.23
											.34	.37
L15	8.46	1	20	78	88			.11	.34			
L17	8.41	2	22	78	36			.25	.19	.001	.12	.12
L20	8.58	1	23	81	55			.33	.14			
L21	7.63	0	35	84	5,000	29	1,250	.78	.32	.006	.27	.17
L22	8.13	1	46	84	260	9	13	.24	.44	.001	.23	.17
L23	8.32	2	29	84	130	8	22					
L24	8.19	5	24	81	84	5	25	.29	.44	.001	.17	.15
											.43	.54
L25	8.30	16	26	85	48	5						
L26	8.19	-	25	84	19			.31	.15	.030	.10	.25
											.41	.47
L27	8.44	2	29	81	88	7	5					
L28	8.44	2	24	86	69	7	7	.11	.49	.002	.16	.33
											.58	.62

TABLE 2-VI. SUMMARY OF AVERAGE RESULTS
MICHIGAN LAKE ERIE BATHING BEACHES

Station	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Geometric Mean Coliform org./100 ml	Geometric Mean Fecal Strep org./100 ml	Geometric Mean Fecal Coli org./100 ml
B1	8.42	2	65	93	2,000	79	680
B3	8.51	2	44	85	960	13	320
B4	8.50	2	41	86	480	60	180
B5	8.51	3	33	79	490	53	152
B7	8.63	3	28	78	340	130	180
B8	8.66	4	27	79	480	77	200
B10	8.61	4	28	76	480	69	254
B14	8.60	3	25	87	360	50	83
B17	8.59	3	25	76	430	90	206
B18	8.51	2	25	83	500	51	190
B21	8.50	3	27	83	990	37	178
B22	8.43	4	26	85	460	430	207
B23	8.68	3	24	82	860	200	490
B25	8.74	2	25	81	300	190	111
B27	8.68	1	32	83	210	190	67
B29	8.81	1	24	87	170	53	123
B31	8.73	2	27	93	350	170	170

TABLE 3-VI. SUMMARY OF AVERAGE RESULTS TRIBUTARIES TO MICHIGAN LAKE ERIE

Tributary	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Geometric Mean Coliform org./100 ml	Geometric Mean Fecal Strep org./100 ml	Geometric Mean Fecal Coli org./100 ml
Huron River	8.37	3.1	36	145	13,000	560	5,700
Swan Creek	8.19	4	94	106	4,100	150	1,350
Stony Creek	8.22	2	26	186	1,700	370	610
Sandy Creek	8.19	3	82	188	5,600	730	1,800
Raisin River	7.93	7	27	125	30,000	85	13,200
Plum Creek	7.77	16	31	221	49,000	2,500	21,500
LaPlaisance Creek	8.05	2	40	130	2,400	180	1,630

TABLE 4-VI. SUMMARY OF MAXIMUM VALUES FOUND IN MICHIGAN LAKE ERIE

Station	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Coliform org./100 ml	Fecal Strep org./100 ml	Fecal Coli % of Total
L2	8.4	6	44	82	56,000	45	42
L3	8.7	8	58	80	110,000	88	45
L4	8.7	9	82	89	75,000	60	45
L5	8.6	15	44	80	97,000	58	55
L6	8.8	5	48	80	30,000	85	20
L7	9.1	4	48	81	42,000	-	-
L8	9.2	7	37	87	100,000	--	-
L9	8.7	7	55	157	23,000	-	-
L10	8.9	6	37	85	3,000	-	-
L11	9.0	58	47	82	2,500	-	-
L12	8.8	6	46	81	36,000	-	-
L14	9.0	28	41	84	6,400	L 10	25
L15	8.8	8	30	82	7,400	-	-
L17	8.8	9	35	78	1,200	-	-
L20	9.0	5	28	82	1,000	10	-
L21	8.0	0	58	84	57,000	310	40
L22	8.7	3	74	84	81,000	55	5
L23	8.8	2	39	86	1,700	75	25
L24	8.8	17	36	84	2,400	L 10	30
L25	8.8	30	34	87	4,700	L 5	-
L26	8.6	-	31	85	140	-	-
L27	8.8	2	34	84	2,700	20	5
L28	9.0	4	27	86	2,000	20	10

TABLE 5-VI. SUMMARY OF MAXIMUM VALUES FOUND AT MICHIGAN LAKE ERIE BATHING BEACHES

Station	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Coliform org./100 ml	Fecal Strep org./100 ml	Fecal Coli % of Total
B1	9.0	14	82	93	25,000	2,000	100
B3	9.2	5	80	88	240,000	850	70
B4	9.0	8	80	89	190,000	200	100
B5	9.0	8	75	82	42,000	380	58
B7	9.1	10	71	81	62,000	2,000	95
B8	9.1	13	79	81	37,000	1,400	100
B10	9.2	15	78	78	33,000	2,500	100
B14	9.2	8	37	99	86,000	420	40
B17	9.2	7	31	80	96,000	500	80
B18	9.3	8	30	88	230,000	250	80
B21	9.4	9	49	87	72,000	160	40
B22	9.3	14	42	90	3,100	3,700	85
B23	9.3	10	36	86	51,000	1,800	90
B25	9.4	8	31	86	8,000	3,500	100
B27	9.3	4	149	87	2,200	2,100	60
B29	9.5	3	30	90	2,000	740	100
B31	9.4	13	37	103	3,000	1,500	90

TABLE 6-VI. SUMMARY OF MAXIMUM VALUES FOUND ON TRIBUTARIES TO MICHIGAN LAKE ERIE

Tributary	pH	Phenols µg/l	Chloride mg/l	Alkalinity mg/l	Coliform org./100 ml	Fecal Strep org./100 ml	Fecal Coli % of Total
Huron River	9.1	14	47	163	140,000	2,800	75
Swan Creek	8.5	12	193	109	26,000	400	45
Stony Creek	8.5	8	38	190	32,000	1,100	95
Sandy Creek	8.8	8	180	198	460,000	6,100	82
Raisin River	8.8	36	33	153	530,000	560	100
Plum Creek	8.1	175	94	234	1,200,000	9,200	60
LaPlaisance Creek	8.7	6	59	145	44,000	400	95

Maximum values of coliform concentrations at several locations showed a similar pattern at higher concentrations. Again two zones of high values were found in the same locations described above. The maximum coliform concentration observed outside of the two zones of polluted water was 42,000 organisms per 100 ml, while maximum values exceeding 100,000 organisms per 100 ml were observed near the mouths of the Detroit and Raisin River.

Average fecal coliform concentrations in Lake Erie ranged from 5 to 30 percent of the total coliform concentrations and geometric mean fecal streptococci in Lake Erie were under 80 organisms per 100 ml at all locations.

All bathing beaches along Lake Erie showed geometric mean coliform less than 1,000 organisms per 100 ml, except Maple Beach (B1) which is located in the influence of the polluted Detroit River. The relatively low counts at the Sterling State Park beaches are misleading due to high concentrations which appear under certain conditions of wind and weather. These values are masked in median or geometric mean values, thus a special survey was made on this beach and is described later in this report.

Average fecal coliform concentrations at the beaches ranged without a noticeable pattern from 23 to 72 percent of the total values. Fecal streptococci geometric means at the beaches ranged from 13 to 430 organisms per 100 ml. Bathing beaches below Otter Creek to the Ohio State line had geometric mean coliform concentrations less than 350 organisms per 100 ml. Maximum coliform concentrations at these locations did not exceed 3,000 organisms during the survey.

Study of Table 3-VI reveals geometric mean coliform concentrations in excess of 1,500 organisms per 100 ml, at the mouths of all Lake Erie tributaries. Highest were Plum Creek, averaging 49,000 coliform organisms per 100 ml and the Raisin River averaging 30,000.

Fecal coliform concentrations were high ranging from 32 to 68 percent of the total values. Fecal streptococci concentrations in Plum Creek averaged 2,500 organisms per 100 ml while all other tributaries averaged under 1,000.

Maximum coliform concentrations found in all Lake Erie tributaries exceeded 25,000 organisms per 100 ml. The maximum value found in Plum Creek exceeded 1 million organisms per 100 ml.

High total coliform concentrations, especially when accompanied by high fecal coliform concentrations, indicate the presence of human wastes which may contain pathogenic organisms capable of causing enteric disease or disorder in humans. The presence of these organisms in concentrations above acceptable levels is considered a threat to the health and welfare of those who use such water for water supply or recreational purposes.

Bacteriological concentrations in Lake Erie from the mouth of the Detroit River to a distance from 2 to 3 miles below this point, indicate the water is polluted to the extent that it cannot safely be used for recreational purposes. Furthermore, following heavy rainfall in the Detroit area the zone of polluted water extends southward to just north of Stony Point. Both the International Joint Commission objective of 2,400 coliform organisms per 100 ml and, 1,000 organisms per 100 ml, commonly used as a standard pertaining to recreational use of water are exceeded in the zone of Lake Erie influenced by the Detroit River.

A similar zone of somewhat less extensive coverage radiating from the mouth of the Raisin River indicates interference with recreational and other water use in this vicinity. The zone of polluted water is extended radially farther out into Lake Erie following heavy rainfall in the Monroe area.

Other areas of the Michigan waters of Lake Erie are of suitable bacteriologic quality for all uses. This statement is especially applicable to the bathing beaches just below LaPlaisance Creek to the Ohio State line. The Detroit or Raisin Rivers do not appear to seriously affect or interfere with water use at the City of Monroe water intake off Stony Point.

Chemical and Physical

Phenols

Average phenol concentrations in the Lake and alongshore ranged from 1 to 16 µg/l with 17 of 24 stations showing averages of 2.0 µg/l or less. The few locations showing high phenolic concentrations showed no pattern and were not located in the vicinity of either the mouth of the Detroit or Raisin Rivers. Maximum phenol values at generally the same stations showing high average values ranged to as high as 58 µg/l at Station L11.

All beaches had average phenol concentrations less than 5 µg/l with most equal to or less than 2 µg/l. Only Plum Creek averaging 16 µg/l and the Raisin River at 7 µg/l were the only tributaries exceeding 4 µg/l. Phenol concentrations near the City of Monroe intake averaged 2 µg/l.

High levels of phenols in waters cause disagreeable tastes and odors in drinking water and tainting of flesh in game fish, and may result in fish kills at extremely high concentrations. With few exceptions, International Joint Commission objectives for average phenol concentrations (2 µg/l) were met during the survey. There is no evidence that phenols in the Michigan water of the Lake constitute a real or even potential interference with water use.

Chlorides

Average chloride concentrations in the Michigan water of Lake Erie ranged from 18 to 44 mg/l with the higher values alongshore and near the mouth of the Detroit River. Average chloride concentrations in Lake Erie are shown as contours in Figure 3-VI. The influence of the Trenton Channel of the Detroit River on chloride concentrations in Lake Erie is clearly shown in this figure, and is felt as far south as Stony Point. A maximum value of 82 mg/l was observed near the mouth of the Detroit River. A maximum value of 74 mg/l was noted near the mouth of the Raisin River.

Chloride concentrations at high levels can interfere with domestic and industrial water supplies by causing objectionable tastes in drinking water and corrosion in industrial processes. Levels found in the Michigan waters of Lake Erie are 3 to 5 times higher than those found at the head of the Detroit River but existing concentrations are not considered high enough to interfere with water use. The year by year increase noted at the City of Monroe water intake (see Figure 13 -I) is alarming and this warning of future difficulties merits attention and action.

pH

Alongshore and in the Michigan waters of Lake Erie pH values ranged from 7.6 to 8.8. The lowest pH values were found near the mouth of the Detroit River, and the highest values were found in the southern part of the Michigan waters.

Extreme pH values can interfere with fish propagation and water supply, but values found in Lake Erie do not indicate a problem exists at this time.

Suspended and Settleable Solids

In the Lake average suspended solids ranged from 11 to 25 mg/l with the higher values near the Raisin and Detroit Rivers. Average settleable solids were low ranging from 1 to 4 mg/l. Solids at certain bathing beaches were considerably higher with suspended solids averaging 80 - 165 mg/l at Sterling State Park and Bolles Harbor beaches just north and south of the mouth of the Raisin River.

Suspended and settleable solids in the Raisin River averaged 20 and 9 mg/l respectively.

Excessive amounts of suspended solids in water can cause interference with domestic and industrial water treatment processes, can cause harmful effects to fish and other aquatic life by clogging the gills and respiratory passages of aquatic fauna, can cause turbidity which interferes with light transmission, and can interfere with boating and esthetic enjoyment of water.

When a part of the suspended solids settles out on stream and lake bottoms as sludge or bottom deposits, damage to aquatic life can occur by blanketing the bottom, killing eggs and essential fish-food organisms, and destroying spawning beds.

Suspended solids in Lake Erie in the vicinity of the mouths of the Raisin and Detroit Rivers have reached levels which indicate pollution and interfere with water uses by causing some of the effects mentioned above. This is especially true near the shore.

Cyanides

All cyanide values in Lake Erie and its beaches were found to be zero except one value of 0.03 mg/l collected at Sterling State Park. Cyanides in the Raisin River averaged 0.03 mg/l at its mouth.

Cyanides are toxic to man as well as fish and other aquatic life. Public Health Service drinking water standards recommend limiting cyanide concentrations to 0.01 mg/l. Cyanide concentrations above 0.025 mg/l are considered detrimental to fish and other aquatic life.

Cyanide concentrations found in the Raisin River and in Lake Erie near the mouth of the Raisin indicate a potential interference with water use from the standpoint of municipal water supply and fish and wildlife propagation. This effect has not been observed in the vast majority of the Michigan waters of Lake Erie but appears to be limited to a small area of the Lake immediately adjacent to the mouth of the Raisin River.

Iron

Limited sampling in Lake Erie for iron revealed an area adjacent to and south of the mouth of the Raisin River with iron concentrations ranging between 0.21 and 0.64 mg/l. Iron concentrations in the northern part of the Michigan waters of Lake Erie were low at 0.01 mg/l.

Excessive concentrations of iron in water can cause interference with domestic and industrial water supplies by causing tastes and stains. Iron is toxic to certain species of fish and other aquatic life in relatively low concentrations. International Joint Commission objectives define maximum limits of iron concentrations as 0.30 mg/l. Iron concentrations in Lake Erie generally meet this objective with the exception of the waters adjacent to and south of the mouth of the Raisin River.

Toxic Metals

All toxic metals analyzed, except cadmium, were detected in the Michigan waters of Lake Erie above the 0.01 mg/l level. The occurrence of metals seemed to be greater in the waters south of Stony Point.

Copper, chromium and zinc ranged from 0.01 to 0.07 mg/l with the higher values adjacent to the mouth of the Raisin River. Lead ranged from 0.01 to 0.12 mg/l with the highest values again in the vicinity of the mouth of the Raisin. All nickel concentrations were 0.02 mg/l or less, and as mentioned before, cadmium was not detected at the sensitivity of the test (0.01 mg/l). Toxic metals were found above minimum detectable concentrations only in the area extending outward 2 to 4 miles from the mouth of the Raisin River.

Toxic metals present a threat to the health and welfare of humans who consume drinking water in which they are present in concentrations greater than those listed in the Public Health Service drinking water standards. They can also interfere with industrial processes and act as toxic agents for fish and other aquatic life.

At this time the concentrations of toxic metals found in Lake Erie are not expected to interfere with water use. Maximum values of chromium and lead in the vicinity of the mouth of the Raisin River indicate a possible future problem.

ABS

All concentrations of alkyl benzene sulphonate found in the Michigan waters of Lake Erie were less than 25 µg/l which are far less than the limit of 500 µg/l which is expected to cause foaming. Therefore it can be stated that there is no demonstrated interference or likelihood of interference with water use from this constituent.

Dissolved Oxygen

Figure 4-VI depicts percent saturation contours for dissolved oxygen in Lake Erie. These are average values considering both surface and depth samples during the four seasons. The difference between surface and depth samples ranged between 5 and 20 percent during fall surveys and as much as 90 percent during spring and early summer surveys in the deeper sections of the Lake. The lowest actual dissolved oxygen concentrations were found as expected during summer months. The location of these areas was adjacent to the mouths of the Raisin and Detroit Rivers.

A band of low dissolved oxygen less than 50 percent saturation extended out from the Raisin River a distance ranging from 1/2 to 3/4 of a mile. In this small area complete depletion of dissolved oxygen values were found. The location of zero dissolved oxygen values was considered in the mouth of the Raisin River hydrologically speaking, especially since within one mile of the mouth average percent saturation values exceeded 100 percent.

The second area of relatively low dissolved oxygen values was found in the Lake immediately below the mouth of the Detroit River in a finger or stream extending southward a distance of 4 to 6 miles at values under 85 percent saturation. In this zone the minimum Lake value found was 4.8 mg/l just off Pointe Mouillee.

Excluding these two areas, the lowest value in Lake Erie was found at Station L17 at the 24-foot depth and was 5.6 mg/l. The corresponding surface sample was 11.9 mg/l. In summary it can be said that all dissolved oxygen values found in the Michigan waters of Lake Erie either at the surfac or at depths exceeded 4.8 mg/l and 58 percent saturation. It should be emphasized again that the Michigan waters constitute only 1 percent of the

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total surface area of Lake Erie.

An area of exceptionally high dissolved oxygen values was found in the Brest Bay area where averages exceeding 120 percent saturation were found. Such high values in natural waters are normally associated with algal growth with subsequent production of oxygen.

The lack of dissolved oxygen in water can be an unfavorable environment for fish and other aquatic life, and can interfere with municipal and industrial water supplies by increasing their corrosive properties. Low levels of dissolved oxygen can cause objectionable odors and make waters less desirable from the recreational and esthetic sense. Levels of dissolved oxygen in all parts of the Michigan waters of Lake Erie (excluding the mouth of the Raisin River) are sufficient at this time to prevent interference with water use.

Temperature

Temperature values in the Michigan waters of Lake Erie ranged up to 24.5°C or 76°F and on specific days during fall and winter months varied only 1° throughout the Lake. During spring and early summer surveys, differences throughout the Lake as great as 6° were observed. Average temperatures in the Lake during the spring and summer tend to be slightly higher than those in the Detroit River. During the fall no difference between the two bodies of water was observed.

Differences at specific stations between surface and depth samples were less than 1°C during fall and winter months, while differences as high as 3° - 4°C were observed during the spring and early summer at the deeper stations on Lake Erie.

Extreme high temperature can kill fish and cause corrosion problems in water supplies, as well as accelerate the rate of utilization of the biochemical oxygen demand in the water. The temperature levels in the Michigan waters of Lake Erie do not interfere with water use therein.

Nitrogen Compounds

This category and phosphates are commonly referred to as essential plant nutrients, or simply as nutrients. Although only the inorganic forms of nitrogen (nitrates, nitrites and ammonia) are readily available for plant utilization, other less stable forms can easily be changed into this form in the presence of dissolved oxygen and thus are considered in this discussion. All nitrogen compounds are reported as nitrogen.

Figure 5-VI depicts average nitrate concentrations in the Michigan waters of Lake Erie as contours. The fluming effect from the mouth of the Detroit River so noticeable in the dispersion of other constituents was not present in the distribution of nitrates in the Lake. High levels of nitrates were observed in the Brest Bay area with average concentrations ranging from 0.35 to greater than 0.50 mg/l, and an area of high nitrate concentration was observed off Pointe Mouillee. Daily values in the Brest Bay showed high values early in May (0.91 mg/l); low values in September (0.11 mg/l); and then higher valuesagain in October and December (0.24 mg/l).

Nitrite values in the Lake averaged between less than 0.001 to 0.009 mg/l with no noticeable pattern in the distribution of these values.

Ammonia nitrogen average concentrations in Michigan waters of Lake Erie are shown in Figure 6-VI. The fluming effect of highly concentrated water from the mouths of the Detroit River and Raisin River was noticeable in the dispersion of average ammonia concentrations. A mass of water exceeding 0.30 mg/l extended approximately 10 miles intothe Michigan waters of Lake Erie.

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Average ammonia concentrations exceeding 0.3 mg/l were found radiating about 1/2 mile into the Lake from the mouth of the Raisin River, and values exceeding 0.20 mg/l were found one to two miles from this point.

Average concentrations of organic nitrogen in the Michigan waters of Lake Erie are shown in Figure 7-VI. The northern part of the Michigan waters had values for the most part less than 0.20 mg/l. The portion of the Lake extending from the Michigan-Ohio State line north to the Raisin River along the Michigan shore had average organic nitrogen values between 0.20 and 0.30 mg/l. A small area just off the mouth of the Raisin River had values exceeding 0.30 mg/l.

Nitrates in drinking water in concentrations greater than 10 mg/l can cause serious illness in infants. Nitrates also cause interference with many industrial processes. Ammonia can interfere with domestic water treatment by combining with applied chlorine to form chloramines instead of the more effective disinfecting agent, free chlorine. Ammonia in water supplies is usually regarded as evidence of recent pollution from human or animal wastes if concentrations exceed 0.10 mg/l.

Nitrogen compounds coupled with phosphorus can act as essential nutrients causing the growth of algae in bodies of water where other environmental factors are satisfactory. In small quantities these algae are desirable as a major source of food for fish. When algal growth exceeds certain limits, nuisances result from undesirable blooms. These are unsightly, can result in obnoxious odors, and can be toxic to fish. A commonly accepted level of inorganic nitrogen compounds (nitrates, nitrites, and ammonia) above which undesirable blooms can be expected to occur is 0.30 mg/l. Figure 8-VI shows average values of inorganic nitrogen in the Michigan waters of Lake Erie.

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All but a small segment of the southern part of Michigan Lake Erie near Toledo had average inorganic nitrogen concentrations in excess of 0.30 mg/l Two areas near the mouths of the Detroit and Raisin Rivers had average inorganic nitrogen concentrations in excess of 0.60 mg/l or more than twice the level above which nuisance growths can be expected.

Nitrogen compounds are not present in the Michigan waters of Lake Erie in concentrations sufficient to cause illness in infants using this supply as drinking water, nor are the existing levels sufficient to cause interference with industrial processes. Average ammonia concentrations of 0.20 mg/l near the City of Monroe water intake could cause water treatment difficulties and excessive dosage of chlorine to achieve adequate disinfection in domestic water treatment processes. Over 85 percent of the Michigan waters of Lake Erie contain inorganic nitrogen in concentrations sufficient to cause undesirable algal blooms and a subsequent serious interference with water use due to premature nutritive enrichment or eutrophication of this body of water.

Phosphates

Figures 9-VI and 10-VI depicts total and soluble phosphate levels in the Michigan water of Lake Erie as contours. Both are reported as phosphate.

Areas of high total phosphate concentration (0.20 - 0.50 mg/l) extended from the mouth of the Detroit River into Lake Erie as far south as Stony Point (Figure 9-VI). Daily average total phosphate concentrations for the entire Lake varied from 0.18 mg/l in the spring to over .30 mg/l in late fall and early winter. Another small zone of high total phosphate concentrations (.30 - .40 mg/l) extended outward from the mouth of the Raisin River about one mile.

Soluble phosphate values shown in Figure 10-VI indicated three areas of

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high concentrations of this constituent. One extended down 6 - 8 miles from the mouth of the Detroit River with concentrations varying from 0.10 to greater than 0.20 mg/l as phosphate (0.033 to 0.065 mg/l as phosphorus). The second area of similar high soluble phosphate concentration radiated outward 1 to 2 miles from the mouth of the Raisin River. The third area extended upward 3 to 4 miles from the Michigan-Ohio State line near Toledo. The vast majority of the remainder of the Michigan waters of Lake Erie had concentrations of soluble phosphate ranging from 0.05 to 0.10 mg/l as phosphate (0.016 to .033 mg/l as phosphorus).

Soluble phosphates in relatively small concentrations are readily available as an essential nutrient for plant growth. The insoluble portion of the total phosphate concentration can be converted to the soluble form by bacterial action and thus become available for such plant utilization. Soluble phosphates present in greater concentrations than 0.015 mg/l reported as phosphorus in combination with inorganic nitrogen compounds in excess of 0.30 mg/l and accompanied by satisfactory environmental conditions such as light and heat, create over abundant growths of algae with concomitant odors and detriment to fish life. To convert soluble phosphates reported as phosphates (as shown in Figure 10-VI) to those reported as phosphorus, divide by three.

Concentrations of soluble phosphates in almost the entire Michigan portion of Lake Erie exceeded the value of 0.015 mg/l as phosphorus. This, coupled with the material presented under "Nitrogen Compounds", gives a picture of a lake rich in nutritive matter well along towards a eutrophic state with its undesirable characteristics. Over 85 percent of Michigan Lake Erie waters contained soluble phosphorus in concentrations sufficient to cause over abundant algal blooms with these undesirable after effects.

Comparison of phosphate and inorganic nitrogen compounds reveals over 85 percent of Michigan Lake Erie in a highly nutritive state indicative of eutrophication.

Alkalinity

Average concentrations of alkalinity were very constant throughout the Michigan waters of Lake Erie, ranging from 78 to 86 mg/l. One exception was the concentration at Station L9 of 119 mg/l with no apparent explanation other than one very high result affecting the average value.

Alkalinity concentrations at Lake Erie bathing beaches were also very consistent in the same range (76-93 mg/l). Tributary alkalinity concentrations were generally much higher ranging from 106 mg/l in Swan Creek to 221 in Plum Creek.

Alkalinity values in Michigan Lake Erie are well within ranges suitable for all water uses.

Biology

Microscopic Plants and Animals

Floating and suspended microscopic plants and animals, commonly referred to as plankton, were repeatedly collected and examined from selected stations in the Detroit River and Lake Erie. Phytoplankton, free-floating microscopic plant life, are of basic importance in aquatic environments since they provide the first step in the food chains of fishes. Their presence is necessary to support animals in the water. By the process of photosynthesis, phytoplankton are able to synthesize protoplasm from the nutrients available in the waters utilizing sunlight for energy.

Zooplankton, the animal plankton, form the food of many young fishes at the critical post-hatching period. The microcrustacean plankters are important animals in the transformation of algal cell material into fish flesh. As primary consumers, they feed upon the phytoplankton. In order to support game fish at the top of the food chain pyramid, the waters must produce large quantities of zooplankton.

Plankton in large numbers can create nuisances. Some species may become toxic. Many cause water treatment problems by clogging filter beds and producing tastes and odors. Through the uptake of nutrients released to the waters by domestic wastes, some industrial wastes, and land drainage, algae can occur in such abundance as to contribute to the increased aging of lakes.

Low oxygen potentials in the lower water strata and the mud-water interface of lakes create acid conditions that liberate nutrients bound in the mudwater interface region to overlying waters. These phosphates contribute to nuisance blooms and augment the algal problems.

In addition to studies of free-floating plants and animals, attached slimes and other microscopic organisms were collected and examined from numerous points in the Detroit River and Lake Erie. Many of these organisms form massive colonies in organically-enriched and highly-polluted waters. Some, such as Sphaerotilus, are filamentous slime bacteria. They are commonly referred to as "sewage fungus." These slime bacteria form ragged white, yellow, pink, or brown masses on all solid objects in rivers and lakes and may even form a carpet over mud surfaces. At times, drifting masses of sewage fungus may continue to grow in open waters of large rivers and cause trouble to fishermen by fouling lines and nets. Sewage fungus is one of the most unsightly products of pollution. Another growth, the filamentous green alga, Cladophora, may also be associated with polluted and nutrient-enriched waters. When dead and windrowed upon beaches, it decays and produces obnoxious odors and may become a fly-breeding habitat. Abundant growths of this alga may then become a nuisance on beaches, prohibit swimming, and interfere with recreation.

Waters of the lake study area were found to be rich in plankton with counts as high as 22,425/ml. The lake area nearest the shore especially supported dense populations of plant and animal plankters.

Collections near the mouth of the Detroit River had phytoplankton counts throughout the season 4 - 7 times lower than those of the lake reflecting the plankton-poor water masses passing from the Detroit River and heading eastward into other waters of Lake Erie. Density levels in general increased with distance from the Detroit River mouth. Average values for the whole season were 2,500 organisms/ml for the outshore locations and 4,200 organisms/ml for the inshore stations (see Table 7-VI).

The abundance of phytoplankton observed in the Michigan waters of Lake

TABLE 7-VI. ABUNDANCE OF PHYTOPLANKTON - LAKE ERIE STATIONS, 1963

Values in Number of Organisms per Milliliter

Station	April 18	May 9	*June 3	July 5	August 6	Sept. 4	*Oct. 3	*Oct. 10	Nov. 4	Nov. 27	Mean
	Date of Collection										
(Outshore)											
2	1775	925	900	950	525	125	350	625	550	275	700
5	2050	7125	2750	1025	525	100	275	1250	1900	2850	1985
10	4450	6075	7775	3625	1225	575	2100	1200	1675	3600	3230
15	8350	3950	5825	3750	1575	725	1800	775	2525	3525	3280
17	5825	7225	6450	3925	1375	750	2500	1550	1250	1650	3250
Mean	4490	5060	4740	2655	1045	455	1405	1080	1580	2380	2489
(Inshore)											
4	22425	6450	12600	5675	875	225	250	1075	3200	225	5300
8	7825	4845	3575	10325	1600	1000	300	500	2875	2950	3580
12	8975	4250	4800	4500	1900	1100	5025	1125	6025	5175	4288
24	4100	5325	4500	6050	5150	1800	4525	1800	3950	4125	4133
28	4800	4650	7875	5175	4225	1500	3750	1650	2625	5350	4150
14	5525	7200	9250	6775	2550	1625	5875	1450	3800	2900	4695
20	5425	8725	3600	2225	1850	2075	2000	1450	950	4400	3272
Mean	8439	5921	6600	5818	2593	1332	3104	1293	3357	3589	4205

* Variations from date of collection shown:

June 3 - Station 2 on May 20; 4, 5, 8 on May 29; 17, 20 on June 4.
October 3 - Stations 2, 4, 5, 8 on September 30.
October 10 - Stations 12, 15, 28 on October 11; Stations 2, 4, 5, 8 on October 14

Erie indicates that its capacity to produce plankton is among the highest in the Great Lakes. The heavy crops of algae observed at the inshore stations near Stony Point and Brest Bay could not be maintained throughout the summer season without an adequate supply of inorganic nitrogen and soluble phosphates. Measurements obtained show inorganic nitrogen and soluble phosphates reported as phosphorus at levels of 0.55 mg/l and 0.036 mg/l, respectively which are characteristic of organically-enriched waters. The nutrient levels at the beginning of the spring growing season that would be expected to produce nuisance blooms are 0.30 mg/l for inorganic nitrogen and 0.015 mg/l for soluble phosphates reported as phosphorus.

The shallowness of the western basin of Lake Erie, coupled with wind and current action, brings about almost uniform vertical distribution of temperature and nutrients which creates an optimal environment for growth and reproduction of plankters.

Atmospheric and photosynthetic oxygen is thoroughly mixed throughout the water mass resulting in the absence of anaerobic organic decomposition near the bottom. High mid-summer temperatures of 24°C serve to increase the rate of decomposition of protein materials and to convert nitrogen into the form needed for growth of algae. Phosphorous, bound in cell material of dead and decaying algae and other organic material, is released in the form of soluble phosphates and a portion recycled as a plant nutrient.

In the Brest Bay area, where the nutrient supply is rich and the algal counts highest, the phosphates and nitrates are recirculated in the water mass by the clockwise currents. The addition of more nutrients gradually increases the concentration. At times of bloom periods, low levels of nitrates were observed, but this can be explained in the well-known capacity of phytoplankton to take up nutrients in excess of actual needs.

A considerable portion of the nutrient supply for maintaining the observed phytoplankton abundance in Brest Bay originates from the discharge of inadequately treated domestic wastes and the paper mill wastes of the Raisin River area at Monroe. Nutrient measurements substantiate this assumption as the phosphate and nitrate levels observed in the Raisin River were 0.4 mg/l and 0.6 mg/l, respectively.

Another symptom of heavy organic enrichment at the inshore stations was the occurrence of sewage tolerant species of green and blue-green algae, and the occurrence of diatoms characteristic of highly eutrophic bodies of standing water. These blooms were concentrated in the Brest Bay area and also observed at the station above Stony Point close to the crib of the City of Monroe's water intake.

Taste and odor producing algae have caused trouble at the City of Monroe's water treatment plant. The intake was moved to its present location in 1950 to obtain waters less prone to tastes and odors.

Turbidity, as in the Detroit River, was high in Lake Erie. In contrast to the river, however, the observable cloudiness was not due primarily to the discharge of wastes, but rather to the high concentrations of plankton themselves.

The filamentous green alga, Cladophora, mentioned earlier as usually being associated with nutrient-enriched waters, was found at most stations in Lake Erie. Heavy growths of this alga were found along the beaches near Bolles Harbor. In addition, sewage fungus was found in the Brest Bay area (Figure 11-VI) indicating the polluted condition of these waters and pointing to the sources of waste originating in the Monroe-Raisin River area.

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In summary, the nutrient-laden waters of the Detroit River, 0.7 mg/l phosphates and 0.3 mg/l nitrates, are not the primary cause of the high plankton counts in the Brest Bay area. The Detroit River influence is felt down as far as Stony Point, but the main stream of nutrients is carried by the prevailing currents into other waters of Lake Erie. The excessive densities of organisms in Brest Bay are primarily caused by the nutritional wastes discharged in the Monroe area and retained there by the rotating currents. The fertilization of the lake area by man-contributed organic matter fosters the abundant crop of algae. This fertilization load simply represents a superimposed burden upon waters which are already in an advanced state of enrichment.

Bottom Organisms

As the environment in which bottom organisms live becomes modified by pollution, undesirable changes occur in the kinds and numbers of organisms present. This is especially true for those organisms that live on the bottom of lakes and streams. Bottom-dwelling organisms do not move great distances and therefore are subjected to all local environmental changes. As a community of organisms becomes upset by pollution, some species abound in disproportionate numbers. Huge aggregations of only one kind of organism may be present. Deposition of fine silt or flocculent ooze from decaying organic matter of industrial and domestic origin constitutes one of the greatest hazards to most species of clean-water associated bottom-dwelling organisms. Oils and greases which are adsorbed into the bottom muds are another source of community disruption.

Based on their response to pollution, bottom dwellers can be separated into three categories: pollution-sensitive, intermediate, and pollution-tolerant organisms. Pollution-sensitive forms such as mayflies, caddisflies, and mussels are associated with clean-water habitats and are important because they provide essential food for many game fishes. Intermediate forms such as snails, fingernail clams, and scuds are capable of surviving in a moderately polluted environment. Pollution-tolerant forms such as sludge-worms, bloodworms, and leeches may survive in areas severely polluted with organic wastes. The elimination of the competition from sensitive organisms and the seemingly unlimited food supply from organic solids permits the surviving tolerant forms to increase inordinately in numbers.

Under conditions of drastic pollution even the tolerant forms may be wiped out and no signs of life will be apparent in the bottom muds. Consequently, the presence or absence of certain bottom organisms in a sample becomes quite meaningful and enables a trained observer to assess the quality of the water passing over the organisms and to evaluate and locate sources of industrial and domestic pollution.

In Michigan Lake Erie, a study of the bottom animal associations revealed polluted areas adjacent to the Raisin River and Sterling State Park, (Figure 12-VI, Table 8-VI) and also at the mouth of the Detroit River extending in the shape of a fan out into the lake. The clustering of these zones close to the mouth of the Detroit River and the Raisin River points to the sources of pollutional discharges which render the bottom unfit for the survival of clean-water associations of organisms. In between the two polluted areas, an association of bottom forms containing sensitive, intermediate, and tolerant specimens indicates that these two polluted areas are independent and separate of each other.

As mentioned earlier, the samples from the river below sources of

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TABLE 8-VI

SUMMARY OF BOTTOM ORGANISM DATA, LAKE ERIE
MEAN NUMBER PER SQUARE FOOT OF BOTTOM

Station	SENSITIVE FORMS		INTERMEDIATE FORMS				TOLERANT FORMS	
	Caddisfly Larvae	Mussels	Snails	Fingernail Clams	Scuds	Midge Larvae	Leeches	Sludgeworms
L-2	-	-	-	-	-	-	1	5837
L-4	-	-	1	-	-	-	-	22
L-5	-	-	-	3	-	-	-	67
L-6	-	-	1	2	-	1	2	70
L-7	-	1	3	15	-	10	3	16
L-8	-	-	3	1	-	2	1	7
L-9	-	1	2	7	-	1	1	1
L-10	-	3	2	2	-	1	1	1
L-11	-	1	5	1	-	2	1	1
L-12	-	1	1	1	-	-	2	1
L-14(1)	-	-	-	-	-	-	1	1
L-15	-	1	1	5	-	1	2	1
L-17	-	1	1	1	-	1	3	2
L-20	3	1	4	1	-	-	3	36
L-21	-	-	4	1	-	-	1	11
L-22	-	1	1	-	-	-	1	41
L-23	1	-	-	-	-	-	-	19
L-24	1	-	-	-	-	1	-	16
L-25	-	1	1	-	-	1	1	1
L-26	1	-	-	-	-	3	-	207
L-27	-	-	-	-	-	-	1	36
L-28	-	-	-	-	-	-	3	51
L-32(1)	-	-	-	-	-	-	1	45
L-41(2)	-	-	-	-	-	-	2	4
T-80	-	-	-	-	-	-	-	9

(1) No macro-bottom organisms, Fall Survey.
(2) No macro-bottom organisms, Spring Survey.

pollution and from the lake did not contain a single burrowing mayfly. Among the causative factors involved in the disappearance of this important fish food organism are the changes in the lake floor sediments themselves. The occurrence of ooze or flocculent sludge and oil laid down by pollution from Detroit and the Monroe area has replaced previously desirable habitats that supported mayflies and other fish-food organisms.

SOURCES AND CHARACTERISTICS OF WASTES

Municipal

In addition to study of operating records of sewage treatment plants (see Figures 11-I and 14-I) of interest to this Project, two 4-day surveys were made of the Monroe Sewage Treatment Plant in cooperation with the Michigan Department of Health during which waste flows were measured, hourly bacteriological samples and 12-hour composite chemical, biochemical, and physical samples collected and analyzed in the Project laboratory.

The outfall for the primary sewage treatment plant serving the City of Monroe is located near the mouth of the Raisin River. Table 9-VI summarizes the results of the two surveys while Table 10-VI lists waste loadings and observed treatment efficiency of the plant.

The Monroe Sewage Treatment Plant was considered the only municipal plant whose effect on water quality in Lake Erie could be demonstrated. Chlorination of the plant effluent was practiced during the first survey but not the second.

Results from the two surveys indicated an influent fairly typical of a weak domestic waste. Exceptions to this general observation included soluble and total phosphates at 20 and 40 mg/l respectively, and high concentrations of certain toxic metals including copper, zinc and lead. These constituents were present in approximately the same concentrations in the plant effluent.

Plant efficiency as measured by percent removal of suspended solids (62 percent) and BOD (59 percent) was very good for a primary sewage treatment plant. Bacterial control was effective during the first survey when effluent chlorination was practiced but poor during the second survey when no chlorine was added for effluent disinfection.

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Study of operating records revealed that similar degrees of plant efficiency were maintained on a long-term basis. Although chlorination was practiced only during summer months, the results during the 1963 season compared favorably with those found during the first survey.

Nutrient concentrations in the form of ammonia and phosphate was high at 8.3 mg/l and 21 mg/l respectively. Oil and grease concentrations in the plant effluent were erratic, averaging 7 mg/l during the first survey and 36 mg/l during the second. This variance appeared to be caused primarily by differences in the plant influent since very little oil was removed during treating in either survey. Phenol concentrations in the plant effluent were high at 47 µg/l.

Study of effluent loadings shown in Table 10-VI revealed this plant contributed 52 gallons of oil and grease, 214 pounds of nitrogen compounds, over 600 pounds of phosphates, 1,180 pounds of suspended solids;and discharges to the Raisin River, a waste equivalent to a population of 8,100.

In summary the operation of this plant is considered far above average for an installation of this type and the operating personnel are so commended.

The table below lists present loadings of iron, oil, phenols and suspended solids which would be effected if International Joint Commission recommended effluent limitations and a suspended solids limitation of both 50 and 85 mg/l were met at the Monroe plant.

Pollutant	Present Loading	Loading after Reduction	Reduction
Oil and Grease	52 gallons/day	31 gallons/day	40
Phenols	0.97 pounds/day	0.47 pounds/day	51
Iron	31 pounds/day	31 pounds/day	0
Suspended Solids			
(reduced to 85 mg/l)	1,180 pounds/day	1,180 pounds/day	0
(reduced to 50 mg/l)	1,180 pounds/day	1,030 pounds/day	12

Industrial

Sources of industrial wastes studied in the lower Raisin River comprise 6 plants near Monroe, Michigan. These plants consist of 4 paper mills, a manufacturer of automobile bumpers and accessories, and an industry producing shock absorbers. The location of these industries is shown on Figure 6-II. Individual grab samples were collected from plant outfalls throughout the Project's duration, and an intensive survey of each industry was performed on a cooperative basis with personnel of the Michigan Water Resources Commission. In the computation of waste loadings contributed by each industry only the increase over values found in the plants raw water supply were used. Tables 11-VI and 12-VI summarize the results of these investigations. Table 11-VI contains average concentrations of selected waste constituents while Table 12-VI summarizes waste loadings in some quantitative measure such as pounds or gallons per day. In most cases, values found during the intensive surveys were used as reported while some were modified by grab samples collected from plant effluents by the Public Health Service.

The total waste volume from these 6 plants is 151 million gallons per day. Another plant, the Consolidated Paper Company - West Side Works, although not operating during the survey or Project operating period, has resumed operation on a part-time basis. Waste constituents from these sources include large quantities of oxygen-demanding material depleting the oxygen resources of the Raisin River beyond recovery. The wastes also contain significant quantities of coliform bacteria, oil, toxic metals, cyanides, suspended and settleable solids.

Nearly 100 percent of the wastes which significantly degrade the water quality of the Raisin River originate from the paper mills where the treat-

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ment employed is inadequate. In fact, the Raisin River, primarily due to the paper mill wastes, is in a continuous state of putrefaction and aesthetically repulsive in appearance. Bacterial wastes and suspended solids from the paper mills and other sources also add to the degradation of the river and Lake Erie near the mouth of the Raisin. The paper companies all provide partial treatment for removal of settleable solids and one provides chemical coagulation in addition. The Ford Motor Company plant maintains extensive treatment facilities for control of the toxic metallic ions, and cyanide bearing wastes. In addition, a small primary sewage treatment plant treats the domestic wastes from the Ford Works. With the exception of the Monroe Auto Equipment Company, all treatment facilities are considered inadequate to prevent interference to water uses in the Raisin River and subsequently Lake Erie.

Coliform concentrations in the effluent of the paper mills at times exceeded 1,000,000 organisms per 100 ml. The bacterial concentrations in the industrial wastes are of particular interest in the Raisin River because of their proximity to Lake Erie bathing beaches at the mouth of the Raisin. This problem will be described in detail in a separate section of this report.

Table 13-VI lists the industries on the Raisin River and includes information on production, waste water volume, significant waste constituents and treatment and control employed for the process wastes.

The Raisin River receives wastes that eventually reach the waters of western Lake Erie. The paper mill wastes combined exceed the assimilative capacity of the Raisin River by discharging wastes equal to the oxygen demanding capacities of a city of 225,000 persons. The paper mill wastes, especially the Consolidated South Plant, contain excessive densities of coliform bacteria. The Ford Motor Company discharges 1,075 pounds of cyanides and 4,080 pounds of toxic metals each day and, under the summer low flow conditions, the large flow from Ford comprises nearly the entir volume of flow in the lower Raisin River. The oil from Ford, although l in concentration due to dilution in the waste canal, is large in quantit 870 gallons/day. These wastes may severely hinder the propagation of aq tic life in the Raisin River and the nearby lake waters due to their tox effect.

Table 14-VI lists those industries in the Raisin River whose efflue discharge is considered to contain certain waste constituents in excessi concentrations.

Shown below is a tabulation of the industrial waste loadings in the Raisin River which would result if excessive concentrations of certain co stituents were reduced to meet International Joint Commission effluent recommendations and a suspended solids effluent limit of 85 mg/l.

Pollutant	Present Loading	Loadings after Reduction	% Reducti
Iron	35 pounds/day	35 pounds/day	0
Oil	870 gallons/day	870 gallons/day	0
Phenols	22 pounds/day	6 pounds/day	70
Suspended Solids	23,500 pounds/day	10,600 pounds/day	50

Thus a 70 percent reduction in phenols and 50 percent reduction in s pended solids could be achieved by meeting these limitations.

TABLE 13-VI. SOURCES OF INDUSTRIAL WASTES - RAISIN RIVER

Industry	Volume (MDG)	Product	Production	Significant Waste Constituents	Waste Treatment or Control
Consolidated Paper Company					
North Side Division	7.5	liner board and corrugated cardboard	435 tons/day	coliform, suspended solids, BOD	sedimentation
South Side Division	7.0	automotive blackboard, boxboard	368 tons/day	coliform, suspended solids, BOD	sedimentation
West Side Division		Not Operating			
Union Bag-Camp Paper Company					
River Raisin Paper Company Division	4.57	liner board	315 tons/day	suspended solids, BOD	sedimentation
Monroe Paper Products Company	2.2	liner board	88 tons/day	coliform, suspended solids, BOD	sedimentation, chemical coagulation
Monroe Auto Equipment Company	0.016	shock absorbers	-	none	none
Ford Motor Company	130	automobile accessories	-	toxic metals, CN, oil	dilution, chemical coagulation, sewage treatment plant, alkaline chlorination
TOTAL	151.3				

TABLE 14-VI. INDUSTRIAL EFFLUENTS CONTAINING EXCESSIVE CONCENTRATIONS OF WASTE MATERIALS

Industry	BOD (mg/l)	Cyanides (mg/l)	Suspended Solids (mg/l)	Coliform Bacteria MF/100 ml
Raisin River				
Consolidated Paper Company				
North Side				
West Clarifier	310		163	29,000
East Clarifier	327		190	46,000
Bypass			277	62,000
South Side	120		189	2,000,000
Ford Motor Company				
Sewage Treatment Plant				460,000
Main Plant		1.02		
Monroe Paper Products Company	126		99	60,800
Union Bag-Camp Paper Company	305		93	

Description of Other Wastes

Shorefront Homes

Estimates of the number of unsewered shorefront homes that discharge sewage directly, or from improperly functioning septic tanks, to Lake Erie or its tributaries were made in the 1962 conference transcript. Consultation with personnel of the Monroe County Health Department revealed several tributaries including Plum Creek and Sandy Creek receiving such wastes directly and via county surface drains. Much of the Lake Erie shorefront from Maple Beach to below the Raisin River is so affected outside of the influence of the sewered area of the City of Monroe. Surface drainage polluted with sewage reaches the Raisin River above the City of Monroe through county drains which permit discharge into the river during wet and, in some reported cases, dry conditions.

Individual reports will be made of the effect of this type pollution in the Maple-Milleville Beach and Sterling State Park Beach areas.

In other areas it can be stated that these sources of wastes do affect water quality along Lake Erie bathing beaches, especially in times of rainfall and specific wind conditions favoring retention of the polluted wake along the shorefront.

Pollution from Boats

Commercial and pleasure boats make heavy use of the Michigan waters of Lake Erie. All such craft represent potential sources of pollution from oil and human wastes. The files of this Project contain reports of oil spills which appeared to originate in the middle of the Lake waters under study indicating pollution from this source.

Estimates of the magnitude of these sources were not made because of the great expense and time required for a complete study with the real possibility of little return on this investment in terms of improved water quality in Lake Erie. This source is recognized as a potential threat to water use in the area.

Storm Water Overflow

Overflow from combined sewers does not pose the same type problem in the Lake Erie area as in the Detroit River. This is due to the absence of the same type physical arrangement. Along the Lake Erie shorefront pumping stations are located which are designed to receive surface drainage and automatically discharge them untreated into Lake Erie during or following rainfall and heavy surface runoff. Sampling the discharge of these stations revealed that undoubtedly sewage from direct discharge or from improperly operating septic tank installations reaches the stations along with surface storm runoff.

The City of Monroe has separated its sewers, but a portion of the sanitary sewers still receive roof runoff from residences and commercial establishments. This places a burden on the receiving sewage treatment plant and that above 10 MGD is bypassed to the Raisin River with only chlorination. Plant records indicate difficulty in obtaining effective bacterial control when the plant influent is significantly increased by infiltration of this storm flow. In addition, there exists a flood relief pumping station along the Raisin River interceptor when unusually high rainfall or flood stage of the river inundates the sanitary sewer to the plant. Operating records indicate this station was used only one time since the conference and that for only one hour.

Coliform data at the mouth of the Raisin River were evaluated with respect to rainfall in the Monroe area. In the lower part of the River sources of industrial and municipal waste overshadowed any noticeable effect of rain on bacterial water quality.

The effect of rainfall on the River above known source of pollution was most evident in late August, 1963 when heavy rains caused the flood pumping station to operate for one hour. Coliform concentrations were 10 to 20 times normal levels for the period following the heavy rainfalls. In times of more moderate rainfall only a slight rise in coliform concentration was noticed in the upper Raisin River, and then for a relatively short period of time.

Additional data collected during significant rainfall might provide insight into this problem. At the present time, however, large volumes of industrial and municipal waste tend to mask any effect of rainfall on Raisin River water quality.

Enrico Fermi Atomic Reactor

The Enrico Fermi Atomic Reactor is located on Lake Erie and is designed to generate electric energy for domestic and industrial use. The plant is not now in active operation but is expected to produce power sometime in 1965.

Domestic wastes from the 150 employees of this installation are treated in a sewage treatment plant of the secondary type. Over 90 percent of the BOD is removed from this plant now operating under the design capacity of 75,000 gallons per day. Operating records are sent to the Michigan Department of Health for review. Treatment and operation appear to be adequate.

The only radioactive wastes originating in the plant are from biweekly steam cleaning of the reactor sub-assembly. Over 99 percent of the radioactive wastes consist of sodium 24 with a half-life of 15 hours. Treatment is provided by storage for 9 days in a surge tank. The effluent is then bled off at a rate determined by the radioactivity remaining in the tank and discharged to Lake Erie through a dilution canal off a lagoon in Swan Creek. Automatic monitoring devices operate continually and prevent discharge of highly concentrated radioactive material to the receiving waters. In the event radioactivity is too high after 9 days storage for discharge into the receiving waters, additional storage equal to three months capacity is available.

At this installation radioactive and domestic wastes are well handled and no danger of interference with water use is evident.

Tributaries to Lake Erie

Tributaries to Lake Erie also serve as sources of pollution to this body of water. The major source, the Detroit River, has been described in detail in Section V of this report. Other tributaries considered in this study include the Huron River, Swan Creek, Stony Creek, Sandy Creek, Raisin River, Plum Creek, and LaPlaisance Creek. Table 15-VI summarizes average quantitative loadings for each of these tributaries for total coliform organisms. Table 16-VI summarizes average values and loadings for the Detroit, Huron, and Raisin Rivers for phosphates, nitrogen compounds, phenols, chlorides, suspended solids, cyanides, and iron.

The Detroit, Huron and Raisin Rivers constitute the major tributaries to the Michigan waters of Lake Erie both in flow and in waste discharge. The Detroit River has been discussed in detail and three intensive surveys were made of the Raisin River which will be summarized in a separate section.

The Huron River is shown as a contributor of wastes high in coliform concentrations, phosphates, and nitrogen compounds. This survey was unable to demonstrate an adverse effect on the Michigan waters of Lake Erie by the Huron. The Huron River discharges into a large marsh at Pointe Mouillee which is subject to backwater from the already polluted waters of the Detroit River passing into Lake Erie. Any change in water quality in the receiving Lake Erie is masked by other sources of pollution. Retention in the Pointe Mouillee marsh complicates the picture from the standpoint of nutrient and coliform loadings. After sources of pollution in the Detroit River have been eliminated or substantially controlled, the real contribution of the Huron River may be ascertained.

The United States section of the Detroit River contributes to Michigan Lake Erie over 95 percent of the pollutional load originating from Michigan sources.

TABLE 15-VI. AVERAGE COLIFORM LOA
TRIBUTARIES TO MICHIGAN LAKE EI

Tributary	Average Coliform Loading BPE*
Detroit River**	77,000
Huron River	317
Swan Creek	10
Stony Creek	51
Sandy Creek	47
Raisin River	4,500
Plum Creek	47

* One BPE = 200 billion coliform organisms

** United States waters

TABLE 16-VI. AVERAGE STREAM LOADINGS
TRIBUTARIES TO MICHIGAN LAKE ERIE

	Detroit River		Huron River		Raisin River	
	Concen-tration*	Loading*	Concen-tration*	Loading*	Concen-tration*	Loading*
Chlorides	23	10,100,000	36	89,200	28.6	141,000
Phosphate	0.53	218,000	1.71	4,240	.36	1,770
Nitrates	0.27	109,000	0.28	694	.13	640
Ammonia	0.33	133,000	0.26	645	.39	1,920
Organic Nitrogen	0.18	72,600	0.13	322	.27	1,330
Suspended Solids	21	8,600,000	4	9,920	9.7	47,800
Settleable Solids	18	7,200,000	-	-	2.9	14,300
Phenols	4.9	2,100	3.1	8	7.1	35
Iron	0.62	260,000	.09	223	0.78	3,840

* Concentration in mg/l, except phenols, which are in ug/l. Detroit River average concentrations are adjusted to flow for the entire United States section at the mouth.

* Loadings in pounds per day.

SPECIAL STUDIES

Several special studies were made during this Project in areas whose pollution problems were not clearly defined by routine investigation of water quality and waste sources. Included in these activities were three intensive surveys of the Raisin River, a pollution study of the Maple-Milleville Beach area, collection and analysis of bottom deposits in the lake, determination of distribution of currents in Michigan Lake Erie, and a special pollution investigation of the Sterling State Park bathing beaches.

Raisin River Intensive Surveys

Three intensive surveys of the Raisin River were conducted by Project personnel. These were conducted during winter and summer months and evaluation made of water quality in the Raisin as well as waste sources discharging into it. Tables 17-VI through 19-VI summarize the results of these surveys. Figure 13-VI shows the sampling stations on a map of the Raisin River. Major waste sources are introduced to the river between station T83 and T84 (Monroe Sewage Treatment Plant and Consolidated Paper Company, South Plant) and between stations T82 and T83 (Consolidated Paper Company, North Plant, Union-Bag Company and Ford Motor Company). Wastes from the Monroe Paper Products enter the river between T88 and T89.

From the upstream stations to station T84 (above most waste sources) coliform concentrations in the river averaged under 20,000 organisms per 100 ml during all surveys and under 5,000 organisms per 100 ml during two. Below station T84 a sudden increase in coliform concentration due to industrial and municipal wastes was observed. Average values at this point were over 100,000 organisms per 100 ml during all surveys. The backwater effect

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of the Lake and increased volume of low bacterial industrial waste from the Ford Motor Company reduced coliform concentrations at the mouth to values of 1,350 organisms per 100 ml during winter months and to 30,000 and 120,000 organisms per 100 ml during summer months.

During survey number two in June, 1963 the effluent of the Monroe Sewage Treatment Plant was monitored and had a geometric mean of 105 organisms per 100 ml during the survey. Nevertheless, an increase between station T84 and T83 of 7,800 to 57,000 organisms per 100 ml was observed. This testifies to the extreme influence of the effluents from the paper mills along the Raisin River upon its coliform concentration and bacterial water quality.

High concentrations of suspended and settleable solids were noted in the effluents of all paper mills, but not in the Ford Motor Company or Monroe Sewage Treatment Plant. Cyanides from one Ford effluent are considered excessive at 1.3 mg/l. Iron concentrations in all effluents were low but the average value at the mouth was high at 0.78 mg/l. Analysis of toxic metals during survey number two indicated substantial quantities of copper, nickel and zinc. Shown below is a summary of amounts from waste sources discharging into the Raisin River between station T89 and the mouth compared to the increase in stream loadings between those two points.

Constituent	Waste Sources pounds/day	Increase in Loadings pounds/day
Phenols	24	15
Chlorides	19,600	60,000
Cyanides	1,050	135
BOD	49,000	35,600
Iron	40	1,300
Suspended Solids	23,300	20,600

The two-mile stretch of the Raisin River immediately above its mouth receives large quantities of industrial and domestic wastes, and is not only grossly polluted, but also effects an area of Lake Erie near its mouth. Waste constituents discharged to the River are high in coliform, suspended solids and cyanide concentrations and include large quantities of oxygen-consuming substances as evidenced by the discharge of 49,000 pounds per day of BOD (equivalent in oxygen consuming capacity to the untreated wastes of a population of over 200,000 persons). The lower Raisin River is frequently completely devoid of dissolved oxygen resulting in a continuous state of putrefaction during the summer months. All uses in the Raisin River, except waste disposal and navigation, have been eliminated by pollution, and deposition of settleable solids at the mouth interferes with this use to the extent that annual dredging is required to remove the material and keep the channels open for ship movement. Bacterial counts in the lower river are excessively high and represent interference with any possible recreational use of water from that standpoint. The effect of the Raisin River upon Lake Erie is seen in the enrichment of the waters of the western basin and coliform levels at bathing beaches near its mouth (including Sterling State Park).

The degradation of the Raisin River and subsequently certain areas of Michigan Lake Erie described above is due primarily to the discharge into the River of large quantities of inadequately treated wastes from the paper mills located along the banks. To a much lesser degree, part of the problem is due to the effluent of the Monroe Sewage Treatment Plant.

TABLE 17-VI. SUMMARY OF RESULTS
RAISIN RIVER SURVEY NUMBER 1
NOVEMBER 16 THROUGH DECEMBER 12, 1962

Station	Average Flow (cfs)	Geometric Mean Coliform Concentration org./100 ml	Average Phenol µg/l	Average Chloride mg/l	Average Iron mg/l	Average Suspended Solids mg/l	Average Cyanides mg/l
T80 (mouth)	330	1,350	5.8	24.7	.78	5	.07
T81	330	3,030	6.0	24.6	.80	9	.24
T82	160	33,900	6.4	23.8	.46	36	.46
T83	148	101,000	9.6	23.9	.28	10	0
T84	135	3,100	3.8	23.2	.18	5	0
T85	134	4,100	7.0	23.0	.15	5	-
T86	132	4,000	4.6	23.2	.07	5	-
T87	132	3,700	2.6	22.2	.18	6	-
T88	132	3,140	8.6	22.7	.09	4	-
T89	132	547	3.5	21.8	.10	2	-
T90	132	295	4.8	21.5	.17	13	0

	COD mg/l	Phenol µg/l	Chloride mg/l	Iron mg/l	Average Suspended Solids mg/l	Cyanides mg/l
Consolidated Paper Company - North Plant	267	0	32	0.16	99	-
Consolidated Paper Company - South Plant	13-310	0-13	23-90	0.09-0.72	17-234	-
Mason Run (Consolidated North and Union-Bag Camp Company)	504	49	23	1.22	298	-
Ford Motor Company Outfall No. 1 Outfall No. 2 Outfall No. 3	22-35	0	23-27	0.10-0.25	3-8	1.3

TABLE 18-VI. SUMMARY OF RESULTS
RAISIN RIVER SURVEY NUMBER 2
JUNE 9 THROUGH JUNE 12, 1963

Station	Average Flow (cfs)	Geometric Mean Coliform Concentrations org./100 ml	Average Phenols µg/l	Average Chlorides mg/l	Average Suspended Solids mg/l
T80 (mouth)	868	120,000	8.6	32.6	8
T81	868	150,000	5.0	26.8	12
T82	704	170,000	23.8	45.2	59
T83	682	57,000	13.6	29.2	37
T84	668	7,800	4.4	41.8	54

Station	Average Flow (cfs)	Average Cyanides mg/l	Average BOD mg/l	Average Copper mg/l	Average Nickel mg/l
T80 (mouth)	868	.03	7.6	.16	.02
T81	868	.30	14.4	.22	.01
T82	704	0	24.8	.06	.03
T83	682	<.01	10.0	.02	.02
T84	668	.01	8.4	.03	.03

Station	Average Flow (cfs)	Average Zinc mg/l	Average Lead mg/l	Average Chromium mg/l	Average Cadmium mg/l
T80 (mouth)	868	.02	<.01	.01	-
T81	868	.04	.01	.02	-
T82	704	.10	.04	<.01	<.01
T83	682	.06	.01	<.01	<.01
T84	668	.01	<.01	<.01	<.01

TABLE 19-VI. SUMMARY OF RESULTS
RAISIN RIVER SURVEY NUMBER 3
AUGUST 26 THROUGH AUGUST 29, 1963

Station	Average Flow (cfs)	Geometric Mean Coliform Concentrations org./100 ml	Average Phenols µg/l	Average Suspended Solids mg/l
T80	245	30,000	6.8	16
T82	72	200,000	26.0	30
T83	60	420,000	19.8	55
T84	46	430,000	12.0	31
T86	45	17,000	99.8	9
T88	45	16,000	15.0	8
T89	45	720	2.5	3

	Coliform Concentrations org./100 ml	Suspended Solids mg/l	Settleable Solids mg/l
Mason Run (Consolidated North and Union-Bag Camp Company)	26,000-50,000	108-203	11-115
Consolidated Paper Company - North Plant	6,200-190,000	192-670	0-180
Consolidated Paper Company - South Plant	100-5,000,000	21-637	0-567
Monroe Paper Products	2,000-80,000	43-372	15-359
Monroe Sewage Treatment Plant	20,000-420,000	23-31	0-2

Maple-Milleville Beach Pollution Study

A special study was made, September 3 - 5, 1963, to determine the influence of the Trenton Channel upon water quality on Maple and Milleville bathing beaches located near the mouth of the Detroit River and designated as regular stations B1 and B2 (see Figures 2-I and 3-I). Bacteriological sampling was undertaken to assist in this determination, and other Project data examined.

The following findings were made:

1. The results of bacteriological analysis adjacent to Maple and Milleville beaches indicate that the water is unsafe for swimming, with values found during the three-day survey ranging from 600 to 2,600 organisms per 100 ml, with fecal coliform values ranging from 20 to 800 organisms per 100 ml. The geometric mean coliform concentration at these beaches during the Project was 2,000 organisms per 100 ml.

2. Water quality adjacent to the two beaches is of much higher bacterial quality than water further offshore. This same phenomenon is demonstrated by comparison of Estral, Dewey and Stony Point Beaches and adjacent Lake Erie bacteriological results (geometric means for the duration of the Project). In this case the beach samples are approximately 25 percent of the magnitude of the adjacent lake stations. The lake beaches and Lake Erie stations are shown in Figure 2-I as numbers B3, B4, L3, L5, L6, and L7.

3. In the Lake Erie bathing beaches from Stony Point south to the Michigan-Ohio state line coliform concentrations at the beaches were higher adjacent to the beaches than at corresponding Lake Erie stations.

4. The Detroit River is the main influence of bacterial water quality at the bathing beaches from the mouth of the river to Stony Point. Below this point sources of pollution originating on shore and from other tributaries

to the Lake have the greater influence on bacterial water quality at Lake Erie beaches.

Bottom Deposits - Michigan Lake Erie

Analysis of bottom materials to determine the effects or extent of water pollution is a field in which little has been done to provide a basis for quantitative interpretation. "Standard Methods" gives only passing mention of procedures to be recommended in the field and laboratory, and considerable difficulty is involved in working with a solid-liquid mixture rather than a liquid.

For these reasons, the analysis can be treated only in a general way, serving to show differences in bottom composition in areas of the Michigan waters of Lake Erie.

Time is also a factor with bottom materials undisturbed underwater. They may remain in much the same condition year after year even after the original source has ceased to exist. Therefore, the bottom condition now existing cannot be directly identified with existing effluents except by circumstantial evidence. It can be definitely stated, however, that the condition of the bottom was caused by the settling of waste materials, and if suspended solids continue to enter the river they will settle in the same areas as before and cause the same problems.

A sampling technique was developed to enable the boat crew to collect the samples while drifting over the area. A special drag-type sampler was used to scoop up the top 0.2 to 0.3 feet of material. The results are qualitative for each site, and no attempt was made to determine thickness of settled deposits.

Analysis of Data

Only one sample was taken at each location, and the locations were widely spaced to cover a variety of conditions in each area. By grouping the results by area certain trends were noted, which will be described under each constituent.

The lake was divided into areas and evaluated according to the bottom material quality shown by the various observations and chemical analysis within the area. Each area was then rated as good, fair, or poor, according to the overall indications for that area.

Good condition - natural bottom conditions of sand, gravel, mud or silt without oil, grease or odor, and does not have abnormally large amounts of waste-associated materials.

Fair condition - natural bottom condition with some evidence of deposited material, slight oil or odor, and moderate amounts of waste-associated materials.

Poor condition - bottom deposits of organic or other material having oily appearance and odor of oil or sewage. Large amounts of waste-associated materials, such as greases, phenols, total nitrogen, phosphates, and iron, are found. High percentages of volatile materials and a pH higher or lower than surrounding areas. Such areas show the results of materials placed in the water by means other than natural processes.

Suspended solids that have settled over the natural bottom will discourage or eliminate the activities of fishes and other aquatic life. In the shallow water, they are offensive to swimmers and boaters, and when fluctuating water levels expose beds of these materials, the resulting appearance and odors destroy the esthetic value of the waterways. Since most of the bottom material in the poor condition areas is light and easily disturbed, there is a potential problem from this material being resuspended in the water in stormy weather, or from passage of large boats.

The resuspended bottom materials in the poor condition areas could cause increase in turbidity, increased oxygen demand, algae growth, and taste and odor problems, which would decrease the quality of the water for riverside or lakeside recreation, fishing, swimming, water skiing, and industrial and municipal water supplies. The increase in turbidity has been observed to occur during stormy weather on Lake Erie.

From the mouth of the Detroit River to Pointe Mouillee the bottom was in poor condition, with this zone extending as far eastward as the Detroit River Light. From Pointe Mouillee to Stony Point the bottom was in fair to poor condition in the center of Swan Creek Bay and in the deep water east of Stony Point. From Stony Point to the Raisin River, poor areas of bottom condition were found in the center of Brest Bay and in the deeper water directly east of the mouth of the Raisin River. The condition of the bottom was very poor at the mouth of the Raisin River.

Below the Raisin River extending south to Otter Creek the bottom was in fair condition near the shore and poor offshore. From Otter Creek to the south end of the Michigan waters the bottom was typified as fair to good condition.

Along the United States shore near the mouth of the Detroit River there existed a large area whose bottom condition was classified poor. This area extended from the Trenton Channel past Pointe Mouillee as far east of the Detroit River Light and southerly to the center of Swan Creek. This area indicates the effluent of the Trenton Channel as the principal contributor.

Figure 14-VI depicts the location of the deposits with classification

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according to the type material deposited on the Lake bottom. Tables 20-VI through 25-VI summarize the results of the bottom deposits for the Raisin River and various segments of Michigan Lake Erie. In addition to the results shown in these tables, analysis of the bottom deposit supernatant was made for phenol, phosphate, nitrate, and ammonia concentrations. All factors, including field observations, were taken into consideration in describing bottom conditions.

Very poor conditions found at the mouth of the Raisin River and in its lake channel are indicative of the heavy load of suspended and settleable solids contributed by the Raisin River to the Michigan waters of Lake Erie.

Areas classified as fair or good were found offshore in deeper waters throughout Michigan Lake Erie.

TABLE 20-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE
MOUTH OF DETROIT RIVER TO POINTE MOUILLEE

	Number of Samples	Maximum	Minimum	Mean	Remarks
pH					7.6 - small area of 7.2 near navigation channel.
Inshore	12	7.6	7.2	7.4	
Offshore	13	9.2	6.6	7.5	
% IRON					High (9%) Pointe Mouillee area.
Inshore	10	9.98	<.01	3.86	
Offshore	9	6.11	.28	2.77	
% OIL AND GREASE					Very high near Detroit River Light off Pointe Mouillee.
Inshore	12	1.12	.03	.65	
Offshore	12	1.05	.01	.45	
% TOTAL VOLATILE SOLIDS					Fair condition; about 6%.
Inshore	12	10.7	1.1	6.07	
Offshore	13	8.1	2.0	5.29	

CONCLUSION: Bottom is in poor condition on the American side extending as far eastward as the Detroit River Light. River is widening and losing velocity throughout this area allowing solids to settle out.

TABLE 21-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE
POINTE MOUILLEE TO STONY POINT

	Number of Samples	Maximum	Minimum	Mean	Remarks
pH					7.4 to 7.6
Inshore	10	7.7	7.2	7.49	
Offshore	25	7.8	7.9	7.53	
% IRON					
Inshore	10	3.20	.02	1.22	
Offshore	24	4.82	.01	2.13	
% OIL AND GREASE					Low nearshore; higher values in center of Swan Creek Bay and east of Stony Point.
Inshore	10	.60	.01	.26	
Offshore	24	.99	.02	.38	
% TOTAL VOLATILE SOLIDS					Fair as far south as Stony Point and poor (10%) east of Stony Point.
Inshore	10	12.0	5.8	8.8	
Offshore	25	13.2	2.0	7.3	

CONCLUSIONS: Bottom is in fair to poor condition with poor areas in center of Swan Creek Bay, and in deep water east of Stony Point. Both areas favor the settling of solids because of reduction in current velocity.

TABLE 22-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE
STONY POINT TO RAISIN RIVER

	Number of Samples	Maximum	Minimum	Mean	Remarks
pH					7.2 to 7.4; 6.7 center Brest Bay.
Inshore	7	7.8	7.2	7.41	
Offshore	27	7.6	6.9	7.3	
% IRON					High west of Stony Point and center of Brest Bay.
Inshore	8	6.30	.002	2.48	
Offshore	24	9.50	.02	2.84	
% OIL AND GREASE					Low nearshore; high in center of Brest Bay.
Inshore	8	1.2	.03	.23	
Offshore	25	1.0	.02	.36	
% TOTAL VOLATILE SOLIDS					High in deep water south of Stony Point and in center of Brest Bay.
Inshore	7	13.4	1.0	6.86	
Offshore	26	18.3	2.8	9.12	

CONCLUSION: A poor area exists in the center of Brest Bay and in deeper water directly east of the Raisin River mouth. Shoreline areas are fair to good.

TABLE 23-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE
RAISIN RIVER

	Number of Samples	Maximum	Minimum	Mean	Remarks
% IRON	4	6.30	2.30	4.33	High 4% in Raisin and around mouth.
% OIL AND GREASE	4	2.74	2.0	1.06	High in Raisin River.

CONCLUSIONS: Condition of bottom is very poor in the Raisin River.

TABLE 24-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE RAISIN RIVER TO OTTER CREEK

	Number of Samples	Maximum	Minimum	Mean	Remarks
pH					7.8 to 8.0 nearshore.
Inshore	4	8.0	7.4	7.6	
Offshore	19	7.7	7.1	7.3	
% IRON					Low values.
Inshore	3	1.24	.003	.47	
Offshore	17	3.1	.006	1.22	
% OIL AND GREASE					Low values throughout.
Inshore	4	.13	.01	.07	
Offshore	19	.86	.02	.15	
% TOTAL VOLATILE SOLIDS					Poor condition
Inshore	3	13.0	4.8	8.3	
Offshore	19	18.3	1.3	6.5	

CONCLUSION: Bottom is in fair condition nearshore and poor offshore.

TABLE 25-VI. SUMMARY OF BOTTOM MATERIALS - MICHIGAN LAKE ERIE
OTTER CREEK TO SOUTH END OF MICHIGAN AREA

	Number of Samples	Maximum	Minimum	Mean	Remarks
pH					7.2 to 7.4; 6.8 to 6.9 nearshore south of Otter Creek.
Inshore	8	7.8	6.9	7.3	
Offshore	19	7.4	6.8	7.2	
% IRON					Low except nearshore south of Otter Creek.
Inshore	5	4.82	.004	1.50	
Offshore	15	5.50	.008	2.28	
% OIL AND GREASE					Low values except south of Otter Creek.
Inshore	6	.56	.007	.14	
Offshore	16	.34	.02	.15	
% TOTAL VOLATILE SOLIDS					Good condition - 4 to 6%.
Inshore	8	7.2	3.3	4.94	
Offshore	17	30.0	3.1	7.56	

CONCLUSION: Bottom is good to fair except for a poor area nearshore south of Otter Creek.

Hydrologic Studies - Michigan Lake Erie

Special hydrologic investigations were made of the Michigan waters of Lake Erie to provide insight into the relationship between sources of wastes going into the Lake and areas affected by pollution. Of special interest was the path of dispersion of the waters of the Detroit River into Lake Erie under varying weather conditions. Rhodamine B fluorescent dye and fluorometer were used in conjunction with surface and sub-surface floats or drogues to assist in this determination. Lake currents outside of the influence of the Detroit River were also determined.

Wind is the primary factor influencing water movement in the open water sections of Lake Erie. The response of surface waters to wind changes is very rapid. Few instances of a carryover effect due to differing wind conditions preceding a survey were noted.

The Detroit River outlet into the lake is a strong factor influencing currents in the immediate area of its debouchment, diminishing rapidly beyond the Detroit River Light. Wind effects are noted as far north as Project sampling range DT 3.9, although the river current is by far the greater influencing force at this point. South of Pointe Mouillee wind forces predominate over Detroit River current.

Seiches and wind set-up affect the shallow areas and mouths of tributaries causing inward and outward water movement independent of the prevailing current pattern in open water sections of the lake. These estuarine-like movements are local in effect, from a current pattern standpoint, but may be much more extensive, in terms of water quality, as is the case with the Raisin River.

Vertical temperature profiles, taken regularly during dye vector work, showed nothing suggesting stratification. Thus, surface current pattern results were assumed to apply to the water mass as a whole.

Horizontal surface temperature profiles run in the northern section of the study area support fluorometric and dye vector study results closely.

The prevailing wind direction on the Michigan waters of Lake Erie is southwest, occurring 24 percent of the time on a ten-month basis (March through December). Winds with a southerly component, namely those from the southeast, south, and southwest, account for 50 percent of the total.

During the months of June, July and August, when recreational water uses are at a peak, the percent occurrence values for a southwest wind and for winds with a southerly component are 19 percent and 49 percent, respectively. These values are somewhat lower than the ten-month average, possibly because the percent occurrence of calm and near calm conditions during the summer is much higher than during the year as a whole.

Figures 15-VI through 18-VI depict current patterns in the Michigan waters of Lake Erie determined under varying wind conditions. The description of the wind as to direction (i.e. south wind) indicates the direction from which the wind blows. Therefore, a south wind comes out of the south and blows toward the north. The large arrow denotes the dispersion of Detroit River currents while the small arrows indicate lake currents considered to be outside of the influence of the Detroit River.

A narrative description of the observed currents under each set of wind conditions follows with an estimate of the frequency of occurrence of the specific wind condition.

North (5 percent occurrence)

Water movement in the Michigan waters of Lake Erie is predominantly southerly to south-southwesterly for a north wind. Thus, Detroit River water

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would be transported south to Stony Point and across the Raisin River Channel if this wind condition prevailed for a sufficient length of time. Little data was obtained in Brest Bay for a north wind, but from what is available, a generally southerly current pattern, paralleling the shoreline may be assumed. It does not appear likely that Detroit River water moves west in the bay as far as the beaches, however. East of the Project study area, movement is to the south in the vicinity of the Detroit River Light, becoming southeasterly as distance from the river mouth increases.

Northeast (9 percent occurrence)

The predominant current direction for a northeast wind within the Project study area in Lake Erie, is southwesterly. As was the case with a north wind, Detroit River water could possibly enter Brest Bay if a strong northeasterly wind persisted for a day or two. Field observations made during April and May of 1964, show that water movement near the beach at Sterling State Park is variable but generally has a southerly component for this wind condition. This variability is probably due to non-steady water level conditions, caused by seiche action or wind set-up while field measurements were being performed.

East (7 percent occurrence)

The current pattern for an east wind is somewhat more complicated than for the two wind conditions just mentioned. Water movement in the West Outer and East Outer Channels is southwesterly near the Detroit River Light becoming westerly near the ends of the channels as wind becomes the dominant force over the river current which dissipates with distance from the mouth.

In the area from Point aux Peaux north to Pointe Mouillee, the water mass appears to rotate in a clockwise direction when east winds are strong. Thus, currents along the beach in this area are northerly for this situation. This was substantiated by results obtained by Dr. Ayers, of the University of Michigan, in a current pattern study at the Enrico Fermi atomic power plant.

In Brest Bay, at Stony Point, and in the area immediately to the east of the bay, water movement is to the west. Studies made by the Project at Sterling State Park in 1964 show that currents along the beach are quite variable for an east wind, and appear to depend on water level fluctuations in the area at the time of observation. Therefore for an east wind, water passing the beach at Sterling State Park could be moving north from the Raisin River, west from Brest Bay, or south from the Stony or Sandy Creek areas.

In that part of the Detroit River debouchment lying to the east of the Detroit River Light and the channels, an east wind appears to cause a large scale counter-clockwise rotation of surface waters.

Southeast (15 percent occurrence)

Current patterns in the study area as a whole are quite similar to patterns for an east wind, with a few differences. The clockwise circulation pattern in the Swan Creek area occurs more frequently for a southeast wind than for an east wind, as the wind intensity required to cause rotation is lower when the wind has a southerly component.

In Brest Bay and nearby areas, water movement is predominantly northwest. Along the beach at Sterling State Park currents are most frequently northerly but may also be to the south. This again is most likely due to localized differences and changes in water level.

South (11 percent occurrence)

Overall water movement in the northern part of the study area is to the south and southeast under the influence of a south wind. To the south, where the effect of the Detroit River current is little felt, water movement is north-northeast. Upon meeting, in the area south of the East Outer and West Outer Channels, the two water masses appear to resolve into one, moving along an easterly course.

Currents alongshore in the Swan Creek area are northerly, creating an eddy in the area from shore to the West Outer Channel.

In Brest Bay, and along the beaches in the bay, water movement is to the north.

Southwest (24 percent occurrence)

For a southwest wind, currents in the Project study area in Lake Erie are predominantly southeast in the northern sector and are northeast in Bres Bay and in the area to the east of the bay.

Water movement alongshore in the Swan Creek area is northerly, turning to the southeast in the vicinity of Pointe Mouillee.

Flow along the beach at Sterling State Park is northerly for a southwes wind. Thus, water quality on the beach will likely be influenced by the Raisin River.

West (10 percent occurrence)

Water movement throughout the study area was found to be easterly for a west wind of moderate to high intensity. At Sterling State Park, currents alongshore are northeasterly most of the time for this wind condition.

For a light west wind, waters in Brest Bay were found, on one occasion, to be circulating in a clockwise direction. At that time currents in the area to the east of the bay were southerly.

Northwest (13 percent occurrence)

Current patterns in the Lake Erie study area are south to southwesterly for a northwest wind. Currents alongshore in the Swan Creek area are southerly. Thus, Detroit River water can, theoretically, move south to Stony Point, and possibly into Brest Bay.

In Brest Bay, a semi-rotational, counter-clockwise water movement was observed on the one occasion currents were studied for this wind condition. Currents at Sterling State Park beach were found to be generally southeasterly for a northwest wind, although directional deviations can occur because of seiche action.

Findings of Investigation

1. In open water sections of the Lake Erie study area, away from the mouth of the Detroit River, currents were generally found to move with the wind prevailing during the period of observation.

2. At the mouth and in the debouchment, the Detroit River current is most important in determining patterns of water movement. The usual south-to-southeast-to-east path traced by water moving from the river mouth into the debouchment, and finally out into the lake, is modified somewhat by east, southeast, and south winds, however. Under the influence of these winds, a counter-clockwise circulation pattern is set up in the area east of the East Outer Channel.

3. Along the beaches from Point aux Peaux north past Swan Creek, two types of current patterns occur. When winds are from the west, north, and

east, which is approximately 50 percent of the time, water movement is southerly, directly from the Detroit River. For southeast through southwest winds, flow alongshore is northerly. For a southeast wind, and possibly for a south wind, also, results suggest that the northerly current movement along the beaches is part of a clockwise circulation pattern extending from shore to the West Outer Channel. Thus Detroit River water can affect water quality along the beaches in the vicinity of Swan Creek, 75 to 85 percent of the time.

4. The possibility of direct water transport from the mouth of the Detroit River into Brest Bay does exist but is probably not significant from a sanitary standpoint. Winds from the northeast and east, occurring approximately 20 percent of the time, could accomplish this if they blew steadily for two days or more, which would be a rare occurrence.

5. At Sterling State Park, northerly water movement may be expected to occur regularly for south through west winds. Thus, at least 40 to 45 percent of the time, Raisin River water can reach the beach areas to the north. For northwesterly and northerly winds, which occur 20 percent of the time, currents along the beach are southerly. Currents along the beach at Sterling State Park are variable and unpredictable when winds are from the northeast, east, and southeast, and also for calm or near calm conditions.

Sterling State Park Beach Survey

Sterling State Park is a large State of Michigan recreational area located on Lake Erie just north of the mouth of the Raisin River. Among recreational facilities present at this installation is a large expanse of bathing beaches on Lake Erie. The park was attended by as many as 1,200,000 persons in 1959, many of whom used bathing facilities there. Following investigation and evaluation by personnel of the Michigan Water Resources Commission and the Michigan Department of Health, and upon their advice, the Sterling State Park was posted as unsafe for swimming by the Michigan Department of Conservation. The State agencies in a special report to the Michigan Water Resources Commission listed several possible sources of waste capable of degrading the sanitary water quality of Sterling State Park, including (a) municipal waste effluent from Detroit, Wyandotte, Trenton, and Monroe, (b) overflow from combined sewers in the southeast Michigan area, (c) wastes from shorefront homes, and (d) industrial wastes from paper mills in the Monroe area.

After posting of the beaches as unsafe for swimming in August 1961, attendance at the park dropped off. This interference with recreational water use was described in the conference proceedings of 1962 and has been an item of continuing interest throughout the life of this Project.

The problem of the sanitary water quality at the Sterling State Park and the waste sources and conditions under which this quality is degraded is complex and defies a simple solution. Average or geometric mean values at this beach during the Project's duration indicate satisfactory water quality from this standpoint. However, samples collected after given conditions of wind and rainfall are high enough to denote a serious pollution problem outside normal sampling limits indicated by geometric means. As a result of these puzzling developments a special investigation of the park was undertaken by Project personnel and an engineering consultant called to duty for this purpose. The results of this investigation are described below:

Description of Area

Sterling State Park is a major recreation area in the southeast part of Michigan located on the west shore of Lake Erie. The park is located on Brest Bay north of the Raisin River extending north to the mouth of Sandy Creek. The park provides facilities for swimming, fishing, boating, and picnicking. There are approximately 7,400 feet of beach shoreline on Lake Erie, and inland waters directly adjacent to Sterling State Park have an area of approximately 245 acres. The additional water recreational area formed by the inland ponds adjacent to and within Sterling State Park are generally used for boating and fishing purposes, with some water skiing activity. Water that is taken for industries in the Monroe area passes through these ponds, the sources being Sandy Creek and Lake Erie water.

Water level changes in Lake Erie affect water movement into and out of the inland ponds resulting in appreciable flows during these periods of rapid water level changes. It is not uncommon for the water level in Lake Erie to change 1 foot within a 6-hour period, which would result in an average water movement for this period equivalent to approximately 500 cfs. In that the water usage of the industries using this as a source of water is approximately 200 cfs, it is readily apparent that the quality of water in the inland areas will be dependent on the quality of water at the west end of Lake Erie at times.

Figure 19-VI shows the area covered by this investigation as well as sampling points referred to in this report. Table 26-VI describes the location of sampling points investigated during this survey. Table 27-VI lists the results of the bacteriological investigation of the Sterling State Park area accompanied by pertinent weather data and remarks.

Present Water Quality Conditions

During the study period, the quality of water on the beaches at the west end of Lake Erie was variable, ranging from acceptable to unacceptable for use as a bathing area. The quality of water is expressed in terms of total coliform, fecal coliforms, and fecal streptococcus with the standard usually accepted for swimming purposes, in terms of total coliforms, as 1,000 coliforms per 100 ml of water. Coliforms are associated with the enteric tract of warm-blooded animals and are quite common in soil as a natural habitat. The fecal coliform concentrations differentiate those coliforms which may be associated with soil or natural environment from that of the enteric tract of warm-blooded animals. In waters from natural surface sources free from pollution the concentration of fecal coliform will always be considerably lower than the total coliform concentrations, approximately 5 per cent. Consequently, high percentages of fecal coliform to total coliform indicate the presence of pollution from domestic fecal sources.

The data from the Sterling State Park area for the 1963 sampling seaso showed that during April, May, and the first 2 weeks in June, the water quali on the beaches adjacent to the park did not meet the standards for swimming. Results for the months of July and August, however, gave colifor results consistently low enough to permit safe swimming. When sampling was

PAGE NOT

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DIGITALLY

TABLE 26-VI. DESCRIPTION OF SAMPLING POINTS STERLING STATE PARK SURVEY

T80	Raisin River at the mouth
T81	Raisin River 0.5 miles upstream from the mouth
T82	Raisin River 1.13 miles upstream from the mouth
T70	Stony Creek at River Road
T71	Mouth of small boat harbor about 1,500 feet south of the mouth of Stony Creek
T74	Mouth of Sandy Creek
T75	Sandy Creek at River Road
T76	Culvert pipe under the road crossing the lagoon west of Sterling State Park's bathing beach
T77	Mouth of the stream on the extreme southern end of Sterling State Park's bathing beach
B17	Detroit Beach north of Sandy Creek
B18	Sterling State Park (northern end)
B21	Sterling State Park (southern end)
B32	Midway between the Raisin River and Sterling State Park
B33	2,500 feet south of the Raisin River
P1	Woodland Beach Pumping Station
P2	Grand Beach Pumping Station
P3	Detroit Beach twin pumping station
P4	
P5	Detroit Beach Pumping Station along Sandy Creek
W1	Mason Run
W2	Monroe Sewage Treatment Plant outfall
W3	Consolidated Paper Company - south outfall
W4	Consolidated Paper Company - north outfall
W5	Monroe Paper Products outfall

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms Percent	Fecal Coliforms Per 100ml	Fecal Strep Org/100ml	Ratio F. Col. / F.Strep
4/6/64	T75				35,000	5	1,750	180	10:1
	B17				1,600	12	190	70	3:1
	T74	Lt.		Partly cloudy	4,000			100	
	B18	S	NNE	with wind up	1,700	10	170	40	4:1
	B21			to 10 knots	2,100	10	210	70	3:1
	T77			Light rain	1,000			20	
	B32				1,100	10	110	10	11:1
4/7/64	T75				1,200	20	240	180	1:1
	B17	Lt to		Cloudy with no	800				
	T74	mod.		significant	300			60	
	B18	W		rain	2,500	25	620	110	6:1
	B21				8,400	45	3,800	360	11:1
	T77				6,600	35	2,300	300	8:1
	B32				2,400	5	120	70	2:1
	T80				51,000	25	12,500	460	27:1
	T81				58,000	40	23,000	630	36:1
	T82				71,000	45	32,000	550	58:1
	B33				24,000	25	6,000	490	12:1
4/8/64	T75				10,000	30	3,000	290	10:1
	B17				4,100	15	615	40	15:1
	T74			Cloudy with	8,300	10	830	120	7:1
	B18	Mod.		light rain and	5,900	25	1,500	20	75:1
	B21	W		winds up to	6,600	35	2,300	40	57:1
	T77			20 knots	6,300	50	3,150	40	79:1
	B32			Flow is out-	1,000	8	80	10	8:1
	T80			ward at T74	53,000	50	26,500	840	32:1
	T81			and T77	35,000	20	7,000	900	8:1
	T82				31,000	45	14,000	750	22:1
	B33				40,000	10	4,000	840	5:1

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964 (CONTINUED)

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms		Fecal Strep Org/100ml	Ratio F. Col. / F.Strep.
						Percent	Per 100ml		
4/13/64	T75			Cloudy with	11,000	5	550	50	11:1
	B17			wind gusts up	83,000	5	4,150	240	17:1
	T74	Strong		to 30 knots.	95,000	5	4,750	170	28:1
	B18	S	N	No significant	106,000	15	16,000	290	55:1
	B21			rain for prev-	190,000	25	47,500	310	153:1
	T77			ious 3 days.	95,000	20	19,000	210	90:1
	B32				110,000	25	27,500	370	75:1
	T80				132,000	5	6,500	460	14:1
	T81				92,000	10	9,200	780	12:1
	T82				45,000	30	13,500	840	16:1
	B21				380,000	5	19,000	250	76:1
4/14/64	B21	Strong S		No sign rain for last 4 days	88,000	5	4,400	100	44:1
4/15/64	B21	Mod W		No rain	220,000	10	22,000	10	2200:1
4/16/64	B21	Mod SSE		No rain	1,040,000	10	104,000	270	385:1
4/20/64	T75			Cloudy with	33,000	10	3,300	340	9:1
	B17	Mod		light rain.	10,000	10	1,000	70	14:1
	T74	E	NE	Currents on	65,000	5	3,250	100	32:1
	B18		to	north edge	52,000	5	2,600	40	65:1
	B21		SE	of Park	16,000	5	800	30	27:1
	T77			tended to go	40,000	5	2,000	60	33:1
	T82			NE while on	66,000	5	3,300	270	12:1
	T81			the southern edge they	49,000	10	4,900	350	14:1

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964 (CONTINUED)

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms Percent	Fecal Coliforms Per 100ml	Fecal Strep Org/100ml	Ratio F. Col./F.Strep.
4/20/64	T82			tended to go	84,000	10	8,400	260	32:1
(cont.)	B33			SE. Winds	71,000	10	7,100	180	40:1
				ranged up to					
				18 knots					
4/21/64	T75			Moderate rain	24,000	5	1,200	480	3:1
	B17	E	SE	in morning.	14,000	10	1,400	50	28:1
	T74	to	to	Winds 5 to 10	7,000	5	350	40	9:1
	B18	SE	NE	knots shifting	18,000	10	1,800	40	45:1
	B21			from E to SE.	11,000	10	1,100	20	55:1
	T77			No significant	12,000	5	600	10	60:1
	T80			rain in prev-	180,000	15	27,000	640	42:1
	T81			ious two days.	122,000	5	6,100	940	7:1
	T82			Currents south-	160,000	15	24,000	1,180	20:1
				erly except for					
				north edge of					
				park.					
4/22/64	T75				10,800	25	2,450	200	12:1
	B17				7,300	7	500	60	8:1
	T74	Mod.		75% Sky	18,000	5	900	40	22:1
	B18	WSW	NE	cover. Winds	22,000	15	3,300	40	82:1
	B21			blowing from	32,000	10	3,200	40	80:1
	T77			10 to 20 knots.	83,000	10	8,300	140	59:1
	B32			No rain. Flow	16,000	25	4,000	100	40:1
	T80			is outward at	88,000	35	31,000	480	65:1
	T81			T77 and T74 on	120,000	25	30,000	500	60:1
	T82			this date which	117,000	35	41,000	1,260	33:1
	B33			is unusual.	2,000	10	200	40	5:1

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964 (CONTINUED)

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms Percent	Fecal Coliforms Per 100ml	Org/100ml	Ratio F. Col. / F. Strep.
4/23/64	T75				3,800	25	950	180	5:1
	B17			25% Sky	4,800	20	960	20	48:1
	T74			cover. Winds	4,800	15	720	10	72:1
	B18			blowing at	7,800	5	390	10	39:1
	B21	Lt.		5-10 knots.	5,100	10	510	10	51:1
	T77	SE	NNE		3,100	30	930	10	93:1
	B32				5,500	10	550	10	55:1
	T80			No rain	42,000	15	6,400	720	9:1
	T81				58,000	20	10,600	440	24:1
	T82				58,000	40	23,000	1,340	17:1
	B33				49,000	15	7,400	60	123:1
4/27/64	B21	Lt.		Cloudy with	5,000	20	1,000	10	100:1
	T80	ESE	N	rain, wind	62,000	9	5,600	620	9:1
				7-10 knots					
4/28/64	B21	Lt.	N	Partly cloudy	39,000	10	3,900	60	65:1
		S		Wind 2-4 knots					
4/29/64	T75				24,000				
	B17	Lt.		Cloudy with	14,000			520	
	B18	S	N	Wind 8 knots	10,000	20	2,000	20	100:1
	B21				35,000			10	
	T80				89,000	5	4,400	320	14:1
	T81				116,000	5	5,800	1,140	5:1
	T82				109,000	5	5,400	1,280	4:1
4/30/64	B21	Lt.	S	Rain; wind	72,000	5	3,600	260	14:1
		ENE		6-8 knots					

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964 (CONTINUED)

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms		Fecal Strep Org/100ml	Ratio F. Col. / F. Strep.
						Percent	Per 100ml		
5/4/64	B21				11,000	10	1,100	100	11:1
5/5/64	T75				5,900	5	290	80	4:1
	B17	Lt.		Mostly fair	1,000	10	100	10	10:1
	T74	SE	SE	with wind	5,000	-	-	20	
	B18			5-10 m.p.h.	600	-	-	10	
	B21			Flow at ex-	2,100	10	210	10	21:1
	T77			treme north	900	10	90	10	9:1
	B32			end of Park	4,400	5	220	10	22:1
				was northerly					
5/6/64	B21	Lt.	NE	Mostly fair	1,300	6	80	100	0.8:1
		SE		with about					
				10 m.p.h.					
				winds					
5/7/64	T75				3,800	10	380	160	2:1
	B17	Mod			31,000	10	3,100	10	310:1
	T74	SSW	N	Fair skies	7,100	10	710	10	71:1
	B18			with no rain	26,000	10	2,600	10	260:1
	B21			for several	31,000	10	3,100	10	310:1
	T77			days	39,000	10	3,900	10	390:1
	B32				54,000	10	5,400	10	340:1
	T80				86,000	10	8,600	70	122:1
	T81				250,000	10	25,000	300	83:1
	T82				360,000	10	36,000	340	106:1
	B33				63,000	5	3,100	40	77:1

TABLE 27-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF STERLING STATE PARK BATHING BEACHES APRIL - MAY, 1964 (CONTINUED)

Date	Sta.	Gen. Wind Dir.	Current Direction off Park	Remarks and Weather Observations	Total Coliform Concentration Organisms/100ml	Fecal Coliforms Percent	Fecal Coliforms Per 100ml	Fecal Strep Org/100ml	Ratio F. Col./F. Strep
5/8/64	T75	Lt		Thunderstorm	77,000	5	3,800	5,500	0.7:1
	B17	to		passed through	47,000	5	2,300	100	23:1
	T74	mod	N	the area about	84,000	5	4,200	100	42:1
	B18	S		six hours be-	66,000	5	3,300	100	33:1
	B21			fore sampling.	120,000	5	6,000	100	60:1
	T77			Winds during	75,000	5	3,800	100	38:1
	B32			sampling were	45,000	5	2,300	100	23:1
	T80			about 10-12	320,000	5	16,000	100	160:1
	T81			m.p.h.	400,000	5	20,000	100	200:1
	T82				470,000	5	23,000	100	230:1
	B33				1,300	10	130	100	1:1

resumed late in October, the water quality was borderline, and during the latter part of November the results showed that the bacteriological counts were very high.

The quality of the water at Sterling State Park throughout the survey conducted during April and the first week of May 1964, was poor. The highest coliform count encountered in the surveys was observed on April 16, when the coliform concentration at its southern end was 1,040,000 per 100 ml. Coliform counts in both the Raisin River on the southern end of the park and in Sandy Creek at River Road on the northern end of the park were, with only one or two exceptions, always in the five and six-figure range. Winds throughout the survey periods were observed from all quadrants, and the currents off the park travelled in both southerly and northerly directions. Currents at the mouth of Sandy Creek were flowing upstream and subsequently into the paper mills' intake on all but two times when observed during the sampling periods. Winds were moderate from the west on these 2 days, and the lake level was falling. Current in the Raisin River was observed during sampling to be flowing in or out about an equal number of times.

In summarizing the results, the values for the total coliforms at Sterling State Park ranged from less than 20 to 1,040,000 per 100 ml. At times, the per cent fecal coliforms of the total coliform count approached 90, indicating the severity of the potential health hazard.

By contrast, the quality of water in Lake Erie offshore from Sterling State Park and in the Brest Bay area was markedly improved and was of adequate quality to serve as a source of water for domestic supply, as well as meet the requirements for swimming purposes. It is evident from Figure 1-VI that the poorer quality of water was found adjacent to the shoreline and a much improved quality of water was found in the Lake Erie water. The effect of the Detroit River on the bacteriological quality in Lake Erie is found generally not to extend below Stony Point, clearly indicating its minor role in the quality of water on the beaches adjacent to Sterling State Park.

Although high concentrations of coliform organisms at the Sterling State Park beaches are of chief concern and were the cause of the posting of the beach as unsafe for swimming, other water quality problems exist. One particularly distressing condition during the summer months is caused by the washing up on shore of floating, decaying organic material, thus further impairing the recreational value of this beach. This obnoxious material is the result of the deposition of settleable solids near the mouth of the Raisin River in waters devoid of dissolved oxygen because of the discharge of large quantities of oxygen-demanding wastes into this river. The settled material or sludge decays, and under anaeobic condition, rises to the surface in a putrefied condition and floats out into Lake Erie and onto the bathing beach.

Fecal streptococcus counts on samples taken in the waters off the park during the 1964 survey were low, ranging from 10 per 100 ml to 840 per 100 ml. Counts in the Raisin River, although higher, were still relatively low. The highest count in the river during the survey was 1,340 per 100 ml. Fecal streptococcus counts in Sandy Creek reached a high of 5,500 per 100 ml on May 8, when the creek was carrying the runoff of an early morning thunderstorm.

Although the per cent fecal coliform of total coliform was generally below 20 per cent, the fecal coliform counts were over 1,000 per 100 ml on the majority of occasions. In addition, the ratio of fecal coliforms to fecal streptococcus at Sterling State Park and Detroit Beach was usually high, reaching a level in excess of 1,000:1 on one occasion. Recent research studies have shown that when the ratio of fecal coliforms to fecal streptococcus exceeds 2:1, the fecal bacteria have a human origin. Thus it is apparent that despite the fact that the majority of the coliforms in the waters at Sterling State Park were non-fecal during the 1964 survey, the remaining fecal bacteria are from a human origin and in high enough populations to cause a definite health hazard.

It is apparent that all of the sources of pollution can have some bearing on the water quality under a given set of conditions. Consequently, improvements in the water quality will result only after a general improvement in the treatment of wastes of the communities discharging to the Brest Bay area.

Sources of Pollution

In the Brest Bay area there are a number of sources of pollution which have the potential of affecting the water quality of the beaches in Sterling State Park. The relative importance of each as a source of pollution depends on a number of factors, which is discussed in a subsequent section.

North of Sterling State Park there are a number of unsewered communities which rely on septic tank method of disposal, the liquid products of which may indirectly find their way to drainage ditches and thereafter be discharged into Lake Erie by gravity or by stormwater pumping stations. Although the flow volume from these communities is small, because of the limited degree of treatment provided, the concentration of pollutants can be excessively high. In some instances shorefront homes discharge septic tank effluent directly into the lake. Homes not on shorefront property use septic tank disposal systems and the effluent is discharged to absorption tiles. The effectiveness of this method of disposal depends on the absorption characteristics of the soil and the ground water level. Also, some absorption tile fields are directly connected to drainage ditches or storm sewers to be discharged into Lake Erie. A storm water collection system carries the water to sumps and is discharged intermittently to Lake Erie at storm water pumping stations.

Several storm pumps located in the Detroit Beach area directly north of Sterling State Park were sampled to determine the quality of water discharged Most of the pumps discharge intermittently only during rainy periods; consequently, only a limited number of samples were obtained. The results are tabulated in Table 28-VI and show that the bacteriological quality of their discharge was poor on most occasions. The pump located on the southern edge of Detroit Beach (see Figure 19-VI) operated in both wet and dry weather Coliform results ranged from 740,000 during a rain to 6,000 during dry weather. Other pumping stations showed coliform counts ranging from 780,000 to 116,000. Fecal coliform percentage for all stations never exceeded 15 per cent and the fecal streptococcus figures ranged from a low of 210 to a high of 49,000.

Another potential source of pollution results from the wastes of seven major industries and the domestic waste from the City of Monroe, all of which discharge into the Raisin River. The Raisin River discharges into Lake Erie approximately 1 mile south of the Sterling State Park area.

TABLE 28-VI. RESULTS OF BACTERIOLOGICAL INVESTIGATION OF OVERFLOW FROM STORM PUMPING STATIONS NEAR STERLING STATE PARK

Date	Sta.	Total Coliform Organisms/100ml	Fecal Coliform Organisms/100ml	Fecal Strep Organisms/100ml
1964				
3/25	P1	780,000	39,000	18,000
	P3	160,000	24,000	29,000
	P5	740,000	37,000	48,000
4/6	P5	107,000	5,300	220
4/7	P5	54,000	5,400	1,000
4/13	P5	6,000	-	210
4/21	P5	86,000	4,300	11,840
4/23	P5	116,000	17,400	5,960
4/29	P1	410,000	20,500	48,000
	P2	170,000	17,000	41,200
	P5	63,000	3,150	9,400
5/7	P3	490,000	49,000	1,730
5/8	P3	400,000	40,000	44,800

The City of Monroe provides primary treatment and the effluent is chlorinated from approximately the middle of May to the middle of September. Surveys show that during chlorination it is possible to reduce the coliforms in the effluent to a level less than 10 per 100 ml. Without chlorination, effluent coliform values were as high as 110,000,000 per 100 ml. Flow through the plant usually ranges from 2 to 6 MGD. The collection system is capable of carrying 16 MGD to the sewage treatment plant. It is necessary to bypass during periods of excessive rainfall, resulting in the discharge of polluted storm water to the river.

The Raisin River receives the waste waters from the paper industries in Monroe. In terms of BOD loading, the wastes discharged have a population equivalent of approximately 225,000 persons. Sampling surveys were made to determine the bacteriological quality of the influent and effluent waters from the following paper mills:

Consolidated Paper Company - North Side Division
Consolidated Paper Company - South Side Division
Monroe Paper Products Company
Union Bag Company - River Raisin Division

The results of these surveys are tabulated separately in Table 29-VI.

Consolidated Paper Company - North Side Division. The results indicated a twofold to over a hundredfold increase in total coliforms in the effluent, as compared to intake water. The effluent values ranged from 24,000 to 3,500,000 total coliform per 100 ml. Fecal coliform counts experienced increases in excess of one thousandfold with total per cent fecal coliform approaching 50 per cent in the effluent, as compared to 10 per cent fecal coliform in the influent. The fecal streptococcus counts increased to a greater extent with effluent counts ranging up to 15,700.

TABLE 29-VI. SUMMARY OF BACTERIOLOGICAL INVESTIGATION OF INDUSTRIAL WASTE SOURCES NEAR STERLING STATE PARK. APRIL - MAY, 1964

Industry	Geometric Mean Concentrations			
	Estimated Discharge (MGD)	Total Coliforms Org/100ml	Fecal Coliforms Org/100ml	Fecal Strep Org/100ml
<u>Effluent</u>				
Consolidated Paper Co.				
South Plant	7.0	219,000	17,600	630
North Plant	1.0	215,000	42,300	5,520
Monroe Paper Products	2.2	3,370,000	130,000	5,630
Mason Run (Consolidated North & Union Bag)	11.0	98,000	18,000	1,040
Weighted Mean Effluent Samples	21.2 (total)	484,000	92,800	1,570
<u>Influent</u>				
Consolidated Paper Co.	-	14,600	1,800	56
Monroe Paper Products	-	1,570	100	80

Consolidated Paper Company - South Side Division. A comparison of the influent and effluent samples shows a twofold to almost a hundredfold increase in coliforms as the water passes through the plant. On one instance, there was a reduction in coliforms. The highest count in the effluent for this plant was 570,000 and the lowest was 38,000. Fecal coliforms for both influent and effluent were usually in the 5 to 10 per cent range. Fecal streptococcus counts were low but showed a significant increase in the effluent as compared to the influent.

Monroe Paper Products Company. The plant is located on the western edge of Monroe and has a water intake on the Raisin River. The results from this plant show that it produces the greatest bacteriological degradation of the paper mills. The lowest coliform count observed in the effluent was 100,000 and the highest was 23,700,000 per 100 ml. Influent quality was much better than this with one value of only 100 per 100 ml. Fecal streptococcus counts as well as per cent fecal figures show a marked increase for the water passing through the plant.

Mason Run. Mason Run discharges to the Raisin River and receives the waste effluents from Consolidated Paper Company, North Division and the Union Bag Company. Results of the survey revealed coliform counts ranging from 3,000 to 540,000 with the per cent fecal values ranging from 5 to 60. Fecal streptococcus values ranged from 100 to 6,700 per 100 ml.

Several tributaries are located near Sterling State Park in the Brest Bay area, all of which are potential sources of pollution which may effect the water quality on the beaches. The major tributary is the Raisin River, which receives the effluents cited in the foregoing discussion. The water quality at the mouth of the Raisin River, in terms of coliform organisms, is generally poor throughout the year and has an average annual discharge of approximately 700 cubic feet per second. The reach of the river from the dam nearest to the mouth of the river has a low hydraulic gradient, and the water level in the river is influenced by the level of the water in Lake Erie. Consequently, water quality at the mouth of the Raisin River will be quite variable, depending upon the changes in water level in Lake Erie. The flow in the Raisin River may be reversed briefly during those periods when the water level in Lake Erie is rising. The coliform counts ranged from less than 100 to 410,000 per 100 ml.

Other tributaries that discharge into Lake Erie and are potential sources of pollution, both as a result of discharges of waste to the streams without treatment as well as runoff from land areas following rainfall, are Sandy Creek, Stony Creek, and a small boat inlet. In addition, the Detroit River discharges into Lake Erie and was considered as a potential source of pollution to the shoreline area.

Sandy Creek discharges into Lake Erie at the northern edge of Sterling State Park, and for this reason its flow could easily influence the water quality of the shoreline adjacent to the park. Observation of the direction of flow at the mouth of the creek shows that it is influenced by the pumpage of water into the nearby Ford Motor Company and paper mill intakes and water level changes in Lake Erie. Approximately 245 acres of backwater area are affected by water level changes in Lake Erie. On many occasions the flow at the mouth of the creek was reversed, indicating that the intake pumpage exceeded the creek flow. Samples taken at the creek at River Road during 1963 and 1964 show that its bacteriological quality was usually poor. Coliform counts ranged from a low of 300 to a high of 310,000. During the spring of 1964, many of the physical indications of raw sewage were also observed in the stream.

Stony Creek and a small boat harbor about 1,500 feet south of the mouth of Stony Creek, both located north of the Detroit Beach area, enter the Lake about one and one-half miles north of the park. Stony Creek sampled at River Road had coliform counts ranging from a low of 360 to a high of 32,000 during the 1963 sampling season. In 1964, coliform values in Stony Creek ranged from a low of 1,800 to a high of 7,400. Coliform counts at the mouth of the boat harbor ranged from a low of 800 to a high of 60,000. Flow from the harbor is negligible except during heavy rains and seiche action.

The Detroit River discharges into Lake Erie approximately 9.5 miles north and 9.6 miles east of Sterling State Park. The water quality of the Detroit River near the mouth has been summarized in Figures 1-V through 12-V.

Factors Influencing Water Quality

Currents. There are numerous meteorological and hydrological factors which will determine the relative importance of these various sources on shoreline water quality. The shoreline currents and current patterns within Brest Bay on Lake Erie are influenced to a great extent by wind movement, water level changes, and seiche effects - all of which are instrumental in the transportation of the potential pollutants to the beach sites.

Current observations were made at three points along Sterling State Park beach in April and May 1964. Dye was placed in the water at about the 2-foot depth and its direction and velocity of movement observed on 14 different days and under a variety of wind conditions.

The direction of water movement is influenced primarily by wind friction but is modified in both direction and velocity at the inshore areas along the beach. Sterling State Park has a typical sandy beach with constantly changing bar patterns running in random fashion both parallel and perpendicular to the shoreline. At each end of the beach a pier extends into the lake about 200 feet, which tends to deflect the current movements alongshore. Seiche action on Lake Erie is practically continuous, and when the surface level is changing the nearshore water shows considerable movement shoreward or lakeward. These factors introduce components affecting the direction of movement of water in the immediate inshore area. Some variable directions due to local effects were found under all wind conditions, but it was observed that the general pattern of flow was evident from the inshore stations studied. The winds from easterly quadrants cause onshore water movements resulting in variable movements and no distinct patterns of northward or southward alongshore currents were evident.

During the survey, southerly winds resulted in northerly current movements along the beach, and westerly winds resulted in northerly current movements along the beach. Northwesterly winds resulted in mostly southerly current movements, and northerly winds did not occur during the survey period but would likely result in southerly currents.

In order to expand the survey data to give an indication of the per cent of time the currents could be expected to move water from the south or from the north to the Sterling State Park beach, a comparison was made with long-term wind data. The nearest available station record is at Grosse Ile, as shown in U.S. Weather Bureau Technical Paper 35, "Climatology and Weather Services, Great Lakes and St. Lawrence Seaway."

The general trend of current movements and related winds observed during the survey in April and May 1964 was compared to the per cent of time the wind blows from certain directions on a monthly and annual basis as shown in the U.S. Weather Bureau publication. For the 10-month ice-free period (March through December) the water could be expected to move along the beach in a northerly direction about 45 per cent of the time, in a southerly direction about 20 per cent of the time, and be variable and unpredictable about 35 per cent of the time.

In June, July, and August when beach use would be at its maximum, norther moving currents can be expected about 40 per cent of the time, southerly currents about 15 per cent of the time, and variable and unpredictable about 45 per cent of the time, including about 15 per cent of the time when calm conditions could be expected.

The water movements in northerly direction create a potential problem from Raisin River water, and in a southerly direction a potential problem from storm pumps, tributaries, and other sources to the north of the park. Variabl movements create a potential hazard from either direction. Whether or not the problem condition materializes depends on other factors such as rainfall, runoff, and seiche action which would introduce the pollutant into the moving mass of lake water.

Rainfall. Rainfall has an effect on three potential sources of pollution in the Sterling State Park area. These are: (1) the stormwater pumps from the Detroit-Woodland Beach areas, (2) Sandy Creek, (3) the Raisin River. These sources are discussed individually and jointly covering sampling results during periods of rainfall.

Bacteriological results from random samples taken at stormwater pumping stations during the 1964 survey show that they are definitely potential sources of coliforms. The coliform counts as high as 780,000 per 100 ml were found at the Woodland Beach pumping station during the storm of March 25 when 1.55 inches fell at the Toledo Airport. With the possible exception of the storm water pumping station located on the southern edge of Detroit Beach, all pump sites were usually dormant except during periods of rain.

Sandy Creek contains relatively high coliform counts during periods of high runoff. The highest flow recorded in the Creek during the survey was about 60 cfs on April 29, which was after thundershowers had passed through the area. Sandy Creek has a monthly dry weather flow of approximately 5 cfs. The coliform count in the creek on April 29 was 24,000 per 100 ml. Another period of relatively high runoff occurred on May 8, when the flow reached about 20 cfs and the coliform count was 77,000 per 100 ml. No records of the direction of flow at the mouth of the creek were taken on these dates. The direction of flow at the mouth will depend on industrial intake, lake water level changes, and the flow rate in Sandy Creek.

The Raisin River was found to be in a continual state of gross pollution, but the highest coliform counts in the river occurred after the rain of May 8. The highest counts during this date reached 470,000 per 100 ml. The Raisin

River receives a significant load of pollution from storm water overflows, but because of its polluted state both before and after a rain, it is discussed specifically in the section on the Raisin River.

During the 1964 survey, the first rainfall occurred on April 21, when a moderate rain fell in the morning. Samples were collected the day of the rain as well as on the preceding and following days. The coliform counts at Detroit Beach, which would be most affected by the storm water pumping, increased from a high count of 10,000 per 100 ml on the day before the rain to 14,000 per 100 ml on the day of the rain; the next 2 days' counts showed a drop of about 50 per cent each day. The Sterling State Park sampling station closest to Detroit Beach showed a decrease in coliform count during the day of the rain with a slight increase on the following day, and then a further decrease on the next day. Currents off the park were southerly on the day of the rain as well as the preceding date. Currents at the mouth of Sandy Creek were upstream, and because of this, the potential effects on the park of bacterial pollution from the Detroit-Woodland Beach area were probably lessened due to the fact that some of the polluted lake water was drawn into the creek.

Rain occurred on April 27, 28, 29, and 30, but complete sampling of the park area only occurred on April 29. Results on this date show coliform counts of 14,000 per 100 ml at Detroit Beach just north of the mouth of Sandy Creek, and 10,000 per 100 ml at Sterling State Park just south of the mouth of this creek. The flow in Sandy Creek was up to 60 cfs on April 29. The direction of flow at the mouth of the creek was not noted at this time, but it is quite possible that with a runoff like this the flow was outward. Currents off the park were northerly at this time and would therefore tend to move effluent from Sandy Creek northward towards Detroit Beach.

A thunderstorm passed through the area early the morning of May 8. Results from samples taken on this day show high coliform counts on all beach stations, decreasing in magnitude at stations farther from the mouth of the Raisin River. The coliform count at Detroit Beach on this date was 47,000 per 100 ml, which was exceeded on one other occasion during the survey. Since the lake currents were northerly and because the direction of flow from Sandy Creek was not noted, it is difficult to tell if the high count was due to pollution from Sandy Creek or the Raisin River.

Following a rain Sandy Creek and the Detroit-Woodland Beach pump houses are potential sources of pollution, in addition to the ever present pollutional aspects of the Raisin River. If the lake currents opposite the beaches are northerly, as it was during the rains of April 29 and May 8, pollution from the above sources, excluding the Raisin River, would probably be swept northward and have little effect on the park. If the current is southerly after a rain and Sandy Creek has a positive discharge to the lake, the pollution from the Detroit-Woodland Beach area and the creek would be enough to cause serious contamination of the waters off Sterling State Park.

Raisin River. The discharge of pollution into Lake Erie from the Raisin River depends on the flow rate and estuary effects in the lower reach of the river. Calculations show that a drop in water level of 1 foot in 6 hours would require an average outflow of 265 cfs from storage in the lower reach of the river. The total flow at the mouth of the river would be equal to the sum of the calculated amount, the river flow and industrial flow. In 1963 the discharge from the river, measured at a U.S. Geological Survey gaging station west of Monroe, averaged 64 and 46 cfs for the months of July and August respectively, as compared to 1,206 cfs for the month of March. It is evident that the flow direction and quantity in the Raisin River at the mouth will depend on water level changes in Lake Erie and river flow rates.

The Monroe Sewage Treatment Plant chlorinates the effluent discharged to the river during the summer months. Samples taken at the mouth of the river throughout the year, however, show that the counts do not drop noticeably during this period. This is not to say that the chlorination is not effective because the counts would be much higher in the summer if chlorination were not practiced.

Coliform counts in the Raisin River were without exception extremely high throughout the entire 1964 survey during the months of April and May. The counts ranged from a high of 470,000 per 100 ml on May 8 following a heavy rain to a low of 31,000 per 100 ml on April 8. It is estimated that the flow during the survey period averaged about 700 cfs, including the industrial effluents.

The high coliform counts in the river are caused by two primary sources. The first is domestic sewage which enters the river from the Monroe Sewage Treatment Plant outfall and storm water bypassing; the second is paper mill effluent which comes from four paper mills located in the City of Monroe. Flow in the sewage treatment plant during dry weather runs from 2 to 6 MGD with effluent coliform counts ranging from 13,000,000 to 110,000,000 organisms per 100 ml during the non-chlorination season. Combined flow from the paper mills totals about 21 MGD with coliform counts up to 23,700,000 per 100 ml. The geometric mean total coliform concentration of the effluent from all the mills, taking into consideration the flows from each plant, is only 440,000 organisms per 100 ml, however. During an industrial waste survey conducted during August 1963 the corresponding geometric mean coliform concentration for these sources adjusted to flow was 553,000 organisms per 100 ml. Thus the Monroe Sewage Treatment Plant is the major source of coliform bacteria in the Raisin River during the non-chlorination season. On the other hand, during the chlorination season (June through September) results from other investigations indicate the greatest source of coliform organisms to be the paper mills along the Raisin River, with the Consolidated Paper Company-South Plant the most significant contributor during the April 1964 period and the Monroe Paper Products the greatest contributor in August 1963. If efficient chlorination were not practiced during the recreation season, the counts in the Raisin River could easily become much higher. During periods of high runoff a mixture of storm water and raw sewage is bypassed at the Monroe Sewage Treatment Plant with minimum chlorination only. It is estimated that coliform counts of the bypassed sewage during the summer would be in excess of 1,000,000 organisms per 100 ml. The bypassing of several million gallons of combined sewage to the river will contribute significantly to the bacterial degradation of the Raisin River.

Samples taken from the paper mills, sewage treatment plant, and the river itself, therefore, show that the river is a high potential source of bacterial contamination of the waters of Sterling State Park. When the river flows into the lake and the lake currents are flowing in a northerly direction, the coliform from the river will be in waters adjacent to the park. During the

1964 survey these conditions were met the majority of the time. Bacteriological results on many occasions verified the fact that the pollution was reaching the park from the river. To illustrate, on April 13 a strong southerl wind was blowing and the currents off the beach were moving to the north. Coliform counts at the southern end of the park closest to the river were 190,000 per 100 ml. At the northern end of the park the counts were 106,000 per 100 ml, and at Detroit Beach to the north of the park the counts were 83,000 per 100 ml. The counts became generally lower as the distance from the river increased. Samples taken midway between the Raisin River and the park were only 110,000 per 100 ml, which does not fit the general pattern, but this station on several occasions showed lower results than were found to the north or south of it: apparently water movement in this area is restricted and the flow from the river eddies around it.

On April 22 the winds were blowing moderately from the west-southwest and the flow patterns in the lake were in a northerly direction. Coliform counts at the southern end of the park were 32,000 per 100 ml; at the northern end 22,000 per 100 ml; and at Detroit Beach 7,300 per 100 ml. Thus a similar pattern results when the water movement in the lake is in a northerl direction. A definitive pattern could not be established on the days that the currents offshore from the park were in a southerly direction.

Throughout the survey, the winds were primarily from the two southern quadrants. Since the prevailing direction of wind in this area throughout the year is from these quadrants, it may be expected that the effluent from the Raisin River will be a constant threat to Sterling State Park.

Sandy Creek. Although Sandy Creek has been shown to carry a significant amount of pollution, stream gage readings indicate that its flow becomes small during the summer months. In the spring its flow from runoff was in excess of 50 cfs at times and could have a definite effect on the beaches if wind conditions are favorable. The flow in Sandy Creek at the mouth is upstream much of the time because of the water usage at the Ford Motor Company and paper mill water intakes. The reverse flow pattern tends to diminish the effects of the creek as a source of pollution on the beach water quality. Sandy Creek, therefore, probably had little pollutional effect throughout the summer and fall because of its low flow.

Summary of Findings

1. The water quality of beach waters in the Brest Bay area is primarily affected by local sources of pollution rather than the Detroit River.

2. Based on the current studies, bacteriological data, meteorological reports, and hydrological data, the Raisin River is the primary cause of beachwater pollution at Sterling State Park.

3. Wind-driven water currents can be expected to move along the beach in a northerly direction 45 per cent of the time, in a southerly direction 20 per cent of the time, and variable and unpredictable about 35 per cent of the time when the lake is free of ice cover.

4. When water currents move along the beach in a northerly direction (a phenomenon expected to occur 45 per cent of the time) the effect of the Raisin River is evident at the park beach. When the currents move in a southerly direction overflow from storm pumping stations, polluted tributarie

and shorefront homes north of Sterling State Park have a dominant effect on sanitary water quality at the beaches.

5. Generally the water quality, measured in terms of coliform and fecal streptococci organisms, at the lake stations opposite Brest Bay were of satisfactory quality for swimming purposes. The bacteriological quality of water representing beach waters adjacent to Sterling State Park were unacceptable at times for swimming purposes and the quality varied considerabl

6. The Raisin River is highly polluted with coliform bacteria throughout the year, with the primary sources being the paper mills in the Monroe area, and the Monroe Sewage Treatment Plant. The predominant effect originates from industrial sources during summer months (June through September) and from municipal sources during the remainder of the year.

7. Septic tank effluents enter Lake Erie directly to a limited extent by waterfront homes in communities north of Sterling State Park, and to a much greater extent indirectly by discharge to drainage ditches and storm water collection systems. The pollution enters the lake intermittently during periods of rainfall and runoff at storm water pumping stations.

8. Because of the high coliform counts experienced and the proximity of the storm water pumping stations to the Sterling State Park area, the discharge of polluted storm water constitutes a health hazard in their immediate vicinity and the northern part of the park during heavy runoff. The severity of this source as a health hazard to Sterling State Park depends on prevailing currents along the shore of Lake Erie in Brest Bay.

9. Sources of pollution above the Detroit-Woodland Beach areas, Stony Creek, and a small boat inlet, have high coliform counts, but the volume of flow is small and they are located approximately one and one-half miles north of the park. Because of the prevailing currents and location, it is believed that these sources affect the water quality on local beaches rather than the Sterling State Park area.

10. The waters of Sandy Creek pose a threat to the quality of water on the north end of the park. Because of the reverse flow of the creek at the mouth resulting from water withdrawal by several major industries, the effect of this source of pollution on water quality at the park beaches is realized only during periods of high runoff or during rapid fall of water level in Lake Erie.

11. To improve the quality of water offshore from Sterling State Park, primary consideration should be given to measures which will improve the quality of water discharged to Lake Erie from the Raisin River. The lower reach of the river is in a continual state of gross pollution as evidenced by the water quality in terms of bacteriological parameters.

Recommendations

These recommendations will be repeated on a more specific basis for each industry and municipality involved. The recommendations listed here emphasize what is necessary to improve conditions at Sterling State Park and assure satisfactory water quality there.

1. The Consolidated Paper Company, Union Bag-Camp Paper Company, and Monroe Paper Products Company should:

   a. Immediately begin effective chlorination of plant effluent to reduce bacterial concentrations discharged to the Raisin River.

   b. Immediately improve operation of existing facilities to remove more effectively suspended and especially settleable solids in their effluent.

   c. Provide holding basins for wastes discharged during emergency bypass to prevent diversion of this discharge to the Raisin River.

   d. Construct additional secondary waste treatment facilities capable of effectively reducing suspended and dissolved organic solids and thus reducing the BOD load discharges to the Raisin River.

2. The Ford Motor Company should:

   a. As soon as possible eliminate detectable concentrations of cyanide from the plant effluent.

b. Immediately begin effective chlorination of the effluent from their sewage treatment plant.

c. Construct secondary treatment facilities for their sewage.

3. The City of Monroe should:

a. Continue at a rapid pace their plan of separating roof runoff from sanitary wastes to prevent overloading municipal waste treatment facilities following heavy rainfall.

b. Immediately expand chlorination of plant effluent to the entire year.

c. Expand existing sewage treatment facilities to provide for secondary treatment capable of further reducing suspended and dissolved organic solids. Present operation of existing facilities is outstanding from the standpoint of reduction of BOD and suspended solids, and additional facilities will be required to achieve increased efficiency.

4. In the area north of Sterling State Park between Sandy Creek and Stony Creek, measures should be taken to eliminate direct and indirect discharge of sanitary sewage to Lake Erie. All discharge of sanitary wastes to the storm pumping stations should be eliminated. Areas having improperly functioning septic tanks and

direct discharge installations should be sewered and the wastes transported to a sewage treatment plant providing complete treatment and chlorination.

5. The practice of allowing discharge of raw and septic tank effluent to surface drains originating in the suburban area outside the City of Monroe should be discontinued. This material is discharged into the Raisin River during heavy rainfall. The area should be sewered with sanitary wastes transported to a sewage treatment plant providing complete treatment and chlorination.

The foregoing recommendations are listed in the order of greatest importance in improving water quality at the Sterling State Park so that this recreational area could be more fully utilized in future years.

Rooted Aquatic Vegetation Study

Rooted aquatic vegetation was observed in abundance during the summer of 1964 along the shoreline of Grosse Ile in the Detroit River and Lake Erie. These prolific growths were pronounced this year primarily due to low water levels. The waters off the shore are shallower, allowing greater light penetration to stimulate growth. This factor, coupled with warmer summer temperature and an abundant supply of essential plant nutrients (soluble phosphorus and inorganic nitrogen) in the adjacent waters or bottom muds, contributes to this problem.

Attached to the weed growths are massive colonies of midge larvae. Two genera of rooted aquatic vegetation were observed - *Potamogeton* and *Vallisneria*, and intertwined among these rooted aquatics were growths of the attached green algae, *Cladophora* and *Hydrodictyon*.

These growths are not only undesirable from the esthetic standpoint, but also interfere with boating by fouling propellors. Later in the season the vegetation will die and their decomposition, accompanied by strong odors, will add to this undesirable situation.

The phenomenon was surveyed only in the last months of Project operation and not incorporated into the regular Biology Section. Solutions to this problem include control of water levels to inundate the shallow areas and prevent growth or abatement of pollution from sources containing significant amounts of phosphorus and nitrogen compounds.

SPECIFIC INTERFERENCE WITH WATER USE

MICHIGAN LAKE ERIE

<u>Water Supply</u>

City of Monroe Water Intake

Pollution from the Detroit and Raisin Rivers appears to have little effect on the chemical and bacterial quality of the municipal intake of the City of Monroe. No other municipal intake is located in the Michigan waters of Lake Erie. The increase in chloride concentration in the plant intake from 30 to 40 mg/l over the past 4 years is possibly indicative of future problems and is caused primarily by the fringe effects of the dispersion of the Trenton Channel into Lake Erie.

Algal growths caused water treatment problems before relocation of the intake to its present location. Algal blooms observed near the present site give indication of problems in the very near future including taste and odors and premature filler clogging. This phenomenon is accentuated by the discharge of pollution in the form of phosphates and nitrogen compounds into the Michigan Waters of Lake Erie from sources on the Detroit and Raisin Rivers. Such pollution results in the high levels of inorganic nitrogen and soluble phosphates indicative of difficulties with objectionable algal blooms. Although no difficulties have been reported during interviews with operations personnel levels of algae and nutrients indicate problems should exist now.

Industrial Water Supply

There is no evidence of interference with industrial water supply on Lake Erie due to the effect of pollution. Extremely gross pollution in the Raisin River, a tributary to the lake, makes the lower few miles of the

River undesirable as a source of municipal or industrial supply.

Recreation

Because of pollution, participation in water contact sports at or near Lake Erie beaches near the mouth of the Detroit River is hazardous, and swimming and water skiing in these areas represent a threat to the health and welfare of the participant.

The bathing beaches at the Sterling State Park, heavily used in former years, were posted as unsafe for swimming by State authorities because of pollution as evidenced by high coliform concentrations near the beaches. Interference with use of this beach is also caused by the deposition on the shore of floating, decaying material.

Accidental or intentional spills of oil and garbage, presumably from vessels, have caused nuisances on other bathing beaches and impairing their use.

Fish and Wildlife Propagation

Bottom conditions caused by pollution in much of the waters of Michigan Lake Erie, represent unfavorable environmental conditions for the propagation of a great variety of game fish and contribute to the interference with this water use by limiting the variety in these areas to those species capable of survival and propogation in polluted waters.

Project records contain accounts of fish kills in tributaries to Lake Erie due to accidental spills of oil and toxic materials. During the past 4 years no duck kills attributable to pollution have been reported.

Heavy algae blooms and concentrations of attached biologic organisms due to pollution from sources high in phosphates, inorganic nitrogen compounds, and organic matter represent an eminent potential interference with the propagation of fish and wildlife in the Michigan waters of Lake Erie. Pollution levels indicate advance stages of enrichment typical of a eutrophic body of water although at this time no interference with fish propagation due to dissolved oxygen depletion in the lower levels of the Michigan sector of the lake was observed by Project personnel.

Navigation

Interference with navigation experienced at the mouth of the Raisin River as it enters Lake Erie requires extensive annual dredging operations by the Corps of Engineers to keep navigable water in use. This is caused by the deposition of suspended solids at the mouth of the Raisin River, a portion of which originates in the discharge of several paper mills along the river.