DEPARTMENT OF NATURAL RESOURCES

Division of Resource Development

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REPORT ON AN INVESTIGATION OF THE POLLUTION IN THE LOWER FOX RIVER AND GREEN BAY MADE DURING 1966 AND 1967

GENERAL INFORMATION

Drainage Basin: Lower Fox River
Drainage Area 11

Area Surveyed: The Lower Fox River and tributary streams downstream from the outlet of Lake Winnebago to its mouth and Green Bay

DRAINAGE AREA AND USES

The Fox River of Wisconsin drains a large area of the east central part of the state. A tributary of the Fox, the Wolf River, drains a fairly big area north of the Fox River basin. In addition to Green Bay, this report will include only that area of the Fox, called the Lower Fox, which consists of a narrow belt running from the Lake Winnebago outlet at Neenah-Menasha northeasterly to Green Bay on Lake Michigan.

The counties in the Lower Fox River basin include a small part of northeast Winnebago County, a small area in northwest Calumet County, the southeast part of Outagamie County and an area through west central Brown County.

The total area of the Fox River drainage basin is 6,520 square miles. Of this area, the Lower Fox comprises 419 square miles or about 6 per cent of the total basin area. Despite the relatively small area of this part of the basin, about 83 per cent of the total fall of the river from the headwaters to Lake Michigan occurs in this last 39 miles of stream. This rapid fall averages about 4.3 feet per mile.

Due to the narrow area of the basin, the tributaries to the stream are quite small. Two of the largest streams tributary to the Lower Fox River are the East River and Ashwaubenon Creek. The East River flows almost parallel to the Lower Fox on the southeast side of the river, and has a drainage area of 143 square miles. Ashwaubenon Creek, near Green Bay, has an area of 30 square miles.

The topography of the basin is fairly flat and rises gently to the borders of the basin. The entire area is glaciated and covered with glacial drift. The underlying bedrock consists chiefly of dolomite, though areas in the eastern part of the basin contain some shale bedrock.

The U. S. Geological Survey operates one streamflow gaging station on the Lower Fox River. This station, which is located at the Rapide Croche Dam near Wrightstown has seventy years of records (1896-1966) and drains 6,150 square miles of the basin. The average flow for the period is 4,145 cfs (cubic feet per second) or approximately 0.68 cfs per square mile. The maximum flow recorded was 24,000 cfs (April 18, 1952), and the minimum flow was 138 cfs (August 2, 1936). During the 1966 water year the mean flow was 5,102 cfs or about 0.83 cfs per square mile. The maximum flow for the 1966 water year was 15,700 cfs and the minimum flow was 1,190 cfs.

Two U. S. Weather Bureau precipitation gaging sites are located within the Lower Fox River drainage basin. One station is at Appleton and the other is at the Green Bay airport. The average annual precipitation for these stations is 27.38 inches. In 1966, the average was 23.40 inches, or 3.98 inches below normal. Average precipitation for the last half of 1966 was 12.41 inches, which is 1.71 inches below normal. The average for the first half of 1967 was 18.22 inches, almost five inches above normal.

The population of this area of the Fox River has increased substantially in recent years. The following is a list of municipalities that are served by public sewerage facilities and their populations for the last three censuses:

	1940	1950	1960
Appleton	28,436	34,010	48,411
Combined Locks	625	720	1,421
De Pere	6,373	8,146	10,045
Green Bay	46,235	52,735	62,888
Kaukauna	7,382	8,337	10,096
Kimberly	2,618	3,197	5,322
Little Chute	3,360	4,152	5,099
Menasha	10,481	12,385	14,647
Neenah	10,645	12,437	18,057
Wrightstown	718	761	840

The total 1960 population for these cities has increased by 34 per cent since 1940. The overall population increase for the state as a whole for this same period was 26 per cent. Much of the basin is urban and suburban area.

The Lower Fox River area is industrialized. There is a heavy development of paper mills resulting in the greatest concentration of pulp and paper industry in the state. Considerable use is made of the stream for industrial and cooling water supply. Hydro-electric power is generated along this section of the stream making use of the large river fall. Green Bay and the extreme lower part of the Fox River are important for shipping. The City of Appleton obtains its municipal water supply from the Fox River. In the rural areas, agriculture, especially dairy farming, is prevalent.

SOURCES OF POLLUTION AND SURVEY FINDINGS

Sources of wastes within the Lower Fox River Drainage Basin are shown in Table 1 appended to this report. The listing of each waste source and tributary stream follows an orderly sequence. First are shown those on the main stem of the Lower Fox beginning just below Lake Winnebago and proceeding downstream to Green Bay. This is followed in turn by consecutive tributaries again in a downstream direction. There are no sources of pollution in this basin discharging directly to the Bay.

The mileages given show the location of the pollution sources, tributaries and sampling points as distances in miles from the mouth of the Fox River. This reference base is also used in establishing mileages for locations out in Green Bay. An attached map shows the location of the pollution sources by number. This waste source number is also used in the pertinent paragraphs in this section and in Tables 1 and 2 of the Appendix. A description of each waste source follows.

1. Seven paper mills in the Neenah-Menasha vicinity discharge process wastewater to the Fox River. Gilbert Paper Company in Menasha makes rag pulp and incorporates it into paper. Strong rag washer water and cooker blow-down is sent to a municipal sanitary sewer and the leaner fractions are diverted to the stream. Excess effluent from paper machine saveall also goes to the river.

2. Paper machines at John Strange Paper Company are equipped with savealls. The concentrated wastewaters are discharged to a municipal sewer and the weaker ones are released to the Fox River.

3. Paper making effluent at George A. Whiting Paper Company is directed through a saveall for recapture of usable fibers before the water is reused or sent to the stream.

4. Bergstrom Paper Company, producers of deinked pulp and paper, treats all of its process wastewaters in new mechanical clarification facilities, which became operational November 1, 1967. This mill feeds flocculation chemicals to their primary treatment system to enhance the efficiency of treatment. Backwash water from Bergstrom's new fresh water treatment filters is returned to the system.

5. Kimberly-Clark Corporation's Neenah Paper Company makes paper from market pulp and cotton rags cooked at that mill. Paper machine

saveall effluent which is not reused in the process is released to the river. Rag cooker liquor and wash water is discharged to a municipal sewer.

6. At Kimberly-Clark's Badger Globe Mill, rich whitewater from paper manufacturing is sent to the municipal sewer and the weaker wastes go to the river. This mill makes no pulp.

7. Paper is made from market pulp at Kimberly-Clark Corporation's Lakeview Mill. New mechanically cleaned primary clarification facilities are under construction at the plant. At present, all effluents discharged from Lakeview to the river are accorded saveall treatment. Fresh water treatment plant backwash sludge plus effluents from mill washups and product color changes go to the municipal sewer system.

8. The Kimberly Clark, Inc. offices, Neenah, are served by a trickling filter type sewage treatment plant Effluent is disinfected prior to discharging to the Fox River. It was determined by an efficiency study conducted on June 14, 1966, that this treatment plant removed 89.4 per cent of the BOD from the raw wastes.

9. The Neenah-Menasha Sewage Commission completed addition of activated sludge facilities to an existing primary treatment plant during 1967. Provision is made for disinfection of effluent prior to discharging to the Fox River. A substantial industrial waste loading from paper manufacturing is received at the sewage treatment works. Excessive clear water enters the sewer systems of the cities of Neenah and Menasha resulting in volumetric overloading of the sewage treatment facilities at times.

10. The Town of Menasha Sanitary District No. 4, located on the east side of the Fox River between the cities of Menasha and Appleton, has an activated sludge type sewage treatment plant which was constructed in 1963. Effluent is disinfected prior to discharging to the Fox River. Excessive clear water enters the sewer system at times resulting in volumetrically overloading the sewage treatment works and occasional bypassing of raw wastes.

11. The Holiday Inn Motel located on Highway 41 north of Neenah has an activated sludge type sewage treatment plant. No provision is made for disinfection of effluent prior to discharging to the Fox River.

12. In Appleton, Riverside Paper Corporation makes paper from purchased stock. Waters returned to the river after use are afforded saveall treatment for reduction of fiber loss. Effluents from the decker washer and deflaker have been connected to the city sanitary sewer since 1964.

13. The Appleton Division of Consolidated Papers, Inc., (Interlake Mill) turns wood into pulp by the sulfite process. Collectible spent sulfite pulping liquors are evaporated to reduce the concentration of matter which reaches the river. Weak wastes are released to the stream.

14. Foremost Foods, Appleton, has five outfalls to the Fox River. The company is in the process of connecting its remaining high strength wastes, which are small in volume, to the city sanitary system.

15. The City of Appleton completed addition of activated sludge facilities to a primary plant in 1964. This plant was designed for an annual average flow of 16.5 mgd, for the maximum month of 20.0 mgd. The design BOD for the annual average was 14,460 #/day and for the maximum month was 24,500 #/day. During a twenty-four hour efficiency study, conducted at this plant on October 25 and 26, 1966, it was determined that the raw waste volume was 8.34 million gallons and the BOD in the raw wastes during this twenty-four hour period was 27,700 pounds. Only 6.89 million gallons received secondary treatment and 1.45 million gallons was bypassed after the primary settling tanks. The BOD in the raw wastes was substantially greater than the plant was designed to handle anc it appears that additional treatment capacity is necessary to provide effective secondary treatment for all wastes. A portion of the City of Appleton is served by combined sewers which makes it necessary to bypass some raw wastes during periods of storm water runoff. Effluent disinfection facilities are prcvided at the sewage treatment plant.

16. Kimberly-Clark Corporation produces groundwood and sulfite pulp as well as paper at its Kimberly mill. Saveall have been installed on the paper machines to retain fiber which would otherwise escape from these sources to the Fox River. Spent sulfite liquor is pumped to "fill and draw" lagoons or hauled for road-binder. The company plans to permanently close the sulfite pulp mill by May, 1968, and thus eliminate the pollution resulting from discharge of spent liquor.

17. The Village of Kimberly has an activated sludge type sewage treatment plant which was expanded during 1960. The plant was designed to handle 408,000 gallons per day. It was determined during a twenty-four hour efficiency study conducted on March 30 and 31, 1966, that the sewage volume received at the plant during this twenty-four hour period was 539,000 gallons and the BOD removal was 77 per cent. Excessive clear water entering the sewer system at times results in overloading the treatment facilities. This volumetric overload contributed to the unsatisfactory efficiency found during the survey. There is evidence from the survey results that some bypassing of raw sewage occurred in the system. No provision is made for disinfection of effluent.

17A. The Kimberly Clark, Inc., Marketing Center, Neenah, has an activated sludge type sewage treatment plant which was constructed in 1966. Provision is made for disinfection of effluent prior to discharging to the Fox River.

18. At Combined Locks, Combined Paper Mills, Inc. makes groundwood and chemimichanical pulp, plus paper. Pulping wastes and sludge from a mill waste "gathering" tank are treated in a small clarifier-vacuum sludge dewatering facility. Saveall treatment is given whitewater from the paper machines.

19. The Village of Little Chute has an activated sludge type sewage treatment plant which was placed in operation in 1961. During a twenty-four hour efficiency study conducted on May 9 and 10, 1967, it was determined that the BOD removal achieved by these treatment facilities was 34 per cent. This efficiency is considerably less than expected from this type of facility and further studies should be made to determine what improvements are necessary to provide satisfactory performance. Excessive clear waters enter the sewer system at times resulting in volumetric overloading of the treatment facilities and occasional bypassing of raw sewage. No provision is made for disinfection of effluent. This treatment works also serves the Riverview Sanatorium.

20. The City of Kaukauna is in the process of adding activated sludge facilities to an existing primary treatment plant. Provision will be made for isinfection of effluent. The City of Kaukauna provides sewage treatment service by contract to the Village of Combined Locks. Combined sewers exist at Kaukauna and separation is essential to provide for effective treatment of all sewage tributary to the sewer system.

21. Kraft pulping, paper making and converting are carried on by Thilmany Pulp and Paper Company, Kaukauna. Converting mill wastes go to the city sewer. Disc filter and paper machine saveall effluent are released to the river without further treatment. All other wastewaters from this company are treated in a flow-through settling lagoon.

22. The Village of Wrightstown has a trickling filter type sewage treatment plant on which construction was completed in 1958. Provision is made for disinfection of effluent. Some of the sewer system is combined which results in volumetric overloading of the sewage treatment facilities at times and occasional bypassing of raw wastes.

23. The groundwood pulp mill operated by Charmin Paper Products Company at Little Rapids was permanently closed effective November 1, 1967.

24. Hickory Grove Sanatorium, De Pere, has an activated sludge type sewage treatment plant which was placed in operation in 1957. Provision is made for disinfection of effluent. A BOD reduction of 53 per cent was found during a twenty-four efficiency study conducted on May 11 and 12, 1966. Further studies are necessary to determine whether a more satisfactory efficiency normally occurs.

25. Paper is made by Nicolet Paper Corporation in West De Pere. All paper machines in this plant are equipped with fiber savealls.

26. U. S. Paper Mills Corporation, another West De Pere firm, makes deinked pulp from waste paper and processes it into paper. A settling lagoon is provided for treatment of the process effluents.

27. The City of De Pere added activated sludge sewage treatment facilities to an existing primary plant in 1964. Provision is made for

disinfection of effluent. It was determined during a twenty-four hour efficiency study conducted on September 21 and 22, 1966, that the plant removed 59 per cent of the BOD from the raw wastes. This efficiency is considerably less than expected from this plant and further studies are necessary to determine whether more satisfactory treatment normally occurs. Portions of the city are served by combined sewers which results in volumetric overloading of the sewage treatment facilities at times and occasional bypassing of raw wastes.

28. Fort Howard Paper Company, Green Bay, makes paper. It also produces pulp by the groundwood and waste paper deinking techniques. Paper-making effluents are passed through savealls before any excess is released to the river. Alum is added to help settle solids carried in the deinking wastewaters, which go to one of four clarification lagoons for treatment.

29. The Fort Howard Paper Company, Green Bay, has a trickling filter type sewage treatment plant which receives sanitary sewage from the plant and office. Effluent is directed to the Fox River.

30. Two types of pulp--groundwood and sulfite--and paper are made at the Green Bay Division of American Can Company. Since 1959, white-water wastes as well as bleach wastes and surplus pulp washer waters are pumped to multiple settling lagoons. Spent sulfite liquor is evaporated. Weak blow pit liquor and evaporator condensate goes to the river.

31. Charmin Paper Products Company makes groundwood and sulfite pulp, as well as paper, at its Fox River and East River mills in Green Bay. Used process waters from the East River mill is piped to the Fox River mill for reuse. There is no discharge from the East River mill. All excess paper machine saveall effluent not reused is directed to the Green Bay Metropolitan sewer system. Groundwood wastes are treated in savealls. Spent sulfite liquor is evaporated.

32. Green Bay Packaging, Inc., a manufacturer of paper and semi-chemical pulp, treats its wood room and paper machine wastewaters by using screens and a flotation saveall. Neutral sulfite spent liquor from wood pulping is burned in a new fluidized bed liquor combustion plant.

33. The Green Bay Metropolitan Sewerage District serves the City of Green Bay, Village of Howard and portions of several towns. The district has a trickling filter type sewage treatment plant which is overloaded and in need of expansion. A research project is presently underway by the district with cooperation and financial assistance from local paper mills and the federal government to study the possibility of the district providing waste treatment service to the paper mills.

A portion of the sewer system of the City of Green Bay is combined. Storm water entering the sewer system results in volumetrically overloading the sewage treatment facilities of the Green Bay Metropolitan Sewage District and periodic bypassing of raw wastes.

33A. The Menasha Corporation has an activated sludge type sewage treatment plant to handle sewage from their office and plant located on Highway 41 southwest of Neenah. Effluent receives further treatment in a pond prior to discharging to the Neenah Slough.

34. The Neenah Foundry discharges wastes with a high suspended solids content to two storm sewers in Neenah which empty into Neenah Slough. Adequate settling facilities should be provided.

35. A milk evaporation process is operated at the Galloway Company, Neenah. Evaporator condensate and cooling waters are discharged to Neenah Slough and there is periodic milk carry-over in the condensate.

36. The Fox River Tractor Company, located on Highway 41 west of the City of Appleton, has a small activated sludge type sewage treatment plant which was installed without approval. Effluent is directed to a drainage course which flows through the Butte des Morts Utility District to Mud Creek. The quality of effluent has been erratic as shown by determinations made on samples. It is desirable that arrangements be made to connect to the sewer system which serves the Butte des Morts Utility District.

37. The Wisconsin Rendering Company, Appleton, is located on Mud Creek and discharges only cooling water to the stream.

38. The Butte des Morts Utility District in the Town of Grande Chute, west of the City of Appleton, constructed a sewer system and activated sludge type sewage treatment plant in 1966. This plant receives industrial wastes from the Elm Tree Bakery after pretreatment for grease removal. Provision is made for disinfection of effluent prior to discharging to Mud Creek near the confluence with the Fox River.

39. The Elm Tree Bakery, Appleton, pretreats bakery wastes by air flotation before discharge to the Butte des Morts Utility District.

40. A septic tank servicing the Terrace Motor Inn, Appleton, overflows to a tributary of Mud Creek. It has been suggested that these sanitary wastes be discharged to the Utility District.

41. A small bottling plant is operated by the Hietpas Dairy Farms, Route 3, Appleton. Approximately 1,000 gallons per day of washup wastes are discharged to a tributary of Mud Creek, which could be termed a "dry run."

42. The Coenen Packing Company, Route 3, Appleton, operates a small packing house. Factory wastes are discharged to a septic tank and tile field which has a small overflow to a Mud Creek tributary.

43. The Brookside Cheese Factory, Route 1, Menasha, manufactures American cheese. Wastes are discharged to Kankapot Creek although no flow was noted above or below the outfall during the survey.

44. The White Clover Dairy Company, Inc., Route 3, Kaukauna, is connected to the Town of Holland Sanitary District.

45. The Town of Holland Sanitary District No. 1 has an activated sludge type sewage treatment plant which was constructed in 1965. This treatment facility receives industrial wastes from the White Clover Dairy. An efficiency study conducted on October 18 and 19, 1966, showed a BOD removal of 69 per cent. Observation of this plant on numerous occasions has revealed an unsatisfactory degree of treatment to be occurring. Additional treatment facilities will be required unless the loading on this plant is reduced to the point where the existing facilities can produce a satisfactory effluent consistently. No provision is made for disinfection of effluent.

46. The Pleasant View Cheese Factory, Route 4, Appleton, manufactures American cheese. Factory wastes discharge to a tributary of Apple Creek, which was dry during the survey.

47. The Fox River Valley Co-op Creamery, Route 2, De Pere, operates as a receiving station. Wastes are discharged to a holding tank with a two-day capacity. Periodically, the contents of the holding tank are discharged to a sand filter with seepage ultimately reaching Ashwaubenon Creek.

48. Austin Straubel Airport at Green Bay has an activated sludge type sewage treatment plant which was placed in operation in 1959. Provision is made for disinfection of effluent.

49. The Paper Converting Machine Company, Green Bay, is connected to the Metropolitan Sewerage System; however, several samples were collected from an outfall discharging to a tributary of Dutchman Creek that had the characteristics of raw sewage.

50. The Rockland River View Cheese Factory, Route 2, De Pere, manufactures American cheese. Factory wastes are discharged to a small pond, which, in turn, overflows to the East River.

51. Scrays Cheese Company, Route 2, De Pere, is a small operation manufacturing Edam cheese. Wastes are discharged to a 600 gallon septic tank which overflows to the East River.

52. Town of Wrightstown Sanitary District No. 1 (consisting of the community of Greenleaf) installed a sewer system and activated sludge type sewage treatment plant in 1962. Effluent is given further treatment in a pond prior to discharging to a branch of the East River.

53. American cheese is manufactured at the Shirley Co-op Cheese Factory, Route 1, De Pere. A septic tank has been converted to a holding tank for factory wastes, which are subsequently hauled out during summer months. When hauling is not practiced, wastes are discharged to Bower Creek.

54. The Liebman Packing Company, Green Bay, discharges wastes to the Green Bay Metropolitan system, except paunch manure, which is lagooned. There was no evidence of wastes reaching Bairds Creek during the survey.

55. The Chicago Northwestern Railroad operates a roundhouse in Green Bay. Oil from this source was observed collecting in a private storm sewer which ultimately discharges to the Fox River.

CHEMICAL

The data pertinent to the condition of the watercourses concerned is tabulated in Table 2. The analytical information presented follows the same sys'em of organization as employed for Table 1. Results for a single source are grouped. Field determinations were made of temperature, pH and dissolved oxygen (D.O.) at the time of sample collection. Determination of biochemical oxygen demand (B.O.D.), solids, bacteriological concentrations and other specified tests were made by the State Laboratory of Hygiene. Definitions of terms used are appended to this report.

BIOLOGICAL

A biological stream survey is a study of stream conditions as they affect the growth and production of biological life within a stream. Where chemical determinations revealed current pollutional loadings, biological analysis indicates a long-term effect of those loadings as they are assimilated into the production of living matter. Biological evaluations may be broken into several aspects including phytoplanktonic organisms, zooplanktonic organisms, vertebrate organisms (fish), and invertebrate organisms. The invertebrate organisms lend themselves best to this type of study in that they are relatively immobile and consequently are directly subjected to the pollutional loadings imposed upon the habitat. Under these conditions, an organism must respond to a particular contaminant by a physiological adaptation or die.

There exists within biological communities all gradations and variations of adaptability toward adverse conditions that may be imposed upon the bio-habitat. Some species cannot tolerate any appreciable pollution whereas others are not only tolerant but appear to thrive under relatively foul conditions. Species intolerant of pollution respond to contamination by reduction in numbers or by complete disappearance from the habitat. Tolerant forms respond according to the severity of pollution. When competition is reduced by the elimination of more competitive forms, the population of more tolerant forms may increase. On the other hand, as the severity of pollution becomes more intense, the tolerant organisms will be reduced or eliminated from the community and only organisms with special adaptations can survive.

Pollution normally expresses itself on the bio-habitat and aquatic organisms in one of two ways. It may be toxic to the organism, and in this situation the substance will usually affect all organisms uniformly. Under such conditions, one does not observe a specific group becoming more or less predominant. The general tendency is rather that all the macro-invertebrates disappear at relatively the same time. This type of ecological situation is noted with wastes containing such items as heavy metals, tars or oils, chlorinated hydrocarbons and a host of others.

Pollution may also express itself in a subsequent change in the bio-environment which favors certain types of organisms and is detrimental to other organisms. This is the situation observed in organic types of pollution such as paper mill wastes, milk plant wastes, sewage treatment plant wastes, etc. Organic wastes need dissolved oxygen to reach a more stable chemical state. The oxygen dissolved in water varies b tween 7 and 14 parts per million depending on the temperature (air contains about 200,000 parts per million).

Aquatic organisms must derive their oxygen from the water and consequently when an organic waste is undergoing stabilization is competes with the macro-invertebrate fauna for the very limited oxygen present. Since the chemical stabilization process will continue until all oxygen has been utilized or the compounds are stabilized, the organisms requiring various oxygen tension levels are deprived of this necessary material. If stabilization occurs very quickly, a good deal of the oxygen is left in the water and natural reaeration will tend to replace that which was lost. However, if stabilization of the organic compounds continues, the dissolved oxygen in the water is reduced to critical levels for organisms that are not adapted for the most efficient utilization of dissolved oxygen. Some aquatic organisms are not only efficient in extracting the last iota of dissolved oxygen out of the water but can resort to deriving oxygen from the air above the water. These organisms are not only favored by low dissolved oxygen levels and the subsequent absence of efficient competitors, but the waste of organic material can also be utilized as food for these organisms and consequently their numbers usually increase.

Another bio-habitat effect of a waste may be to cover the bottom habitat and this is often observed in silt and paper mill wood waste. Again, this will normally favor a particular group of organisms and by quantitatively sampling these bio-environments, a biologist can evaluate a source of pollution on the stream ecology.

It must be pointed out that different stream characteristics give rise to different communities regardless of the presence or absence of pollution. Thus, sampling to determine pollutional effects must be made at carefully selected sites and each sampling site must be evaluated as to its particular physical effect on the bio-habitat. In general, riffle areas reveal populations most indicative of the degree of pollution and consequently specific effort is made to sample in these areas.

The physical collection of the biological samples for the Lower Fox River Basin survey was made with one of three devices capable of sampling a known unit area of bottom; thus, all samples are considered quantitative except those where a qualitative sample is specified. The sampling devices utilized were a Petersen dredge, sampling .8 of a square foot, used in gravel, sand and small stone habitats; the Surber square foot sampler used in rocky and boulder habitats; and the Ekman dredge, with a ¼-square foot sampling area used in sludge, silt and mud. Samples were washed several times and screened through a U. S. Standard 35-mesh screen which retained the bottom organisms and a minimum of debris for preservation and storage. Organisms were separated from debris and were identified and enumerated at the laboratory. All identifications were made to the most specific level possible, but due to taxonomic uncertainties of certain groups, all identifications must be considered tentative. However, these uncertainties in identification are not likely to affect the evaluation of the species in terms of pollutional tolerance.

RESULTS OF BIOLOGICAL INVESTIGATION

The field work for the biological survey of the Lower Fox River Drainage Basin was conducted during the month of July, 1966. Supplementary data obtained during 1963 and 1965 was also used in this investigation to better evaluate specific classes of plankton contributing to nuisance conditions. These classes consisted of algae and invertebrates, fibers and fiber knots, filamenteous slime bacteria, i.e., Sphaerotilus natans being the typical dominant variety, and organic debris consisting of wood chips, bark, plant debris, and seeds.

Filamenteous slime bacteria contribute to unsightly organic masses as well as accumulations on fish lines, nets, and other obstructions which may be present in the stream. Algae forms unsightly scums and "paint pot conditions" along shorelines and on boat exteriors. Suspended waste solids and organic debris form stream bottom deposits which affect the general ecology of the river.

In general, the evaluation of plankton quantities and their composition is as follows: a clean water site is one where collection of volatile solids is approximately 10 micrograms per liter (10 µgms/L) and a nuisance planktonic site is one where volatile solids made up of filamenteous slime bacteria, algae, and fibers is approximately several hundred micrograms per liter concentration. Waste additions, climatic factors, and flow conditions all affect plankton loads at a particular site.

The Biological Station Summary (Table 6) represents an analyses of the biological findings and the data presented forms the basis for interpretation of the existing conditions at given locations in the Lower Fox River. This survey includes a study of 23 biological stations between Neenah and Menasha channels and the mouth of the river at Green Bay. All samples were collected on the main stem of the river.

In describing location of collected samples, one of three letters are used following the sample number, i.e., "LF25C," "LF25E," or "LF25W." The letter "C" means center of stream equidistant across from both banks and/or center of channel which ever is the situation. The letter "W" means west or northwest shoreline of the river from which the sample was collected. The letter "E" means east or southeast shoreline of the river from which the sample was collected. These samples were usually collected between mid-channel of the stream and the respective river shoreline.

The major portion of the Lower Fox River has a rock, course gravel, or organic bottom. These three bottom types were sampled with the aid of a Petersen or Ekman dredge. The relative abundance of the various species was noted from samples secured in this manner. Every physical effort was made to secure a comparable sample at each of the stations investigated. In clean-water areas, 7 to 26 species of organisms were isolated at each station. The biological survey of the Lower Fox River involves some 67 bottom samples distributed over the 23 stations examined.

Fox River - Main Stem

Two samples were collected in the vicinity of Neenah and Menasha Channels at approximately 0.55 miles upstream from each of the two dams at stream mileage 39.4 in the Neenah Channel and 39.1 in the Menasha Channel. Both samples were collected on a rocky stream bottom and were well represented by a typical balanced clean water biological community including caddis and mayfly larvae.

Three samples were collected in Little Lake Butte des Morts downstream from the Neenah Channel and in line with a transit located 1,000 feet below the paper mills' waste outfalls and 1,000 feet uplake from the Neenah sewage treatment plant at stream mileage 38.5. A balanced benthic community was found at sampling sites LF25C and LF25E indicating sufficient dissolved oxygen present. However, slimes and fiber foam noted in the water and on the surface of the lake in this location as well as slimes and wood chips in the collected sample, indicate a semi-polluted condition. Sample LF25W located 500 feet east of Neenah Slough outlet showed a definite decline in both numbers and types of organisms present and, therefore, a polluted water condition. Only very tolerant midgefly larvae and sludgeworms were collected along with fibers and slime in the sample. High volatile solids were collected on the 1963 and 1965 plankton surveys which equaled 10,136 µgms/L and 3,019 µgms/L respectively. Microscopic examination of these solids revealed them to be 99 per cent wood fibers. Sludge deposition was also noted in this location.

Three samples were collected in the vicinity of the Menasha Channel between James Island and the C&NW Railroad embankment and between James Island and Doty Island at stream mileage 37.1. Samples LF24C and LF25W revealed a balanced benthic community indicating sufficient dissolved oxygen present. However, the presence of prolific slimes (Sphaerotilus natans) growing on weeds and rocks along with sludge deposition noted in the area reveals a clean but affected water habitat. Gray colored water with high suspended solids was noted flowing out of three submerged outfalls located between James and Doty Islands. Sample LF24E located between James Island and C&NW Railroad embankment revealed a clean water community without slimes present. This indicates that wastes are channeling into Little Lake Butte des Morts on the south and east sides of James Island thus causing slimes to grow and sludge to accumulate.

Three samples were collected in the vicinity of the downstream side of Stroebe's Island at stream mileage 34.2 and below the aerial electrical cable crossing. Sample LF22E, LF22C, and LF22W revealed the channel and the respective river shorelines to contain an unbalanced benthic community consisting of very tolerant sludgeworms and blood gilled midgefly larvae. Gas bubbles and septic odors were noted coming off the stream bottom indicating anerobic conditions exist at this station due to sludge and organic deposition. Slimes were also collected in sample LF22E and observed on rooted aquatic weeds (coontail and water milfoil) at approximately 100 feet off the east shoreline. This biological evidence suggests a semi-polluted condition on the east side of the river and an unbalanced condition in the channel and along the west shoreline.

Samples were collected in the Appleton area at 0.75 miles upstream from the Appleton Yacht Club and Lutz Park at stream mileage 33.2+. A cross section of the river was sampled and revealed an increase in biological production at this location. Tolerant species of organisms consisting of sow bugs and midge fly larvae increased from 1 or 2 genera at the above station, Stroebe's Island, to an average of 4 genera at this station location. However, no clean water organisms could be collected from the rock and course gravel river bottom indicating an unbalanced benthic population exists. Heavy amounts of planktonic algae (blue green) were observed floating on the surface along with slime growths on rocks in the water. Low dissolved oxygen levels at night probably occur in this area thereby affecting colonization of clean water organisms such as the mayfly and caddis fly larvae.

Samples were collected in the vicinity of the John Street Bridge in Appleton 0.1 miles below Foremost Foods and about 0.1 miles above the Interlake Mill at stream mileage 30.7+. A balanced benthic community was sampled at this river location which suggests a recovery from the unbalanced and semi-polluted conditions noted upstream from this site. Two genera of intolerant larvae (Cheumatopsyche sp. and Caenis sp.) were collected along with a variety of other organisms (tolerant and very tolerant). This station location can thus be classified as clean but it should be noted that a survey in 1955 at this same location produced 6 genera of intolerant organisms instead of 2 genera at present.

Samples were collected in the Appleton area 0.5 miles below the Interlake Mill and approximately 0.2 miles upstream from the Appleton sewage treatment plant at stream mileage 30.2. A cross section of the river was sampled and the biological evidence obtained revealed an unbalanced benthic community in the channel portion of the river. Samples LF18C and LF18CQ revealed 3 genera of tolerant organisms (Asellus sp., Planaria sp. and Glossiohonia sp.) and 8 genera of pollutional sludgeworms, bloodworms, leeches, and clams. Samples LF18E and LF18W contained 2,478 per square foot and 7,484 per square foot, respectively, of sludgeworms and bloodworms, indicating heavy organic loading is occurring along the shorelines at this river location. Wood chips, bark and wood waste deposit were also collected in the bottom samples. Further supporting evidence was obtained from plankton tows collected. Volatile solids (627 µgms/L) were collected in the channel portion of the river and revealed 75 per cent algae (diatoms and blue greens) and 25 per cent slimes (Sphaerotilus natans and Leptomitus lacteus). Volatile solids (1,027 µgms/L) collected 50 feet off the east shore revealed 50 per cent algae and invertebrates (blue-greens, copepods and cladocera) and 50 per cent fibers and fiber knots. Volatile solids (432 µgms/L) collected 50 feet off the west shore also revealed 50 per cent algae and invertebrates (blue-greens and cladocera) and 50 per cent fibers and fiber knots. The above biological evidence indicates that sludge deposition and polluted water conditions are caused from paper mill wastes at this station location.

Samples were collected at black-can buoy #43, 0.7 mile below Interlake Mill and 0.5 mile upstream from the Appleton sewage treatment plant at stream mileage 29.5. Cross sectional sampling of the river bottom again revealed polluted water conditions both in the channel and along the river shoreline. Pollutional organisms (sludgeworms and certain snails, clams, and leeches) numbered 1,236 per square foot of river bottom in the channel area. Slimes were noted in samples LF17C and LF17W and bubbles were coming off the water surface in the channel area and along the east shore. It appears that wood waste breakdown and sludge deposition at this station are causing dissolved oxygen deficiency in the water which affects the benthic community and environment.

Samples were collected in the vicinity of Sunset Point off Kimberly City Park 0.5 mile upstream from the Kimberly Dam at stream mileage 27.9. Cross sectional bottom sampling on a rock and gravel bottom revealed the absence of clean water organisms at all sampling sites. Pollutional organisms (sludgeworms, leeches, clams, snails, and bloodworms) collected in mid channel and along both shorelines numbered 1,343 (channel), 3,168 (east shoreline), and 2,862 (west shoreline) per square foot of river bottom. This biological evidence indicates an enriched organic stream bottom at this station consisting of slimes, fibers, wood chips, and decaying rooted aquatic plants. This station, is, therefore, termed polluted except for the northwest shoreline where the absence of slimes indicates a semi-polluted water condition.

Bottom samples were again collected between dams at Kimberly, 0.3 miles downstream from the upstream dam at stream mileage 27.1. Cross sectional river bottom sampling at this station revealed severe polluted water conditions both in the channel and along the river shoreline to the extent that organisms are severely decreased or excluded from the bio-habitat entirely as noted in sample LF14E (southeast shoreline). Wood chips floating on the water, slime growth on rocks, and floating fiber-foam were observed at this station. The LF14E sample was entirely made up of fibers and tissue sludge which gave off a septic odor. The river water along the southeast shoreline was turbid and white with waste. Volatile solids (973 µgms/L) collected at this site consisted of 50 per cent fibers and fiber knots, 15 per cent slimes (Sphaerotilus natans and Leptomitus lacteus), and 35 per cent diatoms and protozoans (Melosira sp. predominately), volatile solids (1,865 µgms/L) collected in the channel portion of the river consisted of 95 per cent fibers and fiber knots and 5 per cent algae (blue-greens). Volatile solids collected off the northwest shore consisted of 15 per cent fibers and fiber knots, 25 per cent slimes, 15 per cent wood chips, and 45 per cent diatoms and invertebrates (Melosira sp., rotifers, cladocera, and Stephanodiscus sp.).

Generally polluted bottom conditions were found between Combined Locks Dam at river mileage 25.2 and upstream from the De Pere Dam at mileage 7.2 where semi-polluted biological conditions were found. No "clean water" or intolerant forms were isolated at stations located at mileages 25.2, 24.5, 21.7, 19.7, 18.7, 16.2, 14.1, 12.1, and 7.2. A total of 24 bottom samples collected along this portion of stream revealed tolerant and pollutional organisms at a minimum or entirely absent from the bio-habitat. The absence of organisms was noted along the northwest shore of the river both at 0.5 mile downstream from the Rapid Croche Dam and 1.1 miles downstream from the Wrightstown Highway 96 bridge and the second town cross road at river mileages 18.7 and 16.2 respectively. The absence of organisms both in the channel portion and northwest shoreline was also noted 1.0 mile above Little Rapids Dam at river mileage 14.1. An average dissolved oxygen level of 1.2 µgms/L was chemically analyzed between river mileages 18.7 and 14.1. Profuse slimes (Leptomitus sp. and Sphaerotulus natans), rising bubbles, sludge chunks, wood chips, and dead snail shells were noted at sampling sites in this portion of the river. The quantitative samples collected contained large pieces of bark, splinters of wood, wood chip rejects, fibers, as well as silt, leaves, twigs, and miscellaneous bits of natural woody debris. Sludge deposition was noted above the Kaukauna Dam beginning at Riverside Park and continuing downstream to the Rapid Croche Dam. Below Wrightstown, the river channel is generally swept clean with various stages of sludge deposition along both sides of the river giving rise to slime growths down to the Little Rapids Dam. Downstream from Little Rapids Dam, the above conditions were again observed supplemented with prolific growths of rooted aquatic weeds (yellow lily pads). Volatile solids (912 µgms/L) collected in the channel portion of the river consisted of 50 per cent algae and invertebrates (Copepods, cladocera, protozoans, diatoms-Melosira sp.) and 50 per cent fibers and fiber knots. Volatile solids collected 100 feet off the southeast and northwestern shorelines revealed the same composition.

Samples were collected in the vicinity of De Pere, 0.1 mile upstream from the dam and across from De Pere High School and St. Norbert

College at river mileage 7.2. Cross sectional bottom sampling revealed semi-polluted biological conditions. Clean water or intolerant organisms were absent and tolerant and pollutional forms were reduced to a minimum. The absence of fibers, fiber knots, and slimes in collected volatile solids was noted. The 152 µgms/L collected consisted entirely of blue-green algae (Anacystis sp.) of "paint pot" proportions along both shorelines and invertebrates (cyclops and Daphnia sp.) in the channel.

Samples collected at river milages 4.9, 1.7, and 0.1 revealed polluted water conditions from De Pere to the mouth of the Fox River. Clean water organisms were absent, tolerant forms were at a minimum or absent, and very tolerant genera were severely decreased in comparison to the site just above Kimberly which had an average of 2,457 organisms per square foot of river bottom. Septic odors were detected coming off of collected bottom samples from all stations on this portion of the river along with bark, wood slivers and chips, dead snail shells, fibers, and miscellaneous bits of natural organic debris (leaves and twigs). Plankton sampling revealed a higher percentage of algae and invertebrates in this section of the river than upstream above De Pere dam. For example, at river mileage 4.9 a tow sample along the southeast shoreline (66 µgms/L) contained 98 per cent algae and invertebrates (blue-greens and cladocera) and 2 per cent fibers and fiber knots. The northwest shore tow sample contained 97 per cent algae and 3 per cent fibers and fiber knots (63.6 µgms/L) while the channel two sample (61.2 µgms/L) contained 88 per cent algae and invertebrates (Anacystis sp. and cladocera), 10 per cent fibers and fiber knots, and 2 per cent slimes (Sphaerotilus natans). At river mileage 0.1 plankton samples collected also showed high algae percentages (90 per cent in the channel area, 100 per cent along the southeast shoreline and 85 per cent along the northwest shoreline). The remaining portion of each sample consisted of slimes, fibers and fiber knots.

COMPARISON OF BIOLOGICAL RIVER CONDITIONS (1955-1966)

The original January 4, 1968 report contained a biological comparison of the Lower Fox River with data from 1955 and 1966 surveys. This comparison was invalid in that biological sampling techniques differed between the two surveys. In the 1955 survey, an average of 6 samples per station was pooled, thereby giving a relatively high number of intolerant organisms at a given station. Usually, during the 1966 survey, a cross section of three samples was collected at each station and reported individually, giving a low number of intolerant organisms per sample. The latter method is now used in all Wisconsin biological stream surveys. The different techniques used in the 1955 and 1966 surveys do not change the biological conclusions reached in either survey. Biologically, conditions were similar at the same sites for both surveys, but a direct comparison could not be made.

LITERATURE CITED FOR FOX RIVER

1. Balch, Robert F., Mackenthun, Kenneth M., Van Horn, Willis M., and Wisniewski, Theodore F. "Biological Studies of the Fox River and Green Bay from Co-operative State-Industry Surveys of the Lower Fox

River and Green Bay Made in 1955-1956." Bulletin WP102, May 4, 1956, pp. 1-30, 2 tables, 1 figure. (Mimeographed)

2. Lueschow, Lloyd A. "Slime Survey of Wisconsin Rivers 1963-1965." Committee on Water Pollution, Madison, Wisconsin. May, 1966, pp. 1-12, 39-48, 11 tables, 11 figures. (Mimeographed)

3. Scott, Ralph H., Mackenthun, Kenneth M., Bernauer, George F. "Drainage Area 11A-Stream Pollution Lower Fox River." March 21, 1957, pp. 1-47, 11 tables, 10 figures.

LOWER FOX RIVER REAERATION

Stream reaeration through vented hydroturbine draft tubes can be done successfully at four Lower Fox River dams. Vented turbines at the Kimberly, Combined Locks, Rapide Croche and Little Rapids dams have all proved their value. The reaeration capability at Little Rapids Dam ceased to exist when Charmin Paper Products Company permanently closed its groundwood pulp mill at that location.

Although one of the power turbines owned by Nicolet Paper Corporation at De Pere Dam has been vented, some rudimentary testing of that facility has yielded disappointing results. More effort should be expended to develop aeration at this site.

Kimberly-Clark Corporation has vented all three of its turbines at the Kimberly Dam. During periods of low dissolved oxygen concentration in the river, those turbines have drawn about 8,600 to 9,400 pounds of oxygen per day into water passing through them.

Three hydroturbines at Combined Locks Dam have been vented by Combined Paper Mills, Inc. At full gate openings any one of those turbines appears capable of adding approximately 1,500 pounds of dissolved oxygen to a flow-through of water equaling 350 to 380 cubic feet per second.

Thilmany Pulp and Paper Company, working in cooperation with the City of Kaukauna Utility Company and the Green Bay and Mississippi Canal Company has vented two hydroturbines at Rapide Croche Dam. Tests have shown 25,000 to 30,000 pounds of air per day can be introduced to the two turbines resulting in daily addition of 5,000 to 6,000 pounds of dissolved oxygen to the river.

The Little Rapids turbine reaeration facilities operated by Charmin Paper Products Company were capable of supplying 5,550 pounds of oxygen per day to the four vented wheels. When the system operated at capacity, an approximate average of 1,100 pounds of dissolved oxygen per day could be added to that section of the Lower Fox River.

In addition to the turbine reaeration facilities mentioned here, an aeration and mixing wastewater outfall has been installed by Bergstrom Paper Company. During summer low flow periods, this facility appears able to add about two parts per million of dissolved oxygen to the combined wastewater--canal water flow which is passed through that outfall.

GREEN BAY - WATER QUALITY INVESTIGATION

SUMMARY AND CONCLUSION

The water quality investigations on Green Bay, conducted during 1966 and 1967, revealed:

1. Dissolved oxygen concentrations in Green Bay during the summer months are affected by the discharges of the Fox River to a distance of approximately 2 miles beyond the mouth of the Fox River in the channel and to the east of the channel. This is moderately consistent with limited comparative data from 1939 and 1956.

2. Dissolved oxygen concentrations of Green Bay, during the winter months, are influenced by discharges of the Fox River for a distance of at least 27 miles along the east side of the bay. This observation substantiates the conclusion of the 1939 report that a current appeared to exist along the east side of the bay. However, the distance of influence and degree of influence was substantially greater in 1967 than was observed in 1939. Winter data from Lower Green Bay in 1956 was similar to that observed in 1967, but only the 1967 data indicates the substantial dissolved oxygen reductions 27 miles from the mouth of the Fox River.

3. There was apparently no complaint of fish deaths in 1939, but Mackenthun 1956, suggested that after February 3, 1955, the fishermen were finding dead fish in the nets off Sable Point. The 1967 data indicated that dead fish were observed in nets 25 miles from the mouth of the Fox River on March 9. The degree of influence of waste stabilization on Green Bay appears to be related more to seasonal differences (long versus short ice cover) rather than any substantial change in the quantity of decomposable materials. The basic dissolved oxygen conditions observed along the east shore are apparently attributable to waste discharges of the Fox River.

4. Bottom samples collected from Lower and Middle Green Bay in 1956 and 1966 suggest that only tolerant and very tolerant species dominate the macro-invertebrate population. It is significant that intolerant mayflies observed consistently in 1938 and 1939 were not present in 1956 or 1966. This is apparently due to the undesirable dissolved oxygen condition developed during the winter months. In outer Green Bay, the bottom is rock and one would not expect Hexagenia sps. in the profoundal waters but intolerant Pontoporeia affinis is present. This suggests that the D.O. has not been materially affected by waste discharges to Green Bay.

5. Natural productivity (algae) is apparently responsible for the nuisance conditions that develop on Lower Green Bay during the summer months. The Number 20 standard mesh net larve revealed up to 5,000 µg/l inside the Long Tail Point-Sable Point Bar. The area 10 miles from the mouth of the Fox River consistently revealed 1,000 µg/l while clear waters of the outer bay and Lake Michigan revealed 100 µg/l of solids. Nuisance algae populations were typically dominated by blue-green and diatom varities.

6. Dead fish observed in commercial nets are apparently the result of normal capture near the bottom where the fish cannot resurface to replenish oxygen. The fish apparently can actively or randomly seek acceptable dissolved oxygen values and where critical values are encountered, they can move so as not to be affected. Once trapped near the bottom in a gill net, however, they are killed by suffocation.

REFERENCES FOR GREEN BAY BIOLOGICAL SURVEY

Wisconsin State Commission on Water Pollution, State Board of Health, Green Bay Metropolitan Sewerage Commission, 1938-39, Investigation of the Pollution of the Fox and East River and of Green Bay in the Vicinity of Green Bay. Internal Report.

Cooperative State-Industry Survey, 1955-56, Biology Studies of the Fox River and Green Bay. Internal Report.

Howmiller R. P., 1966, Bottom Fauna Investigations in Lower Green Bay, University of Wisconsin Milwaukee. Internal Report.

WATER QUALITY INVESTIGATIONS ON GREEN BAY

During 1965, the Wisconsin Committee on Water Pollution initiated this study to evaluate the water quality of Green Bay and the effect of waste sources discharging to the Bay. Cooperative studies conducted during 1938-1939 by the Committee on Water Pollution, the State Board of Health, and the Green Bay Metropolitan Sewerage Commission concluded that waste discharges of the Fox River affected the dissolved oxygen of Green Bay water for some 20 miles or more during the winter months. The report further concluded that the absence of critical oxygen conditions in the Bay during the summer months was a result of more rapid stabilization of oxygen demanding wastes. A final conclusion was that "No relief may be expected from the conditions observed in Green Bay until equipment which will remove a major portion of the oxygen consuming material in the waste sulfite liquor is installed at all mills discharging waste sulfite liquor into the Lower Fox River."

The study of 1938-1939 was followed by a cooperative study of bottom organisms by the Committee on Water Pollution and the United States Public Health Service in 1952. In 1956, a cooperative survey between the

Wisconsin Committee on Water Pollution and the paper industry was reported and the Wisconsin Committee on Water Pollution published a general pollution report in 1957.

The present investigation was conducted to evaluate water quality and bottom fauna in Green Bay from the mouth of the Fox River to Washington Island, a distance of approximately 70 miles.

WINTER 1966

Sampling on Green Bay was first initiated under this program during the winter of 1966. Ice cover was relatively late and sufficient ice to support vehicles was not available until mid January. On February 9 and 10, 1966, the dissolved oxygen concentrations in Lower Green Bay were evaluated. Table 1B is a summary of the dissolved oxygen observations at the indicated stations and Figure 1 identifies the station locations.

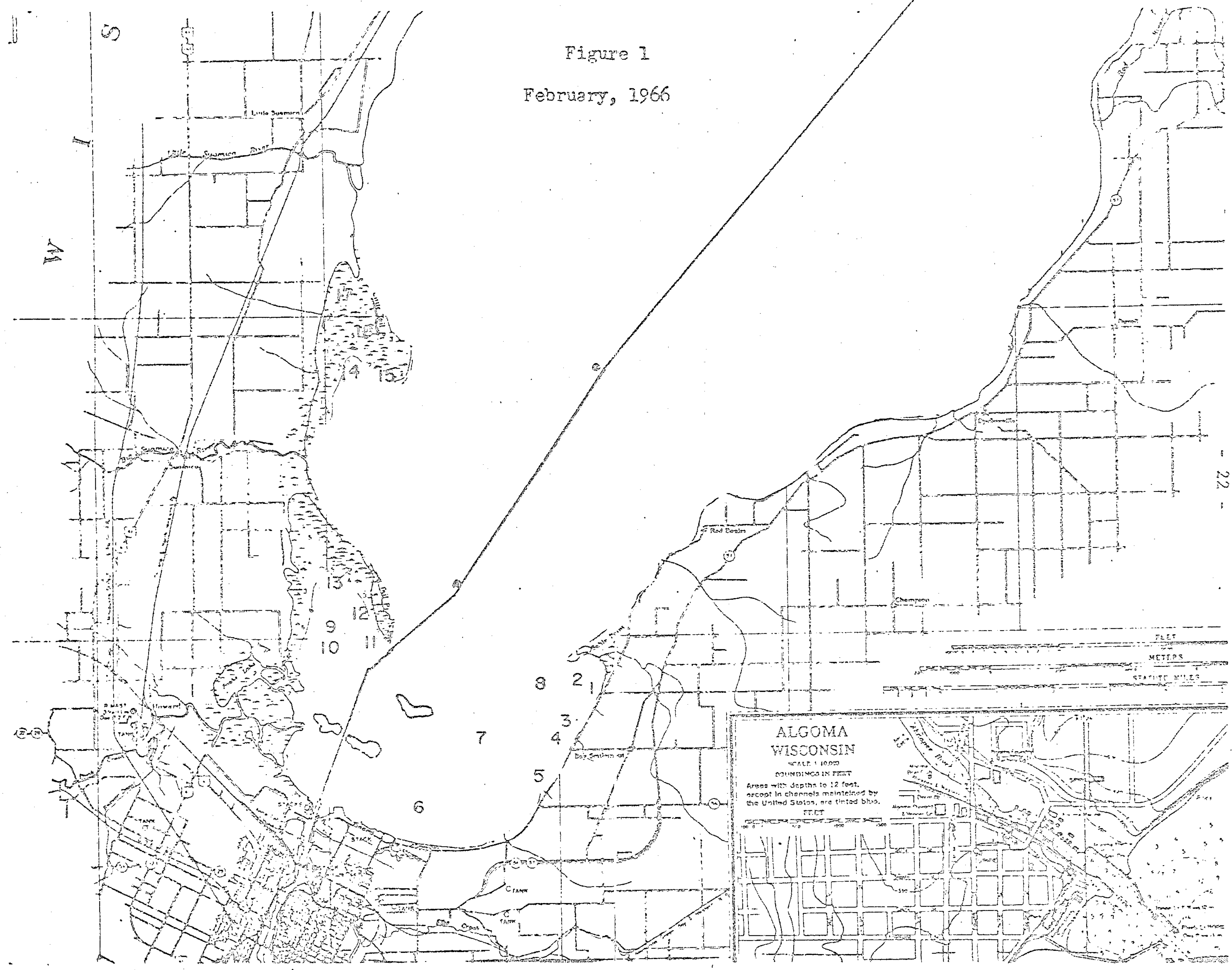
TABLE 1B
D.O. CONCENTRATION INNER BAY AREA
February 9 & 10, 1966

Station Number*	Water Depth (M)	Sample Depth (M)	D.O. mg/l
	Mouth of Fox River to Sable Point		
1	1½	1	13.1
2	3	2½	3.9
3	2	1½	6.2
4	2	1½	6.1
5	2	1½	5.8
6	2	1½	10.0
7	3	1½	8.3
8	3	2	5.5
	In Long Tail Point Bay		
9	2	1½	5.8
10	2	1½	9.4
11	3	2	8.8
12	2	1½	5.7
13	2	1½	6.8
	In Little Tail Point Bay		
14	2	1½	14.9
15	3	1½	15.1
16	1½	1	12.4
17	1½	1	14.5

*For Station Location see Figure 1.

Figure 1

February, 1966



The discharges of the Fox River to Green Bay during the winter months normally revealed variable but sufficient oxygen to sustain fish life. Observed dissolved oxygen values from monitoring stations at the Mason Street crossing in Green Bay varied between 6 and 12 mg/l.

Dissolved oxygen sampling in the Little Tail Point area suggested that the concentrations had not been affected by waste discharges and probably represented dissolved oxygen concentration that might be expected after stabilization of bottom sediments and natural organic matter in the water.

Samples collected 2 and 3 miles from the mouth of the Fox River (Station Nos. 6 and 7) suggested the dissolved oxygen concentration had not been materially altered from river values. The time required for stabilization at the winter temperatures had probably been insufficient to account for a substantial reduction. However, samples collected 4 and 5 miles from the mouth of the Fox River (Stations No. 2, 3, 4, and 5) do show oxygen values that have probably been affected by stabilization of discharge wastes. There was no attempt made to evaluate the dissolved oxygen reduction due to accumulated waste deposits.

Dissolved oxygen sampling in the Middle Bay area was completed from Dyckesville (east shore) to the channel (5 stations) and from Kohl's Landing to the channel (3 stations). Three sampling sites were also selected on the west side of the Bay, south of Pensaukee and three stations were selected at the mouth of the Oconto River. Table 2B is a summary of the data collected on February 9 and 11, 1966. Figure 2 is the location map for the sampling stations.

Stations 18, 19, and 20, 18 miles from the mouth of the Fox River and on the west side of the Bay did not suggest any appreciable dissolved oxygen reduction during this sampling. Low dissolved oxygen values were, however, noted in the immediate vicinity of the Oconto River. Station No. 23, 1½ miles from the mouth of the Oconto River did not reveal any substantial reduction that might be attributable to waste stabilization.

The sampling on the east side of Middle Green Bay indicated that although ice cover had been of only four weeks duration, the dissolved oxygen had been substantially reduced near the bottom in the vicinity of Dyckesville (15 miles from the mouth of the Fox River), but that at Kohl's Landing (25 miles) no depletion of dissolved oxygen in the bottom waters could be observed. On the dates of observation none of the commercial fishing parties observed in the Dyckesville area had reported dead fish in the nets and at the dissolved oxygen values observed (5 mg/l) one would not expect fish deaths.

Dissolved oxygen sampling in the Lower and Middle Green Bay area was again accomplished on March 10, 1966, after approximately 8 weeks of ice cover. At this time spring rains had already covered the ice with water and tributary streams were discharging substantial runoff to the

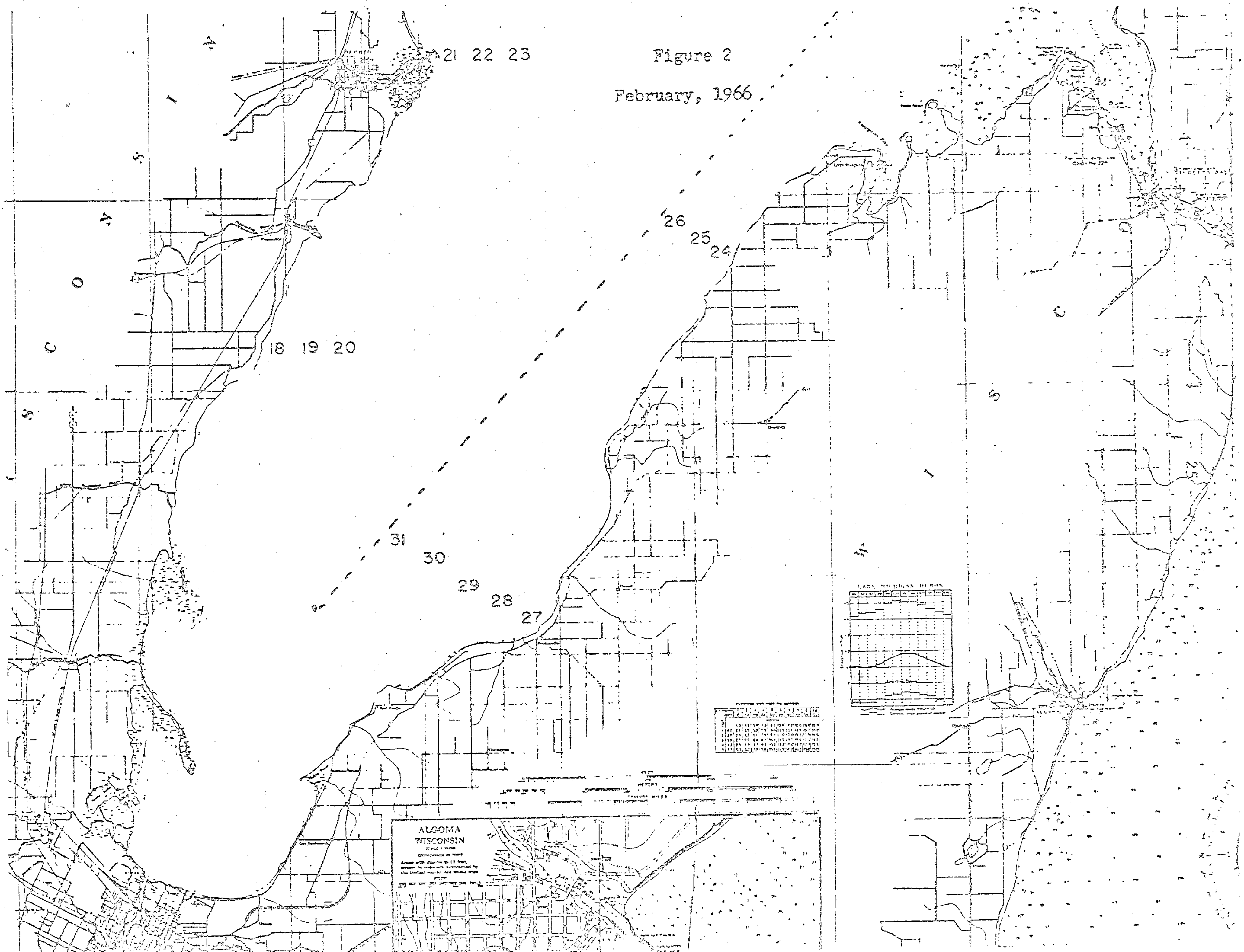
TABLE 2B
D.O. CONDITIONS OF THE MIDDLE BAY
February 9 & 11, 1966

	Station Number*	Water Depth (M)	Sample Depth (M)	D.O. mg/1
South of Pensaukee	18	½	½	15.4
	19	4	Surface	14.7
			3	15.2
	20	7	Surface	14.3
			3	14.4
			6	14.9
Oconto River Area	21	6	Surface	8.6
			5	11.3
	22	6	Surface	14.5
			3	4.5
			6	6.8
	23	7½	Surface	14.0
			4	14.0
			7	11.6
Dyckesville	27	4½	Surface	14.3
			4	6.2
	28	7	Surface	4.2
			3	14.4
			6	14.2
	29	8	Surface	14.1
			3	13.9
			7	4.7
	30	8	Surface	13.7
			3	13.8
			7	5.3
	31	8½	Surface	14.0
			5	13.6
			8	5.4
	24	11	Surface	13.0
			4	12.8
			7	13.0
			10	11.6
	25	14	Surface	13.4
			4	13.5
			7	12.3
			10	12.7
			13	13.5
	26	15	Surface	13.0
			4	12.8
			9	13.0
			14	11.0

*For Station Location see Figure 2.

Figure 2

February, 1966



Bay. The Pensaukee area, Oconto River area, and Kohl's Landing area could not be sampled due to unsafe ice and open water. A summary of March sampling is tabulated in Table 3B. Figure 3 is a description of station location.

TABLE 3B
D.O. CONCENTRATIONS ON INNER BAY AREA
March 10, 1966

	Station Number*	Water Depth (M)	Sample Depth (M)	D.O. mg/1
Sable Point	1	2	1½	9.6
	3	2½	2	8.7
	4	2	1½	8.8
	4A	2	1½	2.2
Long Tail Point	10	2	1½	10.3
	11	2	1½	10.5
	12	2	1½	10.1
	13	2	1½	10.5
Little Tail Point	14	1	½	13.2
	15	2	1½	10.6
Dyckesville	27	4	Surface	10.0
			3½	0.5

*For Station Location see Figure 3.

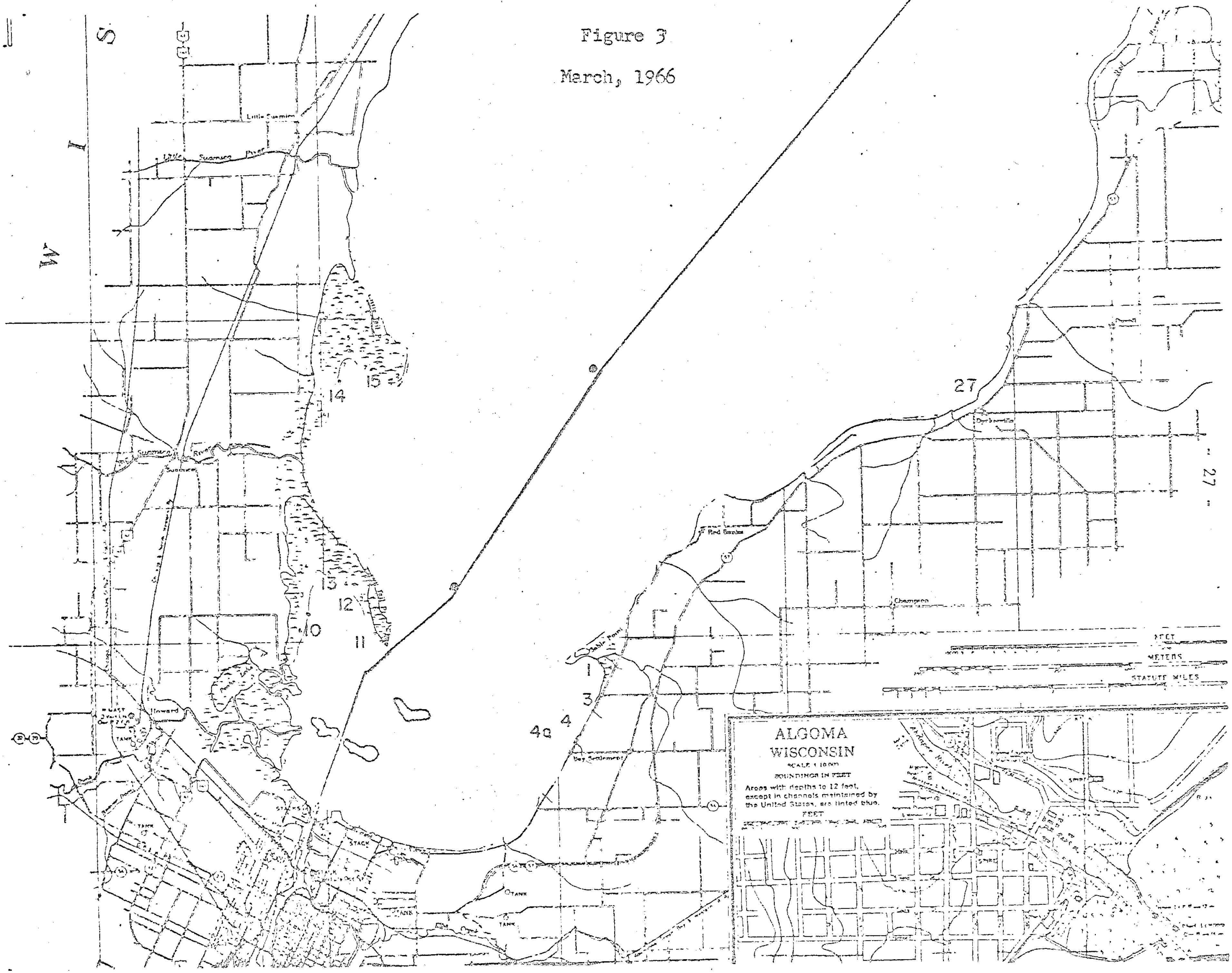
The March sampling again suggested that dissolved oxygen conditions in the Long Tail Point and Little Tail Point areas were not revealing any material reductions in dissolved oxygen concentrations. The difference between the saturated oxygen level at the winter temperature and the observed oxygen level is probably a result of background oxygen demand from organic material in the water and organic bottom sediments. The dissolved oxygen concentrations at Sable Point remained relatively high during 1966 probably as a result of slow stabilization of wastes at low winter temperatures.

At Dyckesville, however, the oxygen conditions were obviously being altered with a 0.5 mg/1 observation at the bottom ¼ mile off shore. Additional samples could not be collected due to unsafe ice.

In summary, 1966 appeared somewhat unusual in that ice cover was late and breakup was early. Only about 1 foot of ice developed on the Bay during the entire winter. These ice conditions are somewhat similar to the observations recorded in 1938. Dissolved oxygen conditions were

Figure 3

March, 1966



remarkably similar to the Sable Point area in 1966 as were observed in 1939. However, in the vicinity of Dyckesville, the limited March sampling suggested the dissolved oxygen to be lower especially near the bottom than was observed in 1939.

SUMMER 1966

Lower Green Bay

Field studies were again initiated during the mid-summer months and Tables 7 through 14 (see Appendix) are a summary of the data collected. Figures 4 and 5 describe the station location in relation to the mouth of the Fox River.

Zone A for purposes of this survey included essentially only the mouth of the Fox River. Monitoring station collections at the Mason Street bridge generally revealed ample dissolved oxygen in the water during the winter months, but low dissolved oxygen values during the summer months. On April 6, the dissolved oxygen was 12.0 mg/l at the surface and 11.2 mg/l at a depth of 20 feet in the channel. By July 5, the concentration was 2.8 mg/l at the surface and 3.4 mg/l at the bottom. On August 12, no dissolved oxygen could be detected in the river at either the surface or the bottom. Gas bubbles were observed and hydrogen sulfide odors were pronounced. The low dissolved oxygen values generally prevailed through October 20.

The water was typically cloudy and secchi disc readings of 1½ to 2 feet were observed on three separate occasions. The highest population of plankton was observed on July 5 when 1,353 micrograms per liter were observed in the Number 20 mesh net. On August 12, the algae population was not noticable on the stream water and, indeed, only 95 micrograms per liter of solids were captured with approximately 50 per cent of that present observed to be debris rather than algae.

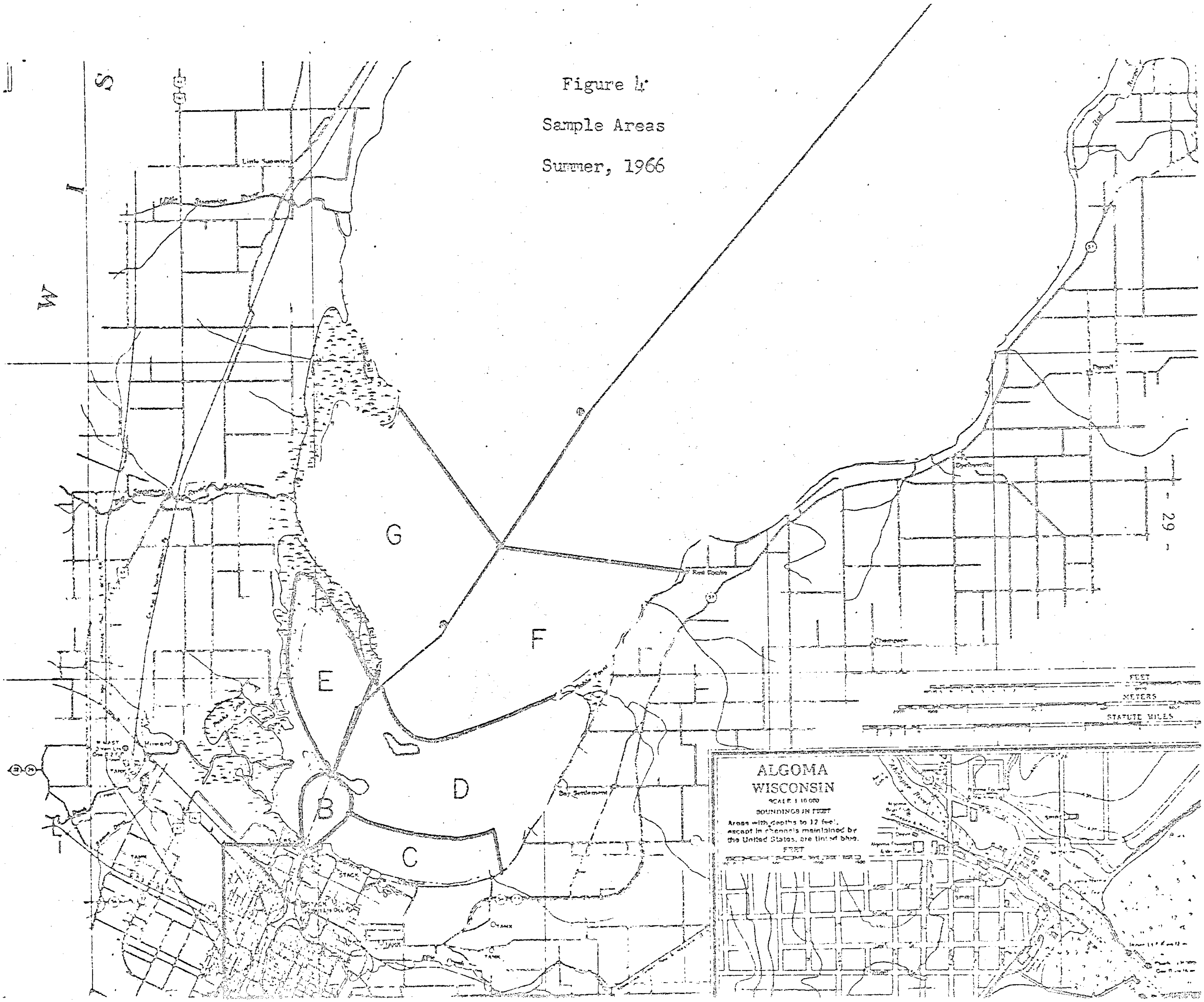
Zone B between the mouth of the Fox River and Grassy Island was also affected by the waste load of the Fox River. On July 5 the dissolved oxygen was still over 4 mg/l. However, on August 12 the dissolved oxygen in this region was less than 1 mg/l. This condition persisted through September 7, but by October 20, the dissolved oxygen was over 4 mg/l at Grassy Island.

Plankton populations in Zone B were difficult to access since lake cargo vessels routinely agitated the bottom and the material often took time to settle out. A reasonable estimate of algae background was probably observed on September 7 when 173 micrograms per liter of solids were recorded. This population was dominated by zooplankton rather than algae. On July 5, 3,350 micrograms per liter were observed almost all of it

Figure 4

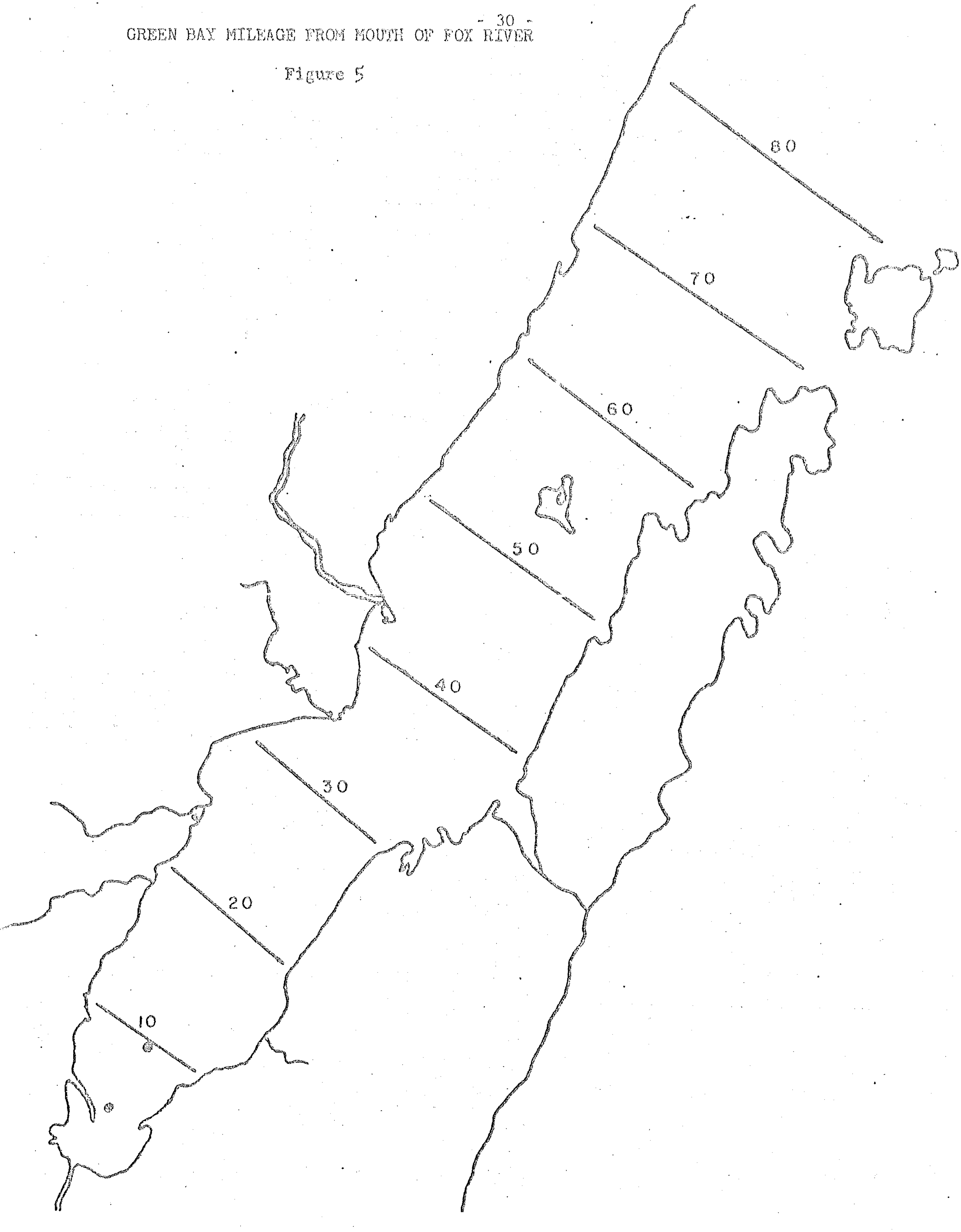
Sample Areas

Summer, 1966



GREEN BAY MILEAGE FROM MOUTH OF FOX RIVER

Figure 5



being blue-green algae or diatoms. This appears to be an algae transition zone between the river and Bay and the plankton population is probably dependent on the wind conditions at the time of collection.

Bottom invertebrae organisms in Zone B were almost nonexistent due in part to the hard clay bottom and secondly, the scouring activity of cargo vessels. It is difficult to access the influence of a low dissolved oxygen on these already undesirable physical conditions.

Zone C was that section of the lower Bay from just east of the channel to the east shore and extending approximately ½ mile from shore. This was defined as a distinct area because of the wind-blown algae accumulations and the wave action along the shoreline.

During the summer and fall months, the secchi disc readings in this region ranged between 1 and 3 feet. On August 12 a series of 7 sample sites were selected ½ mile apart in this region. It was on this date that the Fox River was discharging water with no detectable dissolved oxygen and this condition was noted in Zone C to a distance of approximately 1½ miles east of the channel. Two miles east of the channel the dissolved oxygen was 4.1 mg/l and at 2½ miles the dissolved oxygen concentration was variable but probably in the vicinity of 6 mg/l. On October 20, when the river was still discharging water devoid of dissolved oxygen, the station 1 mile east of the channel was still less than 1 mg/l but at 2 miles the concentration was approximately 3 mg/l.

Bottom invertebrae organism populations were depressed such that within 1 mile of the channel no bottom organisms were observed. Between 1½ and 2 miles east of the channel, 1 to 25 organisms per square foot were noted at 4 sample locations. Three miles east of the channel the population was dominated by midgefly larvae and approximately 20 to 25 bottom macro-invertebraes per square foot were noted. On August 12, the entire shoreline had a heavy algae bloom which was more pronounced 3 miles from the channel than close to the channel.

Zone D included that section of the Bay beyond ½ mile from Green Bay shore to the Long Tail Point-Sable Point Bar. The water was 8 to 10 feet deep except in the channel where the depth was 22 to 24 feet. The bottom was mud and hard pack. The dissolved oxygen conditions in the entire region were generally sufficient to sustain fish and fish food organisms during the summer months. Only 1 sample site in the channel, half-way between Grassy Island and Long Tail Point, revealed less than 2 mg/l of dissolved oxygen. The remainder of Zone D revealed greater than 4 mg/l dissolved oxygen during the summer months. This no doubt represents some depletion due to waste stabilization since without wastes, saturated values of 8 to 10 mg/l dissolved oxygen would be expected.

Secchi disc readings ranged between 1 and 3 feet during the summer months and all algae collections suggested relatively high populations in this region. On July 5, diatoms and blue-green algae accounted for the majority of 5,289 micrograms per liter in the 20 mesh net. On August 12 and 15, 7 sample sites revealed over 1,000 micrograms per liter of zooplankton and algae.

Bottom invertebrae organism populations were dominated by oligochete worms in the channel. Outside the channel, the total population of bottom organisms was typically less than 25 organisms per square foot.

Zone E was that section of the Bay to the west of the channel and inside Long Tail Point. It represents a shallow water area (6 to 10 feet) that is now being filled and altered by the current dredging operations.

Dissolved oxygen collections were made on July 5 and August 15 and there appeared to be no unusual influence of wastes in this area. Plankton populations were similar to Zone D with approximately 1,000 micrograms per liter observed in 4 samples on August 15, 1966. Secchi disc readings were similar to Zone D with 1½ to 2 foot readings. Bottom sediments were sand and mud with a generally low population of organisms dominated by sludgeworms.

Zone F included that sector of the Bay from the Long Tail Point-Sable Point Bar to the outer bell buoy and east of the channel. Dissolved oxygen values did not appear to be affected by waste discharges anywhere in the zone during the summer and fall months. Plankton populations were moderately high and made approximately 1,000 micrograms per liter in the 20 mesh net. Blue-green algae was a primary constituent of this population as it was in the Zones C, D, and E. Secchi disc readings were generally better than in Zones C, D, and E and were routinely 3 to 4 feet. On October 20, Secchi disc values of 6 to 7 feet were noted.

Bottom conditions in this region were variable and included mud, sand, and clay. Bottom macro-invertebrae populations were dominated by sludgeworms, but the numbers were generally under a hundred organisms per square foot. In the channel, where mud was encountered, 2 samples revealed a 136 and 292 oligochaete worms per square foot.

Zone G was that region of the Bay outside the Long Tail Point light and inside Little Tail Point west of the shipping channel. No low dissolved oxygen values were observed on August 15 and waste discharges do not apparently affect this region during the summer months. Plankton populations were approximately 1,000 micrograms per liter as was observed in most of the lower Bay. Diatoms and zooplankton dominated these populations. Secchi disc readings in August were 3 to 4 feet as was observed in section D. The bottom in Zone G was generally mud and tolerant midgefly larvae accounted for 20 to 40 organisms per square foot. Oligochete populations were variable with 40 to 140 organisms per square foot observed.

In addition to the Fox River, the Big Suamico River discharges into Zone G and 5 samples were collected from the vicinity of the mouth of the river on August 15. No depressed dissolved oxygen values were observed either in the Big Suamico River or the receiving Bay at the time of sampling. Plankton populations were twice as high in the river as the Bay, but blue-green algae were not a major constituent of the river water as they were of the Bay water. Secchi disc readings in the Bay were approximately 3 feet while in the river the readings were slightly less than 2 feet. Bottom organism populations were dominated by oligochete worms and tolerant midgefly larvae both in the river and in the receiving Bay. The populations did not suggest any waste associated influence.

Middle Green Bay

Middle Green Bay was that section of the Bay from the entry light (10 miles from the mouth of the Fox River) to Sturgeon Bay approximately 35 miles from the mouth of the Fox. Sample stations were established at 4 mile intervals and at 1 mile intervals east and west of the channel line. Dissolved oxygen conditions in this section of the Bay were not affected by summer waste discharges of the Fox River or by the Pensaukee, Oconto, or Peshtigo Rivers, discharging on the west side of the Bay. At the 10 mile entry light, no apparent stratification could be detected but at the 15 and 25 mile stations the dissolved oxygen at the bottom was approximately 2.5 mg/L. The temperature was 55 degrees compared to 70 degrees at the surface, suggesting some thermal stratification.

At the entrance light (10 mile station) the summer plankton was recorded at 994 micrograms per liter. Four samples collected west of the light all revealed over 1,000 micrograms per liter. The samples were routinely dominated by diatoms although zooplankton and blue-green algae were also major constituents. The summer plankton at the 20 to 35 mile stations were consistently less than inside the 10 mile entrance light. Fourteen plankton samples collected between 20 and 35 miles revealed approximately 450 micrograms per liter of solids in the No. 20 mesh net. Diatoms, zooplankton and blue-green algae were major constituents of the plankton population. Secchi disc readings were generally 6 to 7 feet, slightly better than the 5 to 6 feet observed at the 10 mile entrance light. At 30 and 35 mile stations, the plankton population is reduced even further as 2 summer samples revealed only 240 micrograms per liter and Secchi disc readings were 9 to 10 feet.

Bottom organism populations between 20 and 35 miles were dominated by sludgeworms but the total population was generally less than 150 organisms per square foot. Midgefly larvae (Chironomus) were routinely observed but only approximately 20 organisms per square foot were noted. No mayflies were observed in any of the samples.

Outer Green Bay

Outer Green Bay is designated in this report as that section of the Bay from Sturgeon Bay (35 miles) to Washington Island, 70 miles from the mouth of the Fox River. Dissolved oxygen conditions in this section of

Green Bay were not affected by waste discharges of tributary streams. Moderate oxygen depletions were noted near the bottom during mid-summer at the 40 and 50 mile stations but the 70 mile station on August 19 revealed 8.7 mg/ dissolved oxygen at the surface and 8.0 mg/ at 30 meters just off the bottom. Secchi disc observations continued to improve from 9 to 10 feet at 35 miles to 16 to 20 feet at 70 miles.

Plankton populations were generally reduced to about 100 to 200 micrograms per liter at 40 miles and less than 100 micrograms per liter at 60 miles. One mid-summer sample at 70 miles revealed 43 micrograms per liter. For comparative purposes Lake Michigan at the Sturgeon Bay entrance buoy revealed 67 micrograms per liter. The Secchi disc reading at 70 miles on Green Bay was 22 feet and on Lake Michigan was 23 feet.

The bottom organism populations began to reveal significant numbers of Pontoperin affinis at 40 miles. Pontoperina affinis is a shrimp typical of aerated waters such as Lake Michigan and Big Green Lake. Were the waters of Outer Green Bay substantially affected by waste discharges at any time during the year, this organism would probably be unable to sustain itself.

NUTRIENT CONCENTRATIONS IN GREEN BAY

The quantity of plankton, bottom organism populations, and dissolved oxygen profiles in Green Bay, suggested that waste discharges were not directly responsible for nuisance conditions observed during the summer months. The apparent nuisance conditions developed on Green Bay during the summer of 1966 were a result of primary productivity. Since these nuisance conditions were generally confined to the lower and middle Bay, nutrient samples were collected from the entire Bay to determine if waste associated nutrients might be the contributing factor to excessive productivity. Table 4 is a summary of nutrient conditions observed in Green Bay and one station from Lake Michigan at the Sturgeon Bay entry buoy.

Only 2 nutrient samples were collected from inside the 10 mile light and the results were inconsistent. However, the summer samples collected outside the 10 mile light generally revealed less than the .3 mg/1 total inorganic nitrogen (sum of ammonia, nitrite, and nitrate nitrogen). Soluble phosphorous concentrations were generally less than the acceptable .02 mg/1 but total phosphorous concentrations were generally greater. These nutrient analyses would suggest that the concentrations of nitrogen and phosphorous beyond the 10 mile entry light are marginal for the development of planktonic algae blooms. Indeed, planktonic algae blooms were generally confined to the inner Bay area and were observed only occasionally between the 10 mile light and the 30 mile station. Beyond 40 miles, planktonic algae blooms were not noted. The nutrient data is, therefore, moderately consistent with planktonic algae observations.

TABLE 4B
NUTRIENT CONCENTRATIONS FROM GREEN BAY COLLECTION (1966)

Date	Miles from Mouth of Fox	Nitrogen as T.O.	NH_3	NO_2	NO_3	TION	Phosphorus as Sol.P	Tot.P	Color (s.u.)
10-19-66S	1	1.57	.46	.007	.2	(.667)	.009	.150	50
8-11-66S	4	.45	.11	.004	.08	(.194)	.024	.032	
8-09-66S	10	.83	.12	.003	.08	(.203)	.012	.088	20
8-09-66B	10	1.01	.07	.004	.08	(.154)	.015	.122	22
10-19-66S	10	.39	.05	.002	.06	(.112)	.01	.06	9
8-09-66S	20	.38	.04	.002	.06	(.102)	.004	.058	
8-09-66S	20	.62	.09	.003	.04	(.133)	.012	.066	8
10-19-66B	20	.63	.11	.002	.04	(.152)	.012	.064	7
8-10-66S	30	.50	.06	.002	04	(.102)	.007	.074	8
8-10-66B	30	.42	.09	.002	.18	(.272)	.014	.06	8
10-19-66S	30	.36	.04	.008	.06	(.108)	.009	.064	
8-18-66S	40	.39	.08	.005	.04	(.125)	.011	.048	8
8-18-66B	40	.26	.08	.002	.20	(.282)	.014	.038	5
10-21-66S	40	.29	.10	.01	.14	(.250)	.009	.052	
8-19-66S	60	.25	.02	.004	.05	(.074)	.018	.028	
10-21-66S	60	.11	.09	.004	.14	(.234)	.016	.03	6
8-19-66S	70	.26	.08	.004	.10	(.184)	.01	.02	
8-19-66B	70	.24	.05	.008	.30	(.358)	.01	.024	
10-21-66S	70	.14	.03	.003	.24	(.273)	.014	.044	
5-18-66S	Michigan	.19	.02	.003	.14	(.163)	.014	.016	
8-18-66B	Michigan	.22	.05	.003	.20	(.253)	.008	.022	
10-21-66S	Michigan	.13	.04	.002	.24	(.282)	.016	.032	

WINTER SURVEY 1967

Ice cover on Green Bay was better for sampling in 1967 than 1966. In early February there was over 20 inches of clear ice in the Lower Green Bay. Table 5B is a summary of dissolved oxygen sampling in Lower Green Bay on February 8 and 10, 1967. The sample locations are identified on Figure 6.

TABLE 5B
D.O. CONCENTRATION IN LOWER GREEN BAY
February 8-10, 1967

Field Station	Map Station*	Surface	D.O. Mid Depth	Bottom	Miles from Mouth of Fox
1	1	6.6	---	6.2	2
2	2	6.6	---	5.6	2½
3	3	4.0	---	---	3
4	4	8.3	---	---	1½
5	5	0.2	---	0.1	5
6	6	0.5	---	0.3	4½
7	7	0.3	---	0.1	4
8	8	0.2	---	0.1	5½
February 10, 1967					
4	9	0.0	0.0	0.0	8-9
5	10	0.9	0.0	0.0	8-9
6	11	2.8	0.7	0.0	8-9
7	12	7.3	3.4	0.1	8-9
8	13	10.1	9.0	1.7	8-9
9	14	11.1	9.7	5.5	8-9
10	15	7.5	1.9	0.8	9-10
11	16	9.5	8.8	0.6	9-10
12	17	11.1	10.9	10.8	9-10
13	18	9.1	8.2	0.7	9-10
14	19	8.8	5.3	0.5	9-10
15	20	6.7	4.5	0.1	9-10
16	21	0.4	0.0	0.0	9-10

* For Station Location see Figure 6.

It was apparent from the sampling on February 8 that the dissolved oxygen within three miles of the mouth of the Fox River was ample to sustain fish and fish food organisms. However, at a distance 4 miles from the mouth of the Fox River and east of the channel (Sable Point area) the dissolved oxygen concentration was less than ½ mg/l. This would not be sufficient to support fish life even under cold water conditions and could account for the absence of mayflies in the invertebrae populations.

Dissolved oxygen sampling was continued in the Red Banks area and the dissolved oxygen concentration near shore was essentially 0. The dissolved oxygen concentration increased as one proceeded to the channel area where 2 miles west of the entrance light the profile revealed 11.1 mg/l at the surface, 10.9 mg/l at the mid-water depth, and 10.8 mg/l one meter above the bottom (Station 12). These observations at Map Station 12 are probably not influenced by waste stabilization and observations east of this are apparently more or less influenced by channeling of the wastes from the Fox River along the east side of the Bay.

Figure 6

February 8-10, 1967

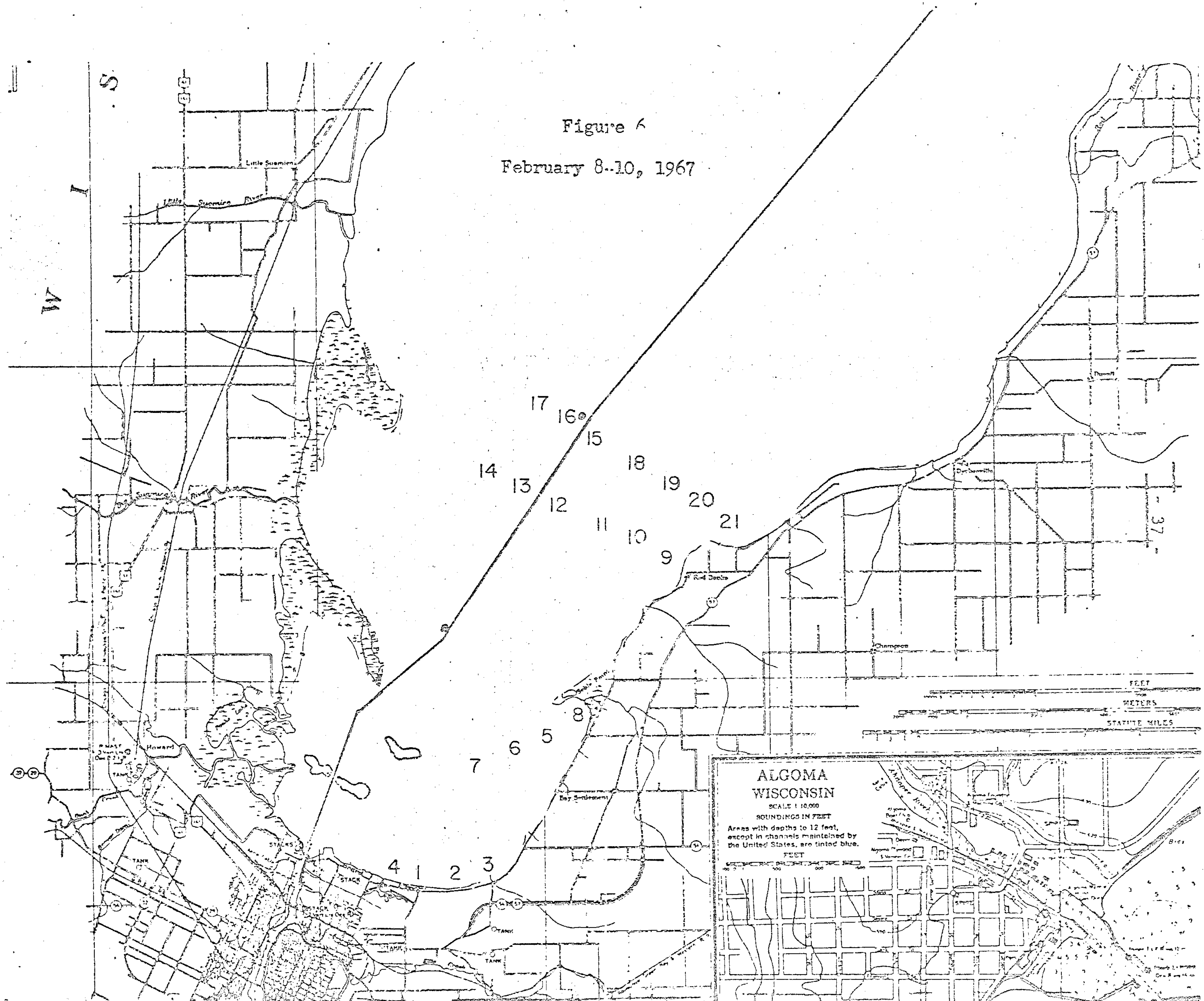


TABLE 6B
D.O. CONCENTRATIONS IN MIDDLE GREEN BAY (DYCKESVILLE AREA)
February 9, 1967

Station Number*	Surface	Mid Depth	Bottom	Miles from Mouth of Fox
1	12.2	--	2.7	14½
2	11.2	10.3	2.3	14
3	11.4	9.5	1.4	13½
4	10.5	10.4	1.5	13
5	7.8	6.1	0.5	12½
6	5.6	1.0	0.0	12
7	3.1	0.7	0.0	11½
8	2.6	0.2	0.0	11
9	8.1	5.4	0.0	10½
10	12.1	12.1	0.6	10
11	4.9	1.1	0.0	13½
12	11.2	9.2	2.9	14
13	12.5	12.3	5.0	13
14	12.4	10.6	1.3	13½
15	12.9	12.6	2.4	14½
16	12.9	12.4	5.4	13½
17	10.4	9.6	0.6	13½
18	11.6	10.3	1.1	14
19	12.0	12.0	2.1	14
20	12.6	11.6	1.5	15
21	13.1	10.6	4.3	16
22	13.0	13.1	10.1	18
23	13.3	12.7	11.1	18

*For Station Location see Figure 7.

Sampling in the Dyckesville area was completed on February 9, 1967, and the summary of the sample results are tabulated in Table 6B. Figure 7 identifies the station location of Stations 1-23. Three additional stations were selected approximately 25 miles from the mouth of the Fox River and the sampling was completed on February 10. The results of the latter sampling are tabulated in Table 7B.

TABLE 7B
D.O. CONDITION IN MIDDLE GREEN BAY
February 10, 1967

Station Number*	Surface	Mid Depth	Bottom	Miles from Mouth of Fox
1	12.3	11.9	11.8	25
2	12.1	12.0	11.8	25
3	10.9	9.9	8.9	25

*For Station Location see Figure 7.

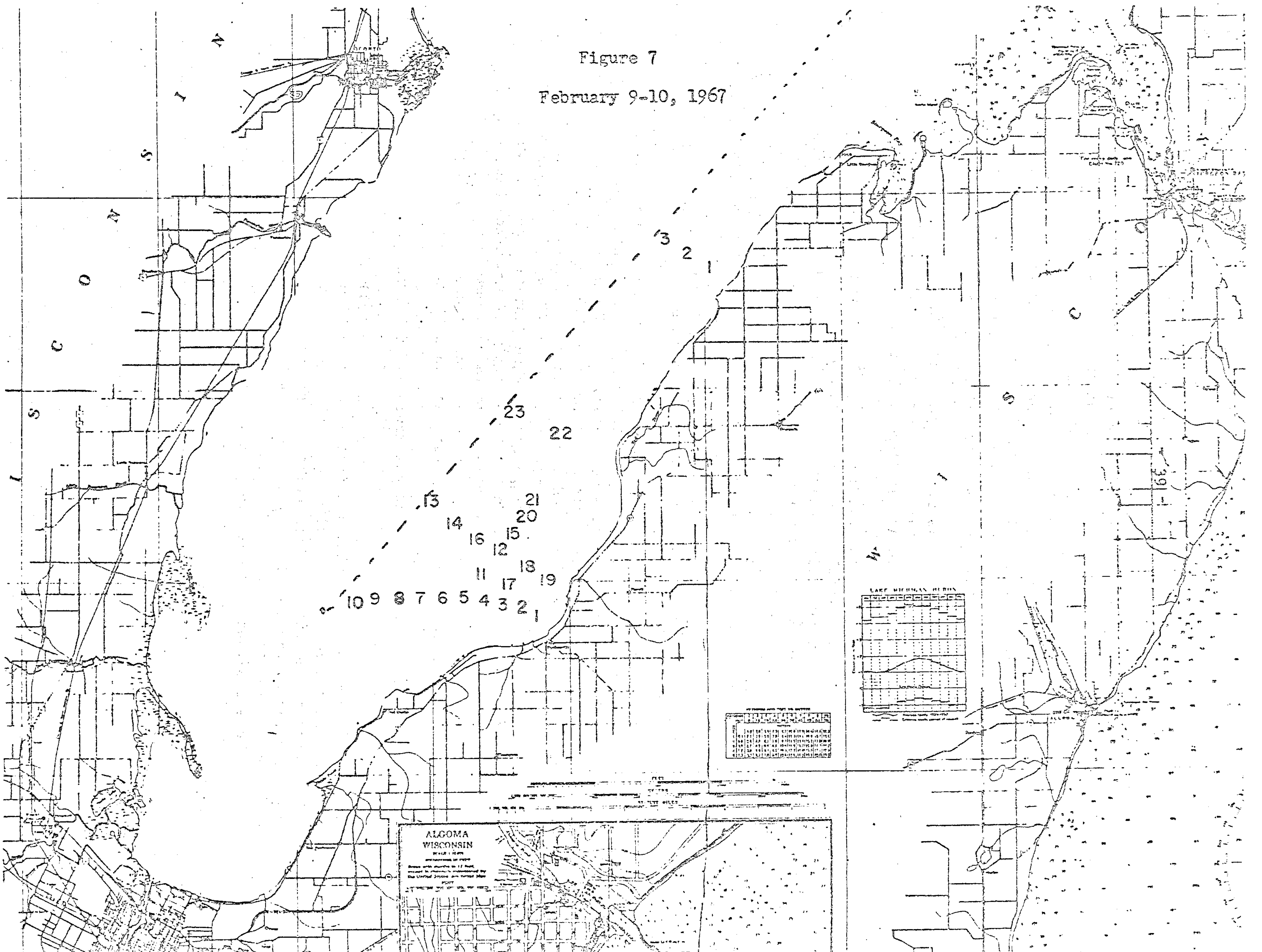


Figure 7

February 9-10, 1967

The area approximately 2 to 3 miles east, northeast of the entrance light revealed no dissolved oxygen at the bottom and only 2 to 3 mg/l at the surface. When proceeding west, north, or east, the dissolved oxygen condition tended to improve. The concentration at the surface was over 5 mg/l at all other sample sites. The concentration at the bottom, however, was significantly reduced (less than 3 mg/l) out to approximately 16 miles. At 18 miles from the mouth of the Fox River, there was no apparent depletion in dissolved oxygen on February 9.

The 3 sample sites 25 miles from the mouth of the Fox River and tabulated in Table 7B suggest that there was no apparent waste associated dissolved oxygen depletion at the time of sampling.

The dissolved oxygen observations during the February sampling were confirmed by commercial fishermen who had been forced to move nets from sites that were recording less than 1 mg/l dissolved oxygen at the bottom and were having no difficulty in areas recording the higher values.

On March 9 and 10, the region from Dyckesville to Little Sturgeon Bay was again surveyed to determine how far the front of low dissolved oxygenated water had proceeded. Table 8B is a summary of dissolved oxygen observations and Figure 8 locates the sample areas.

By March 9, the commercial fishermen had abandoned the Dyckesville area as a site of net fishing. However, the dissolved oxygen conditions were not as low as were observed a month earlier. Stations 2, 3, and 4 which had previously recorded dissolved oxygen values of less than 1 mg/l, on March 9 revealed dissolved oxygen values of no less than 2 mg/l. However, Stations 10, 12, and 13, approximately 18 miles from the mouth of the Fox River that revealed no apparent oxygen depletion in February, revealed less than 1 mg/l on March 9. Commercial fishermen in this area were limited to the immediate shoreline area (approximately ½ mile) where the dissolved oxygen at the bottom was approximately 5 mg/l or more. Stations 27 and 28 (27 miles from the mouth of the Fox River) also revealed less than 1 mg/l dissolved oxygen near the bottom. Commercial fishermen at Station x and y (Figure 9), 26 miles from the Fox River and ½ to 1 mile from shore, reported that on March 5 when the nets were lifted there were no dead fish. On March 10, 2,000 feet of gill net was being removed and the fish in the outer section were dead while those in the section near the shore were alive. A check of the dissolved oxygen conditions in the section of the net where the fish were dead (Station x) revealed 0.1 mg/l. Approximately 800 feet away near the opposite end of the net, the dissolved oxygen was recorded as 9.9 mg/l. These observations adequately explained the reason for the fish mortality. This suggests the magnitude of the oxygen depletion and the sharp boundaries that can be detected miles from the waste source.

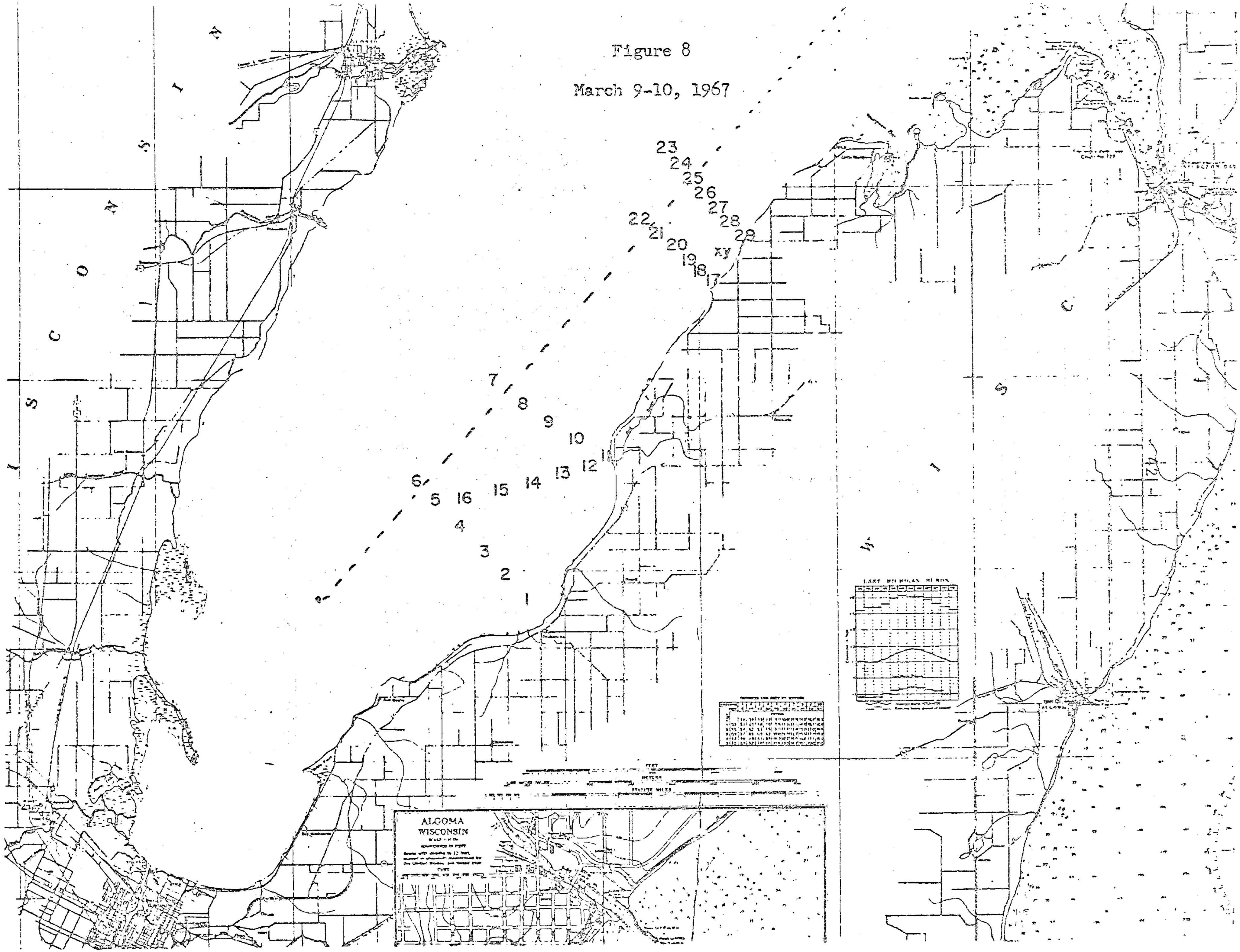
TABLE 8B
D.O. CONCENTRATION FOR MIDDLE GREEN BAY
March 9 & 10, 1967

Field Station	Map Station*	Surface	Mid Depth	Bottom
March 9, 1967				
1	1	10.6	8.9	1.8
2	2	8.3	8.5	3.3
3	3	10.3	9.8	2.5
4	4	10.5	9.7	8.2
5	5	12.9	7.5	9.8
6	6	13.6	12.5	10.0
7	7	11.7	11.3	6.7
8	8	11.7	11.2	5.4
9	9	11.9	10.8	2.0
10	10	8.1	5.1	0.5
11	11	8.6	--	5.4
12	12	8.0	7.7	0.8
13	13	8.7	3.8	0.7
14	14	7.7	8.2	2.2
15	15	8.5	8.5	2.1
16	16	10.0	10.9	2.5
March 10, 1967				
1	17	7.8	--	9.0
2	18	9.1	8.0	2.2
3	19	10.4	10.0	0.9
4	20	--	6.4	--
5	21	11.3	11.2	1.8
6	22	11.2	11.2	4.5
7	23	11.1	10.4	9.0
8	24	11.5	10.5	6.0
9	25	11.4	11.5	6.9
10	26	11.6	11.6	3.4
11	27	11.6	11.3	0.9
12	28	11.0	10.4	0.1
13	29	10.0	9.9	4.9
x	x	0.1	--	0.1
y	y	--	--	9.9

*For Station Location see Figure 8.

Figure 8

March 9-10, 1967



A final dissolved oxygen collection was made on March 23, 1967. Two transacts were developed from the Door County shoreline, one from Chadiour's Landing approximately 25 miles from the mouth of the Fox River and the second at Kohl's Landing, 27 miles from Green Bay. Table 9B is a summary of dissolved oxygen collection data and Figure 9 is an identification of the sampling sites.

TABLE 9B
D.O. COLLECTIONS FROM MIDDLE GREEN BAY
March 23, 1967

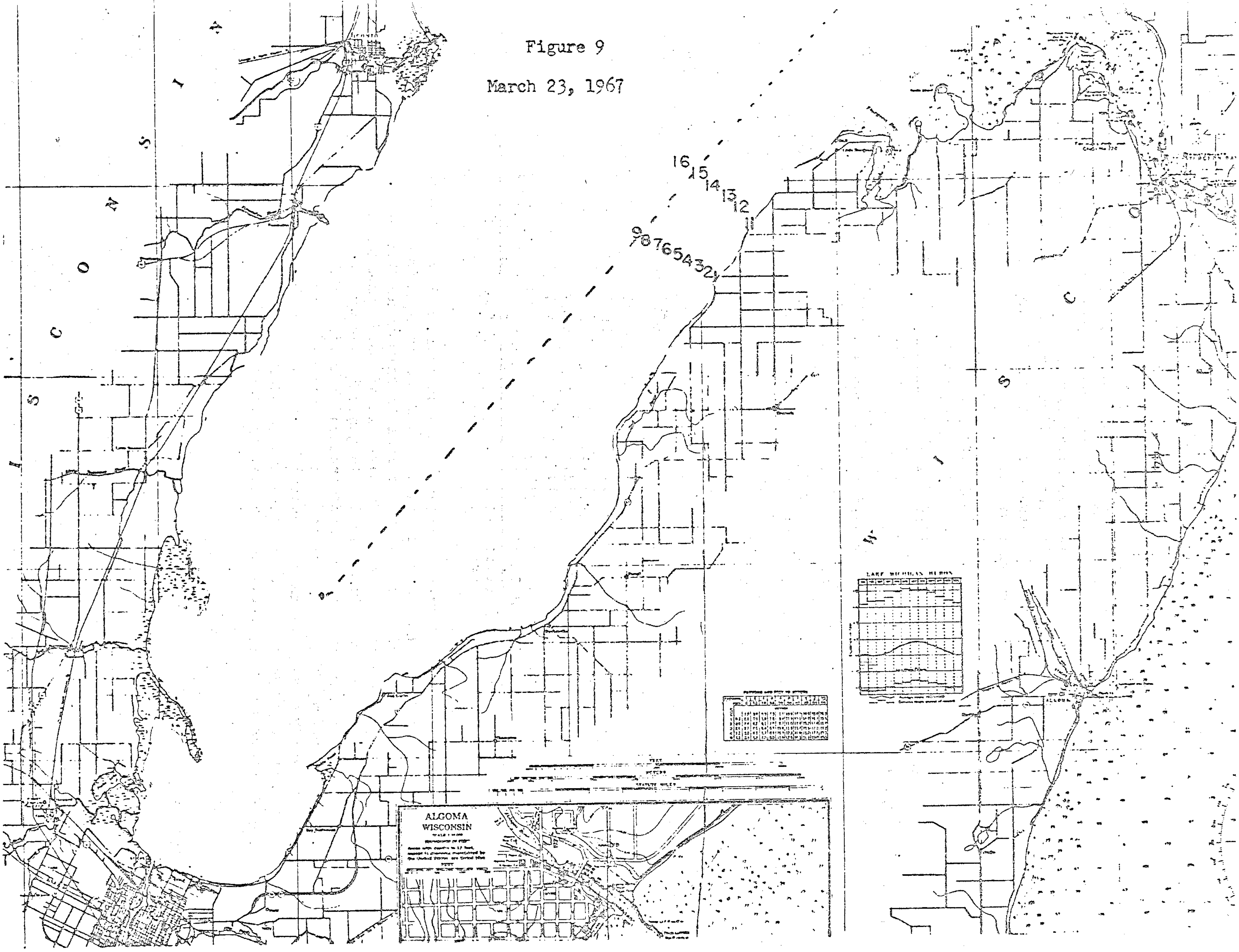
Field Station	Map Station*	Surface	Mid Depth	Bottom
1	1	8.0		3.4
2	2	7.5	4.3	3.2
3	3	9.9	7.8	0.5
4	4	10.4	3.9	0.2
5	5	10.6	3.7	0.1
6	6	10.2	5.3	0.1
7	7	9.3	7.7	0.1
8	8	9.6	8.3	0.2
9	9	10.5	4.2	0.3
1	11	9.9	8.3	3.0
2	12	11.1	11.0	0.2
3	13	12.1	8.2	2.1
4	14	12.5	12.6	4.0
5	15	12.4	12.6	3.6
6	16	12.5	12.6	6.1

*For Station Location see Figure 9.

The sampling of March 23 suggest that at a distance of 25 miles from the mouth of the Fox River the delineation of low dissolved oxygen was not nearly as sharp as it was earlier in the month. However, the low dissolved oxygen encompassed almost all of the bottom waters between the channel and ½ mile from shore. In general, surface waters retained an adequate dissolved oxygen concentration to sustain fish life. At Kohl's Landing (27 miles from the mouth of the Fox River) the dissolved oxygen in the deep waters had apparently been affected but at only one station had it been reduced to less than 2 mg/l. Again surface water observations were probably not materially affected.

Figure 9

March 23, 1967



WATER QUALITY STANDARDS

Water quality standards have been adopted for the state's interstate surface waters. These consist of waters located on the state boundary or flowing into or out of Wisconsin. The November, 1967, water quality hearings pertain to the establishment of intrastate surface waters.

Four classifications have been set forth in the standards. These are: public water supply, fish and other aquatic life, recreational use, and industrial and cooling water use. In addition, all surface waters must meet minimum standards.

According to the interstate standards, Green Bay open waters would meet the water quality standards and requirements for all water uses. Swimming beach waters should meet the standards for body contact recreation. Harbor areas and shoreline sections in the vicinity of pollutional outlets and in areas influenced by the discharges of the Oconto, Peshtigo, Menominee and Fox Rivers should meet minimum water quality standards and the requirements for cooling and industrial water supply.

Most of the inland lakes and other intrastate waters will be classified for recreational use and fish and other aquatic life. Rather than itemize each intrastate water and its various sectors, the approach is to cite as exceptions the waters and sectors that either do not and are unlikely to be able to meet the standards for recreational use and fish and other squatic life or that are classified for other uses. These proposed exceptions are: minimum standards apply to Plum Creek below Holland for 3 miles in Brown County, Tributary of the East River below Greenleaf for 2 miles in Brown County, and Tributary of Dutchman Creek below Austin Straubel Field for 2 miles in Brown County; minimum standards and those for partial body contact recreation, and industrial and cooling water use pertain to the Fox River below the upper dam in the City of Appleton downstream to the mouth; minimum standards and those for industrial and cooling water use in addition to the standards for recreational use, and fish and other squatic life apply to the East River in the City of Green Bay; minimum standards and those for industrial cooling water use and public water supply in addition to the standards for recreational use, and fish and other squatic life apply to the Fox River from Lake Winnebago downstream to the upper dam in the City of Appleton.

DISCUSSION

The discharge of fermentable organic wastes to a confined surface water results in the development of a degree of pollution dependent primarily on the oxygen requirements of such wastes and the amount of dissolved oxygen available in the receiving waters. Where the organic loading, expressed as biochemical oxygen demand, exceeds the self-purification capacity of the stream, crticial and zero dissolved oxygen concentrations develop at downstream locations. This condition creates an environment unsuitable for fish and other clean water forms of aquatic life, renders water unfit for general recreational purposes and undesirable for stock watering. Under high loadings the water may have a dark appearance, be septic and give off offensive odors. The zone of decomposition extending below any sewer discharging such wastes exhibits characteristic chemical-physical-biological phenomena which may be measured by analyses of stream water and biological samples taken above and below such sources of waste.

Biochemical oxygen demand is a measure of the amount of oxygen utilized by fermentable organic matter in undergoing decomposition. For a given section of stream the biochemical oxygen demand--dissolved oxygen relationship is controlled by temperature, time, reaeration and concentration. When the temperature of a water is increased, its ability to hold oxygen is decreased. With increased stream temperature, decomposition proceeds at a more rapid rate and the point of low dissolved oxygen will be found nearer the point of discharge. Conversely, with cold water temperatures the rate of decomposition is slowed up and the zone of low dissolved oxygen is farther downstream from the pollution source. For a given biochemical oxygen demand loading and open stream waters, with temperatures just above the freezing point, critical oxygen conditions are less likely to occur because of the higher initial dissolved oxygen and improved reaeration capacity. With ice cover, much of a stream's reaeration ability may be lost and critical conditions can develop at a substantial distance from the pollution source.

While untreated and insufficiently treated sanitary sewage possesses the same dissolved oxygen consuming properties as organic industrial waste, such sewage also contains bacteria of intestinal origin which may create a public health hazard for persons coming in contact with waters receiving such waste.

The discharge of an undesirable level of settleable and suspended solids may cause the formation of sludge and sediment deposits on the stream bed, interfering with the development of normal biological life of the stream. Furthermore, particulate matter frequently causes turbidity and color to the surface water making it objectionable. Soluble organic solids promote slime growths which attach themselves to the stream bottom and vegetation. Slime growths create an unsightly condition and interfere with the habitat of fish food organisms.

The temperature-dissolved oxygen-waste loading interrelationships and affects of ice cover are brought out in the report and its tables. During the warm weather, critical dissolved oxygen conditions are common on the Fox River from Appleton through the City of Green Bay and for a distance of 2-3 miles into the Bay. In the colder months, from about mid-November into April, the stream dissolved oxygen is generally in excess of 5 mg/l. However, during the winter and particularly after prolonged heavy ice cover, low dissolved oxygen concentrations can extend into Green Bay for a distance of nearly 30 miles.

A summary of the results of cooperative stream surveys from 1964 through 1966 is shown in Table 3. These samples are collected once per week from June through September. A review of the data in Table 3 and other similar information for the Lower Fox River during the past 15 years indicates a deterioration through Little Lake Butte de Morts to the vicinity of Appleton, little change between Appleton and Wrightstown, and an improvement at De Pere. This condition is apparent at the De Pere Dam sampling station. Out of 16 summer samples for dissolved oxygen, none had less than 2 mg/l and only 2 were less than 3 mg/l during 1966. In contrast, summer samples collected during the late 1950's had dissolved oxygen concentrations of less than 1 mg/l, 25-50 per cent of the time.

Table 4 lists the waste flow and the tons of BOD and suspended solids discharged per day from each pulp and paper mill on the Lower Fox River. Corresponding pulp and paper production in tons per day appear in Table 5. A summary of the total mill production and loading to the Lower Fox River appears in Figure 1A of the Appendix. Improved laboratory and shipping procedures were begun about 1960 to better reflect actual stream loadings. Consequently, the BOD plot between the years of 1952 and 1959 has been adjusted to compensate for these changes. In general, during the 15-year period, total production has doubled while the discharge of suspended solids has increased by 50 per cent. There seems to be a down trend in total tons of BOD discharged during the last four years. This is based on both the annual mill and stream surveys. Reaeration has been helpful too in improving low dissolved oxygen conditions.

CONCLUSIONS

The population and industrial growth of the Lower Fox River is proceeding at a relatively fast rate. The major industries have recovery facilities for strong wastes and by the spring of 1968 it is anticipated that all municipal sewage treatment plants within the basin will have provisions for secondary treatment. An improvement in water quality of the Lower Fox River has been noted in the De Pere area. Some municipalities are in need of improved facilities and industry must reduce its pollutional load to alleviate undesirable conditions. Substantial improvements are needed to meet the proposed water quality standards.

Respectfully submitted,

F. H. Schraufnagel
Chief, Water Quality Section

L. A. Montie
Chief, Waste Treatment Section

L. A. Lueschow
Chief Biologist

James Lissack
Regional Director

Gary Karl
Public Health Biologist

J. R. McKersie
Engineer, Water Quality Section

TABLE 1
LOWER FOX RIVER - MAIN STEM
1966-1967

No.	Source or Stream	Miles	Type of Waste	Treatment	Est. Daily Discharge Gallons	Est. Daily Discharge Lbs. B.O.D.
1	Gilbert Paper Company	39.8+	Rag pulping & Paper	Save-all & Metro.	890,000	740
2	John Strange Paper Company	39.8	Paper	Save-all & Metro.	1,600,000	1,840
3	George A. Whiting Paper Company	38.7	Paper	Save-all	320,000	380
4	Bergstrom Paper Company	39.8	De-inked Pulp & Paper	Clarification	4,200,000	19,700
5	Kimberly-Clark Neenah Division	40.1	Rag Pulping & Paper	Save-all & Metro.	530,000	300
6	Kimberly-Clark Badger Globe	39.9	Paper	Save-all & Metro.	530,000	140
7	Kimberly-Clark Lakeview	39.2	Paper	Save-all & Metro.	5,250,000	1,460
	Neenah Slough	38.4				
8	Kimberly Clark STP	37.7	Sewage	Secondary	7,000	1.2
9	Neenah-Menasha, Cities of	37.6	Sewage	Secondary	16,000,000	2,080
9A	Kimberly Clark Marketing Center	37.5	Sewage	Secondary	?	?
10	Menasha, Town of Sanitary District #4	36.0	Sewage	Secondary	465,000	140
11	Holiday Inn	35.8	Sewage	Secondary	9,850	1.3
	Mud Creek	34.2				
12	Riverside Paper Corporation	33.3	Paper	Save-all	2,530,000	1,500
13	Consolidated Papers Inc.	32.1	Sulfite Pulp	S.S.L. Evaporation	8,130,000	30,880
14	Foremost Foods	30.8	Dairy	None	1,281,000	299
15	Appleton, City of	30.0	Sewage	Secondary	8,339,000	5,890
16	Kimberly-Clark Kimberly	29.0	Sulfite Pulp & Paper	Save-all & Lagoon	11,490,000	28,600
	Tributary	27.4				
17	Kimberly, Village of	27.0	Sewage	Secondary	359,000	90
18	Combined Paper Mills Inc.	27.0	Chemi-mechanical Pulp & Paper	Save-all & Clarification	3,050,000	5,760
19	Little Chute, Village of	26.8	Sewage	Secondary	403,000	167
	Kankapot Creek	23.7				
20	Kaukauna, City of	23.1	Sewage	Secondary	1,275,000	255
21	Thilmany Pulp & Paper Co.	23.0	Kraft Pulp & Paper	Save-all & Lagoon	26,160,000	33,660
	Plum Creek	17.4				
22	Wrightstown, Village of	16.8	Sewage	Secondary	90,000	40
23	Charmin Paper Products Co.	12.9	Groundwood Pulp	Little Rapids Pulp Mill Closed 10/31/67	30,000	100
24	Hickory Grove Sanitorium	12.0	Sewage	Secondary	14,800	6

No.	Source or Stream	Miles	Type of Waste	Treatment	Est. Daily Discharge Gallons	Est. Daily Discharge Lbs. B.O.D.
	Apple Creek	11.2				
25	Nicolet Paper Company	7.0	Paper	Save-all	1,620,000	580
26	U.S. Paper Mills Corp.	6.8	De-inked Pulp & Paper	Save-all & Lagoon	620,000	4,060
27	De Pere, City of	6.2	Sewage	Secondary	1,500,000	1,065
	Ashwaubenon Creek	5.6				
	Dutchman Creek	4.8				
28	Fort Howard Paper Company	3.7	De-inked Pulp & Paper	Save-all & Lagoon	11,400,000	32,720
29	Fort Howard Paper Company STP	3.6	Sewage	Secondary	41,000	15
30	American Can Company, Green Bay	1.4	Sulfite Pulp & Paper	S.S.L. Evaporators & Lagoons	16,300,000	43,180
	East River	1.4				
31	Charmin Paper Products Co.	1.0	Sulfite Pulp & Paper	S.S.L. Evaporators	15,380,000	45,520
32	Green Bay Packaging Inc.	0.8	Neutral sulfite sulfite semi-chemical pulp & Paper	Fluidized bed & Clarification	2,830,000	25,720
	Storm Sewer	0.7				
33	Green Bay Metropolitan Sewage District	0.1+	Sewage	Secondary	13,500,000	16,200
	NEENAH SLOUGH					
33A	Menasha Corporation	2.6	Sewage	Secondary	?	?
34	Neenah Foundry	2.5	Foundry	None	?	?
	Neenah Foundry	0.6	Foundry	None	?	?
35	Galloway Company	0.6	Milk	None	?	?
	MUD CREEK					
36	Fox River Tractor Company	3.7	Sewage	Secondary	?	?
37	Wisconsin Rendering Company	0.6	Cooling Water	None	?	?
	Tributary #1	0.5				
	Tributary #2	0.5				
38	Butte des Morts Utility Dist.	0.4	Sewage	Secondary	255,400	19
	Tributary #1					
39	Elm Tree Bakery	0.3	Bakery	Air Flotation	--	--
	Tributary #2					
40	Terrace Motor Inn	0.5	Sewage	Septic Tank	?	?

No.	Source or Stream	Miles	Type of Waste	Treatment	Est. Daily Discharge Gallons	Lbs. B.O.D.
	TRIBUTARY					
41	Hietpas Dairy Farms	2.7	Milk	None	1,200	2
42	Coenen Packing Company	2.1	Packing	Septic Tank & Tile Field	?	?
	KANKOPOT CREEK					
43	Brookside Cheese Factory	7.6	Milk	None	5,000	21
	PLUM CREEK					
44	White Clover Dairy	11.6	Milk	Connected to Sanitary District	--	--
45	Holland, Town of, Sanitary District	11.2	Sewage	Secondary	61,000	265
	APPLE CREEK					
	a. Tributary					
46	Pleasant View Cheese Factory	2.6	Milk	None	4,000	9
	ASHWAUBENON CREEK					
47	Fox River Valley Coop Creamery	7.6	Milk	Sand Filter	2,250	1
	DUTCHMAN CREEK					
	a. Tributary #1	3.8				
	b. Tributary #2	0.5				
	a. Tributary #1					
48	Austin-Straubel STP	2.8	Sewage	Secondary	48,500	6
	b. Tributary #2					
49	Paper Converting Machine Co.	0.1	Sewage	Connected to City System	?	?
	EAST RIVER					
	a. Tributary					
50	Rockland River View Cheese Factory	18.1	Milk	Pond	4,400	9
51	Scray's Cheese Company	14.0	Milk	Septic Tank	1,600	13
	b. Bower Creek	5.2				
	c. Baird's Creek	1.7				

No.	Source or Stream	Miles	Type of Waste	Treatment	Est. Daily Discharge Gallons	Lbs. B.O.D.
			a. Tributary			
52	Wrightstown Sanitary District No. 1	1.6	Sewage	Secondary & Pond	16,500	20
			b. Bower Creek			
53	Shirley Farmers Coop Cheese Factory	11.3	Milk	None	?	?
			c. Baird's Creek			
54	Liebmann Packing Company	1.8	Paunch Manure	Lagoon	0	0
			STORM SEWER			
55	C & NW Railroad	0.3	Oil	None	?	--

TABLE 2
LOWER FOX RIVER - MAIN STEM
1966-1967

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/l	Temp. °C.	pH	D.O. mg/l	MFCC per 100 ml.
1	Gilbert Paper Company	39.8+	Outfall						
2	John Strange Paper Company	39.8	Outfall						
3	George A. Whiting Paper Company	38.7	Outfall						
4	Bergstrom Paper Company	39.8	Outfall						
5	Kimberly-Clark Neenah-Division	40.1	Outfall						
6	Kimberly-Clark Badger Globe	39.9	Outfall						
		39.3	Above Neenah Dam, East Side	7-7	--	--	--	11.9	--
				7-22	10.1	24½	9.2	13.5	900
				7-26	6.4	24½	9.0	8.6	11,000
				9-12	8.8	23	9.0	14.8	<100
				2-14-67	1.2	3	8.0	11.9	100
				9-7-67	9.5	22	9.3	11.6	400
		39.3	Above Neenah Dam, Middle --Surface	7-7	--	--	--	11.0	--
		39.3	--1½ Meters	7-7	--	--	--	11.2	--
		39.3	Above Neenah Dam, West Side	7-7	--	--	--	10.7	--
				7-22	8.9	24½	9.2	12.8	700
				7-26	4.3	24½	9.0	8.6	3,800
				9-12	7.4	23	9.1	14.7	100
				2-14-67	1.4	3	7.6	9.4	<100
				9-7-67	10	22	9.2	11.6	700
7	Kimberly-Clark Lakeview	39.2	Outfall						
		38.8	Above Menasha Dam, East Side	7-7	--	--	--	11.3	--
				7-22	8.7	24	9.2	11.7	3,000
				7-26	5.7	25	9.1	9.3	500
				9-12	10.2	24	9.4	15.4	200
				2-14-67	0.6	3	8.1	13.1	<100
				9-7-67	12	22	9.2	12.1	500

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		38.8	Above Menasha Dam, Middle --Surface	7-7	--	--	--	11.1	--
		38.8	--1½ Meters	7-7	--	--	--	11.1	--
		38.8	Above Menasha Dam, West Side	7-7	--	--	--	11.1	--
				7-22	10.1	24½	9.2	11.6	500
				7-26	5.1	25	9.1	9.2	5,000
				9-12	10.1	24	9.4	15.1	300
				2-14-67	1.8	3	8.0	12.0	< 100
				9-7-67	13	22	9.3	12.5	500
8	Kimberly-Clark Corporation	37.7	STP Outfall	11/1/67	20	--	7.6	--	--
9	Cities of Neenah & Menasha	37.6	STP Outfall	10/30/67	7.4	--	7.6	--	--
9A	Kimberly-Clark Marketing Center	37.5	STP Outfall	--	--	--	--	--	--
		37.4	R.R. Bridge Below, East Side	7-26	8.5	27	9.2	12.7	8,000
				9-12	9.3	23½	9.2	13.7	4,000
				2-14-67	8.0	4	8.0	12.8	3,000
				9-7-67	13	22	9.2	11.4	1,000
		37.4	R.R. Bridge Below, Center	7-26	13	26½	9.2	10.7	46,000
				9-12	19.6	24½	8.8	10.2	50,000
				2-14-67	4.9	4	8.0	12.6	280,000
				4-7-67	8.0	22	9.2	10.8	3,000
		37.4	R.R. Bridge Below, West Side	7-26	11.5	27	9.2	11.6	320,000
				9-12	13.0	24	9.1	12.7	30,000
				2-14-67	2.1	3	7.8	11.7	1,000
				9-7-67	12	23	9.1	10.4	20,000
10	Town of Menasha Sanitary District	36.0	STP Outfall	10-31-67	36	--	7.1	--	--
11	Holiday Inn	35.8	STP Outfall	9-27	34.1	24	7.8	0.6	--
				11-10	19.7	--	--	--	--
				10-31-67	16	--	7.5	--	--
		33.6	Above Appleton, East Side	7-7	--	--	--	7.9	--
				7-22	8.4	24	8.7	7.2	100,000
				7-27	6.8	26	8.8	6.0	110,000
				9-12	6.5	23½	8.2	6.1	80,000
				2-14-67	3.1	2	7.8	11.6	130,000
				9-7-67	12	22	9.0	5.0	29,000

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/l	Temp. °C.	pH	D.O. mg/l	MFCC per 100 ml.
		33.6	Above Appleton Center --Surface	7-7	--	--	--	8.1	--
		33.6	--1½ Meters	7-7	--	--	--	6.0	--
		33.6	Above Appleton Center	7-22	9.5	24	8.8	6.7	90,000
				7-27	6.9	26	8.8	5.1	100,000
				9-12	8.4	24	8.6	8.2	130,000
				2-14-67	3.4	2	7.6	11.6	83,000
				9-7-67	16	23	9.0	8.2	400,000
		33.6	Above Appleton West Side	7-7	--	--	--	7.5	--
				7-22	10.1	23½	8.9	7.2	90,000
				7-27	6.8	26	8.8	5.8	90,000
				9-12	7.9	24	8.4	7.8	50,000
				2-14-67	3.2	2	7.6	11.2	< 1,000
				9-7-67	16	23	9.1	9.0	30,000
12	Riverside Paper Corporation	33.3	Outfall						
13	Consolidated Papers Inc.	32.1	Outfall						
14	Foremost Foods	30.8	Outfall #1	2-7-67	13.1*	--	--	--	--
		30.8	Outfall #2	2-7-67	15.8*	--	--	--	--
		30.8	Outfall #3	2-7-67	< 6 *	--	--	--	--
		30.8	Outfall #4	2-7-67	43 *	--	--	--	--
		30.8	Outfall #5	2-7-67	430 *	--	--	--	--
15	City of Appleton	30.0	STP Outfall	10-25	53.2*	17	7.4	1.2	--
16	Kimberly-Clark Kimberly	29.0	Outfall						
		28.2	Above Kimberly East Side	7-7	--	--	--	4.8	--
				7-22	12.7	23½	7.9	2.0	480,000
				7-27	10.0	26½	8.0	2.3	1,000,000
				9-12	8.9	22½	7.4	1.6	600,000
				2-14-67	6.0	2	7.6	12.7	200,000
				9-7-67	13	22	8.0	1.8	2,800,000
		28.2	Above Kimberly Center -- Surface	7-7	--	--	--	4.3	--
		28.2	--1½ Meters	7-7	--	--	--	3.9	--

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/l	Temp. °C.	pH	D.O. mg/l	MFCC per 100 ml.
		28.2	Above Kimberly Center	7-22	6.6	24	8.4	3.3	150,000
				7-27	9.8	27	8.0	2.2	280,000
				9-12	9.6	23	7.4	1.9	500,000
				2-14-67	4.0	2	7.8	12.3	54,000
				9-7-67	13	23	7.9	1.6	290,000
		28.2	Above Kimberly West Side	7-7	--	--	--	4.2	--
				7-22	9.5	23½	8.2	2.9	130,000
				7-27	9.2	26½	8.0	2.1	90,000
				9-12	11.8	23	7.5	2.2	240,000
				2-14-67	5.8	2	7.8	12.4	20,000
				9-7-67	13	22	8.2	1.7	300,000
17	Village of Kimberly	27.0	STP Outfall	8-24-67	32.4*	20	7.6	1.5	--
				3-30	22.4*	9	7.4	5.5	--
18	Combined Paper Mills, Inc.	27.0	Outfall						
19	Village of Little Chute	26.8	STP Outfall	5-9-67	99 *	11	7.6	0.1	--
		24.5	Above Kaukauna East Side	7-7	--	--	--	3.2	--
				7-21	8.6	25	7.4	1.5	>300,000
				7-28	9.8	27	7.4	0.1	--
				9-12	14.3	23	7.2	0.1	1,100,000
				2-14-67	12.0	2	7.8	11.7	300,000
				9-7-67	17	22	7.5	0.0	1,300,000
		24.5	Above Kaukauna --Surface Center	7-7	--	--	--	3.7	--
		24.5	2½ Meters	7-7	--	--	--	3.4	--
		24.5	Above Kaukauna Center	7-21	8.1	25	7.5	2.0	>400,000
				7-28	7.2	27	7.4	0.4	--
				9-12	10.3	22½	7.3	0.5	1,000,000
				2-14-67	7.8	2	7.8	12.3	61,000
				9-7-67	13	22	7.5	0.2	1,100,000
		24.5	Above Kaukauna West Side	7-7	--	--	--	5.1	--
				7-21	7.1	25	7.4	2.7	>150,000
				7-28	7.7	27	7.4	0.9	--
				9-12	8.6	23	7.3	1.1	1,600,000
				2-14-67	4.1	2	7.8	13.2	34,000
				9-7-67	8.0	22	7.5	0.4	700,000
20	City of Kaukauna	23.1	STP Outfall	10-9	77.1*	--	7.4	--	--
21	Thilmany Pulp & Paper Company	23.0	Outfall						

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/l	Temp. °C.	pH	D.O. mg/l	MFCC per 100 ml.
		19.7	Below Kaukauna East Side	7-7	--	--	--	0.6	--
				7-21	7.1	24	7.4	0.0	>150,000
				7-28	7.7	28	7.3	1.1	--
				9-12	12.4	23	7.2	0.0	2,600,000
				2-14-67	7.2	1	7.9	11.9	50,000
				9-7-67	9.5	22	7.4	0.2	160,000
		19.7	Below Kaukauna --Surface Center	7-7	--	--	--	0.6	--
		19.7	--2½ Meters	7-7	--	--	--	0.5	--
		19.7	Below Kaukauna Center	7-21	8.7	24	7.4	0.0	>300,000
				7-28	8.9	27	7.4	0.2	--
				9-12	11.4	23	7.2	0.0	2,500,000
				2-14-67	7.8	1	7.8	12.2	--
				9-7-67	8.9	22	7.4	0.3	100,000
		19.7	Below Kaukauna West Side	7-7	--	--	--	0.9	--
				7-21	8.0	24	7.4	0.0	>250,000
				7-28	8.7	27	7.3	0.2	--
				9-12	11.7	23	7.2	0.0	2,200,000
				2-14-67	8.3	1	7.9	12.0	260,000
				9-7-67	9.8	22	7.5	0.3	400,000
		18.7	Above Wrightstown, East Side	7-20	7.4	25	7.4	1.4	200,000
				7-28	7.5	27	7.3	0.4	--
		18.7	Above Wrightstown, Center	7-20	8.0	25	7.4	1.3	140,000
				7-28	8.0	27½	7.3	0.4	--
		18.7	Above Wrightstown, West Side	7-20	7.5	25	7.4	1.7	100,000
				7-28	8.7	27½	7.4	1.1	--
22	Village of Wrightstown	16.8	STP Outfall	6-15	38.0*	15	7.3	2.5	--
		14.1	Below Wrightstown East Side	7-7	--	--	--	1.2	--
				7-20	3.5	25	7.6	2.7	11,000
				7-28	6.6	28	7.4	2.0	--
				9-12	9.8	22½	7.1	0.2	1,200,000
				2-15-67	8.1	1	7.6	11.0	100,000
				9-7-67	6.2	21	7.5	0.6	21,000
		14.1	Below Wrightstown, Center --Surface	7-7	--	--	--	1.3	--
		14.1	--2 Meters	7-7	--	--	--	1.1	--

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		14.1	Below Wrightstown Center	7-20	8.9	25	7.6	2.6	11,000
				7-28	7.4	27½	7.4	1.5	--
				9-12	9.4	22½	7.2	0.2	460,000
				2-15-67	10.0	1	7.8	11.7	180,000
				9-7-67	6.7	21	7.5	0.3	11,000
		14.1	Below Wrightstown, West Side	7-7	--	--	--	1.1	--
				7-20	6.0	25	7.6	2.9	9,000
				7-28	6.9	28	7.4	1.5	--
				9-12	9.8	22½	7.2	0.2	>2,500,000
				2-15-67	8.3	1	7.8	11.8	160,000
				9-7-67	5.2	21	7.5	0.4	17,000
23	Charmin Paper Products Co.	12.9	Outfall						
		12.4	Below Little Rapids East Side	7-20	5.7	24	7.8	3.2	8,000
				7-29	8.3	26	7.2	0.6	420,000
				9-8	6.3	22½	8.2	8.8	33,000
		12.4	Below Little Rapids Center	7-20	5.2	24	7.8	2.5	8,000
				7-29	7.6	26	7.1	0.3	410,000
				9-8	5.5	22	7.6	5.5	44,000
		12.4	Below Little Rapids West Side	7-20	6.1	24	7.8	3.6	12,000
				7-29	8.1	26½	7.2	0.2	370,000
				9-8	5.7	22	7.6	5.0	41,000
24	Hickory Grove Sanitary	12.0	STP Outfall	5-11	44.0*	15	7.1	4.0	--
		7.5	Above DePere East Side	7-7	--	--	--	7.4	--
				7-20	7.8	23	7.8	5.4	22,000
				7-29	7.2	26½	7.4	4.2	10,000
				9-8	7.4	22½	8.4	10.4	15,000
				2-15-67	4.8	½	7.6	10.7	50,000
				9-6-67	8.3	25	8.4	9.0	1,800
		7.5	Above DePere --Surface Center	7-7	--	--	--	7.3	--
		7.5	--3 Meters	7-7	--	--	--	6.4	--
		7.5	Above DePere Center	7-20	6.4	23	7.8	4.6	20,000
				7-29	6.1	26½	7.2	2.1	20,000
				9-8	7.2	21½	8.2	9.4	18,000
				2-15-67	5.7	½	7.6	11.4	57,000
				9-6-67	11	22	8.1	7.4	1,600
		7.5	Above DePere West Side	7-7	--	--	--	7.4	--
				7-20	7.5	23	7.8	4.9	13,000
				7-29	5.7	26½	7.2	1.7	20,000
				9-8	7.3	22	7.8	8.0	14,000
				2-15-67	6.9	½	7.6	11.0	69,000
				9-6-67	8.6	22	7.7	4.0	700

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		7.2	Dam Headrace	2-3	2.8	½	7.4	10.2	73,000
				2-24	4.4	0	7.5	12.8	35,000
				12-12	10.1	1	7.4	--	71,000
				2-1-67	5.4	½	7.4	10.6	56,000
				2-28-67	5.4	1	7.5	10.7	32,000
25	Nicolet Paper Co.	7.0	Outfall						
26	U.S. Paper Mills Corporation	6.8	Outfall						
27	DePere, City of	6.2	STP Outfall	9-21	111.0*	19	7.0	1.0	--
		6.1	Below DePere East Side	7-7	--	--	--	5.7	--
				7-19	6.3	25	7.6	4.7	23,000
				7-29	5.8	26	7.5	6.1	15,000
				9-8	8.9	22½	7.8	9.5	28,000
				2-16-67	7.2	0	7.6	12.0	52,000
				9-6-67	9.2	23	8.1	8.1	13,000
		6.1	Below DePere --Surface Center	7-7	--	--	--	5.5	--
		6.1	--4 Meters	7-7	--	--	--	4.2	--
		6.1	Below DePere Center	7-19	6.7	25	7.5	3.6	16,000
				7-29	8.3	26	7.5	5.8	9,000
				9-8	8.6	22½	7.8	10.2	26,000
				2-16-67	8.4	0	7.5	10.8	29,000
				9-6-67	10	24	8.1	8.4	5,000
		6.1	Below DePere West Side	7-7	--	--	--	5.4	--
				7-19	7.4	25	7.6	5.4	130,000
				7-29	10.3	26	7.4	6.7	100,000
				9-8	8.4	27	7.6	9.0	2,600,000
				2-16-67	8.4	0	7.4	10.1	170,000
				9-6-67	7.1	22	7.5	5.8	3,100,000
28	Fort Howard Paper Company	3.7	Outfall						
29	Fort Howard Paper Company	3.6	STP Outfall	5-18	39.0*	27	7.2	--	--
		2.3	Mason Street	3-29	4.1	3½	7.7	13.1	16,000
				4-28	4.6	9	7.4	7.7	9,000
				5-31	2.4	17½	7.4	4.3	3,500
				6-29	3.4	21½	7.2	1.7	12,000
				7-29	7.1	27	7.3	2.2	25,000
				8-31	5.2	23	7.2	0.1	130,000
				9-28	6.9	15	7.3	3.5	16,000

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/l	Temp. °C.	pH	D.O. mg/l	MFCC per 100 ml.
				11-2	6.8	6	7.2	4.5	21,000
				11-30	7.8	1½	7.4	10.6	71,000
				4-13-67	7.4	5	7.8	10.7	16,000
				6-1-67	2.5	18½	7.4	4.6	18,000
				6-29-67	1.8	21	7.6	5.2	28,000
				7-26-67	6.3	31	7.3	7.2	17,000
				9-13-67	0.6	21	7.8	7.0	12,000
30	American Can Co. Green Bay	1.4	Outfall						
31	Charmin Paper Paper Products Co.	1.0	Outfall						
32	Green Bay Packaging Inc.	0.8	Outfall						
33	Green Bay M.S.D.	0.1+	STP Outfall	10-11	143.0*	21	7.5	0.0	--
		0.1	Mouth--East Side	7-7	--	--	--	0.0	--
				7-19	10.0	26	7.2	0.0	40,000
				7-29	>17.1	29	7.0	0.0	610,000
				9-8	13.4	26	7.2	0.9	60,000
				2-16-67	15.5	0	7.5	10.6	33,000
				9-6-67	18	23	7.4	3.4	60,000
		0.1	Mouth - Center --Surface	7-7	--	--	--	0.7	--
		0.1	--3 Meters	7-7	--	--	--	0.3	--
		0.1	--5 Meters	7-7	--	--	--	0.1	--
		0.1	Mouth - Center	7-19	10.3	27	7.2	0.0	90,000
				7-29	>19.4	29	7.0	0.0	510,000
				9-8	15	26	7.2	0.9	40,000
				2-16-67	15.2	0	7.5	10.5	25,000
				9-6-67	17	23	7.2	3.5	120,000
		0.1	Mouth--West Side	7-7	--	--	--	0.7	--
				7-19	10.8	26½	7.2	0.0	60,000
				7-29	>17.9	29	7.0	0.0	510,000
				9-8	15	26	7.2	0.7	100,000
				2-16-67	17.2	0	7.4	10.5	67,000
				9-6-67	9.5	24	7.3	2.5	70,000
		0.0	Green Bay						

NEENAH SLOUGH

		3.0	U.S. 41 Above	11-19-64	2.7	3	7.4	8.0	2,200
				5-19-65	2.0	18	7.4	4.3	--
				9-27	2.1	12	7.2	4.5	1,500

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
33A	Menasha Corp.	2.6	STP Outfall	--	--	--	--	--	--
									(SUSP SLDS)
34	Neenah Foundry #2	2.5	Marathon	11-19-64	--	--	--	--	(744)
			St. Storm	5-18-65	1.1*	--	6.9*	--	(508*)
			Sewer Out-	9-27	13.1	22	--	--	(1290)
			fall	11-10	12.3	--	--	--	(796)
		1.5	Cecil St.	11-19-64	4.5	3	7.6	7.7	300
			Below	5-19-64	3.6	19	7.6	8.0	--
				9-27	2.6	14	7.2	5.5	12,000
									(SUSP SLDS)
34	Neenah Foundry #1	0.6+	Monroe St.	11-18-64	15.6*	--	--	--	(210)
			Storm	5-18-65	3.4*	--	6.7*	--	(166)
			Sewer Out-	9-27	1.4	38	--	--	(46)
			fall	11-10	3.1	--	--	--	(428)
35	Galloway Co.	0.6	Monroe St.	11-18-64	15.6*	--	--	--	--
			Storm	5-18-64	5.1*	--	7.6	--	--
			Sewer Out-	9-27	>222.	27	8.7	--	--
			fall	11-10	7.7	--	--	--	--
		0.1	Main St.	11-19-64	<1	7	7.6	4.6	61,000
			Below	5-19-65	16.3	19	7.8	6.0	--
				9-27	4.0	18	7.2	2.9	420,000
		0.0	Fox River						

<u>MUD CREEK</u>

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
36	Fox R. Tractor Company	3.7	STP Outfall	11-10	12.6	--	--	--	--
				11-1-67	73	--	7.4	--	--
		2.9	US 41	9-28	30.1	13	7.8	0.2	500,000
				11-1-67	3.9	7	7.6	8.1	--
		2.4	Spencer Ave.	9-28	130	15½	7.0	0.0	12,000,000
				11-1-67	5.8	8	7.8	9.6	--
		1.1	Prospect Ave.	9-28	7.4	12	7.6	0.7	140,000
				11-1-67	4.3	8	7.6	8.9	--
37	Wis. Rendering Company	0.6	Outfall	9-27	10.5	13	7.5	--	--
				11-10	24.3	--	--	--	--
38	Butte des Morts U.D.	0.4	STP Outfall	5-17-67	8.9*	16	7.4	1.7	--
		0.0	Fox River						

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
			MUD CREEK TRIBUTARY #1						
39	Elm Tree Bakery	0.3	Outfall	9-28	226	20	7.3	--	--
		0.3-	College Ave.	11-1-67	25	12	8.4	8.1	--
			MUD CREEK TRIBUTARY #2						
40	Terrace Motor Inn	0.5	Outfall	9-28	16.9	15	7.4	--	15,000
				11-10	--	--	--	--	700,000
				11-6-67	226	--	--	--	--
				11-1-67	7.4	--	7.5	--	--
			LOWER FOX RIVER TRIBUTARY						
		2.9	CTH "E" Above	12-15	NO FLOW				
41	Hietpas Dairy Farm	2.7	Outfall	12-15	225	--	8.2	--	--
		1.7	Town Road	12-15	NO FLOW				
		2.2	CTH "OO" Above	12-15	NO FLOW				
42	Coenen Packing Company	2.1	Outfall	12-15	1340	--	6.9	--	--
		1.6	CTH "OO" Below	12-15	NO FLOW				
		0.0	Lower Fox River						
			KANKOPOT CREEK						
		7.6+	US 10 Above	11-7	NO FLOW				
				11-30	NO FLOW				
43	Brookside Cheese Factory	7.6	Outfall	11-7	156	19	4.6	--	--
		7.6		11-30	1580	22	9.6	--	--
		7.3	Town Road Below	11-7	NO FLOW				
				11-30	NO FLOW				
		0.0	Fox River						
			PLUM CREEK						
		11.8	CTH "Q" Above	9-1	NO FLOW				
				10-20	NO FLOW				

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
44	White Clover Dairy	11.6+	Outfall	4-20-67	4.0	28	7.8	--	--
		11.6		4-20-67	>122	52	>10.2	--	--
		11.5	CTH "O"	9-1	1.5	22	7.3	5.4	80,000
				10-20	1.4	20	7.4	4.9	170,000
45	Town of Holland Sanitary District	11.2	STP Outfall	11-2-65	731	23	7.5	--	-- (SUPS SLDS)
				9-1	967	29	7.3	--	(1536)
				10-18	521 *	23	7.6	0.0	--
				3-30-67	980	--	--	--	--
				4-20-67	1260	19	6.7	--	(1560)
				7-6-67	746	28	6.7	--	--
		10.9	Below	9-1	580	26	7.6	0.0	9,600,000
				10-20	147	14	7.8	1.3	64,000,000
		7.9	CTH "Z" Below	9-1	33.8	23	8.4	10.2	80,000
				10-20	113	12½	8.2	0.0	280,000
		6.0	Town Road	9-1	8.3	23	8.4	5.8	14,000
				10-20	7.4	9	8.1	3.1	6,000
		0.0	Fox River						

APPLE CREEK TRIBUTARY

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		6.0+	Above	12-15	NO FLOW				
46	Pleasant View Cheese Factory	6.0	Outfall	12-15	>831	--	6.8	--	--
		5.3	Buchanan Road Below	12-15	NO FLOW				
		0.0	Fox River						

ASHWAUBENON CREEK

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
47	Fox River Valley Coop. Creamery	7.6	Outfall	11-4-65	50.6	10	7.2	--	--
				12-12	1910	--	5.1	--	--
		0.0	Fox River						

DUTCHMAN CREEK

a. Tributary #1

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		2.9	Above	9-13	NO FLOW				
				11-15	NO FLOW				
48	Austin-Straubel STP	2.8	STP Outfall	9-13	16. *	--	7.3	2.1	--
				11-15	96.1	--	7.4	--	--

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		2.6	CTH "GH" Below	9-13	5.3	21½	7.9	2.9	50,000
				11-15	12.9	8	7.9	5.6	40,000
		1.5	Town Road Below	9-13	4.1	22½	8.8	12.7	28,000
				11-15	1.2	4	8.0	13.1	4,500
		0.1	CTH "GG" Below	9-13	NO FLOW				
		0.0	Dutchman Creek						
			b. Tributary #2						
		0.1+	Above	11-15	NO FLOW				
				12-12	NO FLOW				
49	Paper Converting Machine Company	0.1	Outfall	11-15	36.3	--	9.1	--	--
				12-12	147	--	--	--	1,300,000
		0.0	Dutchman Creek						
			EAST RIVER						
		18.1+	Above	11-7	8.0	5	8.2	11.9	1,600
				11-30	5.7	3	8.2	13.1	6,000
50	Rockland River View Cheese Factory	18.1	Pond Outfall	11-7	39.0	7	7.6	4.9	--
				11-30	280	3	7.0	0.4	--
		17.9	STH "57" Below	11-7	8.4	5	8.1	9.4	16,000
				11-30	5.0	3	8.1	8.8	3,800
		14.0+	Above	11-7	0.9	6	8.2	10.3	1,700
				11-30	3.6	2	8.2	12.3	2,200
51	Scray's Cheese Co.	14.0	Outfall	11-7	1030	16	7.4	--	--
				11-30	1030	16	7.2	--	--
		13.9	Town Road Below	11-7	3.0	4	7.7	9.2	2,000
				11-30	5.0	2	8.2	11.6	32,000
		4.3	Allouez Ave.	8-3	1.5	22	7.6	4.8	--
				8-24	3.9	21	8.2	8.7	6,000
				11-8	3.8	6½	8.4	12.8	2,700
		2.1	Mason St.	8-3	4.9	22½	7.4	2.8	150,000
				8-24	3.0	20	7.4	5.7	21,000
				11-8	4.0	5½	7.8	10.0	27,000
		1.3	Baird St.	8-3	4.3	22½	7.3	0.7	530,000
				8-24	3.0	21	7.3	2.5	23,000
				11-8	4.7	5½	7.4	6.6	12,000

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
		1.0	Main Street	8-3	6.4	23	7.3	0.5	30,000
				8-24	4.5	21	7.2	1.5	11,000
				11-8	9.1	5	7.2	5.3	14,000
		0.7	Webster Ave.	8-3	9.5	23	7.3	0.4	8,500,000
				8-24	3.8	21½	7.2	1.6	60,000
				11-8	7.8	5.5	7.2	4.4	20,000
		0.3	Monroe St.	8-3	7.7	24	7.3	0.4	4,200,000
				8-24	5.6	22	7.2	1.6	100,000
				9-8	7.1	23	7.2	1.0	40,000
				11-8	10.5	6	7.0	4.5	13,000
		0.0	Fox River						
			EAST RIVER TRIBUTARY						
		1.7	STH "96" Above	4-6	(NO FLOW)				
				9-28	(NO FLOW)				
				10-20	(NO FLOW)				
52	Village of Greenleaf, Wrightstown Sanitary District #1	1.6	STP Pond Outfall	4-6	27.8*	4	8.8	10.0	--
				9-28	8.4	13	9.2	--	--
				10-20	10	10½	9.2	18.2	10,000
		0.8	Town Road Below	4-6	(NO FLOW)				
				9-28	(NO FLOW)				
				10-20	(NO FLOW)				
		0.0	East River						
			BOWER CREEK						
		11.4	Town Road Above	5-16-67	(NO FLOW)				
				7-6-67	3.5	21	7.5	5.8	400,000
53	Shirley Farmers Coop. Cheese Factory	11.3	Outfall	5-16-67	1560	--	5.1	--	--
				2-6-67	885	21	6.2	--	40,000,000
		11.1	Below	5-16-67	84.5	19	7.0	0.0	--
				7-6-67	94.9	19	7.3	1.4	3,200,000
		10.2	CTH "X" Below	5-16-67	2.9	20	8.8	13.6	--
				7-6-67	3.5	25	7.7	5.4	7,000
		0.0	East River						
			BAIRD"S CREEK						
		1.9	Above	4-20	0.9	10	8.2	10.5	600

No.	Waste Source	Miles	Sample Source	Date	B.O.D. mg/1	Temp. °C.	pH	D.O. mg/1	MFCC per 100 ml.
54	Liebmann Packing Company	1.8	(NO DISCHARGE)						
		1.7	Below	4-20	0.6	10	8.0	10.2	< 100
		1.3	Danz Ave.	8-3	6.8	29	11.2	6.2	<100
				8-24	1.8	21	8.8	9.6	12,000
				11-8	1.4	8	8.4	15.4	3,300
		0.7	Henry St.	8-3	1.8	20	8.6	5.6	270,000
				8-24	1.7	18	8.2	7.9	10,000
				11-8	7.4	8	7.6	5.2	230,000
		0.3	Main St.	8-3	97.4	21	7.3	0.0	7,000
				8-24	5.1	19	8.4	1.7	210,000
				11-8	>17.9	9	8.4	3.9	210,000
		0.0	East River						
			PRAIRIE AVENUE STORM SEWER						
55	C & NW Railroad	0.3+	Outfall						
		0.3	Drainage Ditch	10-20	2.1	12	7.2	6.8	--
		0.3-	Outfall						
		0.1	Storm Sewer	10-20	108	--	--	--	(OIL) (266)
				11-15	100	--	--	--	--
		0.0	Fox River						

* Composite Sample

( ) Additional Information

TABLE 3
LOWER FOX RIVER-D.B. 11A
SUMMARY OF RESULTS OF COOPERATIVE STREAM SURVEYS

Station	Discharges C.F.S. Maximum 1964	Maximum 1965	Maximum 1966	Minimum 1964	Minimum 1965	Minimum 1966	Miles	Dissolved Oxygen Mg/L Maximum 1964	Maximum 1965	Maximum 1966	Minimum 1964	Minimum 1965	Minimum 1966	Dissolved Oxygen No. of Samples Below 3Mg/L '64	3Mg/L '65	3Mg/L '66	2 Mg/L '64	2 Mg/L '65	2 Mg/L '66	1 Mg/L '64	1 Mg/L '65	1 Mg/L '66	5-Day B.O.D. Mg/L Maximum 1964	1965	1966	Temperature Range °C 1964	1965	1966	No. of Samples '64	'65	'66
Neenah Channel							38.8	10.6	10.8	9.9	3.0	3.1	4.4	0	0	0	0	0	0	0	0	0	6.9	9.6	10.3	13-25	12-23	15-26	18	18	18
Kaukauna							23.9	4.8	7.4	4.6	0.0	0.0	0.0	14	13	15	13	9	15	8	8	12	26.8	22.6	16.9	13-28	14-26	16-27	18	16	18
Wrightstown	3,460	7,830	4,280	876	1,260	1,200	17.3	2.4	7.4	4.2	0.0	0.0	0.0	13	15	16	17	13	16	13	12	14	20.2	27.6	13.2	13-28	13-26	15-26	18	19	18
De Pere Dam (1)							7.2	5.1	6.0	5.9	0.4	0.2	2.9	9	7	2	7	5	0	2	2	0	13.6	10.9	16.6	17-28	16-26	18-28	13	12	16
C B N W R R Bridge							1.1	3.7	7.2	4.4	0.0	0.0	0.4	15	12	12	12	11	10	7	9	6	26.6	13.3	20.7	16-28	14-25	16-27	14	17	17

(1)-Data for 1964 covers period of June through August

TABLE 4
LOWER FOX RIVER-PULP AND PAPER WASTE

	Miles		1952 MGD Flow	1952 Ton/Day BOD	1952 SS	1957 Flow	1957 BOD	1957 SS	1962 Flow	1962 BOD	1962 SS	1963 Flow	1963 BOD	1963 SS	1964 Flow	1964 BOD	1964 SS	1965 Flow	1965 BOD	1965 SS	1966 Flow	1966 BOD	1966 SS
Gilbert Paper Co.	39.8+	Rag pulp & paper	.52	.25	.82	.49	.36	.35	1.09	.60	.99	.89	.61	.76	.93	.68	1.32	1.11	.52	1.20	.89	.37	.32
John Strange Paper Co.	39.8	Paper	2.78	1.30	2.70	3.03	2.49	4.62	1.91	.70	1.37	2.10	.72	1.60	1.74	.84	1.43	3.22	2.81	1.01	1.60	.92	1.57
C. A. Whiting Paper Co.	38.7	Paper	.07	.01	.02	.21	.06	.17	.15	.03	.10	.24	.05	.16	.13	.04	.21	.15	.06	.19	.32	.19	.75
Bergstrom Paper Co.	39.8	Paper	.97	.40	2.79	1.00	.45	4.00	.65	.52	2.06	.67	.51	3.46	1.15	1.25	6.08	1.10	1.84	6.23	1.52	1.55	5.21
		de-ink pulp	1.65	3.83	24.04	1.54	6.00	3.71	2.31	6.70	13.26	2.27	7.22	9.41	2.38	6.74	18.62	2.40	9.02	11.42	2.58	7.90	16.20
K-C, Neenah Div.	40.1	Rag pulp							.26	.32	.41	.24	.20	.31	.36	.10	.21	.46	.11	.26			
		paper							.77	.33	.48	1.03	.38	1.12	.56	.23	.62	.37	.18	.46	.53	.15	.46
K-C, Badger Globe	39.9	Paper	2.39	.13	.74	2.14	.40	1.12	2.22	.37	.62	2.01	.26	.66	1.69	.29	.63	1.07	.17	.37	.53	.07	.18
K-C, Lakeview	39.2	Paper	5.30	1.06	2.94	6.32	1.49	2.97	5.79	1.27	3.59	5.82	.58	4.07	5.49	.92	2.17	5.71	1.20	3.11	5.25	.73	3.38
Riverside Paper Corp.	33.3	Paper	.61	.23	.46	.69	.26	.69	2.35	1.21	3.75	2.10	1.51	4.59	2.11	1.17	2.21	1.89	.97	2.60	2.53	.75	3.91
Consol. Papers Inc.	32.1	Sulphite pulp	10.46	28.64	1.31	10.82	22.86	2.63	11.43	2.157	5.20	12.50	17.58	6.68	11.88	15.06	6.25	7.97	16.81	7.62	8.13	15.44	4.13
Kimberly-Clark Corp.	29.0	Sulphite pulp	3.00	20.42	1.62	3.38	13.09	1.16	2.66	34.49	.88	4.29	16.37	4.25	3.90	13.59	1.44	3.80	21.17	2.03	3.43	10.07	1.53
		paper	5.40	.72	7.23	9.16	2.20	22.86	8.81	5.20	19.92	6.20	5.94	22.69	7.74	5.76	19.26	6.79	5.20	17.89	8.04	4.23	24.86
Combined Paper Mills Inc.	27.0	Gr. Wd. & chemi-mechanical pulp	.03	.03	.59	.54	1.10	.96	1.16	2.55	4.59	.99	1.21	1.41	1.02	3.49	1.93	1.06	1.09	1.74	.90	2.29	.63
		paper	2.77	1.56	12.37	3.13	1.52	5.83	2.11	1.72	7.21	2.01	1.26	4.91	2.13	1.45	6.33	1.92	1.01	4.70	2.07	.59	4.90
Thilmany Pulp and Paper Co.	23.0	Kraft pulp and paper	17.00	10.03	12.41	*18.80	8.57	4.12	*15.79	21.48	5.84	*21.27	11.63	8.26	*22.40	13.51	5.94	*26.70	16.98	10.30	*26.16	16.83	11.68
Charmin Paper Products Co.	12.9	Groundwood				.23	.40	.47	.04	.10	.21	.05	.16	.06	.06	.17	.12	.03	.11	.09	.03	.05	.06
Nicolet Paper Co.	7.0	Paper	1.13	.02	.23	1.30	.04	.23	2.68	.49	1.40	2.33	.15	.46	1.75	.10	.23	1.49	.10	.33	1.62	.25	.98
U S. Paper Mills Corp.	6.8	De-inked pulp and paper										63	.77	1.30							.64 .18	1.71 .32	6.10 .19
Fort Howard Paper Co.	3.7	Gr. Wd. & De-ink pulp	2.17	5.13	1.79	2.64	8.05	2.31	4.72	12.30	2.95	3.93	10.94	2.81	4.52	11.17	4.11	5.40	12.17	5.99	5.89	14.68	3.74
		paper	6.44	6.44	4.60	4.91	.59	5.08	5.63	3.17	8.92	7.02	2.46	6.99	7.22	2.02	9.35	8.03	2.05	9.40	5.51	1.60	16.80
American Can Co.	1.4	Sulphite pulp and paper	+8.53	28.59	4.15	+10.44	22.28	7.26	19.89	34.89	6.07	13.12	31.64	5.30	19.63	22.40	4.80	21.33	23.46	7.56	16.30	21.59	7.23
Charmin Paper Products Co.	1.0	Sulphite pulp and paper	4.45	15.96	2.47	10.76	14.67	5.81	11.04	34.40	11.93	14.51	24.23	11.54	15.42	28.30	12.49	14.53	22.96	8.96	15.38	22.76	14.67
Green Bay Packaging Inc.	0.8	Semi-chem. pulp and paper	2.50	9.04	1.79	3.26	15.39	3.33	2.78	17.20	3.37	3.38	22.90	4.93	3.15	24.05	2.63	2.10	16.65	2.67	2.83	18.86	2.97

* Includes mun. sew. + Incl. Bl. plant to E. River

TABLE 5
LOWER FOX RIVER-PULP AND PAPER PRODUCTION
TONS PER DAY

	Miles	1952 Pulp	1952 Paper	1957 Pulp	1957 Paper	1962 Pulp	1962 Paper	1963 Pulp	1963 Paper	1964 Pulp	1964 Paper	1965 Pulp	1965 Paper	1966 Pulp	1966 Paper
Gilbert Paper Co.	39.8+	13.00	40.0	11.2	56.60	12.31	59.13	17.24	58.12	16.91	61.83	15.10	66.88	15.60	68.65
John Strange Paper Co.	39.8		169.0		202.00		181.00		188.84		185.14		216.89		227.60
C. A. Whiting Paper Co.	38.7		13.5		16.8		17.30		18.00		15.00		17.30		18.80
Bergstrom Paper Co.	39.8	91.75	108.8	122.09	134.41	139.03	142.42	153.97	144.12	161.77	143.68	162.92	206.17	170.77	300.51
K-C, Neenah Div.	40.1					7.74	38.60	10.56	59.20	7.60	60.30	8.90	51.90	9.00	63.10
K-C, Badger Globe	39.9		89.51		92.40		91.90		89.10		66.30		65.40		65.30
K-C, Lakeview	39.2		150.04		176.20		184.70		162.70		180.30		169.00		154.10
Riverside Paper Corp.	33.3	42.00	75.00	55.00	83.00	50.00	82.00	17.00	80.90	17.00	87.60	35.00	81.70	35.40	83.90
Consol. Papers Inc.	32.1	121.50		133.00		136.80		178.20		158.60		161.80		149.70	
Kimberly-Clark Corp	29.0	81.98	278.40	93.50	470.75	96.47	452.84	71.12	470.30	60.50	460.50	83.50	385.00	78.65	405.60
Combined Paper Mills Inc.	27.0	80.11	201.78	89.70	214.00	90.04	218.04	66.36	182.37	100.86	224.57	71.54	204.95	80.08	234.11
Thilmany Paper and Pulp Co.	23.0		396.50		486.80		537.00		664.00		699.67		672.00		796.33
Charmin Paper Products Co.	12.9			33.71		11.52		16.72		13.82		11.70		7.00	
Nicolet Paper Co.	7.0		28.74		31.00		62.30		63.00		86.60		88.90		95.30
U S. Paper Mills Corp.	6.8								36.69						46.35 38.85
Fort Howard Paper Co.	3.7	158.00	188.00	233.00	284.00	287.00	358.30	293.40	366.80	320.10	344.60	403.00	492.00	399.00	484.00
American Can Co.	1.4	134.00	205.00	133.00 103.00	386.00	138.90 88.80	377.18	136.40 96.07	414.85	137.30 78.44	415.05	130.87 58.31	448.71	136.63 60.26	436.67
Charmin Paper Products Co.	1.0	316.00		368.18		648.95		815.10		848.04		921.50		1103.53	
Green Bay Packaging Inc.	0.8	90.00	†	182.00	†	189.00	†	200.00	233.00	196.00	242.00	191.00	246.00	164.00	248.00

Table 6(1)
BIOLOGICAL STATION SUMMARY-1966
LOWER FOX RIVER-DRAINAGE BASIN # 11A

Sample	Date	River Mileage	Sample Area	Station Location	Current	Bottom	Intolerant Spp.	Intolerant No.	Tolerant Spp.	Tolerant No.	V. Tolerant Spp.	V. Tolerant No.	Remarks
LF#27C	7/22/66	39.4	Neenah Channel	0.3 Mi. above dam & 0.4 Mi. below lake outlet	Slow	Rock	4	22	4	35	4	43	Green filamenteous algae.
LF#26C	7/22/66	39.1	Menasha Channel	0.8 Mi. above bridge @ Red Nun Buoy #78 & 0.5 Mi. above dam	V. slow	Rock	7	39	6	20	4	25	B. G. algae-Rivularia sp.
LF#25C	7/26/66	38.5	Neenah Channel in L. Lake Butte des Morts-Center	1000 ft. below mills O.F. down from Neenah Channel	Slow to moderate	Silt, sand, wood chips & coal	1	4	3	64	3	84	Slimes on aquatic weeds, fiber foam, wood chips.
LF#25E	7/27/66	38.5	L. Lake Butte des Morts-off east shore 300 ft.	1000 ft. above Neenah STP, 1500 ft. below mills O.F.	Slow to sluggish	Sand, silt & vegetation	3	12	6	338	9	240	Bubbles, fibers & foam. Elodea weed.
LF#25W	7/26/66	38.5	L. Lake Butte des Morts-off east shore 500 ft.	1000 ft. below mills & 500 ft. east of Neenah Slough outlet	Slow to sluggish	Fibers & sludge; fibers from mill O.F.; slimes noted	0	0	0	0	3	24	Volatile Solids 11/65-3,019 Mgms/L 1/63-10,136 Mgms/L (99% fibers & fiber knots).
LF#24C	7/26/66	37.1	Menasha Channel mouth-Center-50ft. N.E. off James Is.	200 ft. below 3 sub-merged O.F.'s and 300 ft. off east shore @ James Is.	Moderate	Rock, C. gravel	3	9	5	232	4	88	Sphaerotilus natans prolific on weeds & rocks.
LF#24E	7/26/66	37.1	Menasha Channel mouth-between east shore & James Is.	200 ft. below 3 sub-merged O.F.'s and 200 ft. east of James Is.	Moderate	Hard sand, aquatic weeds	6	17	10	82	10	134	Prolific aquatic vegetation Volatile Solids 11/65 929 Mgms/L Algae in water. (45% algae & invert. 55% fibers & knots).
LF#24W	7/26/66	37.1	Menasha Channel mouth-between CNWRR embankment & James Is.	200 ft. below 3 sub-merged and 250 ft. NE. of James Is. & 75 ft. S. of RR.	Moderate	Rock, C. sand, & gravel	7	108	9	166	10	99	Grayish colored water; sludge deposition Volatile Solids 11/63 1,389 Mgms/L 11/65 1,920 Mgms/L (Algae & invert. 90%. Fibers & knots 10%).
LF#22C	7/27/66	34.2	Stroebe's Island-Center of river Ch.	Below aerial elect. cable @ downstream tip of Stroebes Is.	Sluggish	Silt	0	0	2	24	3	24	Algae noted; bubbles coming up.
LF#22E	7/26/66	34.2	Stroebe's Island-east main bank	Same as LF22C @ 100 ft. off east shore	Sluggish	Silt	0	0	2	88	1	200	Slimes duckweed, algae; wood chips in sample; coontail, mil-foil, septic odor.
LF#22W	7/26/66	34.2	Stroebe's Island-west main bank	Same as LF22C @ 100 ft. off west shore	Sluggish	Silt	0	0	1	40	3	288	Duckweed; heavy algae; septic odor; wood chips in sample.
LF#21C	7/27/66	33.2+	Appleton-Center of Channel	0.75 Mi. above Yacht Club @ Red Nun Buoy #68 and Black Can # 69	Slow	Rock, C. gravel	0	0	3	12	6	49	Heavy planktonic algae; slimes noted on rocks.
LF#21E	7/27/66	33.2+	Appleton-east shore	Same as LF21C @ 100 ft off east shore	Slow	Silt & sand	0	0	3	86	11	750	Heavy planktonic algae; slimes on weeds & rocks; aquatic weed growth.
LF#21W	7/27/66	33.2+	Appleton-west shore	Same as LF21C @ 50 ft. off west shore	Slow	Rock & C. gravel	0	0	7	50	9	385	Slime growth noted on rocks.
LF#19C	7/28/66	30.7+	Appleton-Channel	@Appleton John St. Bridge-, 0.10 Mi. below foremost foods & 0.10 Mi. above Interlake mill	Slow	Rock	2	2	5	92	8	89	Heavy planktonic algae.
LF#18C	7/28/66	30.2	Appleton-Channel	@ Red Nun Buoy # 50, 0.5 Mi. below Interlake mill & 0.2 Mi. above Appleton STP	V. Slow	Rock & C. gravel	0	0	0	0	8	259	Vol. Soldis 627 Mgms/L 11/65 (75% algae & invert. 25% slimes). Leaves & bark in sample; planktonic algae noted.
LF#18CQ	7/28/66	30.2	Appleton-Channel	Same as LF18C	V. slow	Rock & C. gravel	0	-	3	-	2	-	Off 8" rock; Rivularia sp.-B.G. algae.
LF#18E	7/28/66	30.2	Appleton-east shore	Same as LF18C @ 50 ft. off east shore	V. slow	Rock, wood debris	0	0	1	373	7	2,676	Vol. Solids 1,027 Mgms/L 11/65 (50% algae & invert. 50% fibers & fiber knots). Heavy wood chips; bark noted, slimes,

Sample	Date	River Mileage	Sample Area	Station Location	Current	Bottom	Classification Intolerant Spp.	No.	Tolerant Spp.	No.	V. Tolerant Spp.	No.	Remarks
LF#18W	7/28/66	30.2	Appleton-west shore	Same as LF18W @ 75 ft. off west shore	V. slow	Sand & silt	0	0	1	11	4	7,481	Decaying algae; Vol. Solids 432 Mgms/L 11/65 (50% slimes 50% algae & invert.). Slime growth; small wood chips in sample.
LF#17C	7/28/66	29.5	Appleton-Channel	@ Black Can Buoy # 43, 1.2 Mi. below Interlake Mill & 0.5 Mi. below Appleton STP	V. slow	C. gravel & rock	0	0	4	21	7	1,236	Slimes & bubbles noted, algae noted.
LF#17E	7/28/66	29.5	Appleton-east shore	Same as LF17C @ 75 ft. off east shore	V. slow	Silt	0	0	1	3	3	31	Algae noted, bubbles noted.
LF#17W	7/28/66	29.5	Appleton-west shore	Same as LF17W @ 75 ft. off west shore	V. slow	C. gravel & rock	0	0	1	14	7	481	Slimes noted, heavy planktonic algae duckweed & other weeds.
LF#16C	7/28/66	27.9	Kimberly-Channel	@ Red Nun Buoy # 32, 0.5 Mi. above Kimberly Mill dam & o.25 Mi. below Sunset Point	V. Slow	Rock	0	0	3	89	11	1,343	Planktonic algae; slime chunks floating. Vol. Solids-886 Mgms/L 11/65 (65% algae & invert.; 25% slimes & 10% fibers & fiber knots).
LF#16E	7/27/66	27.9	Kimberly-east shore	Same as LF16C @ 100 ft. off east shore out from lilly pad bed	V. slow	Rock	0	0	0	0	4	3,168	Algae noted; Vol. Solids-176 Mgms/L 11/63 (30% fibers and fiber knots; 68% algae & invert. & 2% slimes). Lilly pads along shoreline; more slimes than in Channel.
LF#16W	7/27/66	27.9	Kimberly-west shore	Same as LF16C @ 75 ft. off west shore	V. slow	Rock & gravel	0	0	3	288	8	2,862	Prolific weed growth; duckweed ; Vol. Solids 1,093 Mgms/L 11/63 (52% algae & invert.; 15% fibers & fiber knots & 33% chips & seeds).
LF#14C	7/21/66	27.1	Kimberly-Channel	@ Red Nun Buoy # 30A, 0.3 Mi. below Kimberly dam & above Combined Locks dam	V. slow	Rock	0	0	3	63	11	69	Wood chips floating; slimes on rocks; Vol. Soldis 1,865 Mgms/L 7/63 (95% fibers & fiber knots, 5% algae & invert.).
LF#14E	7/21/66	27.1	Kimberly-east shore	Same as LF14C @ 25 ft. off east shore & lilly pads	V. slow	Sludge & paper fibers	0	0	1	4	0	0	Septic odor in sample; water turbid & white with waste; floating fiber foam & chips; sample is all fibers; Vol. Solids 973 Mgms/L 11/65 (50% fibers & fiber knots; 15% slimes & 35% algae & protozoan).
LF#14W	7/21/66	27.1	Kimberly-west shore	Same as LF14C @ 50 ft. off west shore	V. slow	Silt	0	0	1	112	2	304	Wood chips; algae rooted aquatic plants; organic debris; Vol. Solids 499 Mgms/L 11/65 (15% fibers & fiber knots; 25% slimes; 45% algae & invert. & 15% wood chips).
LF#13QC	7/21/66	25.2	Combined Locks-Channel	0.5 Mi. below combined Locks dam	Moderate	Rock	0	-	3	-	7	-	Heavy slimes on rocks & sample wood chips & slabs floating; qualitative off wood slabs; v. hard sampling.
LF#13E	7/21/66	25.2	Combined Locks-east shore	Same as LF13QC @ 20 ft off east shore	Moderate	Rock	0	0	2	7	4	176	Vol. Soldis 11/65 1,254 Mgms/L (20% slimes; 20% fibers fiber knots & 60% algae & invert.). Floating fresh wood slabs; floating bark; very heavy slimes; light colored water below mill.
LF#13W	7/21/66	25.2	Combined Locks-west shore	Same as LF13QC @ 40 ft. off west shore	V. slow	Sand & organic	0	0	1	28	8	380	Vol. Solids 11/65 1,508 Mgms/L (50% fibers & fiber knots; 10% slimes & 40% algae & invert.). Bullheads jumping out of water; 2 dead bullheads noted with sores; filamentous algae & prolific weeds.
LF#12C	7/21/66	24.5	Kaukauna-Channel Center	0.5 Mi. above Kaukauna Dam@ Riverside Park boat landing	V. slow	Sludge & slimes	0	0	1	28	2	12	Heavy Sphaerotilus natans present; floating and aquatic vegetation; bubbles coming up and sludge clumps; duckweed along west shoreline; Vol. Solids 11/65 1,235 Mgms/L (60% fibers & fiber knots; 20% slimes & 20% algae & invert.).
LF#12E	7/21/66	24.5	Kaukauna-east shore	Same as LF12 @ 100 ft. off east shore	V. slow	Sludge, silt, & slimes	0	0	1	16	3	72	Same as LF#12; duckweed & algae noted; Vol. Solids 11/65 1,017 Mgms/L (45% fibers & fiber knots; 10% slimes & 45% algae & invert.).

Table 6(?)

Sample	Date	River Mileage	Sample Area	Station Location	Current	Bottom	Intolerant Spp.	Intolerant No.	Tolerant Spp.	Tolerant No.	V. Tolerant Spp.	V. Tolerant No.	Remarks
LF#12W	7/21/66	24.5	Kaukauna-west shore	Same as LF12 @ 30 ft. off west shore	V. slow	Si t	0	0	5	280	7	216	Heavy organic debris; small amt. wood chips; heavy duckweed; Vol. Solids 11/65 1,510 Mgms/L (40% fibers and fiber knots; 10% slimes & 50% algae & invert.).
LF#10C	7/21/66	21.7	Kaukauna-Channel	1.5 mi. below paper mill & Kaukauna STP & below Red Light #24	V. slow	Sludge	0	0	2	10	4	12	Wood chips & slimes; rising bubbles, fibers in sample; floating sludge clumps.
LF#10E	7/21/66	21.7	Kaukauna-east shore	Same as LF 10 @ 400 ft. off east shore	V. slow	Silt & sludge	0	0	1	12	[illegible]	12	B.G. algae-Oscillatoria sp. Arthrospira sp. Fibers, fine wood chips, slimes lily pads along shore; decaying algae.
LF#10W	7/21/66	21.7	Kaukauna-west shore	Same as LF10 @ 200 ft. off west shore	V. slow	Sand, silt & sludge	0	0	0	0	1	8	Floating sludge, slimes, bubbles; wood chips, lily pad bed.
LF#9C	7/21/66	19.7	Rapid Croche Dam Area-Channel	0.5 Mi. above Rapid Croche Dam under power lines	V. slow	Rock	0	0	0	0	1	4	Slimes on rocks-Sph. natans Wood fibers, slimes, chips; sludge clumbs.
LF#9E	7/21/66	19.7	Rapid Croche Dam Area-east shore	Same as LF9 @ 25 ft. off east shore	V. slow	Silt	0	0	1	8	0	0	Sph. natans paper fibers; floating aquatic weeds; wood chips, dead snails.
LF#9W	7/21/67	19.7	Rapid Croche Dam Area-west shore	Same as LF9 @ 25 ft. off west shore	V. slow	Silt	0	0	1	4	0	0	Wood chips, sludge, slimes.
LF#8C	7/20/66	18.7	Rapid Croche Dam Area-Channel	0.5 Mi. below Rapid Croche Dam & 0.1 Mi. upstream from Red Nun Buoy	V. slow	F. gravel & sands	0	0	0	0	2	336	Sph. natans in sample & water; wood chips & algae present; organic debris noted.
LF#8E	7/20/66	18.7	Rapid Croche Dam Area-east shore	Same as LF8 @ 15 ft. off east shore	V. slow	Silt	0	0	2	24	1	88	Sludge clumps floating; slime growths, wood chips.
LF#8W	7/20/66	18.7	Rapid Croche Dam Area-west shore	Same as LF8 @ 25 ft. off west shore	V. slow	Silt	0	0	0	0	0	0	No organisms present; rising bubbles, slime growths; algae, sludge clumps, wood chips; prolific lilly pad bed.
LF#7C	7/20/66	16.2	Wrightstown-Channel	Second twn. X rd. downstream @ 1.1 Mi. below Wrightstown Hwy. 96 bridge	V. slow	Rock covered with slimes	0	0	0	0	1	1	Slime cover on rocks; hard sampling.
LF#7E	7/20/66	16.2	Wrightstown-east shore	Same as LF7 @ 0.9 Mi. below Wrightstown & 25 ft. off east shore	V. slow	Rock	0	0	0	0	4	10	Slimes profuse in sample; aquatic weeds & algae; sludge chunks noted.
LF#7W	7/20/66	16.2	Wrightstown-west shore	Same as LF7 @ 1.0 Mi. below Wrightstown & 50 ft. off west shore	V. slow	Rock	0	0	0	0	0	0	Profuse Sph. Natans; no organic present; rising bubbles, sludge & chunks.
LF#6C	7/20/66	14.1	Little Rapids Dam Area-Channel	1.0 Mi. above Little Rapids Dam where CTH 22 parallels the river	V. slow	Sand & silt	0	0	0	0	0	0	No organisms present; wood chips sludge clumps; planktonic algae; Sph. natans present.
LF#6E	7/20/66	14.1	Little Rapids Dam Area-east shore	Same as LF6 @ 50 ft. off east shore lilly pad bed	V. slow	Silt & organic	0	0	0	0	3	52	Wood chips & slimes noted; rising bubbles-algae noted.
LF#6W	7/20/66	14.1	Little Rapids Dam Area-west shore	Same as LF6 @ 60 ft. off west shore cat-tails	V. slow	Silt	0	0	0	0	0	0	Physical conditions better than opposite shore.
LF#5C	7/20/66	12.1	Little Rapids Dam Area-Channel	1.0 Mi. below Little Rapids Dam & adjacent to Hickory Grove Sanitarium off Red Nun Buoy # 6	V. slow	Sand & organic	0	0	0	0	1	16	Planktonic algae & Cladophora sp.; Wood chips, snails, lily pad growth along shore; Vol. Solids 11/65 912 Mgms/L (45% fiber & fiber knots; 50% algae & invert. & 5% wood chips).

Table 6(4)

Sample	Date	River Mileage	Sample Area	Station Location	Current	Bottom	Intolerant Spp.	Intolerant No.	Tolerant Spp.	Tolerant No.	V. Tolerant Spp.	V. Tolerant No.	Remarks
LF#5E	7/20/66	12.1	Little Rapids Dam Area-east shore	Same as LF5 @ 100 ft. off east shore	V. slow	Sand & organic	0	0	1	1	3	12	Dead snails, wood chips, fibers; planktonic algae; Vol. Solids 11/65 471 Mgms/L (45% fibers & fiber knots; 50% algae & invert. & 5% chips).
LF#5W	7/20/66	12.1	Little Rapids Dam Area-west shore	Same as LF5 @ 100 ft. off west shore	V. slow	Silt & organic	0	0	0	0	1	4	Wood chips & fibers-prolific; lily pads-Vol. Solids 11/65 780 Mgms/L (40% fibers & fiber knots; 10% chips & 50% algae & invert.).
LF#4C	7/20/66	7.2	De Pere-Channel	Above dam & across from De Pere High School & St. Norbert College	V. slow	Silt & organic	0	0	1	4	1	4	Prolific amt.-wood chips & dead snails; prolific planktonic algae; Vol. Solids 11/65 152 Mgms/L (100% algae & invert.).
LF#4E	7/20/66	7.2	De Pere-east shore	Same as LF4 @ 100 ft. off east shore	V. slow	Silt	0	0	1	4	0	0	Prolific planktonic algae growth; no wood chips as in channel.
LF#4W	7/20/66	7.2	De Pere-west shore	Same as LF4 @ 75 ft. off west shore	V. slow	Silt	0	0	1	8	0	0	"Paint Pot" algae conditions; no wood chips as in channel.
LF#3C	7/19/66	4.9	De Pere-Channel	Just below De Pere STP @ Red Nun Buoy # 22 & 2.3 Mi. below dam	V. slow	Organic debris & chips	0	0	0	0	1	480	Vol. Solids 11/63 61.2 Mgms/L (88% algae & invert.; 10% fibers & fiber knots & 2% slimes).
LF#3E	7/19/66	4.9	De Pere-east shore	Same as LF3 @ 50 ft. off east shore	V. slow	Silt & wood debris	0	0	1	4	1	8	Vol. Soldis 11/63 66 Mgms/L (98% algae & invert.; 2% fibers & fiber knots). Wood chips, dead snails, slimes, organic debris, and algae.
LF#3W	7/19/66	4.9	De Pere-west shore	Same as LF3 @ 50 ft. off west shore	V. slow	Silt & organic	0	0	0	0	2	20	Vol. Solids 11/63 63.6 Mgms/L (97% algae & invert.; 3% fibers & fiber knots). Prolific weed growth, septic odor, snail shells.
LF#2C	7/19/66	1.7	Green Bay Area-Channel	@ Green Bay Main Str. bridge adjacent to H. C. Prange Co.	None to V. slow	Silt, sludge, paper & debris	0	0	0	0	1	20	Wood chunks, paper, dead snail shells, oil slick on sample.
LF#2E	7/19/66	1.7	Green Bay Area-east shore	Same as LF2 @ 50 ft. off east shore	V. slow	Organic debris & wood chips	0	0	1	4	1	232	Coal chunks, algae on pilings.
LF#2W	7/19/66	1.7	Green Bay Area-west shore	Same as LF2 @ 50 ft. off west shore	V. slow	Silt, organic & coal chips	0	0	0	0	1	320	Same as LF#2 comments.
LF#1C	7/19/66	0.1	Green Bay Area-Channel	0.1 Mi. upstream from mouth @ coal dock @ Red Nun Buoy 38-Green Bay	Indeterminate	Silt, wood chips & organic	0	0	1	4	1	4	Septic odor, wood chips, oil slick, aquatic grasses; Vol. Solids 11/65 147 Mgms/L (90% algae & invert.; 5% slimes & 5% fibers & fiber knots).
LF#1E	7/19/66	0.1	Green Bay Area-east shore	Same as LF1 @ 75 ft. off east shore	Indeterminate	Silt & wood chips	0	0	0	0	2	24	Vol. Solids 11/65 211 Mgms/L (100% algae & invert.). Dead snails, oil slick, septic odor, wood chips & fibers. Sphaerotilus natans noted; organic debris.
LF#1W	7/19/66	0.1	Green Bay Area-west shore	Same as LF1 @ 50 ft. off west shore	Indeterminate	Silt	0	0	3	24	2	664	Vol. Solids 11/65 286 Mgms/L (85% algae & invert.; 5% wood chips; 5% slimes & 5% fibers & fiber knots). Fine coal granuals, wood chips, septic odor.

TABLE 7(1)
GREEN BAY INVESTIGATIONS 1966 & 67
SEE FIG. 4 FOR STA. LOCATION

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Intol.	Bottom Organisms No. Per Square Foot Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	µg/l	Plankton 20 Mesh Tow Net % Zoopl.	% Diatoms	% BC	% Debris	Secchi Disc (Feet)
A Mouth	4-06		Channel	12.0		11.2													
A Mouth	7-05		Channel	2.8	2.9	3.4	78°							1353	40	40	20		2
A Mouth	8-12	1	Channel	0.0	0.0	0.0								108	35	25	30		1½
A Mouth	9-07	1	Channel	1.1	0.0	0.4	68°	Mud		4		2	132	95	10	20		40	
A Mouth	10-20	1	Channel	0.0		0.1	57°	Mud		2			12	208	25	50	15	10	1½
B ½GI	5-03	2	Channel	6.6		6.7	46°							4949	10	45		45	1
B ½GI	5-03	3	Channel	6.9			46°							9447	5	25		70	1
B ½GI	7-05	6	Channel	4.1	4.5	4.5	78°							1641	50	20	35		1½
B ½GI	9-07	2	Channel	0.7	0.6	3.1	68°	Mud		4			102	173	80	20			2
B Bell	8-12	2	Channel	0.0	0.0	0.2		Mud & Debris		No Organisms					10	30	50	5	1
B Bell	10-20	5	Channel	0.3		1.2	54°							182	85	15			2
B	7-05	4	21	4.6			78°							3350	5	45	50		1½
B GI	8-12	12	24	0.0	0.0	1.4		Clay		No Organisms				126	70	20	10		1½
B GI	10-20	6	21	5.9		4.25	52°							1620	20	50		30	3
C ½	8-12	3		0.0				Sand		No Organisms				186	5	40	50	3	3
C 1	8-12	4		0.0				Sand		No Organisms				54	10	40	45	2	1
C 1	10-20	2	12	0.6		0.9	50°												3
C 1½	8-12	5		0.7				Sand					1	404	7	30	60	T	1
C 2	8-12	6		4.1		1.9		Mud		4				340	35	15	50		1
C 2	10-20	3	12	2.8		2.5	50°	Sand		4			4	735	95	4	1		3
C 2½	8-12	7		8.3		4.4		Mud		16		8		2718	60	10	30		1
C 3	8-12	8	9	7.1		6.2		Mud		32		24		2444	60	10	30		1½
C 3	8-12	9	9	6.9		5.1		Mud		22		8	4	2222	65	5	30		2
C 3	10-20	4	12	7.6		7.4	50°												2½
D SP	7-05	8	9	5.2		5.7	76°							1404	55	20	20		1½
D SP	8-15	4	12	5.8		4.5		Mud		12		14	16		35	40	25		2
D C	5-03	4		7.8			47°							3341	10	40		50	1
D C	7-05	7	9	7.0		6.8	76°							5289	15	40	40		2
D C	8-12	10	9	8.6		4.3		Mud		2			8	2257	70	10	20		1½
D C	8-12	11	9	7.0		0.6				4			4	2874	75	10	15		1½
D C	8-15	2	12	4.7		4.4		Mud					18	2066	35	30	35		2
D C	8-15	3	12	5.9		5.5		Mud		2		4	26	1981	35	30	34		1½
D LTP	5-03	1	15	9.5			46°							761	45	50			1
D LTP	7-05		15	6.3	6.1	5.7	72°							1141	10	20		70	3
D LTP	8-11	4	30	8.3	8.0	9.1		Mud		3		4	26	1417	65	20	15		2
D LTP	8-12	15	18	10.2	9.9	8.0		Mud		72		72	212	896	70	20	10		3

TABLE 7(2)

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Intol.	Bottom Organisms No. Per Square Foot Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	µg/l	Plankton 20 Mesh Tow Net % Zoopl.	% Diatoms	% BG	% Debris	Secchi Disc (Feet)
D LTP	9-07	3	24	8.9	7.2	7.7	68°	Mud		4		22	214	814	70	21	9		3
D LTP	10-20	8	21	10.1		9.7	50°							731	34	51	10	5	6
D ½G-LTP	8-12	13	18	4.6	0.9	2.5		Mud		10		2	152	1013	70	10	20		2
D ½G-LTP	8-15	1	12	1.7		1.5		Mud					24	1401	70	20	7		2
D ½G-LTP	10-20	6.5	21	3.9		3.3	52°												3
D ½G-LTP	10-20	7	21	8.8		8.4	50°												4
E	7-05	4	9	5.3		5.4	73°							1364	55	10	30		1½
E	8-15	5	12	7.2		7.5		Mud					72	1094	65	25	10		2½
E	8-15	6	12	7.2		6.8		Mud, Sand			2		104	980	70	15	15		2½
E	8-12	7	9	7.1		6.7		Mud, Sand			2	5	27	914	71	17	12		2
F L	4-06		21	13.0		13.1													
F L	8-11	1	21	7.6	7.4	7.5		Mud				4	136	499	35	50	15		3
F L	9-07	4	24	8.5		4.1	66°	Mud		2			292	388	45	25	30		3
F L	10-20	9												735	60	35	5		6
F E1	7-05	3	12	6.8		6.7	70°							1235	65	25	10		3
F E1	8-11	2	21	7.7	7.5	7.3		Sand			1		7	1189	20	65	15		3
F E2	8-11	3	21	8.3	8.2	8.2		Sand			4	1	30	688	50	20	30		2
F E1	8-12	14		10.2				Sand					3	784	52	15	33		2
F E1	8-12	16	12	11.9		9.3		Sand					24	1081	50	25	25		3
F E2	8-12	17	12	12.6		8.5		Sand			9	1	27	1049	45	15	40		3
F Bell	5-04		15	11.5		11.1	45°							757	15	85			2
F Bell + 1	8-11	10	30	10.4	8.6	7.0		Mud			6	4	88	1221	20	45	40		4
F Bell E-1	8-11	9	21	9.9	8.3	7.1		Clay			2		46	1081	15	55	30		4
F Bell E-2	8-11	8	12	9.0		7.9		Clay						1152	40	30	30		3
F Bell + 1	9-07	5	24				66°	Mud				6	60	183	40	20	40		5
F Bell + 1	10-20	10												486	40	52	8		7
G LTP	2-10	14				14.9													
G LTP	2-10	15				15.1													
G LTP	2-10	16				12.4													
G LTP	2-10	17				14.5													
G LTP	3-10	14				13.2													
G LTP	3-10	15				10.6													
G	8-15	8	12	9.3		8.9				30		3	71	1043	65	15	15		3
G	8-15	9	15	9.5		9.1				21		1	38	1268	20	65	15		4
G	8-15	10	15	9.6		8.8				37		1	93	830	45	35	17		3
G	8-15	11	12	9.1		8.7				23			144	593	60	20	18		2½
G BS	5-04					11.6								1025	15	85			3½

TABLE 8
GREEN BAY INVESTIGATIONS 1966-67
PESHTIGO RIVER MOUTH AREA

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Bottom Organisms No. Per Square Foot Intol.	Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	μg/1	Plankton 20 Mesh Tow Net % Zoopl.	% Diatoms	% BG	% Debris	Secchi Disc (Feet)
Mouth	8-10	5	9	2.2		2.2		Sand		1		1	3	638		4	1	95	3
½ Mouth - Bouy	8-10	4	12	7.9		6.0		Sand		6			2	544	23	70	7		5
River Bouy	8-10	3	33	7.9	5.9	4.5		Mud	8	20	16	24	552	696	25	70	5		6
½ Mi. Beyond Bouy	8-10	2	33	6.7	7.5	4.8		Sand		24		104	380	482	20	70	10		
½ Bouy-Reef Light	8-10	1	18	7.1		7.1		Sand		9		36	426	583	25	70	5		6

TABLE 9
GREEN BAY INVESTIGATIONS 1966-67
BIG SUAMICO RIVER MOUTH AREA

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Bottom Organisms No. Per Square Foot Intol.	Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	μg/1	Plankton 20 Mesh Tow Net % Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
1 Mi. No. of Bouy	8-15	12		10.2				Sand		24			30	712	70	5	23	3
Entrance Bouy	8-15	13	12	10.6		8.8		Sand		48			188	737	40	25	32	3
1 Mi. So. of Bouy	8-15	16	12	10.7		9.7		Sand Mud		37			87	838	45	24	31	3
½ Mouth - Bouy	8-15	14		10.4				Sand		29			23	872	50	28	22	2½
Mouth	8-15	15	12	7.5		6.0		Sand Mud	1	97		2	166	1701	45	55		2

TABLE 10
GREEN BAY INVESTIGATIONS 1966-67
PENSAUKEE RIVER MOUTH AREA

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Bottom Organisms No. Per Square Foot Intol.	Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	μg/1	Plankton 20 Mesh Tow Net % Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
1 Mi. Out, 1 Mi. So.	8-16	4		8.2				Sand		35			16	1380	70	20	10	4
1½ Mi. Out	8-16	5	12	8.5		8.5		Sand		29			44	899	60	30	10	5
1 Mi. Out	8-16	6	12	8.3		7.9		Sand		79			75	411	70	25	5	4½
½ Mi. Out	8-16	7		8.7				Sand Mud	1	32		17	121	813	60	20	20	3½
Mouth	8-16	8	9	8.7		7.7		Sand		7		1	29					2½
Above Fish Plant	8-16	9	9	7.7		7.4		Rock	2	25		7	46	2359	50	25	25	4
1 Mi. Out, 1 Mi. No.	8-16	10	12	8.7		8.6		Sand	1	64	1	1	58	582	40	40	20	4½

TABLE 11
GREEN BAY INVESTIGATION 1966-67
10 TO 20 MILES FROM MOUTH OF FOX RIVER

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Bottom Organisms No. Per Square Foot Intol.	Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	Plankton 20 Mesh Tow Net µg/l	% Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
10-0-EL	7-05		18	7.0	7.2	6.1	71							564	85	5	10	6
10-0-EL	8-09		21	7.2		7.1	70	Mud			4	8	98	994	35	50	15	4
10-0-EL	9-07	6	24				66							226	20	20	60	6
10-0-EL	10-20	11												854	30	61	9	8
10-E-1	8-11	5	21	8.6	8.3	8.2		Sand		6		1	58	1342	30	50	20	4
10-E-1	8-11	6	21	8.1	8.3	7.2		Sand		4		8	65	1245	35	40	25	3
10-E-3	8-11	7	15	7.7		7.0		[illegible]	1	7	1		15	877	40	40	20	3
10-W-1	8-15	17	27	9.7	8.5	7.8		Mud		6	4	2	158	1227	40	25	35	4
10-W-2	8-16	1	18	8.3	8.2	8.1		Mud		4		6	148	1539	35	55	10	4½
10-W-3	8-16	2	18	8.4	8.4	8.3		Sand		11			97	1434	25	50	25	5
10-W-4	8-16	3	12	8.2		8.1		Rock	155	4	2		32	1119	30	50	20	4½
15-0	8-09		30	8.1	8.1	2.5	70	Mud		8	4	12	312	371	60	25	15	7
15-0	9-07	7					68								10	30	60	6
15-0	10-20	12												1125	17	80	30	8

TABLE 12
GREEN BAY INVESTIGATIONS 1966-67
20-30 MILES FROM MOUTH OF FOX RIVER

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Bottom Organisms No. Per Square Foot Intol.	Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	Plankton 20 Mesh Tow Net µg/l	% Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
20-0	8-09		33	7.9	7.1	7.4		Mud		4		20	92	334	55	40	5	7
20-0	9-07	8	33				68							252	20	42	38	6
20-0	10-20	13												650	42	50	8	8
20-0	10-19																	
20-E-3	8-16	15	30	9.0	8.3	8.0		Mud		18		6	100	674	80	5	15	6
22-E-3	8-16	14	33	8.5	8.6	8.2		Mud		4		3	124	385	30	25	45	7
22.5-0	9-07	9	33											283	40	25	35	6
22.5-3E	9-07	9A					67							346	30	35	35	6
25-0	8-10	7	72	8.3	8.2	2.3	70	Mud		10			348	476	50	10	40	6
25-W-4	8-16	11	36	8.8	8.2	8.1	71	Mud		1		17	113	935	40	55	5	6
25-W-2	8-16	12	36	9.2	8.5	6.8	70	Mud		6		10	156	590	20	30	50	7
25-E-3	8-16	13	33	8.9	8.2	7.0	72	Mud		11		4	146	466	35	15	50	7
25-0	9-07	10	39				68							617	30	40	35	6
25-E-3	9-07	10A												316	25	60	15	5½
25-W-3	9-07	10B					68							345	20	35	50	6
25-W-5	9-07	10C												285	35	20	45	7
25-0	10-20	14												582	51	40	9	7

TABLE 13
GREEN BAY INVESTIGATIONS 1966-67
30-70 MILES FROM MOUTH OF FOX RIVER

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Intol.	Bottom Organisms No. Per Square Foot Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	Plankton 20 Mesh Tow Net µg/l	% Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
30-0	8-10	6	63	8.2	8.0	3.9	70						70	303	50	10	40	9
30-0	9-07	11	51											181	60	10	30	
30-0	10-20													445	50	40	10	10
35-0	9-07	12	63											268	65	12	23	10
35-0	10-20	16												485	50	45	5	9
40-E-6	8-18	2	78	8.3	8.2			Mud Sand		2	12		172	82	40	25	35	11
40-E-3	8-18	3	87	9.0		3.8	70	Mud	2	4	20		376	131	85		15	12
40-0	8-18	4	93	8.8		5.6		Mud	597		84		440	133	90	5	5	13
40-W-3	8-18	5	48	8.2		6.2		Hard	1	2	2		4	125	90	2	8	11
40-0	9-07	13	93											128	61	13	26	15
40-0	10-21	18												417	60	35	5	12
45-0	9-07	14	93				67							275	61	21	18	15
50-0	8-18	6	93	8.8		5.0		Hard	220	4	8		44	125	88	2	10	12
50-E-1	8-18	7	78	9.1		5.2	67	Hard	748		28		104	185	80		10	12
50-E-3	8-19	1	93	8.3		4.7	68	Mud			12	12	156	191	93	-	7	14
50-0	9-07	15	81											129	85	8	7	14
50-0	10-04	19												84	20	65	15	
55-0	9-07	16												86	90	5	T	15
55-0	10-21	20												401	20	65	15	14
60-E-4	8-19	2		8.6	8.4		68	Sand	8	1	20		143	59	90		6	14
60-0	8-19	3		8.3	7.2		68	Sand	154	8	4		46	50	60	30	10	16
60-W-2	8-19	4					68	Mud	557		24		172	77	90		10	15
60-0	9-07													119	95	5		15
60-0	10-21	21												227	20	65	15	13
70-0	8-19	5		8.7	8.2		68	Hard	17				6	43	70	25	5	22
70-0	9-07	18	93												95	5		16
70-0	10-21	22												70	80	10	10	21

TABLE 14
LAKE MICHIGAN
AT STURGEON BAY

Station Location	Date	Field No.	Depth (Feet)	Dissolved Oxygen Surface	Dissolved Oxygen Mid	Dissolved Oxygen Bottom	Temp. Surface	Bottom Type	Intol.	Bottom Organisms No. Per Square Foot Tol. Midges	Tol. Others	Very Tol. Midges	V.T. Tubif.	Plankton 20 Mesh Tow Net µg/l	% Zoopl.	% Diatoms	% BG	Secchi Disc (Feet)
Sturgeon Bay Bouy	8-18	1		9.2		8.7	64	Sand	64	6			8	67	50	50		23
Sturgeon Bay Bouy	9-08	1												40	100			17
Sturgeon Bay Bouy	10-21	17												192	30	60	10	14

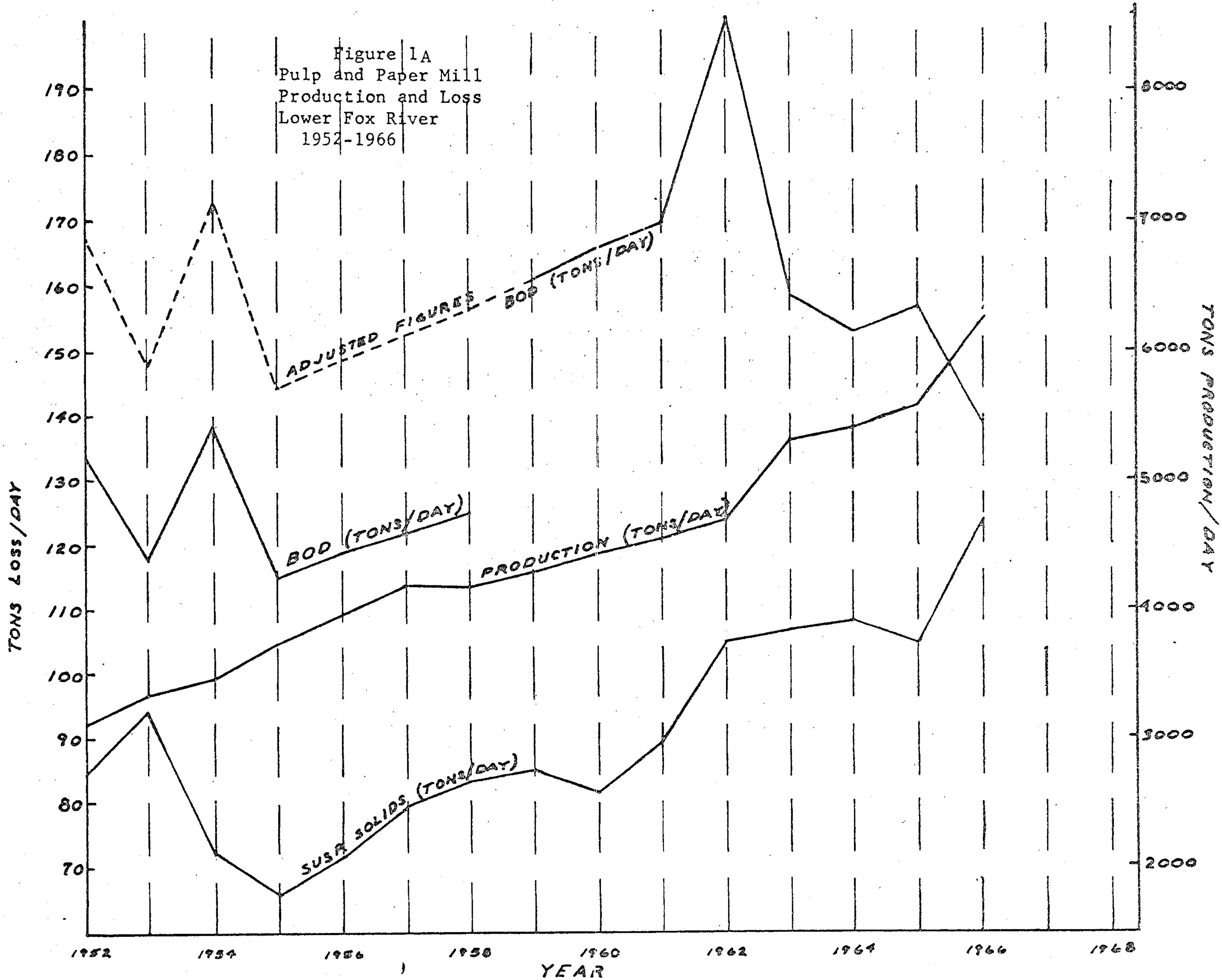
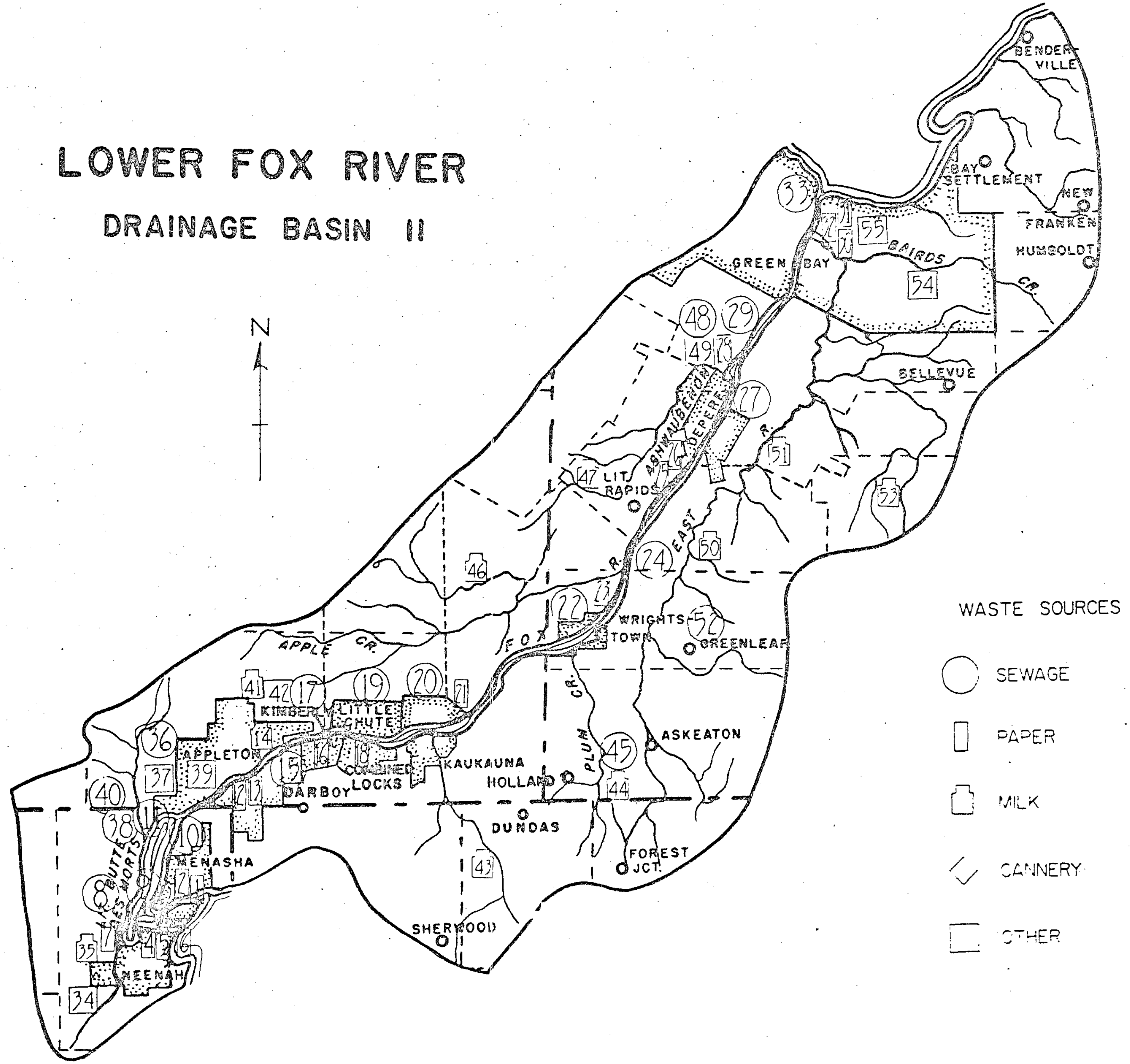


Figure 1A
Pulp and Paper Mill
Production and Loss
Lower Fox River
1952-1966

LOWER FOX RIVER

DRAINAGE BASIN II



DEFINITIONS

Milligrams per liter (mg/l) is a weight to volume relationship showing the amount in milligrams of a substance present in a volume of 1 liter. For most pollution considerations a concentration of 1 mg/l is equal to 1 part per million (ppm).

The dissolved oxygen (D.O.) in milligrams per liter (mg/l) is a measure of the amount of oxygen dissolved in the water. A saturated solution of dissolved oxygen in water will contain 14.6 mg/l at 0^{o} Centigrade ($32^{o}F$) and 8.4 mg/l at $25^{o}C$ ($77^{o}F$). Concentrations of less than 5.0 mg/l D.O. interfere with fish propagation and concentrations of less than 3.0 mg/l D.O. are considered critical for fish life.

The biochemical oxygen demand (B.O.D.) is expressed in mg/l and is a measure of the amount of organic matter oxidized through biochemical processes. In general, a high B.O.D. indicates the presence of a large amount of organic material. It is normal to find a B.O.D. of from 2 to 3 mg/l in river waters receiving natural drainage.

The pH value indicates the concentration of hydrogen ions in the water and is used to determine whether a water is acid, neutral or basic. A pH of 7.0 indicates that the water is neutral. A pH lower than 7.0 indicates acidity and a pH higher than 7.0 indicates basicity.

The membrane filter coliform count (MFCC) indicates the density of coliform organisms. Since these organisms may be of intestinal origin and are numerous in sewage, high numbers are indicative of sewage pollution with its possible hazards to public health.

Suspended solids are solids mixed with and generally imparting a cloudy appearance to water, sewage, or other liquids. Settleable solids are suspended solids which will settle in quiescent water or sewage in a reasonable period commonly, though arbitrarily, taken as two hours.

Pollutional load is the quantity of polluting material discharged into a body of water. It is usually expressed in terms of pounds of biochemical oxygen demand per day, pounds of solids per day, or both.

Toxic wastes are wastes containing ingredients which cause mortality of fish or other aquatic life irrespective of the amount of dissolved oxygen present. Ammonia, acids, alkalies, cyanides, phenols and salts of the heavy metals are examples of toxic substances.

Biota is a term for all the living forms in a stream ranging from bacteria through microscopic plants and animals and insect larva, to higher forms such as fish and rooted plants.

Plankton are microscopic drifting organisms found in natural waters. The plant forms are known as phytoplankton whereas the animal forms are called zooplankton.

Aerobic organisms are organisms which require free (elementary) oxygen for their growth. Anaerobic organisms will grow in the absence of free oxygen and derive oxygen by breaking down compounds containing oxygen combined with other substances. Facultative organisms are organisms which can adapt themselves to growth in the presence, as well as in the absence, of dissolved oxygen.