EPA-R2-72-070
October 1972

ENVIRONMENTAL PROTECTION TECHNOLOGY SERIES

Storage and Treatment of Combined Sewer Overflows

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Monitoring, Environmental Protection Agency, have been grouped into five series. These five broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The five series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

EPA-R2-72-070
October 1972

STORAGE AND TREATMENT OF COMBINED SEWER OVERFLOWS

Project 11023 FIY

Project Officer

Clarence C. Oster
Lake Superior Basin Office - EPA
7401 Lyndale Avenue
Minneapolis, Minnesota 55455

Prepared for

OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 - Price $2

EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

The objective of this study was to demonstrate the feasibility and economic effectiveness of a combined wastewater overflow detention basin.

A paved asphalt detention basin with a storage volume of 8.66 acre feet was constructed at Chippewa Falls, Wisconsin to receive overflow from a 90 acre combined sewer area including all of the central business district. The system was designed so that the stored combined sewage could be pumped to the wastewater treatment plant when precipitation subsided.

During 1969, due to dry weather, the pond received only sixteen discharges, but completely filled twice and overflow to the river occurred. During 1970, there were 46 discharges and the pond filled once overflowing to the river. Over the two year period, 37.75 million gallons of combined sewage (93.7 per cent of the total discharge volume) were withheld from the river for subsequent treatment.

There were no observed detrimental effects on treatment plant operation due to the increased intermittent flows from the detention pond. The estimated cost of operating and maintaining the pond and associated facilities was $7,300 per year for the two year period. Capital costs were $6,780 per acre of drainage area including some relief combined sewer and increased size of units at the wastewater treatment plant.

This report was submitted in fulfillment of Project No. 11023 FIY, under the partial sponsorship of the Environmental Protection Agency.

CONTENTS

Section		Page
I	Conclusions	1
II	Recommendations	3
III	Introduction	5
IV	Design and Construction	9
V	Evaluation Plan	25
VI	Results of Operation	37
VII	Discussion of Results	85
VIII	Acknowledgements	99
IX	References	101
X	Appendices	103

FIGURES

		PAGE
1.	Project Location Map	6
2.	Mass Rainfall Curve	7
3.	Storm Frequency - Intensity Graph	11
4.	Three Point Hydrograph	12
5.	Diversion Structure and Bay Street Pumping Station	14
6.	Pumps in Bay Street Station	15
7.	Discharge to Bay Street Station	16
8.	Combined Sewage Pumping Station	17
9.	Combined Sewage Pumping Station and Pond Drain Structure	17
10.	Pond Drain Structure and Recording Rain Gage	18
11.	Pond Overflow Structure	19
12.	Pond Overflow Structure at High River Stage	19
13.	Detention Basin Plan	20
14.	Detention Basin During High River Stage	21
15.	Detention Basin and Nearby Buildings	21
16.	Wastewater Treatment Plant Flow Diagram	23
17.	Recording Rain Gage	27
18.	Palmer-Bowlus Flume	28
19.	Liquid Level Recorder Enclosure	29
20.	Liquid Level Recorder	30
21.	Sampler Located in Wet Well of Combined Sewage Pumping Station	31
22.	Upper Portion of Combined Sewage Sampler	32
23.	Pond Drain Sampler	33
24.	River Sampler Shelter	35
25.	Storm of July 14, 1969 Hyetograph and Hydrograph	82
26.	Storm of August 6, 1969 Hyetograph and Hydrograph	83
27.	Storm of August 11, 1970 Hyetograph and Hydrograph	84

TABLES

No.		Page
1.	Labor Costs for Pond Cleaning	37
2.	Labor Costs for Pond and Pumping Station Inspection	38
3.	Pumping Costs Associated with Pond Operation	39
4.	Added Cost of Treatment Plant Operation due to Storm water.	40
5.	Summarized Operation and Maintenance Costs	41
6.	1969 Combined Sewage Discharges - Volume and Duration	45-47
7.	1970 Combined Sewage Discharges - Volume and Duration	48-53
8.	BOD_5 and Suspended Solids for Combined Sewage Discharges to Pond - 1969	54-58
9.	BOD_5 and Suspended Solids for Combined Sewage Discharges to Pond - 1970	59-65
10.	Settleable Solids, Volatile Suspended Solids and Coliform Organisms - Average Values for 1969 Discharges to Pond.	66-67
11.	Settleable Solids, Volatile Suspended Solids, and Coliform Organisms - Average Values for 1970 Discharges to Pond.	68-69
12.	Characteristics of Overflows to River.	70
13.	1970 Pond Drain Data	71
14.	1969 Wastewater Treatment Plant Data	72-75
15.	1970 Wastewater Treatment Plant Data	76-81
16.	Treatment Effect of Pond During Overflows to River	87
17.	Characteristics of the Chippewa River	89-96

SECTION I

CONCLUSIONS

1. During the two year study period 37.75 million gallons of combined sewage (93.7 per cent of the total overflow volume) were withheld from the river for subsequent treatment.

2. Of the 62 overflows to the pond, 59 were entirely withheld from the river, and three resulted in pond overflows discharging a small amount of combined sewage to the river.

3. During the study period, 49,520 pounds of BOD_5 and 90,390 pounds of suspended solids were stored and later pumped to the wastewater treatment plant. These loads represented 98.2 per cent of the total BOD_5 and 95.8 per cent of the total suspended solids contained in the overflows.

4. The estimated average operating and maintenance cost attributed to the storage pond system was $7,300 per year. The largest portion of this cost ($5430/yr.) was due to the estimated increased cost of treatment plant operation.

5. The total capital cost for the demonstration project was $610,067. This cost can be sub-divided into the following components:

Detention Pond Construction	$ 59,818.07
Pumping Station, Pond Structures & Piping	$158,386.74
Combined Relief Sewer & Separate Sewers	$222,937.73
Electrical Work	$ 21,146.59
Treatment Plant Revisions	$117,420.00
Engineering	$ 28,857.99
Land	$ 1,500.00
Total	$610,067.12

6. At an interest rate of 6 per cent, the annual cost of capital recovery over a 20 year period is $53,200. The total annual cost under these conditions (including operation and maintenance) is then $60,500.

7. The estimated capital cost for complete sewer separation in the study area was $497,500.

8. The overflow detention basin stored combined sewage for periods of up to fourteen hours without odors developing.

9. Although it was located in close proximity to the central business district, no complaints were received regarding any phase of the pond operation.

10. A program of river sampling revealed no significant changes in river quality which could be attributed to overflows from the detention basin.

11. The average BOD_5 of the combined sewage overflows was 150 mg/L, and the average suspended solids concentration was 280 mg/L.

12. The treatment effect of the pond was highly variable. The BOD_5 and suspended solids removals normally expected from primary sedimentation could not be attained consistently.

13. The increased duration of peak flows at the wastewater treatment plant had no apparent detrimental effect on the operation of the modified activated sludge plant.

14. Substantial relief from basement flooding in the downtown area was attained as a result of the demonstration project.

SECTION II

RECOMMENDATIONS

1. Storage followed by secondary treatment should be given serious consideration as an alternative to complete separation in areas served by combined sewers.

2. A major factor in determining the feasibility of storing the overflows should be the existence of a suitable site relative to the point of overflow and the location of the wastewater treatment plant.

3. A site located in or near a developed area should not be ruled out on this basis alone.

4. Careful analysis of the existing wastewater treatment plant hydraulic capability should be undertaken in conjunction with any investigation of overflow storage.

5. If it is possible that the treatment plant could become overloaded due to increased peak hydraulic loads, consideration should be given to returning the stored overflows during off-peak periods only.

6. Future retention basins should have provisions for adequate water for flushing the basin bottom after emptying.

7. Suitable access should be provided to the basin bottom for street sweepers and trucks necessary to remove solids accumulation.

8. Overflow to the basin should be regulated by an automatic gate controlled by the depth of flow in the intercepting sewer.

SECTION III

INTRODUCTION

In 1966 the City of Chippewa Falls, Wisconsin was under orders from the State Regulatory Agency to provide separation of combined sewers in the downtown area or to provide a method of treating the combined wastewater overflows.

The City decided to investigate the feasibility of treating the overflows and made application to the Federal Water Pollution Control Administration for a Research and Development Grant for this work as provided in the Clear Water Restoration Act of 1966.

On December 23, 1966 the City was awarded an F.W.P.C.A. Research and Development Grant (22-WIS-2) of $289,685 for preliminary studies and reports, construction and engineering and post-construction operations, studies and reports. This report was prepared to make the findings of the project design, construction and evaluation available in a form requested by the Federal Water Pollution Control Administration.

In addition, the City made application for and received a 25 per cent grant from the State of Wisconsin for preliminary studies and reports and construction and engineering.

Construction of the project was started in October of 1967, and was completed in March of 1969. The post-construction studies and evaluations started on April 1, 1969, and concluded on December 31, 1970. The post-construction studies and evaluations were originally scheduled to be concluded on March 31, 1970, but due to dry weather during the summer of 1969, an extension and supplemental funding were requested. On March 30, 1970 a nine month extension to December 31, 1970 and supplemental funding of $15,000 or 75 per cent of the eligible costs, whichever is less, was approved.

The project consisted of the construction and operation of a 75,000 gpm combined wastewater pumping station, 2.82 million gallon detention pond, increased intercepting sewer pumping station capacity and final settling tank capacity, combined relief sewer and some separation.

The purpose of the project was to demonstrate that the combined wastewater overflows could be retained for a period of time, returned to the intercepting sewer and treated at a secondary treatment plant. It was further intended that the storage and treatment be accomplished without creating any nuisance conditions and without disrupting the operation of the wastewater treatment plant.

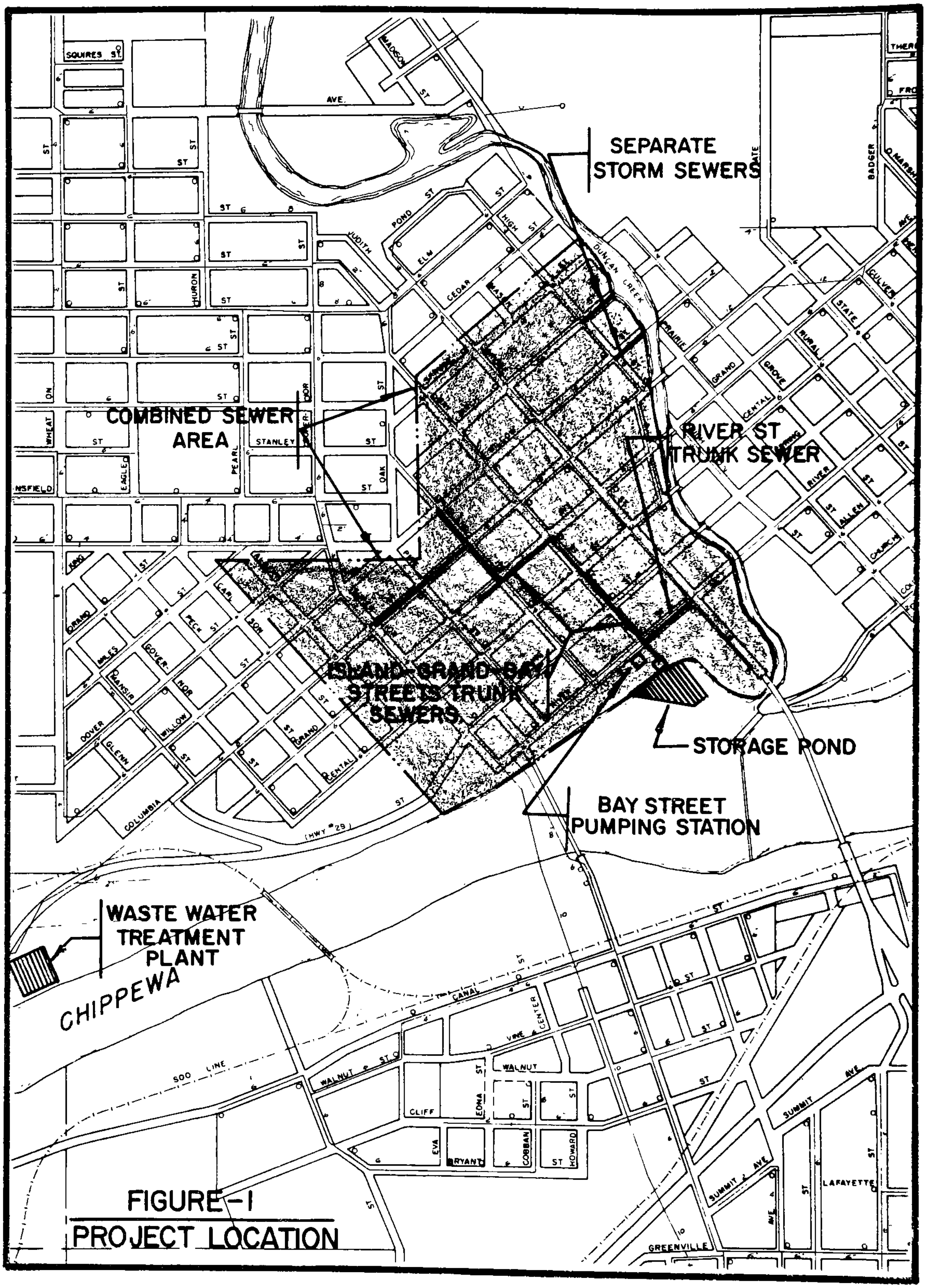


FIGURE-1
PROJECT LOCATION

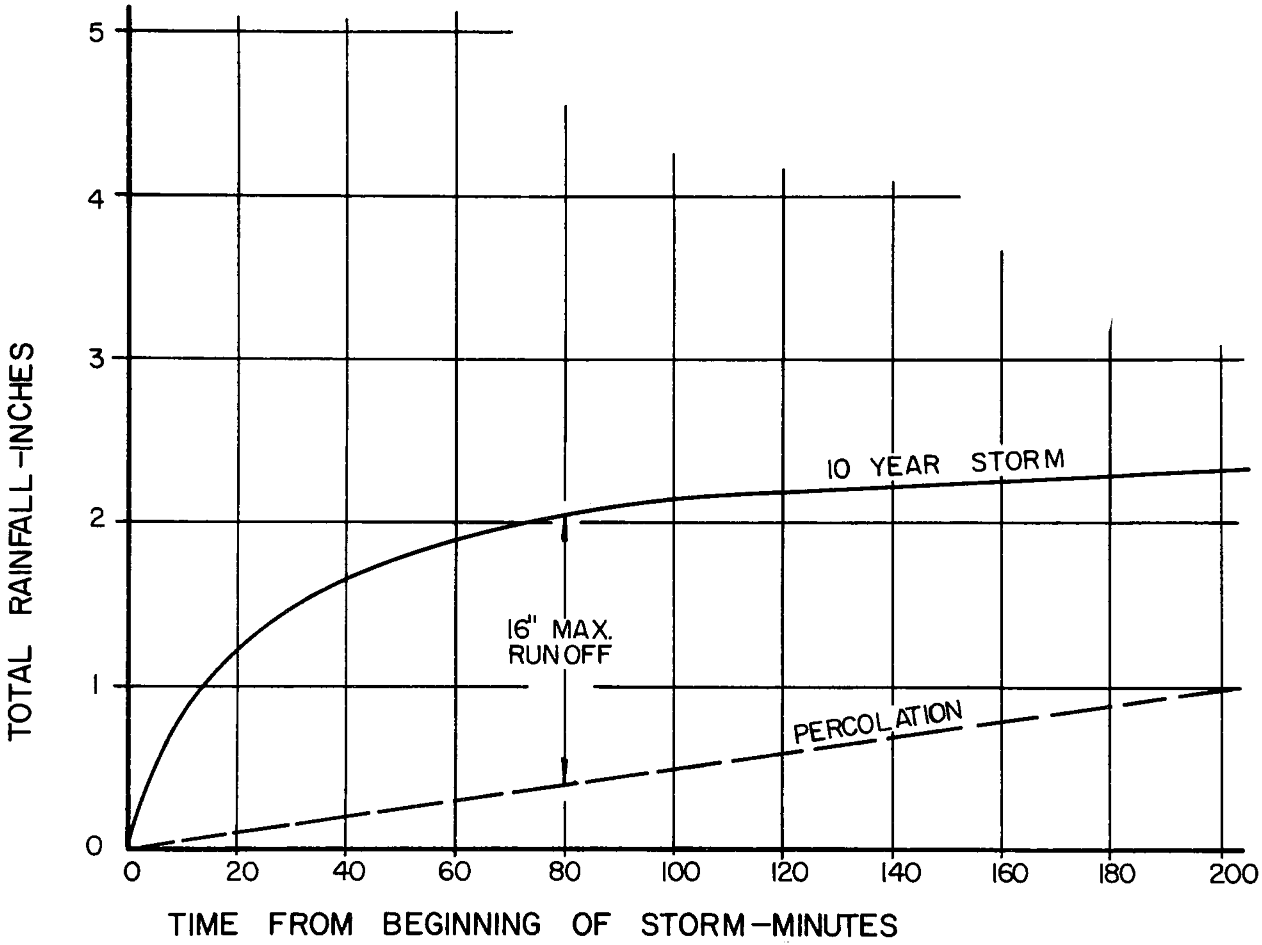


FIGURE -2-

MASS RAINFALL CURVE

SECTION IV

DESIGN AND CONSTRUCTION

The combined sewer tributary area selected for this project consisted of ninety acres in the downtown area of Chippewa Falls including all of the Central Business Distrct. This area is tributary to the Bay Street pumping station which discharges to the intercepting sewer leading to the waste-water treatment plant. Prior to construction of the project bypassing occurred to the Chippewa River through a 42 inch corrugated metal pipe sewer whenever the capacity of the Bay Street pumping station was exceeded.

The detention pond was located between the Bay Street pumping station and the river in the area of the 42 inch outfall. This site was the only feasible location for the pond. The shape of the pond, which departed from the usual rectangle or square, was dictated by site conditions. Figure 1 is the project location map.

The total volume of rainfall which the pond was designed to hold was determined from the mass rainfall curve for a ten year storm less the theoretical percolation expected. Figure 2 is a plot of these curves.

From the curves, the maximum runoff for given conditions is 1.6 inches. The total volume of runoff from the ninety acre tributary area was calculated as:

$$Vr = \frac{R}{12} A$$

Where Vr is the volume of runoff in acre feet, R is the runoff in inches and A is the area in acres.

$$Vr = \frac{1.6}{12} \times 90 = 12 \text{ Acre Feet}$$

Similar calculations for theoretical runoff for a five year storm would be about ten acre feet, and for a two year storm would be about 7.5 acre feet. Figure 3 shows intensity as a function of duration for storms of various expected frequencies in the Chippewa Falls area.

The total length of the design storm was calculated by using a three point hydrograph as shown in Figure 4. The calculation of Q Max, the peak rate of flow to the pond, was based on the capacity of the combined relief sewer. This sewer capacity was determined from the capacity of the tributary sewers rather than from a theoretical calculation using the Rational Method. This method of sizing was used to insure that "bottlenecks" would not be created in the system to cause basement flooding during rainstorms.

The peak rate of runoff from the design storm was taken as 164 cubic feet per second (cfs). The length of the design storm was calculated as:

$$T = \frac{24.2\ Vr}{Q\ Max} \qquad (2)$$

Where T is the time in hours.Vr is the volume of runoff in acre feet and Q Max is the peak rate of runoff in cfs.

$$T = \frac{24.2\ (12)}{164} = 1 \text{ Hour } 46 \text{ Minutes}$$

The Bay Street pumping station formerly had a pumping capacity of 4,000 gallons per minute (gpm), but the maximum rate that could be conveyed by the force main and intercepting sewer was 6,000 gpm. The pumping capacity was therefore increased to 6,000 gpm. The estimated average dry weather flow was 2,000 gpm, so 4,000 gpm of combined wastewater could be pumped during rainstorms without overflowing to the detention pond.

During the period of a design storm, the Bay Street pumping station will deliver:

4,000 gpm x 106 Minutes = 424,000 Gal. = 1.3 Acre Feet

This represents the amount by which the total volume of runoff could be reduced when calculating the size of the pond.

The design volume of the detention pond was 12.0 - 1.3 = 10.7 acre feet. The maximum design water depth was 7.7 feet.

Because of site restrictions imposed after the preliminary design, the volume of the pond actually constructed was 8.66 acre feet. This volume is approximately equivalent to the expected overflow from a five year storm.

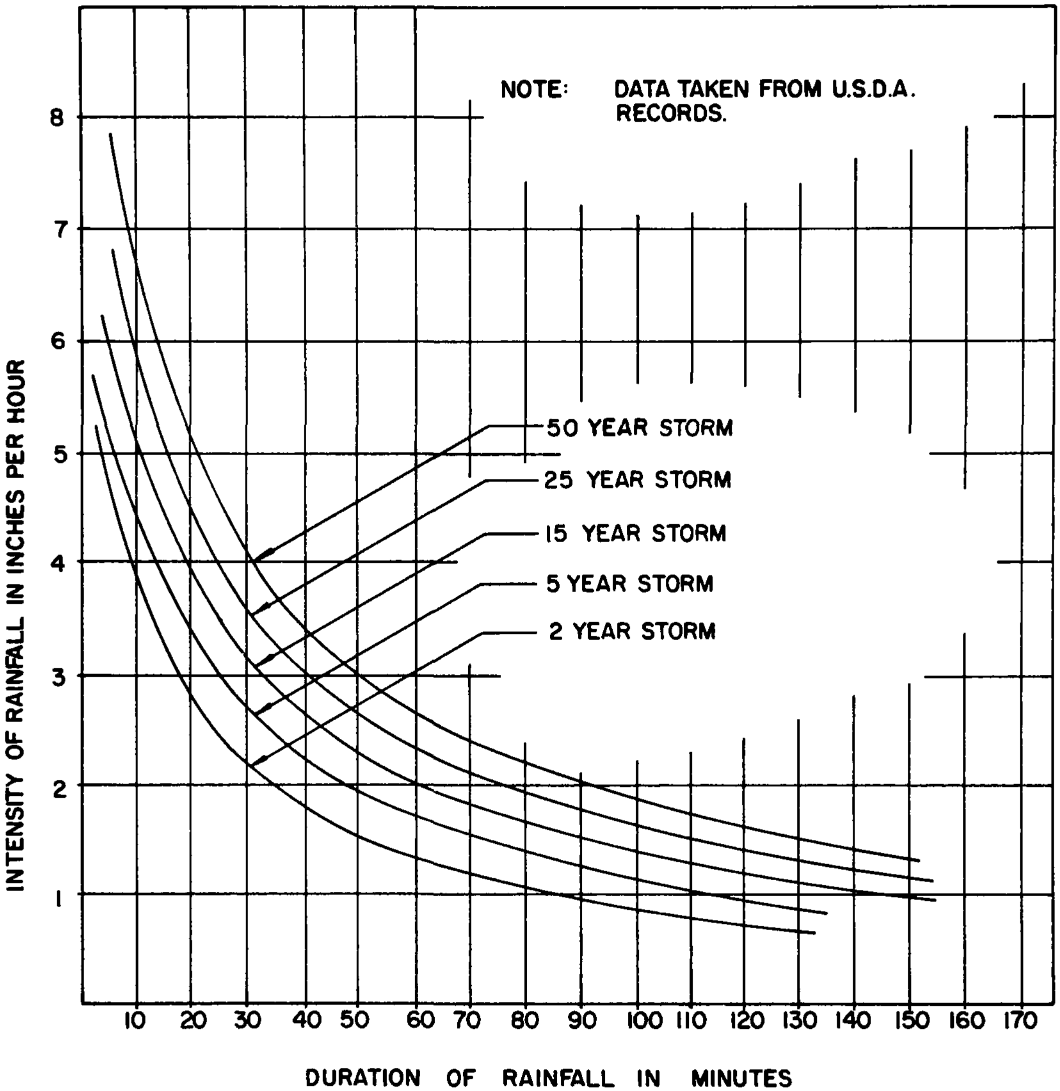


FIGURE 3
GRAPH
SHOWING THE EXPECTED FREQUENCY AND INTENSITY OF STORMS IN THE AREA OF CHIPPEWA FALLS, WISCONSIN

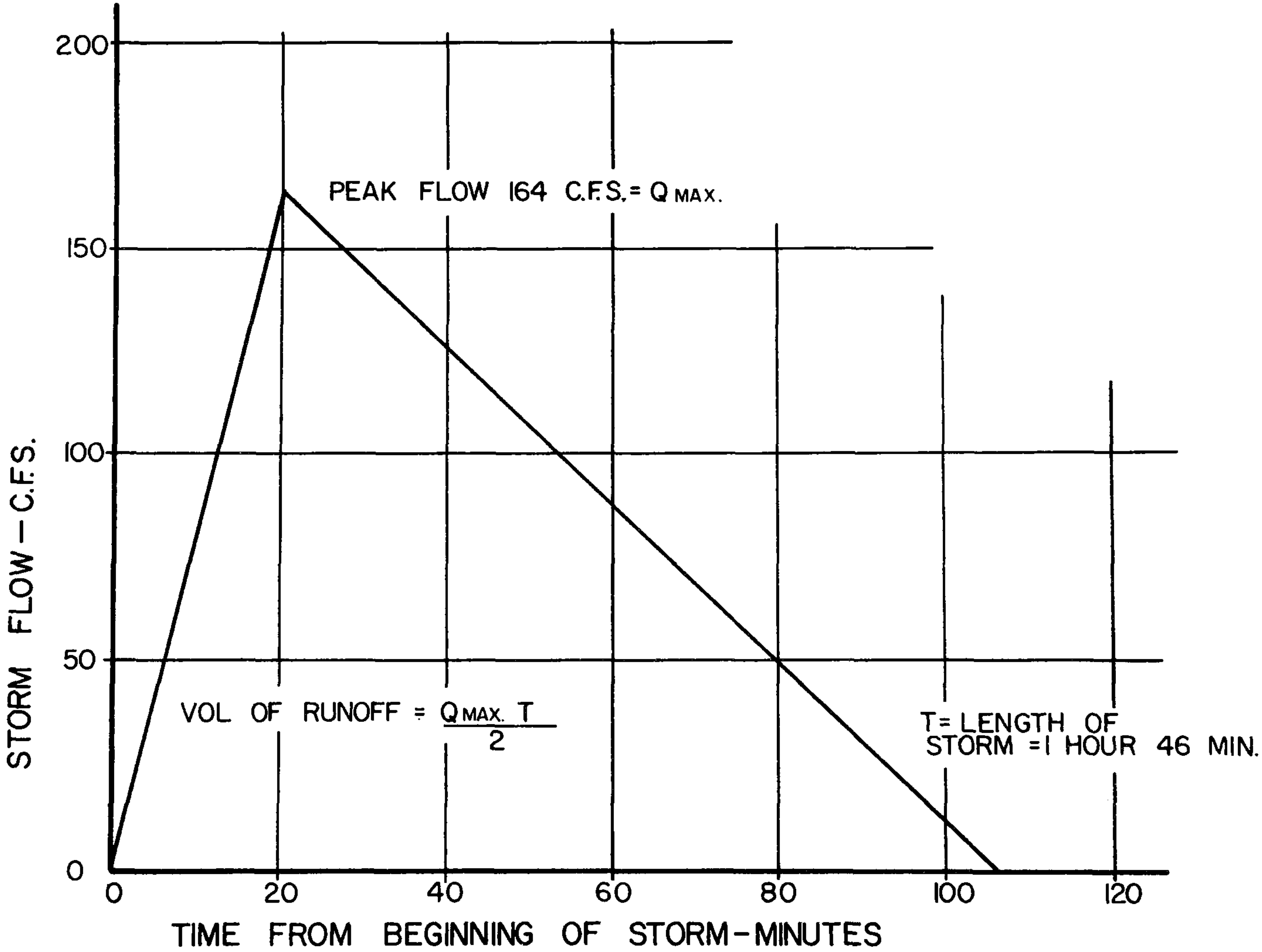


FIGURE -4-
3-POINT HYDROGRAPH

Overflow to the pond occurs when the depth in a diversion structure immediately upstream of the Bay Street station exceeds a fixed elevation.

The elevation of the invert of the trunk sewers at the discharge to the Bay Street pumping station is only 0.4 feet above normal river level. Gravity flow to a retention pond could not be obtained, hence a combined wastewater pumping station was designed to pump all of the overflow to the pond. This station has a capacity of 75,000 gpm which slightly exceeds Q Max.

The stored combined sewage and waste is returned to the Bay Street pumping station by gravity through a regulating butterfly valve controlled by liquid level in the wet well of the Bay Street Station.

Assuming a full pond and a maximum combined wastewater pumping capacity of 4,000 gpm, and time to empty the pond is:

$$\frac{8.66 \times 325{,}900}{4{,}000} = 706 \text{ Minutes} = 11 \text{ Hours } 46 \text{ Minutes}$$

The pond has a combination overflow and drain structure in the dike on the river side. This structure provides for the overflow to the river when the total storm runoff to the pond exceeds 8.66 acre feet. In the event of power failure at the combined wastewater pumping station or the Bay Street pumping station, gates in the river overflow structure can be opened to allow bypassing the pond contents to the river. Flap gates in the combined wastewater pumping station allow emergency bypass flow to go through the station without pumping.

Relief valves in the pond bottom were designed to prevent rupture of the bottom during periods when the river level rises above the pond bottom.

The pond walls were designed as earth dikes with 2:1 exterior slopes and 3:1 interior slopes. The interior of the pond, top of the dikes and the exterior of the dike on the river side were paved with 2 inches of hot mix bituminous surfacing to facilitate cleaning, and to allow vehicular traffic within the pond for maintenance and grit removal. Riprap was specified to cover the bituminous paving on the exterior of the dike on the river side.

A watermain extension and fire hydrant were specified to be located adjacent to the combined wastewater pumping station for flushing of the pond bottom.

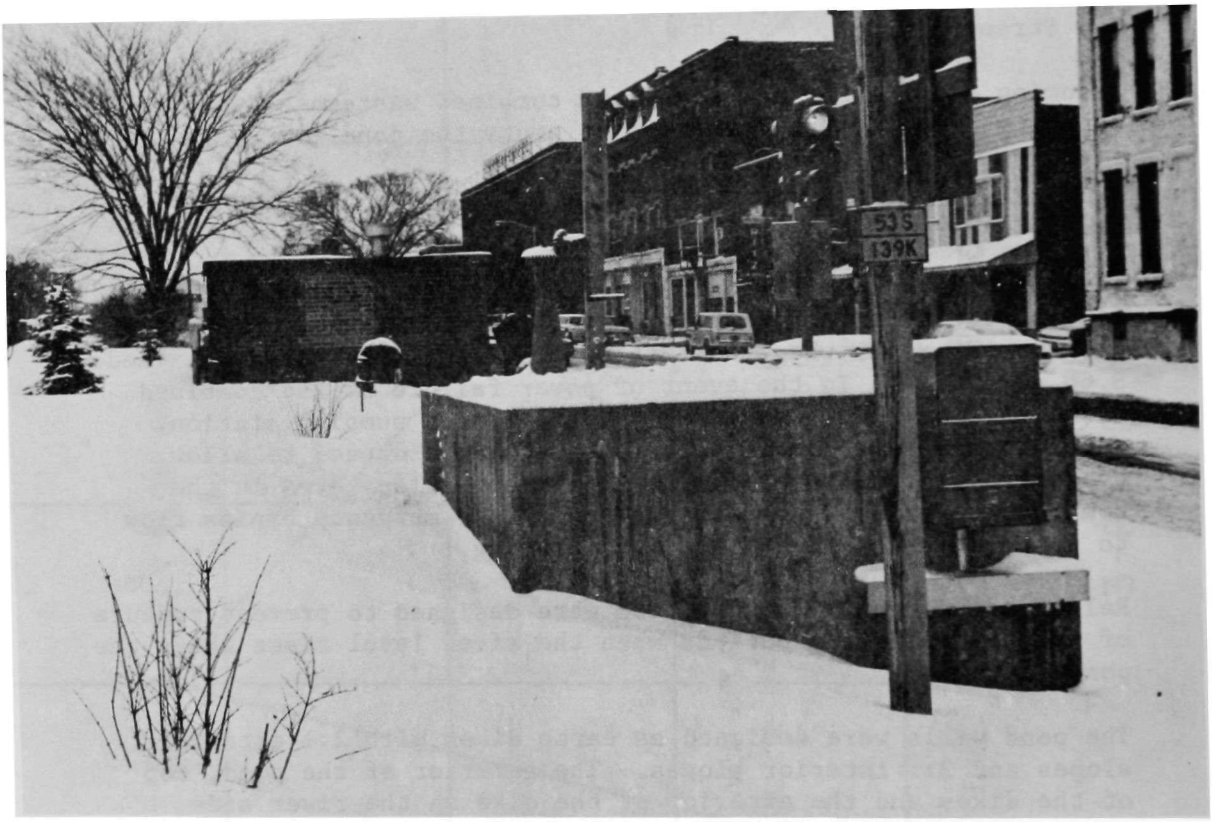


Figure 5. Overflow diversion structure (foreground) and Bay Street Pumping Station.

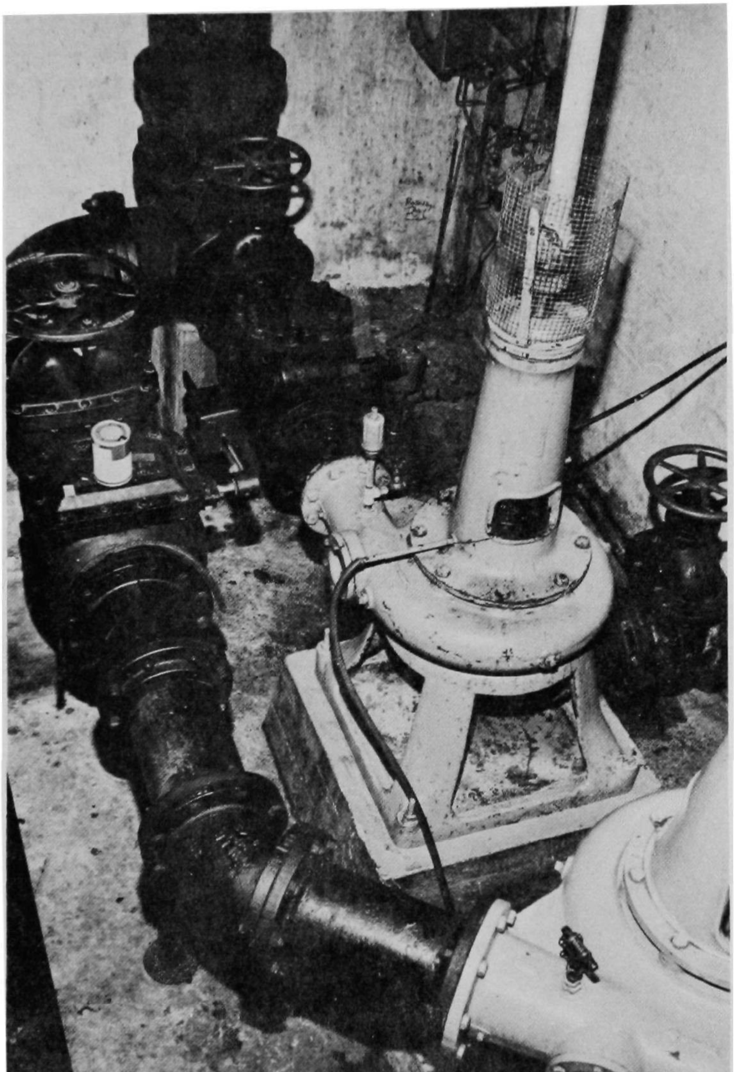


Figure 6. Pump arrangement in Bay Street Station.

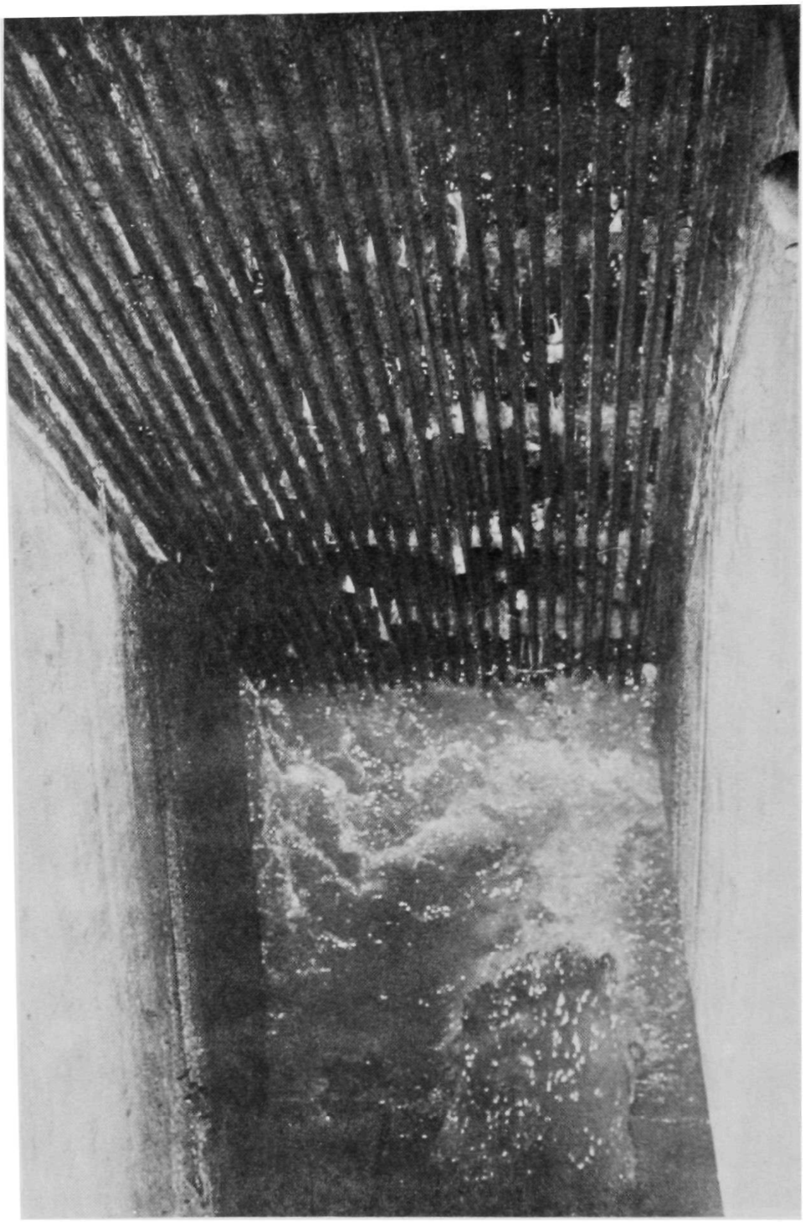


Figure 7. 24 inch trunk sewer discharging to Bay Street pumping station. Pumps are protected by a hand-raked bar screen.

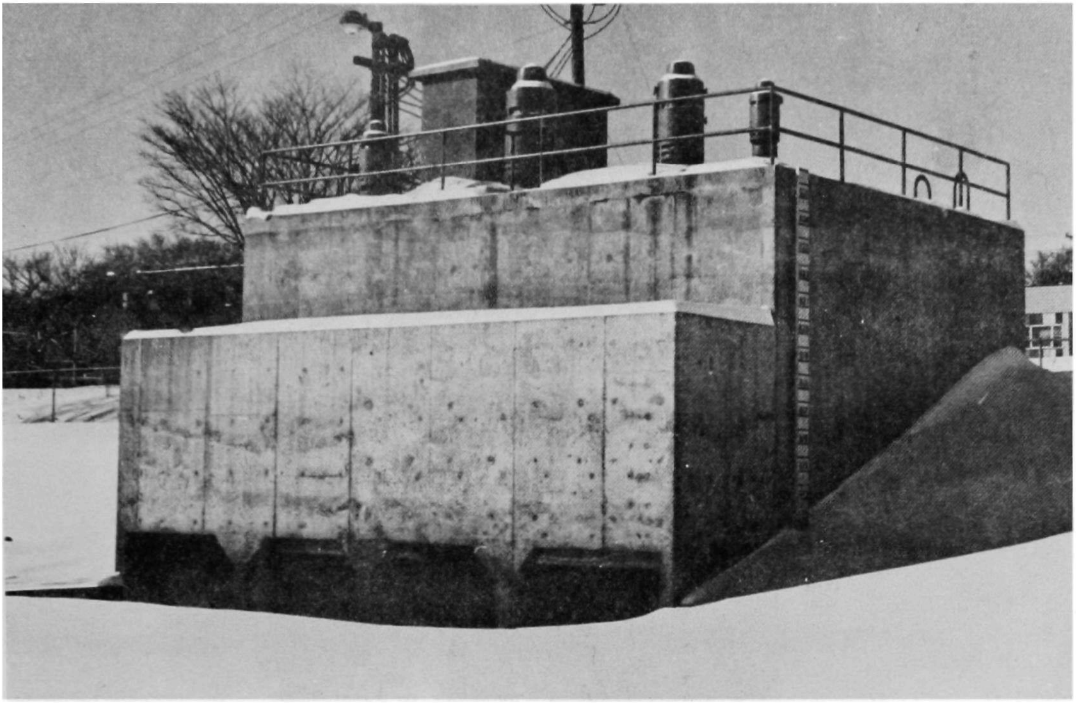


Figure 8. Combined sewage pumping station viewed from pond.

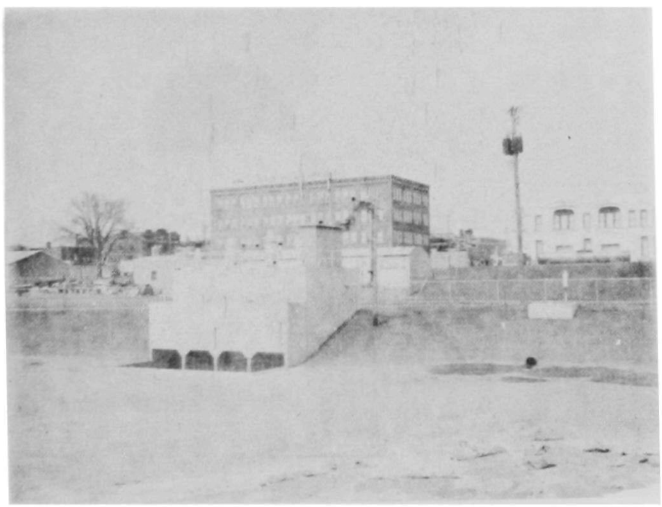


Figure 9. Combined sewage pumping station and pond drain structure.

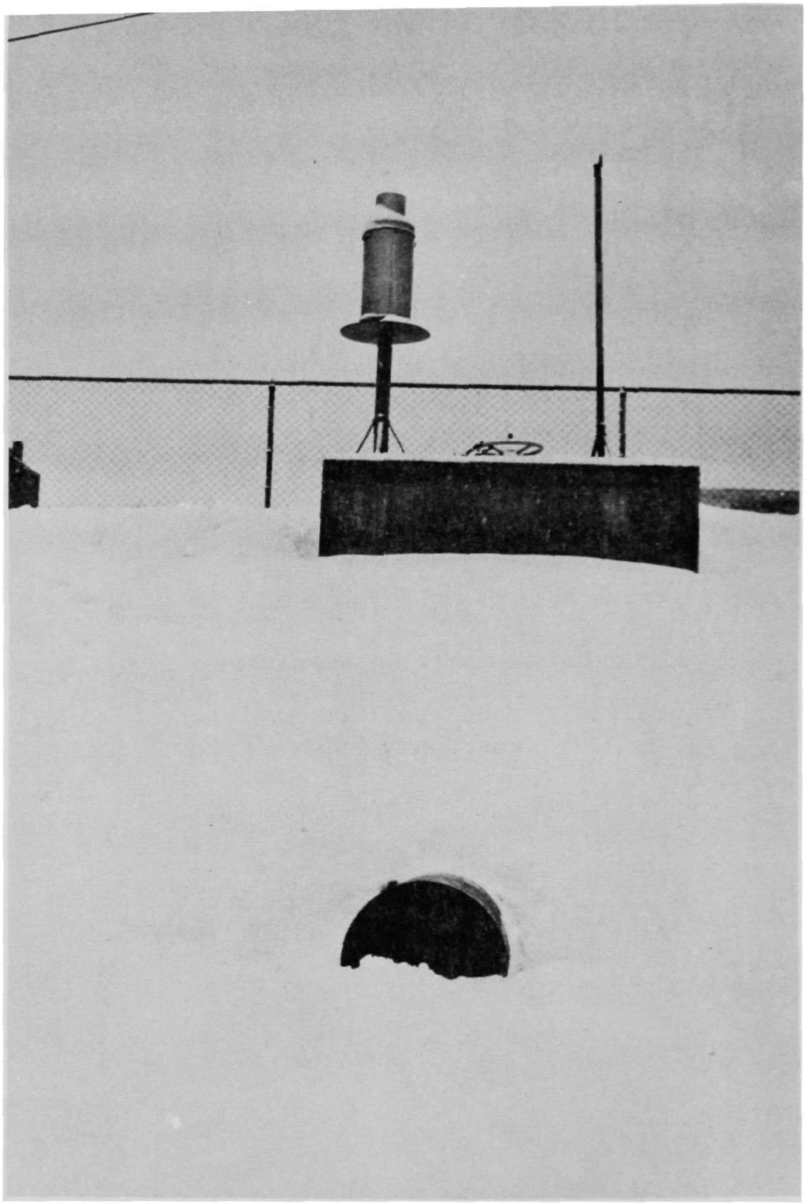


Figure 10. Pond drain structure and recording rain gage.

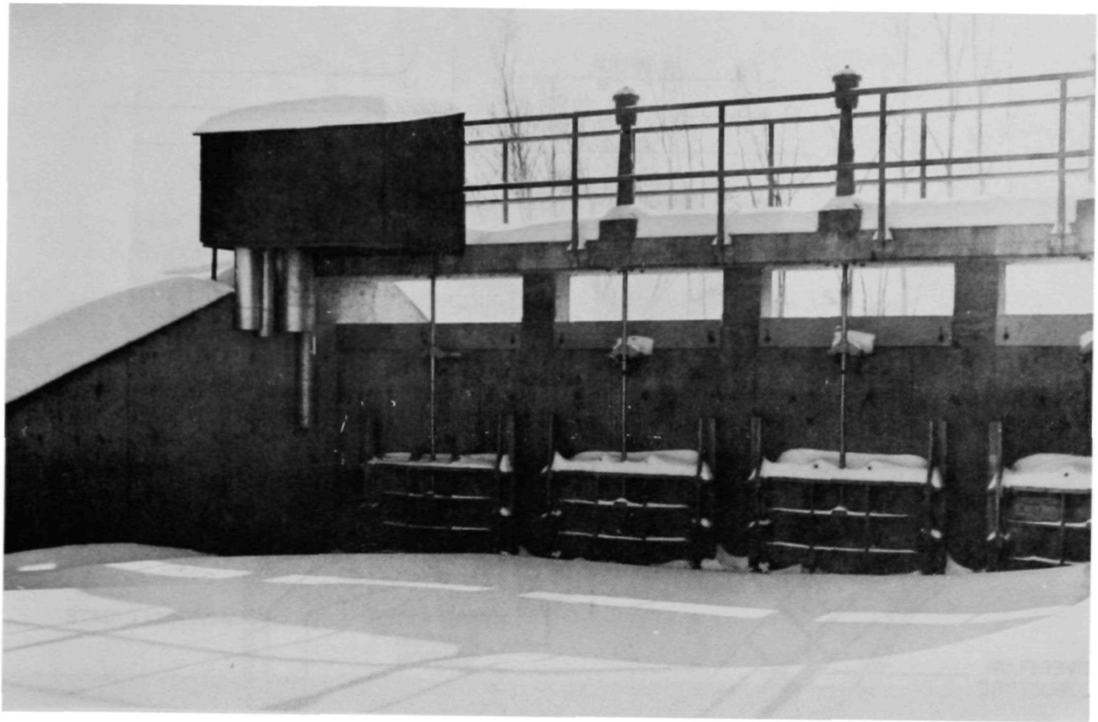


Figure 11. Pond overflow structure with emergency bypass gates.

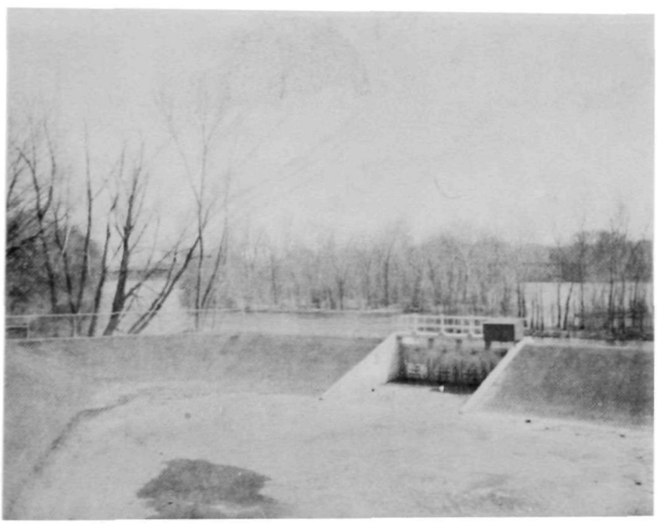


Figure 12. Pond overflow structure at high river stage.

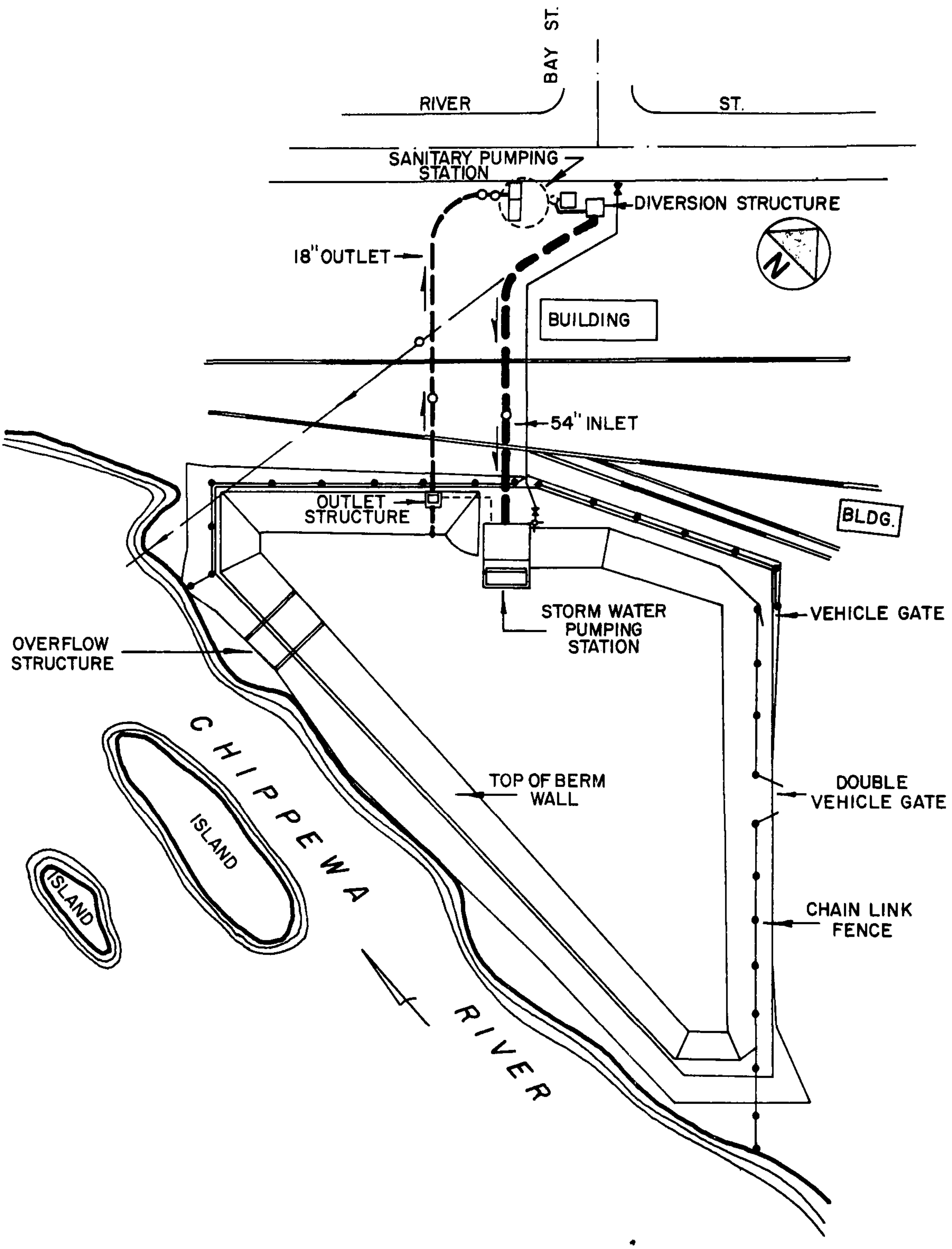


FIGURE -13-

DETENSION BASIN PLAN

Figure 14. Detention basin during high river stage.

Figure 15. View of pond in winter showing proximity of business district.

The design of additions to the wastewater treatment plant was being done at the same time as the design of the detention basin. These additions provided for secondary treatment.

The wastewater treatment plant is an activated sludge plant capable of being operated as conventional activated sludge, contact stabilization or step aeration. The plant is designed for an average DWF of 3.2 MGD for waste with characteristics of 320 mg/L (8,500 pounds) BOD_5 and 280 mg/L (7,500 pounds) suspended solids. The maximum flow that can be taken through the plant is 14.11 MGD or 9,800 gpm which is the capacity of the intercepting sewers entering the plant.

The four aeration tanks were designed on the basis of 50 pounds of 5 day BOD per day per 1,000 cubic feet of volume. The two final settling tanks are 65 feet diameter peripheral feed tanks sized on the basis of 3.2 MGD average DWF plus 4,000 gpm of combined wastewater from the retention pond.

The final tanks were increased in size from a diameter of 45 feet to 65 feet because the greater length of time at high flows (9 MGD for over 14 hours) would tend to flush the activated sludge out of the smaller tanks. Normally, the peak intercepting sewer flow (14 MGD) would occur for only a short period of time and this would not adversely affect the plant.

The construction of the project was divided into four divisions identified as A, B, C and D. Division A was the construction of the detention pond, including grading, paving, riprap, fence and landscaping; Division B was the construction of the combined wastewater pumping station, detention pond structures, piping and Bay Street pump station modifications; Division C was the construction of the combined relief sewer and some separate sewers; Division D was the electrical work on the project.

The final contract amounts were as follows:

DIVISION A		\$ 59,818.07
DIVISION B		\$158,386.74
DIVISION C		\$222,937.73
DIVISION D		\$ 21,146.59
	SUB-TOTAL	\$462,289.13
TREATMENT PLANT EXPANSION (Attributable to Demonstration Project)		\$117,420.00
ENGINEERING		\$ 28,857.99
LAND		\$ 1,500.00
	TOTAL PROJECT COST	\$610,067.12

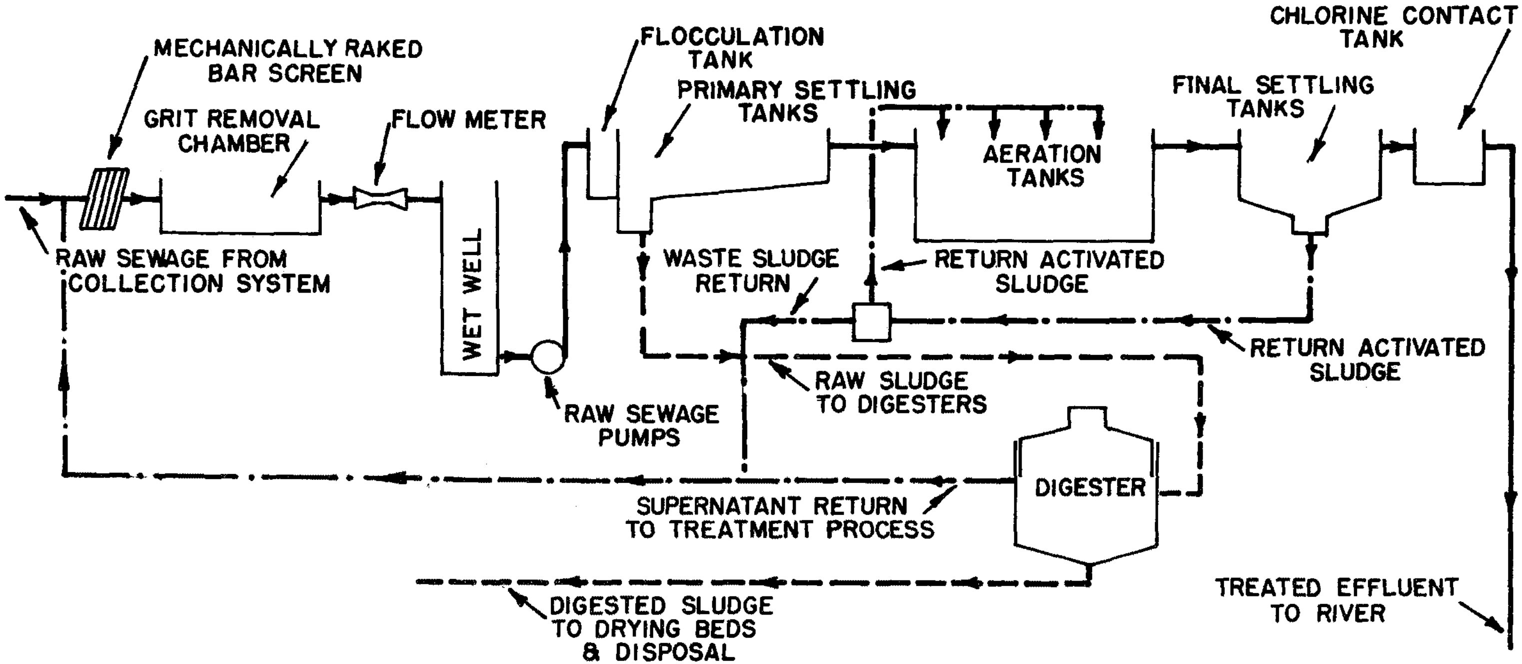


FIGURE —16—
WASTE WATER TREATMENT PLANT — FLOW DIAGRAM

Project construction began in October of 1967 and was completed and accepted by the City in March of 1969.

No unusual construction problems were encountered. The pond paving subcontractor experienced no difficulty in paving the slopes of the pond sites.

SECTION V

EVALUATION PLAN

For a meaningful evaluation of the storage pond as a method of controlling combined sewage overflows, a considerable amount of information was required. Equipment was installed at the pond site in order to provide the following data:

Rainfall	-	Time Rate and Total
Discharge to Pond	-	Time Rate
	-	Volume
	-	Characteristics
Overflow from Pond to River	-	Time Rate
	-	Volume
	-	Characteristics

The rainfall was measured by a Belfort Instrument Company Catalog No. 5-780 Universal Recording Rain Gage with 4.8 inch capacity (dual traverse) and six hour time scale charts. The rain gage was located on the top of the pond drain structure.

The overflow from the Bay Street station diversion structure to the pond was measured by a Palmer-Bowlus flume installed in a 78 inch reinforced concrete pipe. The flume was designed as outlined by Wells and Gotaas (1), fabricated of steel pipe, and installed in the pipe as it was laid. The space between the flume and pipe was grouted.

A tee section manhole just upstream of the flume area was used for access to measure the head on the flume. A scow float was installed in the pipe and a Stevens Type A 35 water-level recorder was installed at the ground surface to measure the water level. A rating curve for the flume was calculated as outlined by Ludwig & Ludwig (2). The water level was measured and the rating curve was used to develop the hydrograph rather than a direct flow measurement in gpm or cfs because of the wide range of flows expected (0 to 75,000 gpm). The chart time scale was 28.8 inches per day and the gage scale was 1.6 (1 foot on the chart equals 6 feet of level fluctuation.)

The discharge to the pond was sampled in the wet well of the combined wastewater pumping station by a SERCO automatic sampler which took a discrete sample every five minutes for two hours. The sampler was equipped with an automatic float starter activated by a rising water level in the wet well of the combined wastewater pumping station.

The overflow from the pond to the river was measured by a 22 foot long sharp crested weir located in the overflow structure. The weir head was measured by a Stevens Type A-35 water-level recorder with a cylindrical float. The chart time scale was 9.6 inches per day and the gage scale was 1:6.

The overflow to the river was sampled by a SERCO automatic sampler located at the overflow structure. A discrete sample was taken every sixty minutes during overflows for up to twenty-four hours. This sampler also was equipped with an automatic float starter activated by rising pond level.

The dissolved oxygen readings were taken with a Weston & Stack Dissolved Oxygen Analyzer Model 300 B with agitator probe.

In May of 1970, at the suggestion of the Demonstration Project Review Committee, a sampler was installed in the pond drain structure. The samples were taken from the pond drain line at 10 minute intervals and composited automatically in equal volumes.

All samples were analyzed for five day BOD, suspended solids, volatile suspended solids, settleable solids, and fecal and total coliform organisms. The analyses were performed at the wastewater treatment plant laboratory which is certified by the State of Wisconsin Department of Natural Resources. All procedures were taken from Standard Methods for the Examination of Water and Wastewater (3). It was found that the sample volumes for the settleable solids determinations were often too small for the standard Imhoff cone test. Therefore, an alternative technique was used in which the samples were allowed to settle for an hour, and suspended solids were determined on the supernatant. Settleable solids were obtained by subtracting the supernatant suspended solids from the total suspended solids concentration. Results were then reported as mg/L rather than the usual ml/L. The major disadvantage to this procedure was that most of the floatable solid material was included in the results as settleable solids. The data could thus be more correctly labeled as settleable plus floatable solids.

The membrane filter technique was used in determining the most probable number of coliform organisms.

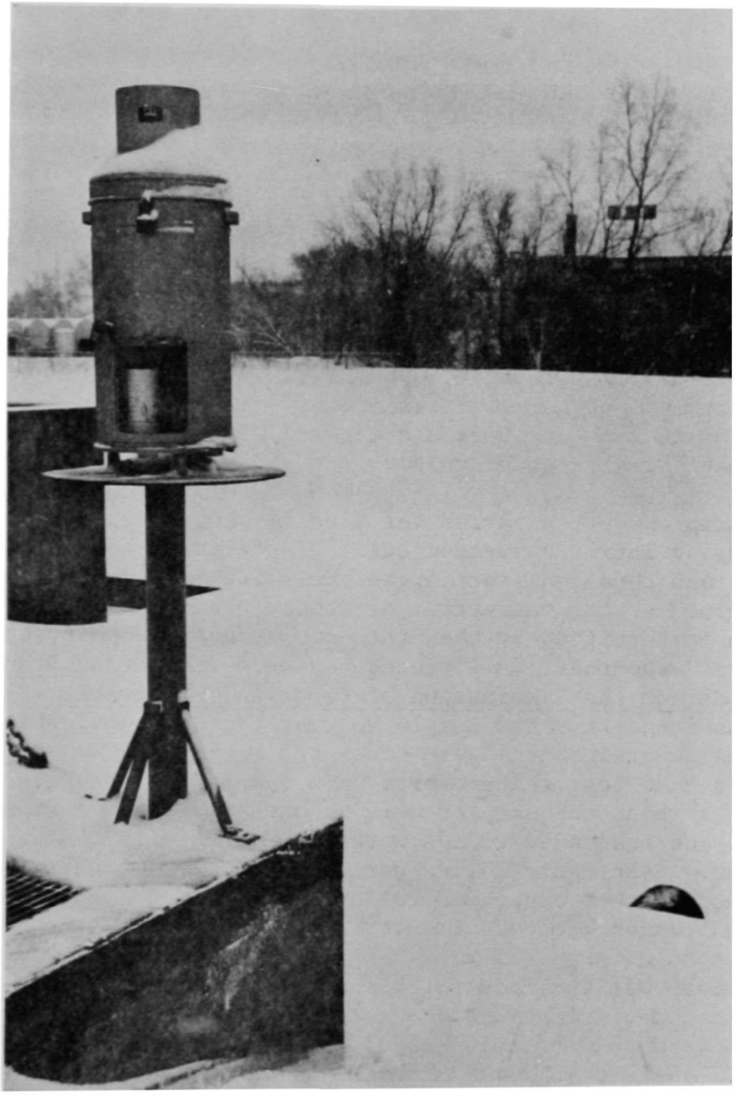


Figure 17. Rain gage at pond site.

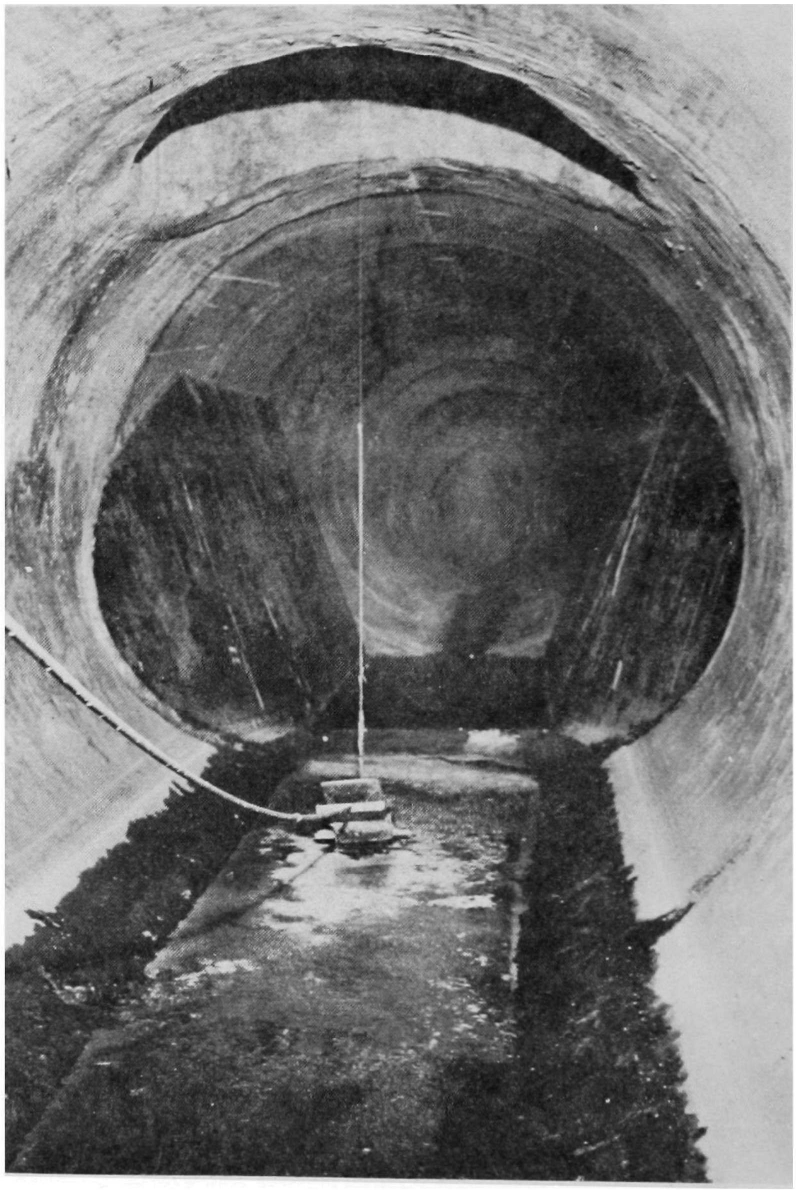


Figure 18. Palmer-Bowlus flume and scow float used to measure combined sewage discharge.

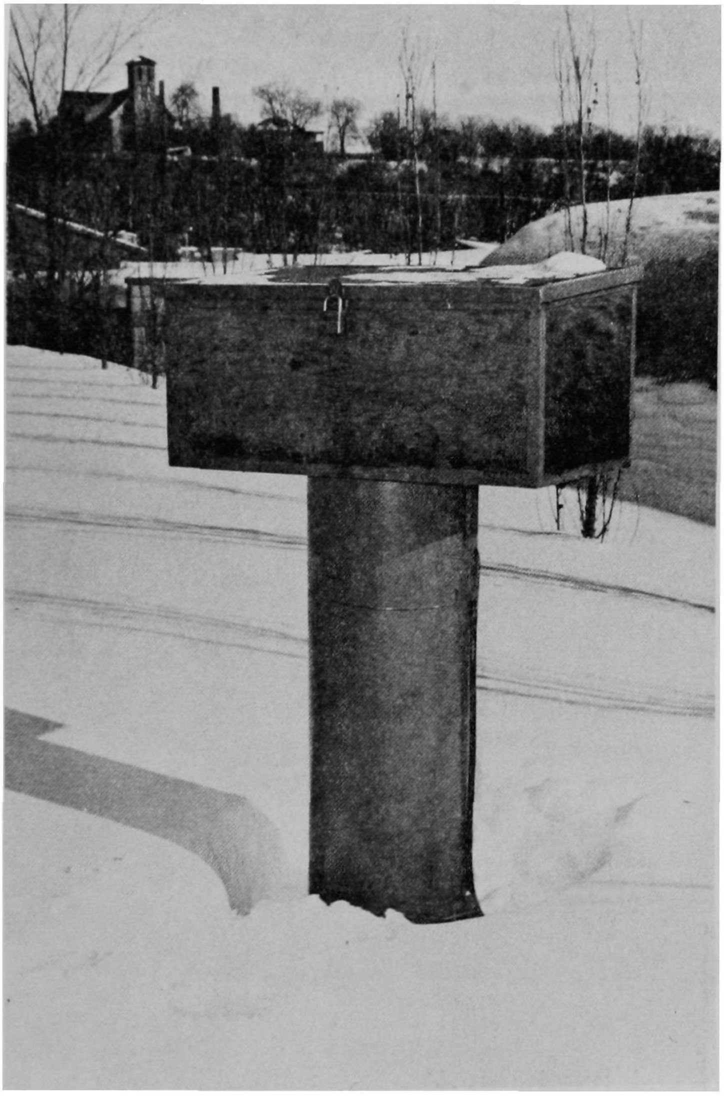


Figure 19. Enclosure for liquid level recorder above tee section manhole.

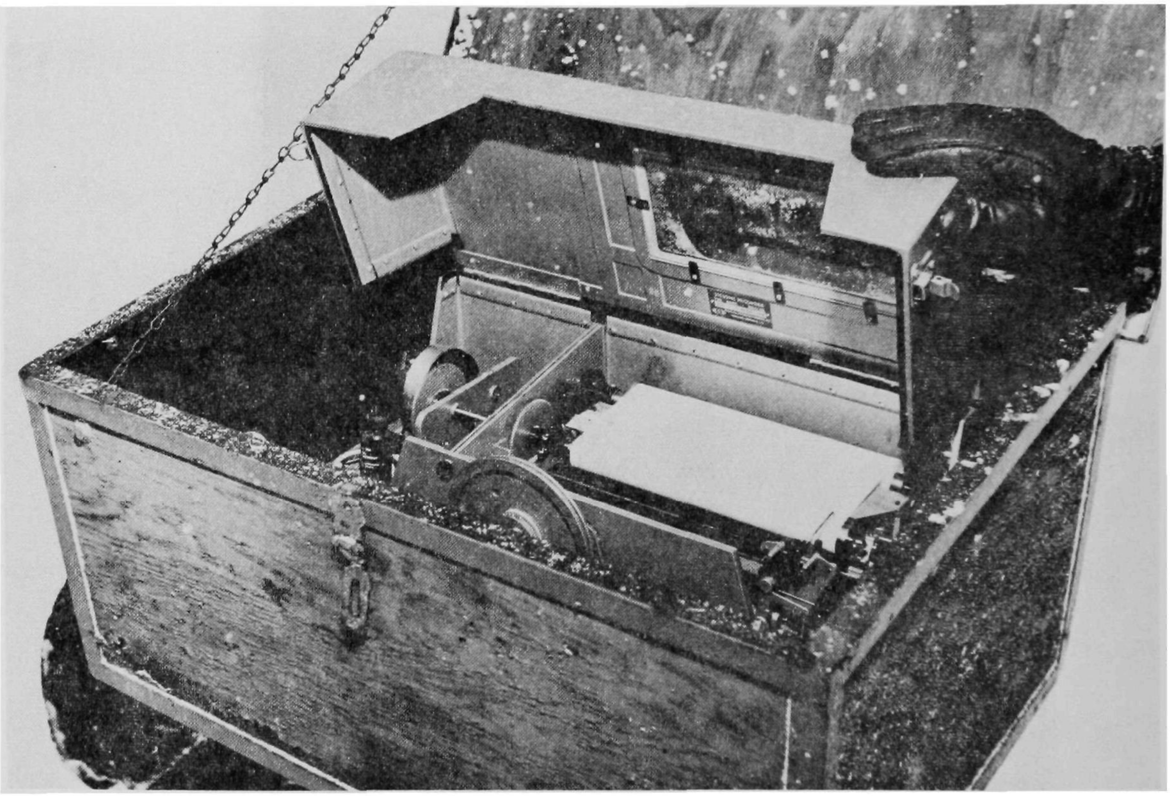


Figure 20. Liquid level strip chart recorder.

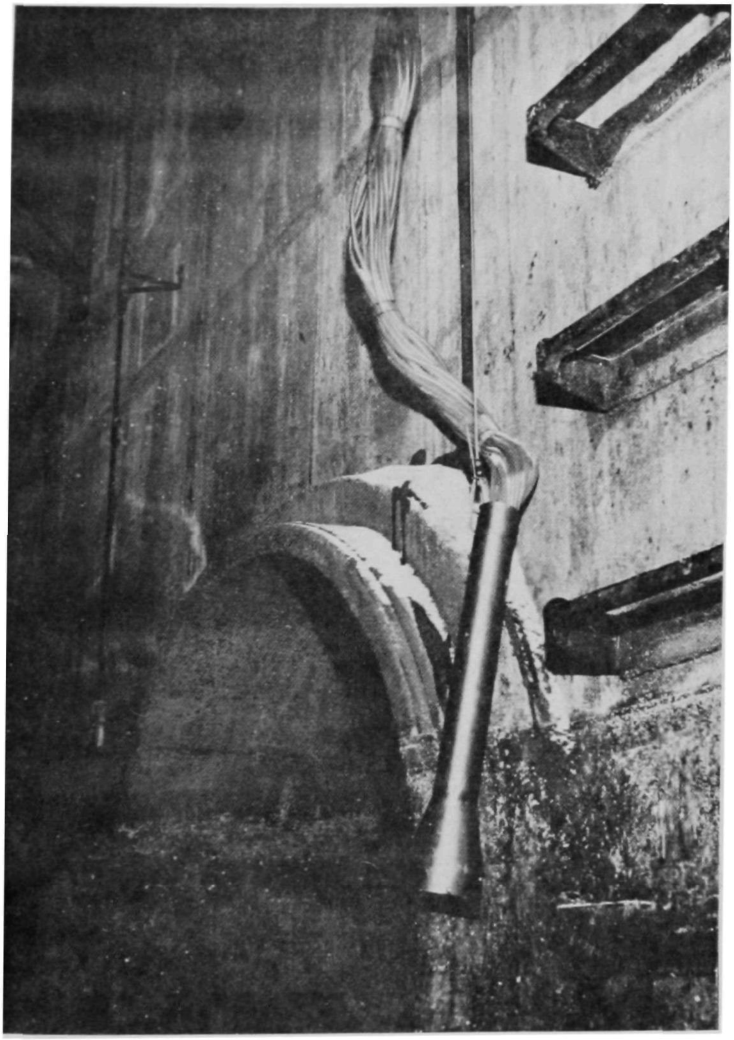


Figure 21. SERCO sampler in wet well of combined sewage pumping station.

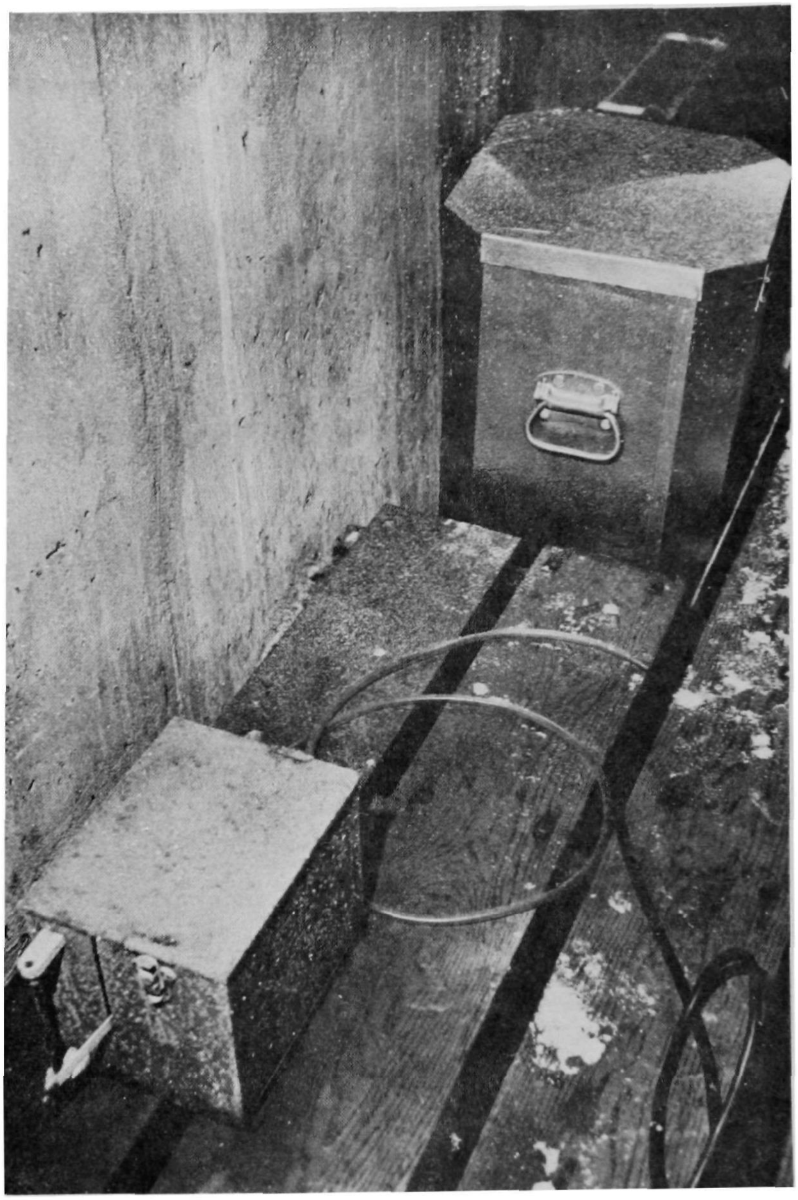


Figure 22. Sampling apparatus at upper level of combined sewage pumping station.

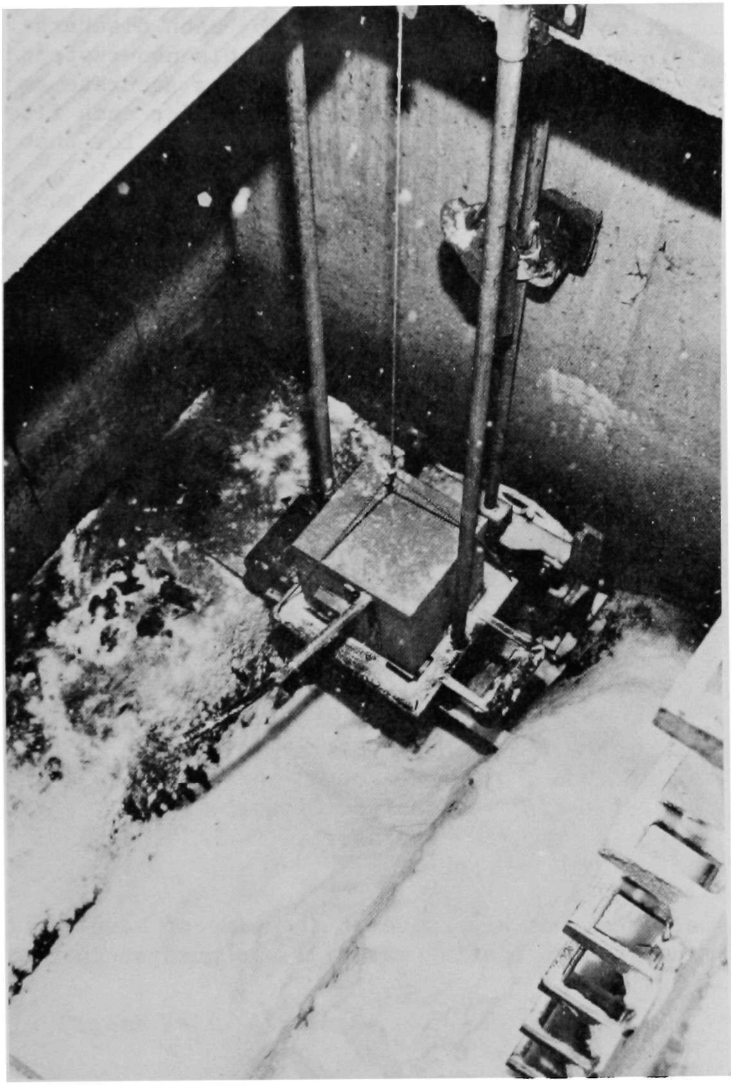


Figure 23. Automatic sampler at pond drain structure.

The volume discharged into the pond during each overflow was determined from the recorded head on the Palmer-Bowlus flume. In the computations, the rating curve for the flume was approximated by four linear sections. The liquid level data could then be converted directly into flow data. BOD_5 and suspended solids loads were calculated using the average concentration and the total volume for each discharge. This method minimized the effect of any single non-representative sample, and it was felt to be at least as accurate as the more involved technique of calculating a load for each five-minute interval based on the individual grab sample for that interval.

Fewer individual samples were available from the pond overflows to the river since the time interval for sampling was 60 minutes rather than 5 minutes. Discharge volumes were computed from the recorded head on the sharp crested weir, and loads were again determined using average concentrations.

In order to determine any possible effect of pond operation on the quality of the Chippewa River, a river sampling and testing program was undertaken. The river was sampled at two locations - one at Bridge Street, upstream from the detention pond, and one at Main Street, downstream from the pond but above the sewage treatment plant. Samples were generally taken on a weekly basis throughout the study period. The following analyses were performed on the samples:

Settleable Solids
Suspended Solids
Suspended Volatile Solids
Fecal Coliform Organisms
Total Coliform Organisms
5-Day BOD
Dissolved Oxygen
Temperature
pH

A visual check was also made at the time of sampling to determine if any floating material was present in the river.

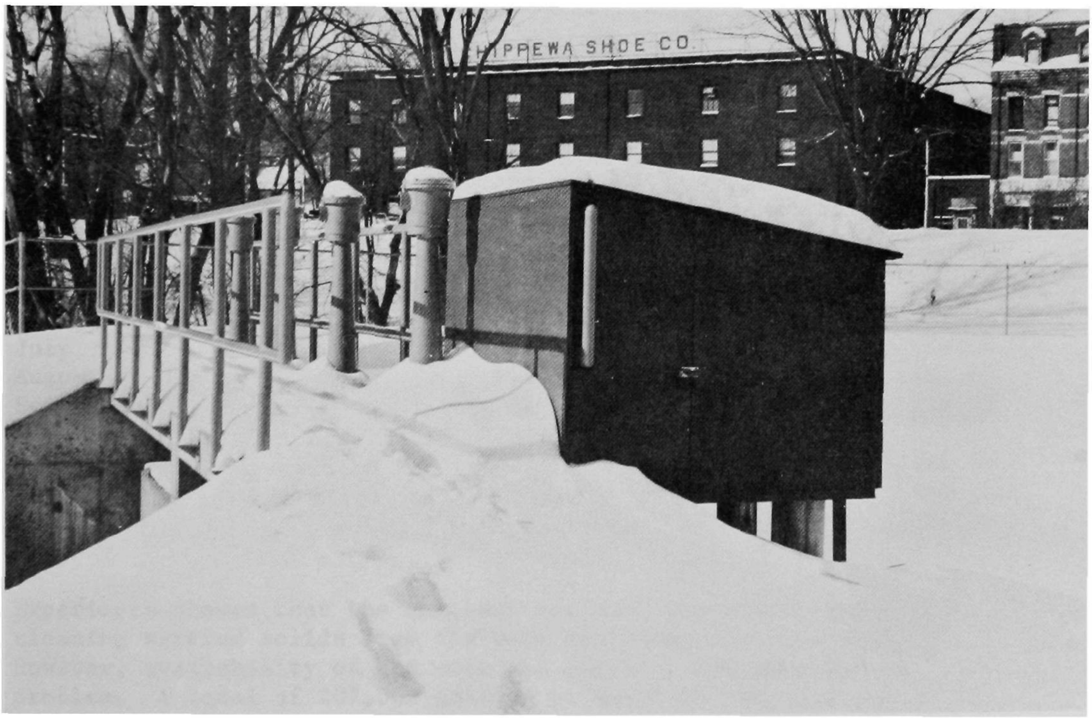


Figure 24. River sampler shelter at pond overflow structure.

SECTION VI

RESULTS OF OPERATION

The pond has been operating since April 1, 1969 with the first bypass to the pond occurring on April 20, 1969. After each bypass the pond was cleaned either using a fire hose or a street sweeper. The labor and associated costs for pond cleaning were as follows:

TABLE 1

MONTHLY LABOR COSTS FOR POND CLEANING

Month	Labor (Man Hours)	Cost
April 1969	15	$ 47.40
May	3 street sweeper	$ 51.00
June	21	$ 66.40
July	35-1/3	$ 112.00
August	18	$ 56.80
October	10	$ 31.60
May 1970	28	$ 88.50
June	44	$ 139.00
July	48	$ 152.00
August	144 (18 C.Y. sand removal)	$ 455.00
September	82	$ 259.00
	TOTAL	$1,454.70
	1969	$ 365.20
	1970	$1,089.50

Experience showed that the quickest and most economical means of cleaning settled solids from the pond was using a street sweeper. However, availability of the unit and operator was sometimes a problem. A total of 207,000 gallons of water in 1969 and 234,000 gallons in 1970 were used for pond flushing and cleanup. At the Chippewa Falls water rates, the costs for cleaning water during 1969 and 1970 were $55.30 and $62.40 respectively. In addition to the labor involved in cleaning operations, daily checks of the pond were made during the regular inspection of the Bay Street pumping station. The labor attributed to checking the pond is tabulated by month as follows:

TABLE 2

MONTHLY LABOR COSTS FOR POND AND PUMPING STATION INSPECTION

Month	Hours	Cost
April 1969	10 Hr. 40 Min.	$ 33.70
May	10 Hr. 10 Min.	$ 32.10
June	10 Hr. 55 Min.	$ 34.50
July	11 Hr. 45 Min.	$ 37.10
August	13 Hr. 15 Min.	$ 40.80
September	12 Hr. 10 Min.	$ 38.40
October	12 Hr.	$ 37.90
November	13 Hr. 20 Min.	$ 42.20
December	13 Hr. 20 Min.	$ 42.20
TOTAL	107 Hr. 35 Min.	$338.90
April 1970	20 Hr. 50 Min.	$ 66.20
May	23 Hr. 30 Min.	$ 73.60
June	28 Hr. 15 Min.	$ 89.30
July	30 Hr. 15 Min.	$ 98.80
August	27 Hr.	$ 85.30
September	26 Hr. 45 Min.	$ 84.50
October	27 Hr. 55 Min.	$ 88.30
November	26 Hr.	$ 82.20
December	28 Hr. 10 Min.	$ 88.80
TOTAL	238 Hr. 40 Min.	$757.00

These costs are undoubtedly inflated somewhat because of the added attention given to the sampling equipment and instrumentation used in the demonstration study. Furthermore, a significant portion of the daily inspection time was for the check of the Bay Street pumping station, which would have been necessary with or without the presence of the storage pond.

In addition to cleaning and daily inspection, the operating costs attributable to the pond system include the cost of pumping the combined wastewater to the pond and the added pumping and treatment costs due to the stormwater which is collected by the combined sewer system. These are costs which would not have been incurred if complete sewer separation had been accomplished. The total runoff for the drainage area was estimated from the rainfall data for 1969 and 1970 by assuming an average percolation of 20 per cent of the total volume of rainfall. By subtracting the volume which overflowed to the river from the total runoff, one can estimate the additional pumpage at the Bay Street station due to the storage pond system. To obtain the total pumpage, the volume which overflowed to the pond (and was pumped by the combined sewage pumping station) must be added. These figures plus associated power costs are tabulated as follows:

TABLE 3

PUMPING COSTS ASSOCIATED WITH POND OPERATION

	1969		1970	
Total Runoff	35.7	Mgal.	59.4	Mgal.
Total Overflow to River	1.03	Mgal.	1.52	Mgal.
Net Volume Pumped By Bay Street Station	34.7	Mgal.	57.9	Mgal.
Energy Used	11,700	Kwh.	19,600	Kwh.
Power Cost	$368		$618	
Total Discharge to Pond (pumped by combined sewage pumping station)	13.8	Mgal.	26.5	Mgal.
Energy Used	722	Kwh.	1,390	Kwh.
Power Cost	$ 23		$ 44	
Total Power Cost for Pumping (excluding sewage treatment plant)	$391		$662	

The cost of treating the additional stormwater is difficult to distinguish from the total cost of operation for the treatment plant. An idea of the magnitude of this cost may be determined as a percentage of the total operating cost by assuming that the cost of treatment is proportional to the flow. This method will probably result in a value somewhat higher than the actual cost since the average organic and solids concentrations in the stormwater are lower than in the sanitary sewage and wastes. Nevertheless, such figures may be useful as conservative estimates of the cost of operating this type of system.

TABLE 4

Added Cost of Treatment Plant Operation Due to Stormwater

	1969	1970
Total Wastewater Flow (millions of gallons)	809.891	820.886
Total Stormwater to Plant (millions of gallons)	34.7	57.9
$\frac{\text{(Storm Volume)}}{\text{(Wastewater Volume)}} \times 100\%$	4.3%	7.1%
Total Operating & Maintenance Cost	$90,211	$98,395
Operating & Maintenance Cost Associated with Stormwater	$ 3,880	$ 6,980

The approximate total cost of operating and maintaining the pond system can be summarized as follows:

TABLE 5

SUMMARIZED OPERATION AND MAINTENANCE COSTS

	1969	1970
PUMPING (EXCLUDING PUMPS IN TREATMENT PLANT)	$ 391	$ 662
ADDED COST OF TREATMENT PLANT OPERATION	$3,880	$6,980
POND CLEANING AND MAINTENANCE	$ 759	$1,909
TOTAL OPERATION AND MAINTENANCE COST	$5,030	$9,551

As might be expected, the operating cost of the retention pond system is dependent to a large extent on the amount of rainfall in the drainage area. During the 1970 test period, 30.43 inches of rainfall were recorded, and the cost of operation was approximately twice the cost of that for 1969 when only 18.25 inches of rainfall were recorded.

It should further be noted that the largest portion of the operation and maintenance cost is due to the increase in hydraulic load at the sewage treatment plant. This is also the least accurate and most difficult to determine of all the costs associated with the pond operation.

Throughout the course of the study, there were no objectionable odors reported from the pond vicinity either during overflow or cleanup periods.

The river reached a high water elevation of 827.4 during the spring of 1969. This water level was 0.6 feet below the top of the dike, but 0.4 feet above the flood control gates. As a result, an undetermined volume of river water entered the pond. There was no apparent ill effect from the high water.

Two minor operational problems were noted as follows:

1. The wet well of the combined wastewater pumping station had a grating cover over the top. In the winter, snow entered the wet well, partially melted, and formed ice in the wet well. This was corrected by covering the grating with plywood in the winter and placing a heat lamp over the wet well sump pump.

2. The grit chamber area on the discharge of the combined wastewater pumps should have been deeper to retain more grit and to keep the snow and ice below the emergency station bypass flap gates.

From April 1, 1969 to December 31, 1970, rainfall was recorded at the pond site on 129 days. On 62 of these days combined sewage discharged to the storage pond, and on three occasions the pond overflowed to the river. Tables 6 and 7 show the rainfall data together with the duration and volume of each discharge to the pond during 1969 and 1970. The BOD and suspended solids data from the discharge samples are given in Tables 8 and 9. During certain discharges, the sampling apparatus was not functioning properly and as a result, the data are not complete.

The values for settleable solids, suspended volatile solids, fecal and total coliform organisms are averaged for each discharge and tabulated in Tables 10 and 11. The three overflows from the pond to the river are described in Table 12. Hourly samples were collected and analyzed for the duration of each pond overflow. However, the liquid level recorder at the overflow structure was out of service during the storm of August 6, 1969, and no discharge data is available for this overflow. The volume discharged to the river has been estimated however, by subtracting the pond storage volume from the volume discharged into the pond.

Table 13 is a compilation of the characteristics of the combined sewage as it drained out of the pond and back to the Bay Street pumping station. The sampler at the pond drain was installed in May 1970 and operated continuously, taking a sample every 10 minutes whenever there was flow through the drain line. The individual samples were combined in equal volumes and thus were not composited according to flow.

The influent and effluent BOD_5 and suspended solids data for the wastewater treatment plant are shown in Tables 14 and 15. Routine collection and compositing of BOD samples was done every third day only. Hence, sampling did not always occur on days of precipitation. The influent BOD and suspended solids values are artificially high since the samples were taken at a point following the addition of the digester supernatant and the waste activated sludge. The reported removal percentages are, therefore, somewhat higher than the actual removals. Detailed operating data for the treatment plant during 1969 and 1970 are summarized in the Appendix. The relatively poor effluent quality in April and early May of 1969 was due to operational difficulties with the return activated sludge pumps.

During the period from January 1, 1970 to December 31, 1970, six different flow configurations were used in the aeration portion of the wastewater treatment plant. However, the effluent quality remainder fairly constant during the dry weather period from January through March.

Based on previous pumping records, the average dry weather sewage and wastewater flow to the Bay Street pumping station is approximately 2000 gallons per minute or 2.88 mgd. Grab samples of the wastewater entering the pumping station during dry weather conditions have shown BOD_5 values of 468 mg/L on a weekday and 296 mg/L on a weekend. The difference can be attributed to the industrial BOD load which is considerably greater on weekdays than on weekends. The major industrial loads are contributed by a meat packing plant, a creamery, a brewery and two plastic factories. However, the meat packing plant does not discharge to the portion of the sewage collection system tributary to the Bay Street pumping station.

Figures 25, 26 and 27 are rainfall hyetographs and hydrographs of of the discharge to the pond during the July 14 and August 6, 1969 and August 11, 1970 storms, respectively. These are plotted in five minute intervals.

The rainfall on July 14, 1969 began at 5:35 a.m. Discharge to the pond began at 5:38 a.m. The Bay Street station was discharging its capacity of 6,000 gpm (13.4 cfs) about two minutes after the discharge to the pond began or about 5:40 a.m. The pond discharge hydrograph peak must be increased by 9 cfs to obtain the total runoff hydrograph peak of 138 cfs because 9 cfs of runoff was pumped by the Bay Street station during the storm. The total volume which discharged to the river, as pond overflow, was 615,000 gallons.

The rainfall on August 6, 1969 began at 9:48 p.m. Discharge to the pond began at 9:55 p.m., and the Bay Street station again was handling its maximum capacity of 6,000 gpm (13.4 cfs) about two minutes after discharge to the pond began or about 9:57 p.m. The combined sewage discharge hydrograph peak of 168 cfs was reached at 10:10 p.m. or 22 minutes after rainfall began. The total runoff hydrograph peak was 177 cfs, and the overflow to the river was estimated to be 412,000 gallons.

The rainfall on August 11, 1970 began at 2:35 p.m. Discharge to the pond began at 2:47 p.m. The Bay Street station was pumping its capacity of 6,000 gpm (13.4 cfs) about one minute after discharge to the pond began or about 2:48 p.m. The hydrograph peak for discharge to the pond of 164 cfs was reached at 3:05 p.m. or thirty minutes after rainfall began. The total runoff hydrograph peak was 174 cfs, and total overflow to the river was 1,523,000 gallons. The July 14, 1969 storm had a rainfall intensity of 3.25 inches per hour for the first twelve minutes and the August 6, 1969 storm had a rainfall intensity of 3.0 inches per hour for the first twenty-two minutes. The August 11, 1970 storm had a rainfall intensity of 2.48 inches per hour for the first thirty minutes.

Using the Rational Formula, C (runoff coefficient)may be calculated as follows:

JULY 14, 1969

$$Q = CIA$$
$$138 = C\ 3.25\ (90)$$
$$C = 0.47$$

AUGUST 6, 1969

$$Q = CIA$$
$$177 = C\ 3.0\ (90)$$
$$C = 0.65$$

AUGUST 11, 1970

$$Q = CIA$$
$$174 = C\ 2.48\ (90)$$
$$C = 0.78$$

The value of "C" appears to increase with an increase in the length of time between beginning of rainfall and peak flow on the hydrograph. This is consistent with studies which have shown an increase in the "C" factor with an increase in the duration of rain.

The pond D.O. was checked after the April 27, 1969 storm. Discharge to the pond started at 12:42 a.m. and ended at 2:07 a.m. The lowest D.O. was 0.8 mg/L near the river overflow structure at 10:00 a.m. The pond D.O. was again checked after the September 21, 1970 storm. Discharge to the pond began at 5:10 a.m and ended at 9:45 a.m. The lowest D.O. was 6.4 mg/L on the north side of the pond at 9:00 a.m.

TABLE 6

1969 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
APRIL 8	0.07	-	-
APRIL 9	-	12:04 A.M. - 1:25 A.M.	27,700
APRIL 14	.14	-	-
APRIL 20	.20	8:53 A.M. - 10:30 A.M.	24,100
APRIL 26	.13	-	-
APRIL 27	.48	12:42 A.M. - 2:07 A.M. 2:58 A.M. - 4:25 A.M. 1:45 P.M. - 2:27 P.M.	23,600 2,900 1,700
MAY 1	.81	6:25 A.M. - 7:25 A.M. 12:58 P.M. - 1:38 P.M.	11,600 4,500
MAY 2	-	12:56 A.M. - 3:12 A.M.	71,900
MAY 5	.05	-	-
MAY 6	.17	-	-
MAY 10	.02	-	-
MAY 17	.66	-	-
MAY 19	.22	-	-
MAY 21	.12	-	-
MAY 26	.10	1:04 A.M. - 1:18 A.M.	3,800
MAY 31	.21	7:41 P.M. - 9:02 P.M.	32,200

TABLE 6 (Continued)

1969 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
JUNE 11	.88	4:00 A.M. - 6:50 A.M. 7:38 A.M. - 1:00 P.M.	RECORDER
JUNE 12	.53	5:30 A.M. - 7:50 A.M.	OUT
JUNE 22	.48	4:35 P.M. - 6:40 P.M.	OF
JUNE 25	.68	10:30 A.M. - 1:50 P.M.	ORDER
JUNE 26	.62	-	-
JULY 2	.69	5:22 A.M. - 7:17 A.M.	155,800
JULY 4	.15	8:25 A.M. - 9:15 A.M.	11,000
JULY 8	1.01	9:00 A.M. - 11:35 A.M.	191,200
JULY 14	2.53	5:38 A.M. - 9:22 A.M.	499,400
JULY 24	.03	-	-
JULY 25	-	8:30 A.M. - 1:10 P.M.	9,500
JULY 26	.24	11:33 P.M. - 9:40 A.M.	65,700
JULY 28	-	1:35 P.M. - 2:45 P.M.	8,700
JULY 30	.23	10:20 P.M. - 11:00 P.M.	7,200

TABLE 6 (Continued)

1969 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
AUG. 6	.40	9:48 A.M. - 10:25 A.M.	90,000
	1.97	9:55 P.M. - 12:45 A.M.	432,000
AUG. 29	.14	-	-
SEPT. 4	.18	3:42 P.M. - 4:40 P.M.	12,900
		8:00 P.M. - 8:50 P.M.	6,100
SEPT. 22	.36	5:05 P.M. - 8:00 P.M.	37,500
SEPT. 25	.22	-	-
SEPT. 29	.15	1:05 A.M. - 3:10 A.M.	13,900
OCT. 1	.22	2:55 A.M. - 3:45 A.M.	11,200
	.30	8:08 P.M. - 9:38 P.M.	13,900
OCT. 5	.20	-	-
OCT. 12	.78	9:17 P.M. - 1:35 A.M.	32,700
OCT. 15	.46	-	-
OCT. 16	.02	-	-
OCT. 19	.10	-	-
OCT. 30	.46	8:10 P.M. _ 10:15 P.M.	7,800
OCT. 31	.28	4:42 P.M. - 6:17 P.M.	7,700
NOV. 1	.08	-	-
NOV. 17	.48	4:57 P.M. - 7:42 P.M.	31,800

TABLE 7

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
APRIL 5	0.14	-	-
APRIL 12	.08	-	-
APRIL 15	.12	-	-
APRIL 19	.77	3:20 P.M. - 11:20 P.M.	58,300
APRIL 20	.10	-	-
APRIL 22	.06	-	-
	.11	5:45 P.M. - 6:30 P.M.	6,200
APRIL 23	.04	-	-
APRIL 28	.06	-	-
APRIL 30	.06	-	-
MAY 1	.08	-	-
MAY 9	.56	9:25 A.M. - 10:55 A.M.	86,400
MAY 11	-	11:10 A.M. - 11:50 A.M.	4,800
MAY 12	.27	1:20 A.M. - 2:05 A.M.	23,700
MAY 13	.41	10:45 P.M. - 12:15 A.M.	6,100
MAY 14	.52	1:32 A.M. - 3:02 A.M.	13,400
MAY 19	.03	-	-

TABLE 7 (Continued)

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
MAY 21	.47	6:50 P.M. - 7:05 P.M. 10:45 P.M. - 12:25 A.M.	1,200 40,000
MAY 22	.50	1:10 A.M. - 2:55 A.M. 4:40 A.M. - 7:55 A.M.	46,200 100,200
MAY 23	.06	-	-
MAY 24	.08	-	-
MAY 25	.10	-	-
MAY 27	.72	11:12 P.M. - 12:00 A.M.	23,700
MAY 28	.48	12:00 A.M. - 3:55 A.M.	109,500
MAY 29	.04	-	-
MAY 30	.26	1:05 A.M. - 3:20 A.M.	10,700
MAY 31	.42	8:15 A.M. - 1:55 P.M.	109,700
JUNE 9	.06	-	-
JUNE 11	.22	7:10 P.M. - 7:55 P.M.	27,100
JUNE 12	.17	5:35 P.M. - 6:20 P.M.	8,200
JUNE 13	.08	-	-
JUNE 15	.68	9:18 A.M. - 12:00 P.M.	40,800
JUNE 16	.02	-	-

TABLE 7 (Continued)

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE OF POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
JUNE 17	.07	7:20 A.M. - 7:37 A.M.	2,900
JUNE 19	.04	-	-
JUNE 25	1.02	8:15 P.M. - 1:25 A.M.	148,300
JUNE 30	.05	-	-
JULY 2	.25	1:10 A.M. - 1:22 A.M. 2:13 A.M. - 2:33 A.M.	900 800
JULY 3	0.05	-	-
JULY 4	.16	-	-
JULY 7	.36	8:38 P.M. - 12:17 A.M.	61,100
JULY 13	.60	2:33 A.M. - 3:25 A.M. 4:35 A.M. - 7:50 A.M.	15,700 51,400
JULY 14	.47	4:10 A.M. - 4:37 A.M. 5:45 A.M. - 6:43 A.M. 8:50 A.M. - 9:23 A.M.	800 20,900 6,700
JULY 15	.13	3:00 A.M. - 3:23 A.M.	10,000
JULY 18	.61	11:57 P.M. - 2:05 A.M.	62,700
JULY 27	.07	-	-
JULY 28	.80	2:00 P.M. - 3:20 P.M. 10:20 P.M. - 12:30 A.M.	106,500 52,600
JULY 30	.90	2:28 A.M. - 3:27 A.M.	152,300

TABLE 7 (Continued)

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE OF POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
JULY 31	.09	2:13 P.M. - 2:28 P.M.	1,300
AUG. 11	2.63	2:47 P.M. - 5:10 P.M.	527,300
AUG. 15	.18	-	-
AUG. 18	.02	-	-
AUG. 29	.24	4:20 A.M. - 10:45 A.M.	82,700
SEPT. 2	.12	2:50 A.M. - 3:25 A.M.	3,500
	.25	11:25 P.M. - 12:10 A.M.	12,000
SEPT. 3	.09	-	-
SEPT. 6	1.41	4:40 A.M. - 11:05 A.M.	288,400
SEPT. 9	.70	3:35 P.M. - 8:30 P.M.	72,500
SEPT. 14	.96	7:30 P.M. - 9:40 P.M.	24,500
SEPT. 15	-	6:00 A.M. - 8:40 A.M.	68,000
SEPT. 17	.21	-	-
	.02	-	-
SEPT. 21	1.28	5:10 A.M. - 9:45 A.M.	188,300
SEPT. 23	.21	10:15 P.M. - 10:45 P.M.	1,000
SEPT. 24	.46	2:45 A.M. - 9:55 A.M.	70,300
SEPT. 25	.26	-	-

TABLE 7 (Continued)

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE OF POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
OCT. 7	.64	2:30 P.M. - 6:20 P.M.	179,900
OCT. 8	1.10	5:00 A.M. - 9:45 A.M. 11:05 A.M. - 11:20 A.M.	138,300 1,200
OCT. 9	.38	12:50 P.M. - 1:50 P.M.	41,500
OCT. 11	.04	-	-
OCT. 22	.01	-	-
OCT. 23	.45	6:55 P.M. - 12:00 A.M.	43,400
OCT. 24	.35	12:00 A.M. - 5:30 A.M.	33,850
OCT. 25	.09	-	-
OCT. 26	1.17	1:15 A.M. - 2:30 A.M. 3:05 P.M. - 7:10 P.M. 8:00 P.M. - 12:00 A.M.	10,600 41,700 91,600
OCT. 27	.42	12:00 A.M. - 9:20 A.M.	RECORDER
OCT. 28	.13	-	OUT OF
OCT. 29	.15	-	ORDER
OCT. 30	.06	-	-
OCT. 31	.17	-	-

TABLE 7 (Continued)

1970 COMBINED SEWAGE DISCHARGES - VOLUME AND DURATION

DATE	PRECIPITATION (inches)	DURATION OF DISCHARGE TO POND	VOLUME OF DISCHARGE TO POND (cu. ft.)
NOV. 1	.13	-	-
NOV. 2	.16	-	-
NOV. 3	.64	12:20 A.M. - 4:50 A.M.	116,700
NOV. 7	.03	-	-
NOV. 9	.79	2:30 A.M. - 8:25 A.M. 9:55 A.M. - 10:45 A.M.	73,700 4,500
NOV. 11	.06	-	-
NOV. 18	.06	-	-
NOV. 19	.32	10:15 P.M. - 12:00 A.M.	6,500
NOV. 20	.15	12:00 A.M. - 12:45 A.M.	1,200
NOV. 25	.01	-	-
NOV. 26	.42 (SNOW)	-	-
DEC. 1	.02	3:00 A.M. - 7:45 A.M.	6,400

TABLE 8

BOD5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1969

MONTH		APRIL			MAY			
DATE	20		27		1		1	
BEGIN OVERFLOW	8:35 AM		12:42 AM		6:25 AM		12:58 PM	
END OVERFLOW	10:30 AM		2:07 AM		7:25 AM		1:38 PM	
CONSTITUENT (mg/L)	BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
5	113	320	227	464	191	400	91	244
10	135	276	212	484	112	240		
15					165	248		
20			208	640	113	80	223	414
25	196	267	252	692	102	100	250	472
30					102	56		
35					132	164		
40					122	132	278	400
ELAPSED 45					122	156		
TIME FROM 50					129	212		
START OF 55					116	150		
OVERFLOW 60					125	160		
TO 65			223	360	113	120		
SAMPLING 70					146	132		
(MINUTES) 75					111	134		
80					108	188		
85					106	228		
90					106	200		
95					108	224		
100	116	300			119	232		
105								
110								
115								
120								
AVG.	140	291	224	528	122	211	210	382
LOAD (LB.)	2,10	440	330	770	90	150	60	110

TABLE 8 (Continued)

BOD$_5$ AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1969

MONTH		JUNE				
DATE		11		22		25
BEGIN OVERFLOW		4:00 AM		4:30 PM		10:30 AM
END OVERFLOW		6:50 AM		6:40 PM		1:50 PM
CONSTITUENT (mg/L)	BOD$_5$	SS	BOD$_5$	SS	BOD$_5$	SS
5		80	74	722	218	374
10			72	450	229	604
15			135	240		
20	179	134	212	472	175	284
25	177	202	247	326	167	106
30	137	240			213	286
35	195	216	169	198		
40	183	146	206	268	172	252
ELAPSED 45	122	220	167	162		
TIME FROM 50			44	70	166	172
START OF 55	117	228			177	172
OVERFLOW 60						
TO 65	112	322			186	260
SAMPLING 70	137	146				
(MINUTES) 75						
80	155	186			182	242
85					209	228
90					168	238
95	148	256			207	282
100					134	192
105					146	240
110					157	218
115						
120						
AVG.	151	198	147	323	182	259
LOAD (LB.)	-	-	-	-	-	-

TABLE 8 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1969

MONTH		JULY							
DATE		2		8		14		26	
BEGIN OVERFLOW		5:22 AM		9:00 AM		5:38 AM		11:33 PM	
END OVERFLOW		7:17 AM		11:35 AM		9:22 AM		9:40 AM	
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
	5	96	140	162	222	129	762	174	436
	10	73	114	198	458	99	200	184	500
	15	23	54	199	446	154	372	230	820
	20	21	20			137	418	229	850
	25	97	144	192	386	112	318	211	500
	30	59	46	217	448	108	282	151	90
	35	42	38	106	318	86	252	138	500
	40	35	40	91	306	56	226	187	200
ELAPSED	45	42	22	65	154	64	142	187	230
TIME FROM	50	58	28	62	226	66	246	141	268
START OF	55	46	14	59	178	54	222	197	368
OVERFLOW	60	23	28					178	248
TO	65	77	88			43	206	126	232
SAMPLING	70	68	66			37	160	227	312
(MINUTES)	75	32	52			52	228	175	224
	80	70	88			21	164	123	268
	85	93	94	73	118	69	322	150	160
	90	67	22	55	100			165	148
	95	75	94	65	114	52	180	150	156
	100	37	20			58	148	125	112
	105	90	90	104	130	75	168	138	140
	110	60	58	129	152	81	186	164	100
	115	24	38	174	198	112	176	164	320
	120	20	46	177	210	44	186		
AVG.		55	60	125	245	78	253	170	310
LOAD (LB.)		530	580	1480	2900	2420	7830	690	1260

TABLE 8 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1969

MONTH		AUGUST		SEPTEMBER					
DATE		6		4		22		29	
BEGIN OVERFLOW		9:55 PM		3:42 PM		5:05 PM		1:05 AM	
END OVERFLOW		12:45 AM		4:40 PM		8:00 PM		3:10 AM	
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
	5	140	232	323	269	281	332	135	224
	10	169	328	407	308	483	580	165	256
	15	260	396						
	20	156	276					149	340
	25					486	768	315	848
	30	59	204	500+	920			163	188
	35	59	184					125	192
	40	47	284					147	256
ELAPSED	45	41	304			341	572	164	160
TIME FROM	50	97	364	488	1044			179	244
START OF	55	38	236			465	852	144	220
OVERFLOW	60	41	164					155	260
TO	65			438	392			121	284
SAMPLING	70	114	332	396	496	261	332	154	408
(MINUTES)	75	57	252	500+	500	188	480	117	176
	80	43	216					105	152
	85	44	220			233	404	113	148
	90	134	272	368	412			147	320
	95	138	348			271	464	140	300
	100	96	252	246	312	215	280	184	288
	105	111	252	296	294			99	176
	110	129	330	317	384	322	656	141	344
	115	142	180						
	120	144	292	317	292	236	240	103	152
	AVG.	103	269	383+	471	315	497	148	270
	LOAD (LB.)	2760	7210	310+	380	730	1160	130	230

TABLE 8 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1969

MONTH		OCTOBER			
DATE		12		30	
BEGIN OVERFLOW		9:17 PM		8:10 PM	
END OVERFLOW		1:35 AM		10:15 PM	
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS
	5	230	316	156	228
	10	136	164	92	118
	15				
	20				
	25				
	30	189	220	82	72
	35				
	40				
ELAPSED	45				
TIME FROM	50				
START OF	55	165	224		
OVERFLOW	60			66	62
TO	65	173	308	77	96
SAMPLING	70	153	184	83	100
(MINUTES)	75	179	248		
	80	190	308		
	85	196	296	62	54
	90	169	232	84	94
	95			71	80
	100			108	112
	105				
	110				
	115				
	120				
	AVG.	178	250	88	102
	LOAD (LB.)	360	510	430	50

TABLE 9

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1970

MONTH		APRIL		MAY					
DATE		22		9		12		28	
BEGIN OVERFLOW		5:45 PM		9:25 AM		1:20 AM		12:00 AM	
END OVERFLOW		6:30 PM		10:55 AM		2:05 AM		3:55 AM	
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
	5	80	432	196	532	66	192	91	124
	10	85	360	219	472	51	140	78	124
	15	86	340			77	132	101	100
	20			190	496	53	144		
	25			163	360	39	124	146	260
	30			150	324	49	148		
	35			138	276	52	172	94	228
	40			132	244	56	200	93	164
ELAPSED	45	171	240	117	176	65	132		
TIME FROM	50	89	124	134	248	44	108	90	80
START OF	55	84	152	129	224	54	124	87	44
OVERFLOW	60	187	280	138	248	68	184		
TO	65	67	124	155	288	51	152	88	84
SAMPLING	70	77	112	160	264	62	112		
(MINUTES)	75			147	248	55	148	86	88
	80	91	132	151	252	52	136		
	85	121	176	184	264	57	144	99	108
	90	96	152	141	248	41	100		
	95	56	128	143	256	42	128	113	144
	100	68	132	149	200	43	108		
	105	56	120	159	204	55	120	107	156
	110	45	136	164	244	38	124		
	115	68	112	165	232	38	120		
	120			157	220	38	80		
	AVG.	90	191		283	52	136	98	131
	LOAD (LB.)	30	70		1520	80	200	670	890

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1970

MONTH		JUNE				
DATE	12		15		25	
BEGIN OVERFLOW	5:35 PM		9:18 AM		8:15 PM	
END OVERFLOW	6:20 PM		12:00 PM		1:25 AM	
CONSTITUENT (mg/L)	BOD_5	SS	BOD_5	SS	BOD_5	SS
5	92	452	128	136	226	322
10	133	348	267	616	219	268
15	143	264	132	176		
20	205	632	237	440	192	188
25	232	636				
30	233	392	98	324		
35			77	212		
40			121	272		
ELAPSED 45			105	248		
TIME FROM 50			129	276		
START OF 55			251	448		
OVERFLOW 60			170	176		
TO 65			151	264		
SAMPLING 70			202	416		
(MINUTES) 75			141	144		
80			180	176		
85						
90						
95			139	204		
100			177	312		
105			172	248		
110			211	240		
115			150	236		
120						
AVG.	173	454	162	278	212	259
LOAD (LB.)	90	230	410	700	1950	2380

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR COMBINED SEWAGE DISCHARGES TO POND 1970

MONTH		JULY						
DATE	7		13		14		18	
BEGIN OVERFLOW	8:38 PM		4:35 AM		8:50 AM		11:57 PM	
END OVERFLOW	12:17 AM		7:50 AM		9:23 AM		2:05 AM	
CONSTITUENT (mg/L)	BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
5	453	596	374	192	41	132	161	458
10	343	656	362	284			174	342
15	311	372	352	324	95	260	75	136
20	432	688			37	100	91	282
25	368	624	312	208			96	156
30	429	628	337	192	73	156	84	216
35	459	984	357	232	148	284	141	
40	248	616	372	256	123	164	77	222
ELAPSED 45	164	576			119	200	91	230
TIME FROM 50					97	136		
START OF 55	384	580	418	236			74	182
OVERFLOW 60	365	568	413	244			71	190
TO 65	425	880	475	432			77	170
SAMPLING 70	320	400	443	688			97	150
(MINUTES) 75	313	752					89	168
80	403	640						
85	230	316					76	116
90	298	388	342	216			81	178
95	213	256	227	488			91	108
100	316	352	208	580			49	76
105	181	220	281	520			65	94
110	252	516	249	468			82	326
115	174	460	237	304			70	310
120	132	212	182	272			99	250
AVG.	314	530	330	341	92	179	91	208
LOAD (LB.)	1190	2020	1050	1090	120	230	350	810

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1970

MONTH		JULY				AUGUST			
DATE		28		30		11		29	
BEGIN OVERFLOW		10:20 PM		2:28 AM		2:47 PM		4:20 AM	
END OVERFLOW		12:30 AM		3:27 AM		5:10 PM		10:35 AM	
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
	5	366	440	99	140	66	328	119	452
	10	222	568	81	132	59	208	110	560
	15	278	360	102	196	83	208	141	428
	20	267	360	257	448	73	532	113	400
	25	157	612	214	340	58	520	138	608
	30	93	576	96	428	38	680	112	352
	35	100	588	78	368	47	716		
	40	198	756	148	392	33	664		
ELAPSED	45	172	640	96	352	33	380	208	544
TIME FROM	50	311	596	114	360	32	360	86	316
START OF	55			216	336	27	248	128	420
OVERFLOW	60	278	472	156	604	33	268	87	224
TO	65	227	600	100	292	41	248		
SAMPLING	70							81	260
(MINUTES)	75			101	216	22	196	104	268
	80	227	512	93	204	31	336	88	304
	85			83	168	32	360		
	90	387		118	148	30	296	71	256
	95	209	320	111	220	48	380	91	380
	100	210	296	252	168	39	228	105	444
	105	244	316	136	416	37	272	75	276
	110	208	300	178	260	30	148		
	115	192	340		228	47	224		
	120								
	AVG.	229	481	135	292	43	355	109	382
	LOAD (LB.)	750	1570	1270	2760	1410	11610	560	1960

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1970

MONTH		SEPTEMBER						
DATE		2		6		9		15
BEGIN OVERFLOW		2:50 AM		4:40 AM		3:35 PM		6:00 AM
END OVERFLOW		3:25 AM		11:05 AM		8:30 PM		8:40 AM
CONSTITUENT (mg/L)		BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
	5	101	268	136	356	424	628	125	220
	10					202	292	264	648
	15	78	140	183	348	178	292	108	200
	20	115	304	61	224	146	164	323	712
	25	129	272	134	192	163	312		
	30			101	176	158	256	103	224
	35	89	100	95	196	140	216	80	156
	40	96	136	174	356	184	200	69	188
ELAPSED	45	93	124	58	188	112	152	67	152
TIME FROM	50					147	404	186	424
START OF	55	83	164	63	244	292	692	101	244
OVERFLOW	60			88	248	229	448		
TO	65	85	208	37	104			103	224
SAMPLING	70	145	352	24	92	193	220		
(MINUTES)	75	88	224	71	140	319	656		
	80			51	108	323	812	229	360
	85	134	324	142	324	211	496	121	256
	90					185	264	170	372
	95			84	292			77	84
	100			69	152	286	484		
	105	86	156	90	332			124	244
	110			115	300	197	332		
	115							112	172
	120			72	424	163	300		
	AVG.	102	213	92	240	213	381	139	287
	LOAD (LB.)	20	50	1650	4290	960	1710	590	1210

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR
COMBINED SEWAGE DISCHARGES TO POND
1970

MONTH	SEPTEMBER				OCTOBER			
DATE	21		24		7		24	
BEGIN OVERFLOW	5:10 AM		2:45 AM		2:30 PM		12:00 AM	
END OVERFLOW	9:45 AM		9:55 AM		6:20 PM		5:30 AM	
CONSTITUENT (mg/L)	BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
5	95	712	153	280	254	288	237	264
10	101	564	143	284	348	512		
15	141	512	138	172	416	424	192	280
20	66	424	154	148	312	320	108	116
25	96	412	165	216	286	252	169	256
30	128	424	193	236	179	264	307	532
35	158	432	170	256	185	348	136	180
40	145	368	183	180	147	288	226	312
ELAPSED 45			181	204	177	312	157	252
TIME FROM 50	105	276	157	144	192	268		
START OF 55			84	120				
OVERFLOW 60	185	344	53	56	138	184	145	268
TO 65	201	612	60	124	139	116	132	256
SAMPLING 70	318	488			248	296		
(MINUTES) 75	301	564	81	112	137	204		
80	196	388	108	180			142	248
85	176	288	115	132	223	192	274	288
90			113	120	149	216	280	224
95			112	116	119	152	284	452
100			93	132	165	380		
105			88	112	207	348	239	360
110			107	152	219	292		
115			91	112	204	348		
120			89	136				
AVG.	161	454	123	162	212	286	202	286
LOAD (LB.)	1880	5300	540	710	2360	3190	420	600

TABLE 9 (Continued)

BOD_5 AND SUSPENDED SOLIDS FOR COMBINED SEWAGE DISCHARGES TO POND 1970

MONTH		NOVEMBER					DECEMBER	
DATE		3		9		19		1	
BEGIN OVERFLOW	12:20 AM		9:55 AM		10:15 PM		3:00 AM	
END OVERFLOW	4:50 AM		10:45 AM		12:00 AM		7:45 AM	
CONSTITUENT (mg/L)	BOD_5	SS	BOD_5	SS	BOD_5	SS	BOD_5	SS
5	56	172	77	156	56	132	102	248
10	45	104	78	88	44	96	126	288
15	55	104	66	84	42	92	115	320
20	57	132	64	100	72	136	92	256
25	54	60					116	228
30	59	144	56	144			133	324
35	133	148	49	152	36	100	86	212
40	54	100	86	180	33	100	84	236
ELAPSED 45	49	80			28	52	121	312
TIME FROM 50	60	112	81	140			97	232
START OF 55								
OVERFLOW 60			53	120	55	104	109	244
TO 65	68	112			58	112	110	264
SAMPLING 70	46	116	55	100	33	72	158	260
(MINUTES) 75	53	132			42	80	72	184
80	32	132	85	176	42	64		
85			38	100	23	72	69	192
90	39	152			42	88	61	216
95	39	180			46	88	69	188
100	30	192			64	108	60	196
105	37	168			68	148	66	204
110	33	164					59	204
115	28	160					64	156
120								
AVG.	51	133	66	128	46	97	94	236
LOAD (LB.)	370	960	300	580	20	40	40	90

TABLE 10

AVERAGE CHARACTERISTICS - 1969 DISCHARGES TO POND

DATE	SETTLEABLE SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM ($x10^6$) (MPN/100 ml)	TOTAL COLIFORM ($x10^6$) (MPN/100 ml)
APRIL 20	-	174	1.07	12.05
APRIL 27	-	302	-	-
MAY 1	-	105	-	-
MAY 1	-	192	1.63	91.75
JUNE 11	-	113	9.23	73.00
JUNE 22	-	172	3.73	35.78
JUNE 25	-	154	6.04	84.60
JULY 2	-	39	-	-
JULY 8	-	151	4.44	134.06
JULY 14	-	115	13.13	112.55
JULY 26	-	230	45.87	186.13
AUG. 6	-	160	-	-
SEPT. 4	403	355	40.50	254.00
SEPT. 22	177	382	61.20	382.00

TABLE 10 (Continued)

AVERAGE CHARACTERISTICS - 1969 DISCHARGES TO POND

DATE	SETTLEABLE SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM ($x10^6$) (MPN/100 ml)	TOTAL COLIFORM ($x10^6$) (MPN/100 ml)
SEPT. 29	288	226	10.02	65.20
OCT. 12	137	213	10.65	144.80
OCT. 30	33	36	-	-

TABLE 11

AVERAGE CHARACTERISTICS - 1970 DISCHARGES TO POND

DATE	SETTLEABLE SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM ($x10^6$) (MPN/100 ml)	TOTAL COLIFORM ($x10^6$) (MPN/100 ml)
APRIL 22	146	106	0.28	12.06
MAY 9	218	177	.30	45.87
MAY 12	124	90	.14	39.09
MAY 28	112	90	.26	18.00
JUNE 12	320	387	1.47	107.33
JUNE 15	228	211	1.39	51.06
JUNE 25	259	253	2.57	59.67
JULY 7	270	433	9.29	160.74
JULY 13	211	279	7.06	347.22
JULY 14	108	143	7.00	173.75
JULY 18	208	173	-	-
JULY 28	437	315	6.06	202.63
JULY 30	235	187	-	-
AUGUST 11	338	150	3.00	113.64
AUGUST 29	366	281	1.26	80.05
SEPT. 2	171	177	.88	121.38

TABLE 11 (Continued)

AVERAGE CHARACTERISTICS - 1970 DISCHARGES TO POND

DATE	SETTLEABLE SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM ($x10^6$) (MPN/100 ml)	TOTAL COLIFORM ($x10^6$) (MPN/100 ml)
SEPT. 6	236	175	.34	31.75
SEPT. 9	294	310	4.14	207.75
SEPT. 15	216	251	1.21	91.18
SEPT. 21	391	246	.69	86.00
SEPT. 24	166	111	.70	65.55
OCT. 7	270	213	1.81	76.67
OCT. 24	268	235	1.06	59.67
NOV. 3	136	114	.14	15.84
NOV. 9	118	119	.26	12.33
NOV. 19	87	80	.12	6.06
DEC. 1	227	149	-	4.94
AVERAGE (1969-1970)	225	196	7.19	101.79

TABLE 12

CHARACTERISTICS OF POND OVERFLOWS TO RIVER

DATE	PRECIP-ITATION (inches)	DURATION OF OVERFLOW	VOL. OF OVERFLOW (cu.ft.)	TIME OF SAMPLING	BOD_5 (mg/L)	SUSPENDED SOLIDS (mg/L)	SETTLEABLE SOLIDS (mg/L)	COLIFORMS (MPN/100 ml) FECAL	TOTAL
JULY 14, 1969	2.53	6:55 AM-	82,300	7:00 AM	53	246	30	18.8×10^6	134×10^6
		9:15 PM		8:00 AM	73	238	25	19.7×10^6	137×10^6
				9:00 AM	58	140	20	21.4×10^6	135×10^6
				AVG.CONC.	61	208			
				LOAD	310 LB.	1070 LB.			
AUG. 6, 1969	1.97	12:00 PM-	55,000*	12:00 PM	26	76	-	-	-
		1:00 AM		1:00 AM	28	88	-	-	-
				AVG.CONC.	27	82			
				LOAD	90 LB.	280 LB.			
AUG. 11, 1970	2.63	3:30 PM-	203,600	3:30 PM	50	184	174	5×10^6	120×10^6
		5:10 PM		4:30 PM	27	204	-	1×10^6	310×10^6
				AVG.CONC.	38	194			
				LOAD	480 LB.	2460 LB.			

* ESTIMATED FROM DISCHARGE TO POND.

TABLE 13

1970 POND DRAIN DATA

DATE	SETTLEABLE SOLIDS (mg/L)	SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/100ml)	TOTAL COLIFORM (MPN/100ml)	BOD_5 (mg/L)
MAY 28	4710	4910	-	-	433
MAY 30	-	316	20,000	2.8×10^6	59
JUNE 12	502	532	660,000	37×10^6	81
JUNE 15	-	-	460,000	22×10^6	-
JUNE 25	190	208	900,000	26×10^6	58
JULY 7	-	326	400,000	16×10^6	36
JULY 13	128	136	4.6×10^6	162×10^6	103
JULY 14	97	124	6×10^6	130×10^6	37
JULY 15	98	136	10^6	30×10^6	37
JULY 28	274	308	-	120×10^6	80
AUGUST 29	112	116	400,000	10×10^6	17
SEPT. 2	-	116	240,000	21×10^6	44
SEPT. 6	606	620	180,000	12×10^6	-
SEPT. 15	1150	1160	400,000	140×10^6	185
OCT. 7	166	172	1.2×10^6	74×10^6	74
OCT. 24	226	228	520,000	31×10^6	53

TABLE 14

WASTEWATER TREATMENT PLANT DATA
1969

DATE	PRECIP-ITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
	(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
April 2		1.74	478	6940	10	150	98.0	976	14,160	14	200	98.5
5		1.49	367	4560	8	100	97.8	372	4,620	22	270	94.2
8	0.07	2.79	177	3990	53	1230	70.1	308	7,170	60	1400	80.5
11		4.13	193	6650	16	550	91.6	288	9,920	3	100	98.9
14	.14	1.71										
17		2.15	398	7140	69	1270	82.6	540	9,680	68	1220	87.7
20	.20	1.97	462	7590	22	350	95.3	1188	19,520	28	460	97.7
23		2.00	375	6260	18	300	95.2	672	11,210	34	570	94.8
26	.13	1.98	260	4340	32	530	87.7	252	4,160	22	360	91.2
27	.48	1.64										
29		2.95	395	9720	89	2190	77.4	628	15,450	94	2310	84.8
May 1	.05	2.14										
2		3.39	204	5770	52	1470	74.6	540	15,270	150	4240	72.3
5		1.71										
6	.17	2.63										
10	.02	2.18										
11		1.41						816	9,600	61	720	92.5
17	.66	3.13	369	9630	15	390	95.9					
19	.22	1.20										
20		2.01	315	5280	12	200	96.2	636	10,660	27	450	95.7
21	.12	1.80										
23		1.79	364	5430	25	370	93.1	936	13,970	41	610	95.6
26	.10	1.08	366	3300	30	270	91.8	876	7,890	42	380	95.4
29		1.90	343	5440	20	320	94.2	1124	17,810	61	970	94.6
31	.21	1.33										

TABLE 14 (continued)

WASTEWATER TREATMENT PLANT DATA
1969

DATE		PRECIP-ITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
		(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
June	1		1.80	168	2520	10	150	94.0	536	8,050	15	230	97.2
	4		1.94	233	3770	27	440	88.4	492	7,960	44	710	91.2
	7		2.00	229	3820	6	100	97.4	1564	26,090	25	420	98.3
	10		2.25	347	6510	22	410	93.7	940	17,640	24	450	97.6
	11	.88	2.94										
	12	.53	4.25										
	13		2.94	240	6000	23	580	90.4	564	13,830	33	810	94.2
	16		1.76	229	3360	18	260	92.1	576	8,450	40	590	93.1
	19		2.27	387	7330	39	740	89.8	808	15,300	41	780	94.8
	22	.48	2.09	99	1730	32	560	67.8	248	4,320	58	1010	76.6
	25	.68	2.43	196	3970	8	160	95.8	332	6,730	27	550	91.8
	26	.62	3.28										
July	1		2.59	213	4600	13	280	93.9	924	19,960	26	560	97.2
	2	.69	2.40										
	4	.15	2.56										
	7		1.92	294	4710	26	420	91.2	912	14,600	38	610	95.8
	8	1.01	2.42										
	10		2.24	243	4540	24	450	90.2	556	10,390	28	520	94.9
	13		2.19	178	3250	4	70	94.8	268	4,890	8	150	97.1
	14	2.53	2.40										
	17		2.89	235	5660	40	960	83.0	660	15,910	34	820	94.8
	21	.03	2.24	243	4540	15	280	93.8	520	9,710	29	700	94.2
	24	.24	2.88	272	6530	14	340	94.9	556	13,350	27	650	95.1
	26		2.63										
	27	.23	3.61	209	6290	6	180	97.1					
	30		3.57	274	8160	21	630	92.3	704	20,960	37	1100	94.8

TABLE 14 (continued)

WASTEWATER TREATMENT PLANT DATA
1969

DATE		PRECIP-ITATION (inches)	INFLUENT FLOW (mgd)	INFLUENT BOD$_5$ (mg/L)	INFLUENT BOD$_5$ (lb)	EFFLUENT BOD$_5$ (mg/L)	EFFLUENT BOD$_5$ (lb)	BOD REMOVAL %	INFLUENT SUSPENDED SOLIDS (mg/L)	INFLUENT SUSPENDED SOLIDS (lb)	EFFLUENT SUSPENDED SOLIDS (mg/L)	EFFLUENT SUSPENDED SOLIDS (lb)	SS REMOVAL %
August	2		3.07	112	2870	6	150	94.6	700	17,920	23	580	96.7
	5		2.36	138	2720	25	490	81.9	420	8,270	28	550	93.4
	6	2.37	2.02										
	8		3.86	176	5670	21	680	88.1					
	11		1.62	188	2540	12	160	93.6	488	6,590	39	530	92.0
	14		4.58	124	4740	15	570	87.9	548	20,930	28	1070	94.9
	17		3.45	230	6620	10	290	95.7	932	26,820	36	1040	96.1
	20		3.65	353	10750	36	1100	89.8	1180	35,920	43	1310	96.4
	23		2.76	158	3640	32	740	79.8	1376	31,670	47	1080	96.5
	29	.14	2.27	250	4730	36	680	85.7	832	15,750	35	660	95.8
Sept.	1		1.69	265	3740	20	280	92.4	1104	15,560	35	490	96.8
	4	.18	2.53	262	5530	26	550	90.2	536	11,310	21	440	96.1
	7		2.12	262	4630	10	180	96.2	520	9,190	18	320	96.6
	10		2.23	262	4870	32	600	87.7	760	14,100	19	350	97.5
	13		2.44	267	5430	12	240	95.5	1164	23,700	18	370	98.3
	16		2.50	271	5650	15	310	94.4	1304	27,200	12	250	98.9
	19		2.18	314	5710	18	330	94.4	808	18,900	16	290	97.9
	22	.36	1.68	311	4360	17	240	94.4	832	11,660	30	420	96.4
	24		2.24	353	6600	11	210	96.8	1164	21,750	19	350	98.3
	25	.22	2.57										
	28		1.62	174	2350	32	430	81.7	752	10,160	21	280	97.2
	29	.15	2.35										

TABLE 14 (continued)

WASTEWATER TREATMENT PLANT DATA
1969

DATE		PRECIP-ITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
		(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
Oct.	1	.52	2.08	267	4630	11	190	95.8	720	12,490	24	420	96.8
	4		2.17	189	3150	9	150	95.3	1124	20,340	14	250	98.9
	5	.20	1.72										
	7		2.60	357	7740	21	460	94.1	1036	22,460	35	760	96.7
	10		2.47	404	8330	20	410	95.0	912	18,790	27	560	97.2
	12	.78	1.88										
	13		2.51	346	7240	77	160	77.8	948	19,840	54	1130	94.3
	15	.46	2.47										
	16	.02	3.63	199	6030	27	820	86.4	892	27,000	42	1270	95.2
	19	.10	1.76	127	1800	14	200	89.0	484	7,100	16	230	96.8
	22		2.08	549	9530	21	360	96.2	1264	21,930	29	500	97.7
	25		2.02	182	3060	43	730	76.4	612	10,310	39	660	93.7
	28		2.11	213	3750	23	400	89.2	740	13,020	50	880	93.3
	30	.46	1.98										
	31	.28	2.94	244	5980	47	1150	80.7	1001	24,540	60	1470	93.2
Nov.	1	.08	2.97										
	3		1.75	297	4460	17	260	94.3	1216	17,750	22	320	98.2
	6		2.25	337	6320	17	320	94.8	936	17,560	28	530	97.1
	9		1.99	270	4480	21	350	92.2	920	15,270	44	730	95.3
	12		2.30	220	4220	30	580	86.4	276	5,290	44	840	84.1
	15		1.99	141	2340	12	200	91.6	328	5,440	23	380	93.0
	17	.48	1.61										
	18		3.18	330	8750	24	640	92.7	752	19,940	30	800	96.1
	24		1.77	330	4870	21	310	93.6	1048	15,470	45	660	95.7
	28		1.63	197	2680	19	260	90.3	876	11,910	52	710	93.9

TABLE 15

WASTEWATER TREATMENT PLANT DATA
1970

DATE	PRECIPITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
	(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
April 5	0.14	1.90										
6		2.15	500	8970	26	470	94.8	1728	30,980	23	410	98.7
9		3.54	480	14170	22	650	95.4	1780	52,550	21	620	98.8
12	.08	1.88	212	3320	18	280	91.5	752	11,790	24	380	96.8
15	.12	2.34	231	4510	16	310	93.1	824	16,080	25	490	96.9
18		2.28	245	4660	20	380	91.8	624	11,870	33	630	94.7
19	.77	1.87										
20	.10	3.15										
21		3.34	218	6070	31	860	85.7	760	21,170	47	1310	93.8
22	.17	2.85										
23	.04	2.38										
24		1.92	462	7400	25	400	94.5	1940	31,060	57	910	97.0
27		1.55	229	2960	25	320	89.0	612	7,910	37	480	93.9
28	.06	2.05										
30	.06	1.91	230	3660	24	380	90.0	616	9,810	30	480	95.1
May 1	.08	1.94										
3		1.63	205	2790	12	160	94.1	240	3,260	6	80	97.5
6		1.91	244	3890	48	760	80.3	344	5,480	31	490	91.0
9	.56	1.80	257	3860	20	300	92.2	684	10,270	47	710	93.1
12	.27	2.52	281	5910	22	460	92.1	902	18,960	21	840	97.6
13	.41	1.89										
14	.52	2.70										
15		3.12	392	10200	22	570	94.3	960	24,980	22	570	97.7
18		1.73	319	4600	30	430	90.5	1000	14,430	30	430	97.0
19	.03	2.38										

TABLE 15 (continued)

WASTEWATER TREATMENT PLANT DATA
1970

DATE		PRECIP-ITATION (inches)	INFLUENT FLOW (mgd)	INFLUENT BOD_5 (mg/L)	INFLUENT BOD_5 (lb)	EFFLUENT BOD_5 (mg/L)	EFFLUENT BOD_5 (lb)	BOD REMOVAL %	INFLUENT SUSPENDED SOLIDS (mg/L)	INFLUENT SUSPENDED SOLIDS (lb)	EFFLUENT SUSPENDED SOLIDS (mg/L)	EFFLUENT SUSPENDED SOLIDS (lb)	SS REMOVAL %
May	21	.47	2.25	257	4820	25	470	90.5	564	10,580	24	440	95.7
	22	.50	3.45										
	23	.06	3.64										
	24	.08	2.41	155	3120	30	600	83.5	260	5,230	14	280	94.6
	25	.10	2.18										
	27	.72	1.97										
	28	.48	3.64										
	29	.04	1.48										
	30	.26	2.22	313	5800	27	500	91.0	784	14,520	43	800	94.5
	31	.42	1.87										
June	2		2.51	133	2780	40	720	70.0	170	3,560	38	800	77.6
	5		2.01	322	5400	22	370	93.3	792	13,280	30	500	96.2
	8		1.90	363	5760	39	620	89.4	1752	27,760	43	680	97.5
	9	.06	2.45										
	11	.22	2.80	289	6750	26	610	91.0	560	13,080	26	610	95.4
	12	.17	2.52										
	13	.08	2.32										
	14		1.81	509	7680	29	440	94.3	2028	30,610	20	300	99.0
	15	.68	2.19										
	16	.02	3.43										
	17	.07	2.29	377	7200	28	530	92.0	1344	25,670	17	320	98.8
	19	.04	2.30										
	20		1.86	142	2200	26	404	81.7	368	5,710	4	60	98.9
	23		2.21	190	3530	12	220	93.2	356	6,560	23	420	93.5
	25	1.02	1.84										
	26		4.79	220	8790	9	360	95.9	912	36,430	16	640	98.2
	29		1.82	275	4170	25	380	90.9	772	11,720	18	270	97.6
	30	.05	2.28										

TABLE 15 (continued)

WASTEWATER TREATMENT PLANT DATA
1970

DATE		PRECIP-ITATION (inches)	INFLUENT FLOW (mgd)	INFLUENT BOD_5 (mg/L)	INFLUENT BOD_5 (lb)	EFFLUENT BOD_5 (mg/L)	EFFLUENT BOD_5 (lb)	BOD REMOVAL %	INFLUENT SUSPENDED SOLIDS (mg/L)	INFLUENT SUSPENDED SOLIDS (lb)	EFFLUENT SUSPENDED SOLIDS (mg/L)	EFFLUENT SUSPENDED SOLIDS (lb)	SS REMOVAL %
July	2	.25	2.24	175	3270	33	620	81.1	520	9,710	31	580	94.0
	3	.05	2.58										
	4	.16	4.92										
	5		--	191		27		85.8	312		19		94.0
	7	.36	2.36										
	8		2.45	208	4250	28	570	86.5	356	7,270	26	530	92.6
	11		2.00	248	4140	11	180	95.6	576	9,610	15	250	97.3
	12		1.83										
	13	.60	2.42										
	14	.47	2.88	318	7640	28	670	91.3					
	15	.13	3.70										
	16		1.98										
	17		2.19	329	6010	31	570	90.6	688	12,570	28	510	95.9
	18	.61	1.97										
	20		1.67	332	4620	30	420	91.0	704	9,810	25	350	96.4
	24		2.61										
	27	.07	1.84	561	8610	19	290	98.3	1844	28,300	29	450	98.4
	28	.80	2.04										
	30	.90	3.07	326	8350	16	410	95.1	636	16,280	20	510	96.8
	31	.09	3.08										
Aug.	3		1.83	537	8200	22	340	96.0	1360	20,760	33	500	97.5
	6		1.80	266	3990	28	420	89.4	540	8,110	35	530	93.5
	9		1.73	97	1400	8	120	91.7	188	2,710	8	120	95.7
	11	2.63	2.24										
	12		4.67	278	10830	14	550	94.9	664	25,860	30	1170	95.4
	15	.18	2.15	386	6920	40	720	89.6	764	13,700	14	250	98.1
	17		1.70										

TABLE 15 (continued)

WASTEWATER TREATMENT PLANT DATA
1970

DATE		PRECIP-ITATION (inches)	INFLUENT FLOW (mgd)	INFLUENT BOD_5 (mg/L)	INFLUENT BOD_5 (lb)	EFFLUENT BOD_5 (mg/L)	EFFLUENT BOD_5 (lb)	BOD REMOVAL %	INFLUENT SUSPENDED SOLIDS (mg/L)	INFLUENT SUSPENDED SOLIDS (lb)	EFFLUENT SUSPENDED SOLIDS (mg/L)	EFFLUENT SUSPENDED SOLIDS (lb)	SS REMOVAL %
Aug.	18	.02	2.01	192	3220	11	180	94.2	376	6,300	28	470	92.5
	21		1.81	236	3560	14	210	94.0	460	6,940	28	420	93.9
	24		1.79	457	6820	64	960	86.0	684	10,210	40	600	94.1
	27		1.98	264	4360	19	310	92.8	620	10,240	74	1220	88.0
	29	.24	2.49										
Sept.	2	.37	1.92	196	3140	23	370	88.3	492	7,880	49	784	90.0
	3	.09	2.13										
	5		1.84	511	7840	7	110	98.6	1000	15,350	12	180	98.8
	6	1.41	2.06										
	8		2.46	548	11240	16	330	97.0	1412	28,970	34	700	97.5
	9	.70	4.16										
	11		1.79	256	3820	14	210	94.5	356	5,310	10	150	97.2
	14		1.56	200	2600	23	300	88.5	440	5,720	46	600	89.5
	15	.96	2.33										
	17	.23	2.12	202	3570	19	340	90.5	620	10,960	22	390	96.4
	20		1.68	123	1720	18	250	86.1	560	7,850	22	310	96.0
	21		1.84										
	23		1.96	573	9370	13	210	97.7	676	11,050	21	340	96.8
	24	.46	2.98										
	25	.26	2.51										
	26		2.68	306	6840	10	220	96.7	268	5,990	12	270	95.5
	30		--	544		21		96.1	656		13		98.0
Oct.	3		2.09	279	4860	7	120	97.5	416	7,250	15	260	96.3
	6		2.19	637	11630	14	260	97.7	856	15,630	15	270	98.2
	7	.64	2.02										
	8	1.10	3.18										

TABLE 15 (continued)

WASTEWATER TREATMENT PLANT DATA
1970

DATE	PRECIP-ITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
	(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
Oct. 9	.38	3.89	298		6	190	98.0	420	13,630	13	420	96.9
11	.04	1.80										
12		1.83	125	1880	4	60	93.0	796	12,150	31	470	96.1
15		1.83	179	9670	5	80	97.2	516	7,880	16	240	96.8
18		1.88	410	6430	14	220	96.5	912	14,300	24	380	97.3
22	.01	2.01										
23	.45	1.99										
24	.35	3.80	265	8400	31	980	88.3					
25	.09	1.67										
26	1.17	2.47										
27	.42	5.54	179	8270	8	370	95.5	456	21,070	12	560	97.3
28	.13	2.84										
29	.15	2.57										
30	.06	2.40	209	4180	3	60	98.5	408	8,170	12	240	97.0
31	.17	2.58										
Nov. 1	.13	2.07										
2	.16	1.81	148	2230	10	150	93.2	312	4,710	11	170	96.5
3	.64	3.86										
6		2.17	247	4470	11	200	95.5	524	9,480	13	240	97.5
7	.03	2.08										
9	.79	2.57	388	8320	14	300	96.3	1008	21,610	17	360	98.3
11	.06	1.83										
12		2.40	255	5100	10	200	96.0	744	14,890	13	260	98.2
15		1.86	298	4620	15	230	94.9	344	5,340	16	250	95.3
18	.06	1.96	271	4430	12	200	95.5	400	6,540	6	100	98.5
19	.32	2.01										
20	.15	3.20										

TABLE 15 (continued)

WASTEWATER TREATMENT PLANT DATA
1970

DATE	PRECIP-ITATION	INFLUENT FLOW	INFLUENT BOD_5		EFFLUENT BOD_5		BOD REMOVAL	INFLUENT SUSPENDED SOLIDS		EFFLUENT SUSPENDED SOLIDS		SS REMOVAL
	(inches)	(mgd)	(mg/L)	(lb)	(mg/L)	(lb)	%	(mg/L)	(lb)	(mg/L)	(lb)	%
Nov. 21		2.84	819	19400	9	210	98.9	1356	32,120	13	310	99.0
24		2.11	613	10790	8	140	98.6	1064	18,720	13	230	98.7
25	.01	2.21										
26	.42	1.96										
27		1.81	363	5480	13	200	96.4	688	10,390	18	270	97.3
30		1.84	631	9680	10	150	98.4	1000	15,350	23	350	97.7
Dec. 1	.02	2.15										
3		1.91	326	5190	6	100	98.1	412	6,560	11	180	97.3
6		1.76	480	7050	11	160	97.7	672	9,860	18	260	97.3
9		1.96	220	3600	43	700	80.4	228	3,730	28	460	87.7
12		2.04	397	6750	13	220	96.5	776	13,200	18	310	97.6
15		1.98	669	11050	14	230	98.0	1060	17,500	32	530	96.9
18		1.67	717	9990	22	310	96.9	1140	15,880	56	780	95.0
21		1.75	272	3970	6	90	97.7	372	5,430	32	470	91.3
28		1.56	474	6170	86	1120	82.0	1032	13,430	344	4480	66.6
30		1.92	408	6530	179	2870	56.1	776	12,430	64	1020	90.7

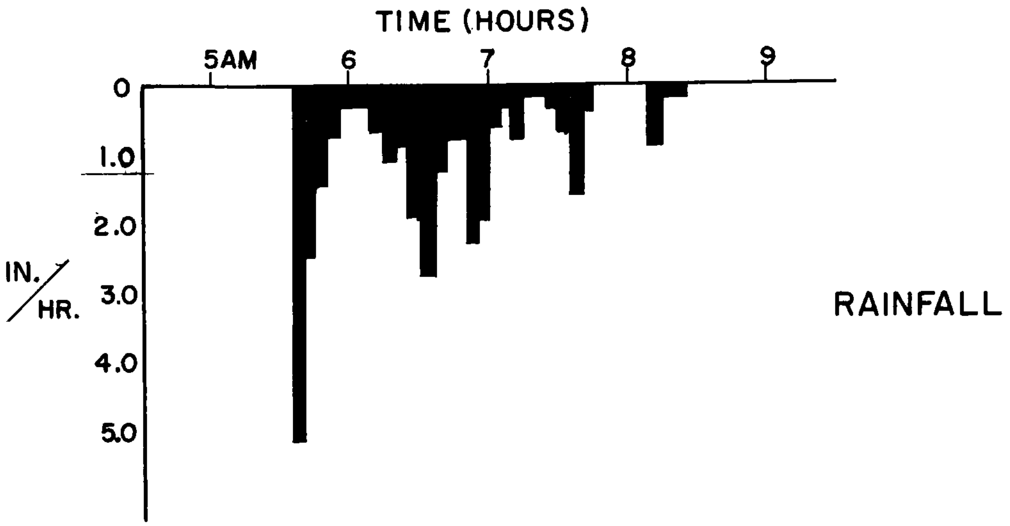
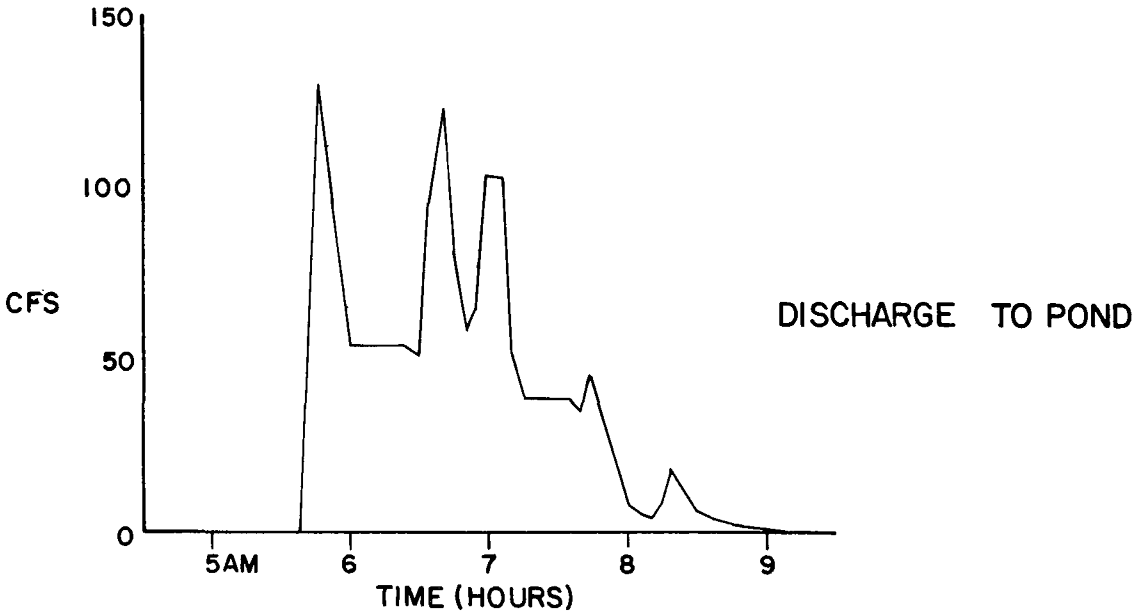


FIGURE -25-
CHIPPEWA FALLS, WISC.
STORM OF JULY 14,1969



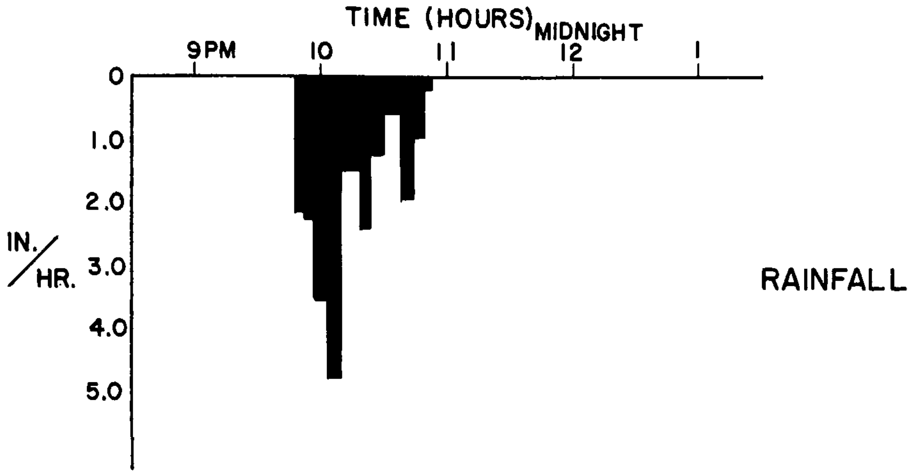
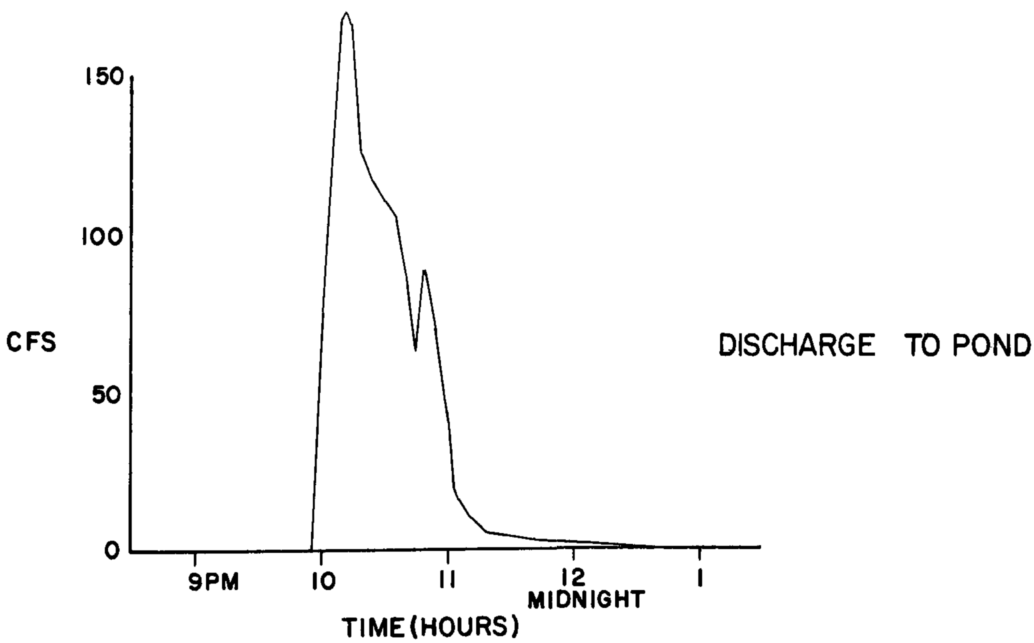


FIGURE - 26 -
CHIPPEWA FALLS, WISC.
STORM OF AUGUST 6, 1969



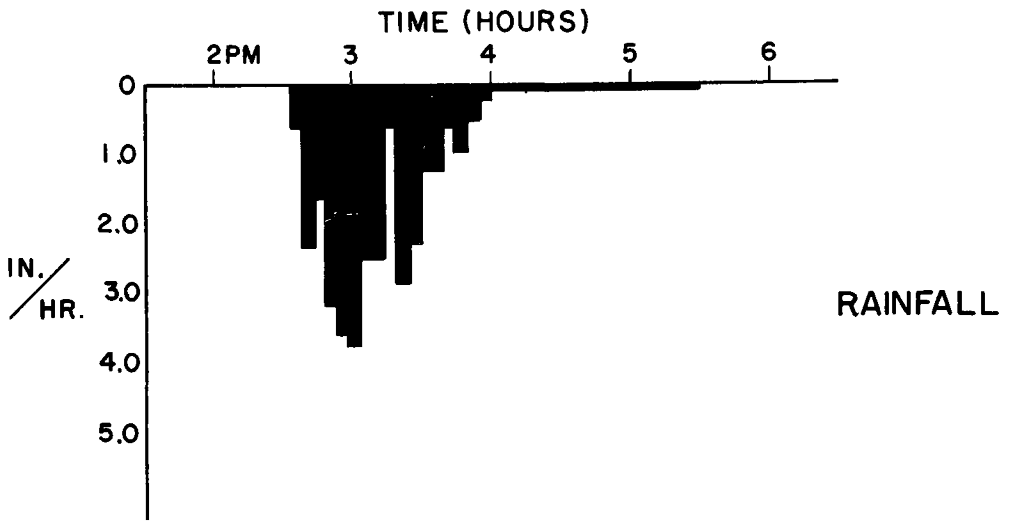
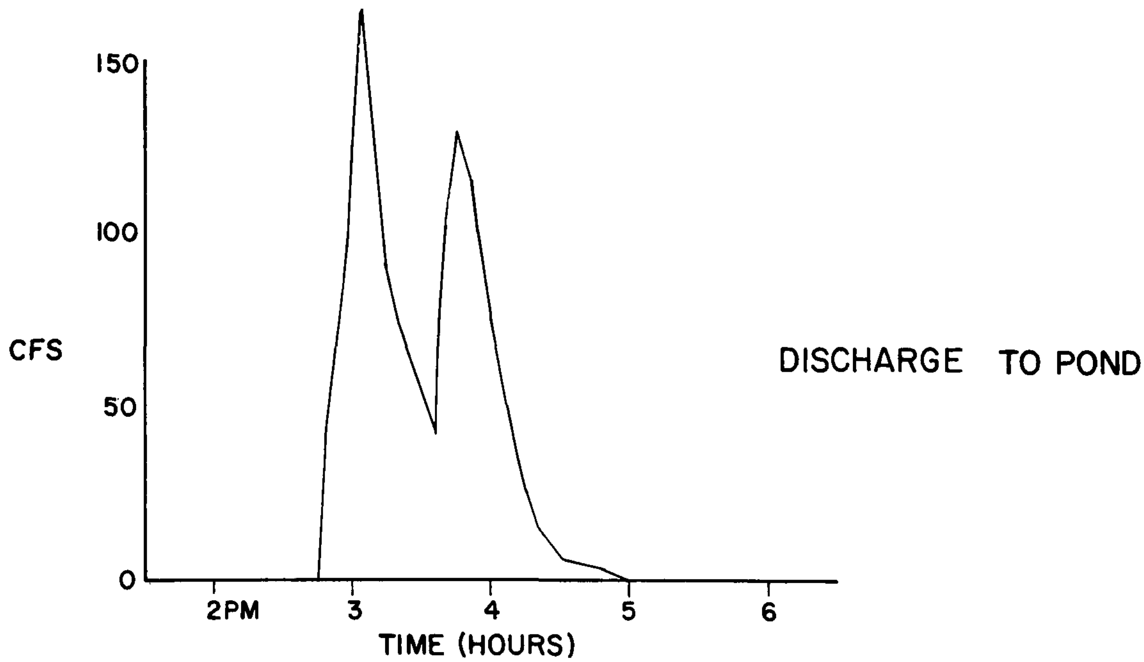


FIGURE-27-
CHIPPEWA FALLS, WISC.
STORM OF AUGUST 11, 1970



SECTION VII

DISCUSSION OF RESULTS

It may be expected that the BOD_5 and suspended solids concentrations for any given combined sewage overflow would be affected by a number of factors. The sanitary sewage and waste flow varies in both volume and characteristics and will obviously have an effect on the characteristics of the combined sewage. The intensity, duration, and total volume of rainfall, as well as the land use and runoff characteristics of the drainage area are also expected to be significant factors. A detailed statistical correlation of the above parameters with the observed overflow data is not within the scope of this study. However, a review of the data can provide some indication of the overall effectiveness of the retention pond system.

The average BOD_5 concentrations for the combined sewage discharged to the pond ranged from a minimum of 43 mg/L on August 11, 1970 to a maximum of 383 mg/L on September 4, 1969. The August 11 storm produced 2.63 inches of precipitation and the discharge to the pond was 527,300 cubic feet. On September 4, 1969 the precipitation was 0.18 inches and the resulting discharge to the pond was 12,900 cubic feet. The overall average BOD_5 of the discharges to the pond for the entire test period was 150 mg/L. The suspended solids mean concentrations ranged from 60 mg/L to 534 mg/L with an overall average of 280 mg/L.

With a few exceptions, the individual samples taken from the combined sewage discharges to the pond show relatively constant BOD_5 and suspended solids values throughout each sampling period. This consistency may be in part due to the sampling location. The samples were taken from the wet well of the combined sewage pumping station, and a certain amount of mixing of the contents undoubtedly took place. Such mixing may have had the effect of smoothing out any large variations in the quality of the combined sewage.

With a total pumping capacity of 6000 gpm and an average sanitary sewage flow of 2000 gpm, the Bay Street pumping station could pump approximately 4000 gpm of storm water to the wastewater treatment plant. A "first flush" effect could not be observed in this system even if such an effect were present, since during each storm the initial discharge of combined sewage was pumped to the wastewater treatment plant.

Although a consistent first flush effect was neither expected nor apparent in the data, there were several discharges to the pond in which the initial samples were considerably higher in suspended solids than the subsequent samples. This effect is not nearly as prominent in the BOD_5 data, however. Apparently when large amounts of solids are washed into the sewers at the beginning of a storm, the majority of these solids are relatively inert and non-biodegradable. An extreme example occurred during the storm of August 11, 1970, when 11,600 pounds of solids were discharged to the retention pond. Eighteen cubic yards of sand were removed from the pond following this storm. Some of the sand may have originated at a street improvement project which was under construction at the time. A comparison of the three rainfall hyetographs with the suspended solids data, indicates a correlation between initial rainfall intensity and initial suspended solids concentration. During the July 14, 1969 storm, the initial intensity was 5.1 inches/hour and the sample taken after the first five minutes had a suspended solids concentration of 762 mg/L. The following two storms which overflowed the pond were lower in initial intensity at 2.1 inches/hour on August 6, 1969 and 0.6 inches/hour on August 11, 1970. The corresponding suspended solids concentrations were also lower at 232 mg/L and 328 mg/L, respectively.

Since only three pond overflows occurred during the test period, there is very little data available to evaluate the treatment effect of the pond. Normally, primary sedimentation is expected to remove approximately 30 per cent of the BOD_5 and 60 to 70 per cent of the suspended solids in domestic sewage. However, the storage pond is not designed to be a clarifier. Furthermore, the characteristics of the combined sewage are so variable that the degree of treatment to be expected of the pond is not at all obvious. As shown in Table 16, the three pond overflows vary widely in the apparent degree of treatment attained. BOD removals ranged from 22% to 74% and suspended solids removals from 18% to 70%. The reason for the exceptionally high removals on August 6, 1969 is not apparent. However, some insight may be gained by examining the time lag from the start of discharge into the pond to the start of overflow to the river. This will give an approximate detention time for that portion of the total discharge which initially overflowed to the river. As might be expected, the longest detention time resulted in the greatest BOD and suspended solids removals. Other parameters which are usually important in clarifier design are the overflow rate and the weir rate. However, in the case of a storage pond in which the discharges are highly variable and of relatively short duration, these factors are less clearly defined and controllable. It is clear that both parameters will have higher values for higher rates of overflow. It is reasonable to expect that the quality of the effluent would be poorer for higher overflow

TABLE 16

TREATMENT EFFECT OF POND DURING OVERFLOWS TO RIVER

STORM OF JULY 14, 1969 — TIME OF OVERFLOW - 6:55 AM - 9:15 AM

VOLUME OF OVERFLOW = 615,800 GALLONS

	AVERAGE CONCENTRATION			LOAD (LB)	
	TO POND	TO RIVER	% REMOVAL	TO POND	TO RIVER
BOD_5	78 mg/L	61 mg/L	21.8	2420	310
SUSPENDED SOLIDS	253 mg/L	208 mg/L	17.8	7830	107
FECAL COLIFORM (MPN/100 ml)	13.1×10^6	20×10^6			
TOTAL COLIFORM (MPN/100 ml)	112.5×10^6	135×10^6			

STORM OF AUGUST 6, 1969 — TIME OF OVERFLOW - 12:00 PM - 1:00 AM

VOLUME OF OVERFLOW = 412,000 GALLONS

	AVERAGE CONCENTRATION			LOAD (LB)	
	TO POND	TO RIVER	% REMOVAL	TO POND	TO RIVER
BOD_5	103 mg/L	27 mg/L	73.8	2760	90
SUSPENDED SOLIDS	269 mg/L	82 mg/L	69.5	7210	280

STORM OF AUGUST 11, 1970 — TIME OF OVERFLOW - 3:30 PM - 5:10 PM

VOLUME OF OVERFLOW = 1,523,000 GALLONS

	AVERAGE CONCENTRATION			LOAD (LB)	
	TO POND	TO RIVER	% REMOVAL	TO POND	TO RIVER
BOD_5	43 mg/L	38 mg/L	11.6	1410	480
SUSPENDED SOLIDS	355 mg/L	194 mg/L	45.3	11610	2460
FECAL COLIFORM (MPN/100 ml)	3×10^6	3×10^6			
TOTAL COLIFORM (MPN/100 ml)	114×10^6	215×10^6			

rates. This is substantiated by the data to the extent that the overflow of August 11, 1970 which had the highest recorded peak and average discharge rates, produced the lowest BOD_5 removal (11.6%). However, the average suspended solids removal (at 45.3%) was higher than that achieved on July 14, 1969 (17.8%).

No significant reduction in the number of total or fecal coliform organisms was observed through the pond during the three pond overflows. Disinfection was not provided, and the detention time alone was not sufficient for any substantial die-off to occur.

The maximum daily flow received at the wastewater treatment plant during the test period was 7.5 mgd on August 7, 1969. On 55 separate occasions the daily wastewater flow exceeded the design dry weather flow of 3.2 mgd. Nineteen of these recorded discharges were greater than 4 mgd. The high combined sewage flows had no apparent detrimental effect on the operation of the treatment plant.

On days when the influent flow exceeded 4 mgd, the effluent BOD_5 concentrations averaged 18 mg/L and the suspended solids 23 mg/L. On August 7, 1969 when 7.5 million gallons were received at the plant, the effluent BOD_5 was 21 mg/L. During April of 1969 the spring runoff produced four consecutive days when the influent flow exceeded 4 mgd. On the third day of this period, the plant effluent BOD_5 was 16 mg/L.

It appears that neither the combined sewage flows from the storage pond nor those pumped directly from the collection system had any deleterious effects on the quality of the plant effluent.

The results of the river sampling program shown in Table 17 indicate very little difference in quality between the two sampling points. Samples taken following each of the three pond overflows to the river showed no significant variation from previous or subsequent samples. Settleable solids data is not included in Table 17 since no measurable amount was ever observed.

On August 26, 1970 some floating logs were noticed near the Bridge Street sampling point upstream of the storage pond. On September 30, algae and floating scum were observed in the river both upstream and downstream from the pond. With these exceptions, no floating material other than ice was noted in the river during the study period.

In discussing the quality of the Chippewa River, it should be pointed out that the flow in the river is controlled by two hydroelectric dams upstream of the retention pond. The upper of the two dams is located approximately three miles upstream of the pond and forms

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER

DATE	ABOVE OR * BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (°C)	pH
1969									
APRIL 10	ABOVE	5.5	1.0	110	700	1.9	12.6	3	7.05
	BELOW	25.0	1.5	210	1620	1.6	12.7	2	7.05
APRIL 17	ABOVE	2.4	0.2	0	80	0.8	11.0	8	6.90
	BELOW	2.6	0.6	10	420	0.9	11.0	9	6.95
APRIL 22	ABOVE	1.0	0.2	0	20	0.8	10.5	9	6.95
	BELOW	6.0	3.8	40	580	0.8	10.5	9	7.05
APRIL 29	ABOVE	3.6	2.0	--	--	1.4	10.3	10	7.10
	BELOW	2.8	1.8	--	--	1.4	10.5	10	7.20
MAY 1	ABOVE	2.0	1.4	10	60	1.1	9.2	11	7.05
	BELOW	1.4	1.0	48	246	1.5	9.3	11	7.15
MAY 13	ABOVE	1.4	1.0	7	54	3.6	7.4	15	7.00
	BELOW	2.6	1.6	8	32	4.3	7.2	15	7.05
MAY 20	ABOVE	1.6	1.0	--	--	1.7	8.9	16	7.40
	BELOW	1.2	0.4	--	--	1.8	8.7	16	7.00
MAY 22	ABOVE	1.2	0.4	11	14	1.3	8.5	17	7.25
	BELOW	1.8	0.6	18	64	1.4	8.6	16	7.15
MAY 27	ABOVE	3.2	1.2	6	25	1.2	8.1	18	7.25
	BELOW	2.4	1.4	24	39	1.2	8.1	18	7.35

* ABOVE - Sampling location upstream of pond
BELOW - Sampling location downstream of pond

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (°C)	pH
1969									
MAY 29	ABOVE	3.0	0.6	--	--	0.5	7.8	18	7.30
	BELOW	2.4	0.4	--	--	0.7	7.9	18	7.35
JUNE 3	ABOVE	1.6	0.4	71	26	1.7	8.1	17	7.25
	BELOW	1.4	0.2	44	59	2.2	8.2	16	7.30
JUNE 10	ABOVE	0.8	0.6	15	6	1.2	7.2	18	7.20
	BELOW	1.2	0.6	31	13	1.3	7.3	18	7.25
JUNE 17	ABOVE	1.6	0.8	--	--	1.5	6.6	20	7.20
	BELOW	1.8	0.4	--	--	1.4	6.7	19	7.30
JUNE 24	ABOVE	2.6	1.6	58	136	1.6	6.8	18	7.30
	BELOW	2.0	1.0	49	112	1.2	6.8	18	7.35
JUNE 26	ABOVE	1.4	1.0	126	216	1.7	7.9	19	7.40
	BELOW	1.8	1.4	31	86	1.8	7.9	19	7.40
JULY 1	ABOVE	3.0	1.6	--	--	1.8	8.0	20	7.10
	BELOW	3.4	1.8	--	--	2.6	8.1	20	7.30
JULY 3	ABOVE	4.6	1.6	--	--	1.8	7.8	20	7.35
	BELOW	6.0	2.0	--	--	2.0	8.0	20	7.45
JULY 10	ABOVE	1.8	1.2	--	--	1.9	7.2	22	7.40
	BELOW	2.2	1.0	--	--	2.0	7.2	21	7.40

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (^{o}C)	pH
1969									
JULY 15	ABOVE	1.0	0.6	--	--	1.7	6.4	23	7.40
	BELOW	0.8	0.4	--	--	1.7	6.4	23	7.35
JULY 17	ABOVE	3.0	2.4	--	--	2.05	7.2	23	7.40
	BELOW	3.8	2.2	--	--	2.4	--	23	7.40
JULY 22	ABOVE	2.4	1.8	--	--	1.8	6.4	24	7.30
	BELOW	2.8	2.0	--	--	1.9	6.4	24	7.35
JULY 24	ABOVE	1.6	1.0	40	20	1.6	6.1	24.5	7.20
	BELOW	2.0	1.4	270	280	1.6	6.1	24	7.30
JULY 29	ABOVE	2.4	1.6	150	360	2.1	6.0	25	7.25
	BELOW	2.8	2.2	40	460	2.0	6.0	25	7.25
JULY 31	ABOVE	1.6	0.8	70	240	1.8	4.8	24	7.10
	BELOW	1.4	0.8	40	240	1.8	4.7	23	7.15
AUGUST 5	ABOVE	2.6	1.4	10	320	2.5	4.4	25	7.20
	BELOW	2.8	2.0	20	400	2.7	4.3	25	7.15
AUGUST 7	ABOVE	2.3	1.3	30	480	2.2	4.9	25	7.30
	BELOW	2.6	2.1	60	380	2.3	4.7	25	7.35
AUGUST 12	ABOVE	1.0	0.4	190	760	1.9	4.4	25	7.25
	BELOW	0.8	0.4	140	440	2.0	4.4	25	7.35

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (°C)	pH
1969									
AUGUST 14	ABOVE	1.2	0.8	90	420	0.95	4.3	25	7.15
	BELOW	1.0	0.6	60	340	1.3	4.5	25	7.25
AUGUST 19	ABOVE	1.3	1.0	20	120	1.2	4.8	25	7.40
	BELOW	1.6	1.2	--	80	1.3	4.8	25	7.45
AUGUST 21	ABOVE	2.2	1.8	30	100	1.8	4.7	25.5	7.10
	BELOW	1.6	1.2	--	180	2.0	4.7	25	7.20
AUGUST 26	ABOVE	1.6	1.4	--	--	0.6	5.4	25.5	7.20
	BELOW	1.8	1.6	--	--	1.1	5.4	25.5	7.20
SEPT. 4	ABOVE	1.2	0.8	10	20	1.0	5.7	25	7.10
	BELOW	1.0	0.6	30	180	0.8	5.6	25	7.30
SEPT. 9	ABOVE	2.6	2.0	60	220	1.5	6.9	23	7.25
	BELOW	2.2	1.4	90	240	1.6	6.9	23	7.20
SEPT. 11	ABOVE	1.0	0.6	--	--	1.7	6.9	21	7.45
	BELOW	2.6	1.8	--	--	1.9	6.8	21	7.60
SEPT. 18	ABOVE	2.4	1.6	50	100	2.4	8.2	22	7.60
	BELOW	4.0	1.8	70	140	2.6	8.2	22	7.70
SEPT. 23	ABOVE	1.4	0.6	30	120	1.2	8.0	19	7.40
	BELOW	1.8	0.8	50	200	1.5	7.9	19	7.50

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (°C)	pH
1969									
SEPT. 25	ABOVE	2.0	1.4	15	180	2.5	8.3	18	7.50
	BELOW	2.2	1.6	25	140	2.45	8.3	18	7.60
OCT. 2	ABOVE	2.6	2.0	5	30	0.8	8.3	18	7.30
	BELOW	1.8	1.4	20	60	1.3	8.5	18	7.40
OCT. 7	ABOVE	1.6	1.2	--	--	1.9	9.7	16	7.40
	BELOW	1.8	1.4	--	--	1.8	9.4	16	7.50
OCT. 9	ABOVE	1.4	1.0	--	--	1.6	9.1	16	7.50
	BELOW	1.6	1.2	--	--	1.4	9.2	10	7.55
OCT. 23	ABOVE	2.2	1.8	4	37	1.7	10.3	10	7.60
	BELOW	2.8	2.4	18	42	1.9	10.6	10	7.70
OCT. 28	ABOVE	2.6	2.0	--	--	1.7	9.4	9	7.60
	BELOW	1.4	1.0	--	--	1.9	9.6	9	7.60
NOV. 13	ABOVE	1.6	1.2	--	--	0.35	10.8	6	7.10
	BELOW	2.4	2.0	--	--	0.4	10.7	6	7.30
NOV. 25	ABOVE	1.6	1.4	13	29	0.4	10.4	5	7.15
	BELOW	2.2	1.8	17	27	0.5	10.6	5	7.30

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (^{o}C)	pH
1969									
DEC. 4	ABOVE	1.2	1.0	--	33	1.5	12.7	5	7.65
	BELOW	2.0	1.0	59	145	1.3	12.9	4	7.50
DEC. 11	ABOVE	1.0	0.8	4	124	1.7	12.4	2	7.35
	BELOW	0.8	0.6	7	133	1.3	12.6	1.5	7.40
DEC. 30	ABOVE	0.8	0.6	24	72	1.35	13.2	1	7.15
	BELOW	9.6	7.0	29	57	1.2	12.4	1	7.35

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (°C)	pH
1970									
MARCH 21	ABOVE	1.8	1.4	4	108	0.8	9.4	3	7.10
	BELOW	1.0	0.8	20	172	0.7	9.6	3	7.20
MARCH 25	ABOVE	1.2	1.0	14	132	1.7	9.6	2	7.10
	BELOW	1.6	1.2	18	240	1.4	9.6	3	7.15
APRIL 1	ABOVE	1.1	0.9	12	144	1.8	10.3	3	6.85
	BELOW	1.5	1.3	16	152	1.6	10.4	3	7.00
APRIL 15	ABOVE	6.15	2.25	54	161	2.35	11.8	4	7.10
	BELOW	6.0	1.95	56	152	1.65	11.8	4	7.25
APRIL 29	ABOVE	2.0	1.7	3	88	2.95	10.4	15	7.10
	BELOW	4.3	2.0	5	56	3.15	10.3	15	7.20
MAY 13	ABOVE	2.4	1.6	2	64	1.45	9.4	16	7.30
	BELOW	3.1	1.8	4	52	1.7	9.5	16	7.50
JUNE 3	ABOVE	2.4	1.4	79	352	1.65	8.8	20	7.40
	BELOW	2.8	1.4	64	460	1.8	8.6	20	7.50
JUNE 18	ABOVE	2.0	1.2	44	370	2.6	6.1	23	7.20
	BELOW	2.2	1.4	37	410	2.9	6.1	23	7.30
JULY 1	ABOVE	2.0	1.8	37	90	2.0	5.9	25	7.30
	BELOW	1.8	1.6	198	560	2.5	7.6	25	7.30

TABLE 17

CHARACTERISTICS OF THE CHIPPEWA RIVER (continued)

DATE	ABOVE OR BELOW	SUSPENDED SOLIDS (mg/L)	VOLATILE SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (MPN/ /100 ml)	TOTAL COLIFORM (MPN/ /100 ml)	BOD_5 (mg/L)	D.O. (mg/L)	TEMP. (^{o}C)	pH
1970									
JULY 15	ABOVE	2.2	2.0	87	145	3.1	6.1	25	7.00
	BELOW	2.4	2.3	61	120	2.4	6.1	25	7.10
AUGUST 5	ABOVE	3.0	1.4	2	35	3.1	5.5	26	7.20
	BELOW	2.8	1.8	8	45	2.2	5.4	26	7.30
AUGUST 26	ABOVE	2.4	1.8	2	65	3.7	7.0	27	7.60
	BELOW	3.2	1.8	21	155	4.2	7.1	27	7.60
SEPT. 9	ABOVE	1.8	1.6	2	85	3.25	7.7	23	7.40
	BELOW	1.8	1.4	6	105	2.70	7.5	23	7.30
SEPT. 30	ABOVE	2.6	2.0	3	50	3.95	9.4	18	7.00
	BELOW	2.8	2.0	1	35	3.20	9.3	18	7.20
OCT. 15	ABOVE	2.2	1.8	12	45	1.50	9.7	14	7.00
	BELOW	2.0	1.8	27	65	1.85	9.8	14	7.30
NOV. 5	ABOVE	2.0	1.8	--	45	--	10.4	9	7.05
	BELOW	2.0	1.8	25	225	--	10.4	9	7.25
NOV. 19	ABOVE	2.8	1.8	11	--	3.45	12.4	4	5.15
	BELOW	2.2	1.6	18	--	4.0	12.2	4	5.05

Lake Wissota as a large storage area. The lower dam is about 800 feet upstream of the pond and 300 feet upstream from the mouth of Duncan Creek. The two dams are used for flood control as well as power generation. At certain times of the year the entire river flow may be temporarily impounded by the dams. Under these conditions, the only inflow to the river in the vicinity of the retention pond is from Duncan Creek. During periods of precipitation, Duncan Creek may contain a considerable amount of storm water runoff from areas of the City which are served by separate sewers.

Since the combined sewers remain in use in the 90 acre area tributary to the Bay Street pumping station, no data are available on the quality of separate storm water runoff from the central business district of Chippewa Falls. However, studies from other cities (4) have shown mean BOD concentrations in storm water ranging from 10 mg/L to 147 mg/L, and mean suspended solids concentrations of 210 mg/L to 2080 mg/L.

The estimated volume of storm water runoff which was withheld from the river during the two year period was 92.6 million gallons. Even if the average BOD_5 and suspended solids concentrations in the storm water were as low as 10 mg/L, the total contribution of BOD and suspended solids from this volume of separate storm water would have been considerably greater than the 880 pounds of BOD and 3810 pounds of suspended solids present in the three pond overflows to the river.

Prior to the construction of the storage pond, any heavy rainfall or high water in the Chippewa River would cause extensive basement flooding in the downtown area. When the pond and associated pumping facilities were put into operation, the flooding problem was eliminated.

Of the 62 recorded combined sewage discharges to the pond during 1969 and 1970, 59 discharges (95.2 per cent of the total) were prevented from reaching the river untreated. On a volume basis, 40.30 million gallons of combined sewage discharged to the pond during the test period, and 2.55 million gallons overflowed from the pond to the river. Thus 93.7 per cent of the total volume discharged was withheld from the river. The BOD_5 and suspended solids loads associated with the discharges were 50,400 pounds and 94,200 pounds respectively. Of these totals, 49,520 pounds or 98.2 per cent of the BOD_5 and 90,390 pounds or 95.8 per cent of the suspended solids were withheld from the river and subsequently treated. These figures are somewhat conservative since a small volume discharged to the pond (but not to the river) while the recorder was out of service and this volume is not included in the totals.

The above results were achieved for a total initial project cost of $610,067. The estimated cost of complete sewer separation for the 90 acre tributary area was $497,500. The average annual operating and maintenance cost of approximately $7,300 would have been saved if complete separation had taken place. However, separation would not have provided the added benefit of secondary treatment for nearly all of the storm water runoff from the tributary area.

Furthermore, a separation program would have entailed a longer construction period than the eighteen months required for the demonstration project; and the resulting street disruption would have been much more extensive.

The costs of both constructing and operating a retention pond system could be considerably reduced if gravity flow was available from the collection system to the pond and/or the sewage treatment plant.

SECTION VIII

ACKNOWLEDGEMENTS

The support of the Mayor of Chippewa Falls, Wisconsin, Honorable Clarence C. Rushman, and the entire City Council is acknowledged with sincere thanks.

Mr. A. W. Banister of Banister Short Elliott Hendrickson & Associates made the original suggestion for the project and gave counsel and direction throughout the construction and operation.

The design and supervision of construction of the project was performed by D. E. Lund of Banister Short Elliott Hendrickson & Associates.

The project operation and data collection were under the direction of Clyde Lehman, Superintendent of Public Utilities, at Chippewa Falls, Wisconsin. His enthusiastic support for the project is acknowledged with sincere thanks.

Mr. W. R. Liebenow and Mr. J. K. Bieging of Banister Short Elliott Hendrickson & Associates directed the instrumentation design, evaluated the collected data, and wrote a major share of the final report.

Mr. Carl Blabaum of the State of Wisconsin, Department of Natural Resources, gave valuable support and guidance to the project.

The help provided by Louis J. Breinhurst, Project Officer, is acknowledged with sincere thanks.

SECTION IX

REFERENCES

1. Wells, Jr., Edwin A. and Gotaas, Harold B, "Design of Venturi Flumes in Circular Conduits", Transactions American Society of Civil Engineers, Vol. 123, 1958, P. 749.

2. Ludwig, John H. and Ludwig, Russell G., "Design of Palmer-Bowlus Flumes", Sewage and Industrial Wastes, Vol. 23, September 1951, P. 1096.

3. Standard Methods for the Examination of Water and Wastewater, 12th Edition, American Public Health Association, New York, N. Y., (1965).

4. "Storm Water Pollution from Urban Land Activity," Economic Systems Corporation, Water Pollution Control Research Series, 11034FKL, July 1970.

SECTION X

APPENDICES

Page No.

A. 1969 Wastewater Treatment Plant
Operating Data . . . .

Table A-1. Daily Sewage Flow . . . .
Table A-2. Hourly Sewage Flow . . . .
Table A-3. 5-Day BOD. . . . .
Table A-4. Suspended Solids . . . .
Table A-5. Primary Settling Tank Data
Detention Period. . . . .
Table A-6. Primary Settling Tank Data
Surface Loading . . . .
Table A-7. Secondary Settling Tank Data
Detention Period . . . .
Table A-8. Secondary Settling Tank Data
Surface Loading . . . .
Table A-9. Aeration Tank Mixed Liquor. . . . .

B. 1970 Wastewater Treatment Plant
Operating Data. . . . .

Table B-1. Daily Sewage Flow . . . .
Table B-2. Hourly Sewage Flow . . . .
Table B-3. 5-Day BOD . . . .
Table B-4. Suspended Solids . . . .
Table B-5. Primary Settling Tank Data
Detention Period . . . .
Table B-6. Primary Settling Tank Data
Surface Loading . . . .
Table B-7. Secondary Settling Tank Data
Detention Period . . . .
Table B-8. Secondary Settling Tank Data
Surface Loading . . . .
Table B-9. Aeration Tank Mixed Liquor . . . .

APPENDIX A. 1969 Wastewater Treatment Plant Operating Data

Table A-1

1969 DAILY SEWAGE FLOW
(Gallons)

MONTH	TOTAL FLOW	AVE DAILY	MAX DAILY	MIN DAILY
Jan.	60,263,000	1,944,000	2,899,000	1,401,000
Feb.	54,679,000	1,952,000	2,884,000	1,370,000
Mar.	63,069,000	2,035,000	3,619,000	1,384,000
April	72,973,000	2,432,000	5,372,000	1,330,000
May	61,147,000	1,973,000	3,469,000	1,079,000
June	68,579,000	2,286,000	3,649,000	1,236,000
July	88,277,000	2,848,000	4,981,000	1,922,000
Aug.	92,427,000	2,981,000	7,507,000	1,330,000
Sep.	66,812,000	2,227,000	3,035,000	1,622,000
Oct.	69,236,000	2,233,000	3,633,000	1,673,000
Nov.	63,168,000	2,106,000	3,175,000	1,599,000
Dec.	60,256,000	1,943,700	2,577,000	1,387,000
Total	820,886,000			
Average	68,407,166	2,246,725	3,900,000	1,444,417
Maximum	92,427,000	2,981,000	7,507,000	1,922,000
Minimum	54,679,000	1,943,700	2,577,000	1,079,000

Sewage received from septic tank cleaning service in 1969 totaled 22,460 gallons.

Table A-2

1969 HOURLY SEWAGE FLOW

(Gallons)

MONTH	AVE MAX HOURLY	AVE MIN HOURLY	MAX HOURLY	MIN HOURLY
Jan.	120,000	41,000	210,000	18,000
Feb.	126,000	39,000	210,000	6,000
Mar.	141,000	49,000	246,000	12,000
April	185,000	68,000	300,000	12,000
May	153,000	57,000	240,000	36,000
June	189,000	58,000	420,000	48,000
July	195,000	67,000	385,000	60,000
Aug.	207,000	89,000	420,000	36,000
Sept.	186,000	59,000	400,000	24,000
Oct.	165,000	57,000	310,000	36,000
Nov.	166,000	63,000	360,000	36,000
Dec.	159,800	64,000	210,000	48,000
Average	166,067	59,250	309,250	31,000
Maximum	207,000	89,000	420,000	48,000
Minimum	120,000	39,000	210,000	6,000

Table A-3

5 DAY B.O.D.

AVERAGE MONTHLY 1969
(mg/L)

MONTH	RAW	PRIMARY	FINAL	% REMOVAL
Jan.	-	-	-	-
Feb.	350	205	21	94.0
Mar.	480	271	45	91.0
April	345	171	35	88.4
May	327	162	26	90.9
June	236	120	21	89.9
July	229	129	18	92.4
Aug.	191	122	21	88.6
Sept.	274	121	19	92.4
Oct.	279	134	28	88.7
Nov.	265	138	20	91.9
Dec.	305	153	24	91.7
Average	298.3	156.9	25.3	90.9
Maximum	480	271	45	94.0
Minumum	191	120	18	88.4

Table A-4

SUSPENDED SOLIDS

AVERAGE MONTHLY 1969
(mg/L)

MONTH	RAW	PRIMARY	FINAL	% REMOVAL
Jan.	-	-	-	-
Feb.	780	226	42	92.9
Mar.	959	339	68	93.2
April	580	130	38	92.0
May	821	170	64	91.0
June	730	162	34	92.8
July	637	173	28	95.5
Aug.	809	370	35	95.2
Sept.	894	159	21	97.4
Oct.	885	159	35	95.8
Nov.	794	148	36	94.2
Dec.	700	155	32	94.1
Average	780.8	199.2	39.4	94.0
Maximum	959	370	68	97.4
Minimum	580	130	21	91.0

Table A-5

1969 PRIMARY SETTLING TANK DATA
DETENTION PERIOD
(Hours)

MONTH	AT DAILY AVERAGE FLOW	AT MAXIMUM HOURLY FLOW	AT MINIMUM HOURLY FLOW
Jan.	11.7	6.8	78.8
Feb.	17.4	7.0	236.6
Mar.	16.7	6.0	118.3
April	14.0	4.7	118.3
May	17.3	9.5	47.3
June	14.9	3.4	29.6
July	12.0	3.7	23.7
Aug.	11.4	3.4	39.4
Sept.	15.3	3.6	59.2
Oct.	15.2	4.6	39.4
Nov.	16.1	3.9	39.0
Dec.	17.6	6.8	29.6
Average	14.97	5.28	71.6
Maximum	17.6	9.5	236.6
Minimum	11.4	3.4	23.7

Table A-6

1969 PRIMARY SETTLING TANK DATA
SURFACE LOADING
(Gal. per square ft. per day)

MONTH	DAILY AVERAGE	MAXIMUM HOURLY	MINIMUM HOURLY
Jan.	260	675	58
Feb.	261	675	20
Mar.	272	790	39
April	325	963	39
May	264	482	96
June	306	1349	154
July	381	1237	193
Aug.	399	1349	115
Sept.	298	1285	77
Oct.	298	996	116
Nov.	282	1157	116
Dec.	260	675	154
Average	300.5	969.4	98
Maximum	399	1349	193
Minimum	260	482	20

Table A-7

1969 SECONDARY SETTLING TANK DATA
DETENTION PERIOD
(Hours)

MONTH	AT DAILY AVERAGE FLOW	AT MAXIMUM HOURLY FLOW	AT MINIMUM HOURLY FLOW
Jan.	12.3	4.7	55.3
Feb.	12.2	4.7	166.0
Mar.	11.7	4.0	82.9
April	9.8	3.3	83.0
May	12.1	6.6	33.2
June	10.4	2.3	20.5
July	8.4	2.6	16.6
Aug.	8.0	2.4	27.6
Sept.	10.7	2.5	41.5
Oct.	10.7	3.2	27.6
Nov.	11.3	2.8	28.0
Dec.	12.3	4.7	20.9
Average	10.83	3.65	50.25
Maximum	12.3	4.7	166.0
Minimum	8.0	2.3	16.6

Table A-8

1969 SECONDARY SETTLING TANK DATA
SURFACE LOADING
(Gal. per square ft. per day)

MONTH	DAILY AVERAGE	MAXIMUM HOURLY	MINIMUM HOURLY
Jan.	146	379	33
Feb.	146	379	11
Mar.	153	445	21
April	183	542	22
May	149	271	54
June	172	759	86
July	215	697	109
Aug.	225	759	65
Sept.	167	724	43
Oct.	168	559	65
Nov.	158	650	65
Dec.	146	378	86
Average	169	545.2	55
Maximum	225	759	109
Minimum	146	271	11

Table A-9

AERATION TANK
MIXED LIQUOR
1969

MONTH	SUSPENDED SOLIDS (mg/L)	S.V.I.	D. O.	SETTLEABLE SOLIDS
Jan.	-	-	-	-
Feb.	2,396	190	3.2	466
Mar.	3,108	150	2.8	524
April	1,713	145	3.7	261
May	2,657	79	2.4	222
June	1,770	83	2.4	142
July	1,769	80	1.4	146
Aug.	2,240	57	1.4	126
Sept.	1,886	100	1.7	185
Oct.	1,880	123	2.2	253
Nov.	1,853	103	3.4	208
Dec.	1,698	142	2.5	217
Average	2,088	114	2.46	250
Maximum	3,108	190	3.4	524
Minimum	1,698	57	1.4	126

APPENDIX B. 1970 Wastewater Treatment Plant Operating Data

Table B-1

1970 DAILY SEWAGE FLOW
(Gallons)

MONTH	TOTAL FLOW	AVE DAILY	MAX DAILY	MIN DAILY
Jan.	64,403,000	2,077,530	2,828,000	1,544,000
Feb.	57,275,000	2,045,535	2,980,000	1,425,000
Mar.	70,496,000	2,274,065	3,453,000	1,457,000
April	74,505,000	2,483,500	3,723,000	1,546,000
May	68,019,000	2,194,161	3,641,000	1,478,000
June	68,936,000	2,297,867	4,791,000	1,615,000
July	70,251,000	2,266,161	4,920,000	1,666,000
Aug.	65,091,000	2,099,710	4,673,000	1,598,000
Sept.	69,656,000	2,322,000	4,273,000	1,555,000
Oct.	74,110,000	2,390,645	5,539,000	1,666,000
Nov.	68,529,000	2,284,300	4,540,000	1,775,000
Dec.	58,620,000	1,890,967	2,689,000	1,496,000
Total	809,891,000			
Average	67.491,000	2,218,870	4,004,000	1,568,000
Maximum	74,505,000	2,483,500	5,539,000	1,775,000
Minimum	57,275,000	1,890,967	2,689,000	1,425,000
Total 1969	820,886,000			
Average	68,407,166	2,246,725	3,900,000	1,444,417

Sewage received from septic tank cleaning service:

1970 122,660 gallons

1969 22.460 gallons

Table B-2

1970 HOURLY SEWAGE FLOW
(Gallons)

MONTH	AVE MAX HOURLY	AVE MIN HOURLY	MAX HOURLY	MIN HOURLY
Jan.	181,548	61,290	310,000	30,000
Feb.	180,642	48,143	310,000	6,000
Mar.	184,129	56,870	310,000	6,000
April	199,266	73,200	310,000	60,000
May	182,161	58,935	330,000	6,000
June	180,000	65,600	396,000	54,000
July	154,903	58,452	420,000	9,600
Aug.	164,000	62,000	540,000	54,000
Sept.	183,000	66,000	360,000	54,000
Oct.	174,967	71,419	420,000	60,000
Nov.	163,266	71,000	360,000	60,000
Dec.	127,935	61,677	180,000	58,000
Average	172,985	62,882	353,883	38,133
Maximum	199,266	73,200	540,000	60,000
Minimum	127,935	48,143	180,000	6,000
Average 1969	166,067	59,250	309,250	31,000

Table B-3

5-DAY B.O.D.

AVERAGE MONTHLY 1970
(mg/L)

MONTH	RAW	PRIMARY	FINAL	% REMOVAL
Jan.	347	195	25	93.0
Feb.	231	154	23	88.9
Mar.	276	172	27	90.3
April	319	169	23	91.7
May	269	149	26	90.0
June	282	168	26	89.2
July	318	203	27	90.6
Aug.	301	193	24	92.0
Sept.	346	216	16	93.4
Oct.	287	160	9	95.8
Nov.	403	252	11	96.5
Dec.	440	264	42	89.1
Average	318	191	23	91.7
Maximum	440	264	42	96.5
Minimum	231	149	9	88.9
Average 1969	298	157	25	90.9

Table B-4

SUSPENDED SOLIDS

AVERAGE MONTHLY 1970
(mg/L)

MONTH	RAW	PRIMARY	FINAL	% REMOVAL
Jan.	807	435	30	96.0
Feb.	676	406	38	90.5
Mar.	922	381	33	95.3
April	1,070	445	33	96.1
May	638	260	26	95.4
June	905	442	24	95.3
July	816	383	24	96.0
Aug.	628	312	32	94.3
Sept.	648	275	24	95.6
Oct.	598	213	17	97.0
Nov.	744	422	14	97.7
Dec.	618	433	67	91.1
Average	755	367	30	95.0
Maximum	1,070	445	67	97.7
Minimum	598	213	14	90.5
Average 1969	781	199	39	94.0

Table B-5

1970 PRIMARY SETTLING TANK DATA
DETENTION PERIOD
(Hours)

MONTH	AT DAILY AVERAGE FLOW	AT MAXIMUM HOURLY FLOW	AT MINIMUM HOURLY FLOW
Jan.	16.4	4.5	47.3
Feb.	16.6	4.5	236.6
Mar.	14.9	4.5	236.6
April	13.0	4.5	23.6
May	15.5	4.3	336.7
June	14.8	3.6	26.3
July	15.0	3.3	148.0
Aug.	16.2	2.6	26.3
Sept.	14.7	3.9	26.3
Oct.	14.3	3.4	23.7
Nov.	14.9	3.9	23.6
Dec.	18.0	7.8	24.4
Average	15.4	4.2	89.9
Maximum	18.0	7.8	236.7
Minimum	13.0	2.6	23.6
Average 1969	15.0	5.3	71.6

Table B-6

1970 PRIMARY SETTLING TANK DATA
SURFACE LOADING
(Gal. per square ft. per day)

MONTH	DAILY AVERAGE	MAXIMUM HOURLY	MINIMUM HOURLY
Jan.	278	996	96
Feb.	274	996	19
Mar.	304	996	19
April	332	996	193
May	294	1,060	19
June	308	1,272	171
July	303	1,349	31
Aug.	281	1,736	174
Sept.	311	1,157	174
Oct.	320	1,349	193
Nov.	305	1,156	192
Dec.	253	578	186
Average	297	1,137	122
Maximum	332	1,736	193
Minimum	253	578	19
Average 1969	301	969	98

Table B-7

1970 SECONDARY SETTLING TANK DATA
DETENTION PERIOD
(Hours)

MONTH	AT DAILY AVERAGE FLOW	AT MAXIMUM HOURLY FLOW	AT MINIMUM HOURLY FLOW
Jan.	11.4	3.2	33.1
Feb.	11.6	3.2	165.8
Mar.	10.5	3.2	165.8
April	9.6	3.2	16.5
May	10.9	3.0	165.8
June	10.4	2.5	18.4
July	10.5	2.3	104.0
Aug.	11.4	1.8	18.4
Sept.	10.3	2.8	18.4
Oct.	9.9	2.4	16.6
Nov.	10.4	2.7	16.5
Dec.	10.0	5.5	17.1
Average	10.6	3.0	63.0
Maximum	11.6	5.5	165.8
Minimum	9.6	1.8	16.5
Average 1969	10.8	3.7	50.3

Table B-8

1970 SECONDARY SETTLING TANK DATA
SURFACE LOADING
(Gal.per square ft. per day)

MONTH	DAILY AVERAGE	MAXIMUM HOURLY	MINIMUM HOURLY
Jan.	156	559	54
Feb.	154	559	11
Mar.	171	559	11
April	187	559	108
May	165	596	11
June	173	715	96
July	170	758	17
Aug.	150	974	97
Sept.	175	649	97
Oct.	180	758	108
Nov.	172	649	108
Dec.	142	325	105
Average	166	638	69
Maximum	187	974	108
Minimum	150	325	11
Average 1969	169	545	55

Table B-9

AERATION TANK
MIXED LIQUOR
1970

MONTH	SUSPENDED SOLIDS (mg/L)	S.V.I.	D.O.	SETTLEABLE SOLIDS
Jan.	3,458	134	2.5	471
Feb.	3,150	84	2.9	279
Mar.	3,929	91	2.3	364
April	4,342	92	2.5	404
May	4,136	100	1.4	417
June	4,231	86	-	359
July	4,064	89	-	360
Aug.	2,983	75	-	227
Sept.	3,981	93	-	228
Oct.	3,606	119	1.4	446
Nov.	4,241	151	1.5	648
Dec.	5,055	170	2.4	856
Average	3,931	107	2.1	422
Maximum	5,055	170	2.9	856
Minimum	2,983	75	-	227
Average 1969	2,088	114	2.5	250

☆U.S. GOVERNMENT PRINTING OFFICE:1972 514-149/75 1-3

1 Accession Number	2 Subject Field & Group	
W		**SELECTED WATER RESOURCES ABSTRACTS** INPUT TRANSACTION FORM

5 *Organization*

Banister Short Elliott Hendrickson & Associates, St. Paul, Minnesota

6 *Title*

Storage and Treatment of Combined Sewer Overflows

10 *Author(s)*

Liebenow, Wilbur, R.

Bieging, James, K.

16 *Project Designation*

EPA, WQO Contract No. 11023 FIY

21 *Note*

22 *Citation*

Environmental Protection Agency report number EPA-R2-72-070, October 1972.

23 *Descriptors (Starred First)*

Overflow*, Rainfall-Runoff Relationships*, Sewage Treatment*, Storm Runoff*, Waste Storage*, Activated Sludge, Capital Costs, Design Storm, Maintenance Costs, Operating Costs, Precipitation Intensity, Sedimentation, Sewage, Water Quality

25 *Identifiers (Starred First)*

Combined Sewers*, Detention Pond*, Chippewa Falls*, Wisconsin*, Chippewa River*

27 *Abstract*

The objective of this study was to demonstrate the feasibility and economic effectiveness of a combined wastewater overflow detention basin.

A paved asphalt detention basin with a storage volume of 8.66 acre feet was constructed at Chippewa Falls, Wisconsin to receive overflow from a 90 acre combined sewer area including all of the central business district. The system was designed so that the stored combined sewage could be pumped to the wastewater treatment plant when precipitation subsided.

During 1969, due to dry weather, the pond received only sixteen discharges, but completely filled twice and overflow to the river occurred. During 1970, there were 46 discharges and the pond filled once overflowing to the river. Over the two year period, 37.75 million gallons of combined sewage (93.7 per cent of the total discharge volume) were withheld from the river for subsequent treatment.

There were no observed detrimental effects on treatment plant operation due to the increased intermittent flows from the detention pond. The estimated cost of operating and maintaining the pond and associated facilities was $7,300 per year for the two year period. Capital costs were $6,780 per acre of drainage area including some relief combined sewer and increased size of units at the waste water treatment plant.

Abstractor Wilbur R. Liebenow | *Institution* Banister Short Elliott Hendrickson & Associates

WR:102 (REV. JULY 1969)
WRSIC

SEND, WITH COPY OF DOCUMENT, TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D. C. 20240