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Combined Sewer Overflow Abatement Program Rochester, NY

Volume II. Pilot Plant Evaluations

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COMBINED SEWER OVERFLOW ABATEMENT PROGRAM, ROCHESTER, N.Y.

Volume II. Pilot Plant Evaluations

by

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The Great Lakes National Program Office, through Section 108(a) of PL 92-500, enters into grants for the demonstration of new methods and techniques and for the development of preliminary plans for the prevention, reduction or elimination of pollution within all or any part of the watersheds of the Great Lakes. The Great Lakes National Program Office has joined with the Municipal Environmental Research Laboratory in carrying out this research and demonstration project to assist the Rochester Pure Waters District to eliminate an urban drainage pollution problem to Lake Ontario.

The deleterious effects of storm sewer discharges and combined sewer overflows upon the nation's waterways have become of increasing concern in recent times. Efforts to alleviate the problem depend upon characterization of these flows both as to quantity and quality. This report describes the results of pilot plant studies of a number of treatment technologies for controlling the quality of combined sewer overflow discharges.

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ABSTRACT

The Rochester Pilot plant treatability studies were designed to interact with combined sewer overflow (CSO) monitoring and system modeling efforts for the Monroe County Pure Waters District with the ultimate objective of evaluating CSO abatement alternatives, as presented in Volume I of this Report.

The studies covered treatment by the following unit processes: flocculation/sedimentation (F/S), swirl degritter and swirl primary separator, microscreening with sonic cleaning, dual-media high-rate filtration, activated carbon adsorption, sludge dewatering and high-rate disinfection. Applied flowrates to the system ranged between 0.3 and 11.2 l/s (5 and 177 gpm).

Pilot operations covered nineteen overflow events during the period of September 1975 through June 1976. The studies evaluated the effects of design loadings and influent quality on system performance. Data were evaluated through application of statistical techniques and development of mathematical performance models. These models were used to develop optimum cost/benefit comparisons of systems. Results were also compared to published literature for similar installations at other locations.

The flocculation/sedimentation system was evaluated employing surface overflow rates from 33 to 82 m^3/day m^2 (800 to 2000 gpd/ft^2). Mathematical performance models were developed for the three chemical treatment cases. These models related SS removal rates to overflow rate and influent SS concentrations.

The swirl separators were pilot tested at flowrates ranging from 0.9 to 4.4 l/s (15 to 70 gpm). Mathematical performance models were developed for each system relating SS removal rates to influent flowrate and influent SS concentration. Chemical treatments were tested on the swirl primary system, but the in-line flocculation technique did not provide sufficient energy to permit effective floc development. The performance equations were compared to previously developed design curves for swirl concentrators.

Testing of the microscreen system was limited due to equipment malfunction. Headloss development across the screen was shown to be related to both hydraulic loading and screen rotational speed. The maximum hydraulic loading attainable for most of the dry and wet-weather testing was on the order of 550 l/min m^2 (13.5 gpm/ft^2) of screen surface when using a 70 micron screen.

Dual-media high-rate filters (DMHRF) were evaluated at hydraulic loading rates between 407 to 1018 l/min m^2 (10 to 25 gpm/ft^2). Results are compared for filtration with no chemical addition and with polyelectrolyte alone and alum plus polyelectrolyte. The performance curves show the effects of the chemical addition and the impact of the upstream (swirl primary separator) treatment on performance of the DMHRF.

Operation of the carbon adsorption system was limited to three storms. Detention times of 13.5 to 45 minutes were evaluated. Optimum BOD_5 removals (80-95 percent) were attained at detention times of 20 to 30 minutes.

Multiple regression modeling of the chlorine (Cl_2) and chlorine dioxide (ClO_2) disinfection data yielded statistically significant equations for the high-rate disinfection systems. The models indicated that disinfection by Cl_2 is more sensitive to mixing intensity and detention time than disinfection by ClO_2. System cost optimization procedures indicated that ClO_2 permitted use of lower detention time facilities. The use of Cl_2 permitted lower overall cost systems relative to ClO_2 for all trial cases of required kill and wastewater quality.

A review of literature is presented on solids handling considerations involved with treatment of CSO.

Cost/benefit comparisons of the F/S and swirl primary separator systems are presented. Cost/benefits of chemical treatment programs are also presented. Cost/benefits of regional configuration alternatives (central versus local treatment) and storage versus treatment sizing are presented in Volume I of this Report.

This report was submitted in fulfillment of Grant No. Y005141 by O'Brien & Gere Engineers, Inc. under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers the period from May 4, 1974 to November 1976, and work was completed as of September 1977.

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FIGURES (continued)

FIGURES (continued)

FIGURES (continued)

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TABLES (continued)

LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

ALPPH	-- alum feed rate
APWA	-- American Public Works Association
ASCE	-- American Society of Civil Engineers
BOD_5	-- 5 day biochemical oxygen demand at 20C
cal	-- calories
cc	-- chemical cost
c_e	-- effluent suspended solids concentration
cm	-- centimeters
c_o	-- influent suspended solids concentration
COD	-- chemical oxygen demand
CSO	-- combined sewer overflow
D.T.	-- detention time
D_2/D_1	-- chamber diameter/inlet diameter
dia	-- diameter
DMHRF	-- dual-media high-rate filter
DOSE	-- chemical dosage
e.s.	-- effective size
FBV	-- flocculation basin volume
ft	-- feet
ft^2	-- square feet
ft^3	-- cubic feet
fpm	-- feet per minute
F/S	-- flocculation/sedimentation
G	-- velocity gradient (sec^{-1} or min^{-1}, as specified)
GT	-- effective mixing intensity
gal	-- gallons
g	-- grams
g_c	-- effluent grit concentration
g_o	-- Influent grit concentration
gpd	-- gallons per day
gpm	-- gallons per minute
G/S	-- swirl degritter
hr	-- hour
ha	-- hactares
H_1/D_2	-- weir height/swirl chamber diameter
hp	-- horsepower
in	-- inches
kg	-- kilograms
l	-- liters
LC	-- labor cost
l/s	-- liters/second
m	-- meters

ABBREVIATIONS (continued)

m^2	-- square meters
m^3	-- cubic meters
mg	-- miligrams
mil gal	-- million gallons
mgd	-- million gallons per day
MGTPY	-- million gallons treated per year
ml	-- milliliter
mm	-- millimeter
min	-- minute
mg/l	-- milligrams/liter
M/S	-- microscreen
N	-- Newtons
NOF	-- number of overflow events per year
NUMUNITS	-- number of swirl units
N_F	-- Froude number
O&G	-- oil and grease
OR	-- overflow rate
PC	-- power cost
PCB	-- polychlorinated biphenyl
POLPPH	-- polymer feed rate
P/S	-- swirl primary separator
PVC	-- polyvinyl chloride
R-M	-- rapid mix
rpm	-- revolutions per minute
SA	-- surface area
S.G.	-- specific gravity
SETTS	-- settleable solids
scfm	-- standard cubic feet per minute
SS	-- suspended solids
SWMM	-- stormwater management model
T	-- contact time
TIP	-- total inorganic phosphorus
TKN	-- total Kjeldahl nitrogen
TOC	-- total organic carbon
TS	-- total solids
USEPA	-- United States Environmental Protection Agency
v	-- velocity
V	-- basin volume
VSS	-- volatile suspended solids
WOR	-- weir overflow rate

SYMBOLS

Al	-- aluminum
Cl_2	-- chlorine
ClO_2	-- chlorine dioxide
P	-- phosphorus
Q	-- flowrate, units as specified
/	-- per (to indicate rates)
$ mil	-- million dollars

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The support of this effort by the Storm and Combined Sewer Section, Eidson, New Jersey of the USEPA Municipal Environmental Research Laboratory, Cincinnati, Ohio and of the Office of the Great Lakes Coordinator, Region V, USEPA, Chicago, Illinois and especially of Richard Field, Chief, Anthony Tafuri, Project Officer, Storm and Combined Sewer Section, Ralph Christensen, Chief, Section 108a Great Lakes Demonstration Program, and Larry Moriarty, Project Officer, USEPA, Region II for their guidance, suggestions and contributions is acknowledged with gratitude.

This report has been prepared by O'Brien & Gere Engineers, Inc., Syracuse, New York under the direction of Frank J. Drehwing, Vice President, and Cornelius B. Murphy, Managing Engineer.

SECTION 1

INTRODUCTION

BACKGROUND

The significance of pollution caused by storm-generated discharges has been well documented. A large portion of this pollution is associated with overflows or relief points in combined sewer systems. A nationwide survey by the APWA (1) indicated that combined sewers are used in more than 1300 municipalities serving a population of 54 million. The magnitude of the overflow problem was exemplified by a 2-year study conducted on a 92.7 ha (229 acre) combined sewer watershed in Northampton, England. This study showed that the cumulative yearly five-day biochemical oxygen demand (BOD_5) load in the combined sewer overflows nearly equaled the BOD_5 load contained in the effluent of the local secondary treatment plant. Suspended solids within the overflows were three times the load contributed by the treatment work effluent (1).

Another aspect of the problem was illustrated in a report on the combined sewers in Buffalo, N.Y. (2). In Buffalo, 20 to 30 percent of the annual collection of domestic sewage solids settle in the sewers during dry periods and are eventually discharged during storms. This results in shock loadings which are detrimental to aquatic life in the receiving water.

The most obvious solution to abatement of combined sewer overflows (CSO) is construction of separate storm sewer networks. In terms of dollars per acre served, this is a very costly alternative and is technically difficult in heavily populated and developed urban areas. Moreover, it is possible that quality control of storm sewer discharges may be necessary in the future.

CSO abatement alternatives have been classified into three groupings: (a) nonstructural alternatives, (b) minimal-structural alternatives and (c) capital intensive alternatives. These have been described in detail in Volume I of this Report (3).

Many CSO abatement techniques such as regulator adjustments, elimination of interceptor constraints and in-system storage, while reducing overflow volumes, result in containment of large volumes of wastewater which require treatment. Ideally, the flow-attenuating techniques would allow treatment of the additional contained wastewaters in existing dry-weather treatment facilities during nonstorm periods. However, it appears that existing dry-weather treatment facilities in many communities do not have either the hydraulic or solids-handling capabilities to adequately treat even attenuated storm flows. These stormwater contributions could cause very serious hydraulic and toxic upset conditions in biological treatment systems not specifically designed for this impact.

Therefore, an integral part of most CSO abatement programs is consideration of the treatment technologies to be applied to the intercepted wet-weather flows. Since the characteristics of combined sewage are quite different from those of dry-weather domestic sewage, different treatment concepts may be applied to wet-weather flows. For example, wet-weather suspended solids generally exhibit a fairly coarse size distribution and may readily be removed in primary facilities operated at relatively high hydraulic loading rates.

PURPOSE OF STUDY

The pilot plant treatability studies were undertaken to delineate the treatment alternatives available for control of CSO quality in the Rochester Pure Waters District of Monroe County, New York.

The direction of the pilot plant study was based partly on requirements outlined by the USEPA (73). These requirements stated that all CSO shall have a minimum of primary treatment, phosphate removal,and chlorination with absolutely no bypassing.

A major emphasis of the study was the development of cost/benefit comparisons of processes that would allow primary-level treatment efficiencies. These processes were compared relative to their response to treating variable-quality influent wastewater. Treatment of the highly concentrated first-flush overflow was of particular importance. Most of the comparisons centered around the flocculation/sedimentation and swirl separator systems. Evaluations of chemical treatments were instrumental for the determination of optimum conditions.

Previous studies of the District's combined system (74, 75) cited deficiencies of the existing sewerage system and the effects of wastewater discharges on the area receiving waters. Those studies recognized that measures were necessary for collection, transmission, control and treatment of combined wastewaters originating within the City of Rochester. Subsequent studies (76) have reinforced the earlier studies and documented the impact of CSO on the Genesee River and the Rochester Embayment of Lake Ontario. The objective of this study was to outline a plan of best management practices through a program of CSO monitoring, system modeling and treatability studies. The treatability studies reported herein were designed specifically to interact with the modeling efforts and evaluations of abatement alternatives. The treatability studies and cost estimates were particularly instrumental to evaluation of satellite overflow treatment versus centralized treatment and determination of storage versus treatment capacity optimizations.

The treatment processes included in this study represent those systems that are currently receiving prime nationwide consideration for treatment of CSO. Combinations of the piloted processes could result in process trains capable of providing treatment efficiencies from grit removal through tertiary treatment quality and disinfection. A secondary objective of the pilot program was to provide additional expansion of the nationwide data base for evaluating CSO treatability. Every effort was made to compare results of this study to results reported for similar installations at other locations.

SECTION 2

CONCLUSIONS

1. Most CSO abatement techniques result in containment of large volumes of wastewater which require treatment.

2. High-rate physical and/or chemical treatment processes are well suited to the abatement of pollution from CSO.

3. Multiple regression modelling of the F/S data indicated the following general relationships:

Influent SS (mg/l)	% Removal of SS OR (gpd/sq ft) 800	1500	2000
No Chemical Treatment			
200	15.9	12.0	10.1
500	60.9	59.1	58.2
With Polymer Treatment			
200	53.1	47.6	44.9
500	77.6	75.0	73.7
With Alum plus Polymer			
200	78.2	75.4	74.0
500	89.3	87.9	87.2

Performance of the flocculation/sedimentation (F/S) pilot system was significantly enhanced by incorporation of chemical treatment. Percentage removal of suspended solids (SS) in the F/S system was highly dependent on influent SS concentration as well as overflow rate (OR). Increasing OR from 33 to 82 m^3/day m^2 (800 to 2000 gpd/ft^2) in the F/S system resulted in only marginal loss of performance.

4. Performance of the pilot swirl degritter generally supported the data presented for the pilot swirl degritter evaluated at Denver.

Multiple regression analysis of the data from the 0.91-m (3-ft) dia swirl degritter developed the following general trends

Influent SS (mg/l)	% Grit Removal Flowrate (gpm) 15	40	70
100	69.0	59.8	54.6
300	100.0	91.0	85.7
400	100.0	99.1	93.8

5. After scaling of hydraulic flows and particle settling velocities to prototype scale, the performance data obtained from the pilot swirl primary separator unit generally supported the previously developed design curves developed by APWA.

Multiple regression analysis of data from the 1.8-m (6-ft) dia swirl primary separator indicated the following:

Influent SS (mg/l)	% SS Removal Flowrate (gpm) 15	40	70
100	56.5	32.5	13.3
300	66.6	48.1	33.3
500	70.4	54.1	41.0

6. The hydraulic loading to the FMC pilot microscreening system with ultrasonic cleaning appeared to be limited to about 550 $l/min\ m^2$ (13.5 gpm/ft^2) when using 70 micron screens. However, the data suggested that higher loadings might be attainable if screen rotation was increased above 136 rpm. SS removals averaged within the range of 1.5-43.5 percent when treating CSO.

7. Increasing hydraulic loading to the pilot dual-media high-rate filters (DMHRF) above 407 $l/min\ m^2$ (10 gpm/ft^2) tended to improve specific captures by dispersion of trapped solids deeper into the bed. However, without chemical treatment, SS removals fell rapidly at the higher loadings. When chemicals were employed on or upstream of the filters, performance loss at the higher influx was not as great.

	Flux (gpd/sq ft)	Average % SS Removal Range	Mean	Spec. Capture (lbs/sq ft)
No chemical	10-15	56-83	67	1.34
Treatment	20-25	40-71	50	1.57
With chemical	10-15	66-92	78	1.31
Treatment	20-25	45-95	64	1.59

8. The application of carbon adsorption indicated optimum BOD_5 removal at detention times of 20 to 30 minutes.

Influent BOD_5 (mg/l)	Detention Time (min)	Flux (gpm/sq ft)	BOD_5 Removal (%)
30	13.5	0.42	69
30	19.3	0.61	76
30	30.0	0.94	83
30	45.0	1.41	79
70	13.5	0.42	92
70	19.3	0.61	91
70	30.0	0.94	96
70	45.0	1.41	88

9. Multiple regression modeling of Cl_2 and ClO_2 disinfection data yielded statistically significant performance equations for high-rate disinfection.

10. High-rate disinfection employing relatively short detention time and high-intensity mixing appeared to be a more cost effective method than conventional disinfection for the treatment of CSO. These procedures tend to increase operating costs while decreasing capital costs. CSO treatment facilities remain idle for much of the year; thus, operating cost is a smaller fraction of the overall cost for wet-weather facilities than for dry-weather plant.

11. Disinfection by Cl_2 was preferred to disinfection by ClO_2 on a cost performance basis when treating CSO with site factors specific to Rochester, NY.

12. Cost/benefit comparisons of the F/S and swirl primary separator systems indicated that the choice of treatment methodology for CSO was dependent on the influent quality and the degree of treatment required. In general, the swirl separator was cost competitive with F/S. However, chemical treatments incorporated into a F/S system permitted significantly enhanced removal efficiencies with fairly minor increases in operating costs.

13. Review of the literature indicates that, in general, sludges from CSO treatment should not be bled back to dry-weather treatment plants. Physical/chemical sludges at local overflow sites should be treated at separate on-site facilities. After considering site-specific factors at Rochester, the recommended sludge treatment included lime stabilization, thickening, vacuum filtration and land disposal.

SECTION 3

RECOMMENDATIONS

1. Future studies of flocculation/sedimentation of CSO should include evaluations of OR's above 82 m^3/day m^2 (2000 gpd/ft^2), especially when alum and polyelectrolyte are employed.

2. Pilot and prototype scale swirl units should be tested side-by-side to verify and establish the scaleup procedures for the pilot scale units.

3. Prototype verification testing should be conducted for the swirl degritter and swirl primary separator units.

4. Chemical treatment should be further evaluated in the swirl primary separator unit to study the enhancement in performance.

5. Because of operating difficulties encountered with the FMC Microscreen system, limited data were collected. CSO treatment data from other microscreen systems are available from references cited in the text. Future testing should evaluate loadings above 550 1/min m^2 (13.5 gpm/ft^2) and other screen mesh sizes.

6. This study suggested that treatment efficiency of units upstream of DMHRF had an impact on performance of the DMHRF. This impact should be evaluated further along with additional studies with chemical treatment.

7. It has been demonstrated that carbon adsorption provides significant removals of dissolved organics from CSO. Because of the high costs associated with carbon adsorption, its application should be limited to locations where receiving water loadings of dissolved organics and toxicants are critical.

8. The need for dechlorination of disinfected effluents resulting from high-rate disinfection systems using high Cl_2 dosages should be evaluated.

9. The formation of chlorinated organics and other refractory residuals in high-rate disinfection systems using high Cl_2 and ClO_2 dosages should be evaluated.

10. It is recommended that sludges resulting from the treatment of CSO generated from the Rochester system employ lime stabilization,

thickening, vacuum filtration, and either incineration or land disposal.

11. A more cost effective process should be developed for on-site generation of ClO_2.

12. The utility of employing the swirl separator concept for sludge concentration should be evaluated.

13. Additional process evaluations should be conducted to study the removal of toxicants known to be constituents of CSO.

SECTION 4

PILOT PLANT FACILITIES

GENERAL

The pilot plant facilities were installed at the Joseph-Ward Chlorination Station (Figure 1), a facility which had been abandoned as a chlorination station. It is located near the Central Avenue overflow site (designated as overflow No. 25 for the Characterization and Monitoring Program). The drainage area associated with this overflow comprises an area of 171.3 ha (423 acres), 137 ha (340 acres) of which could be characterized as commercial usage. The remainder of the area is associated mainly with residential use.

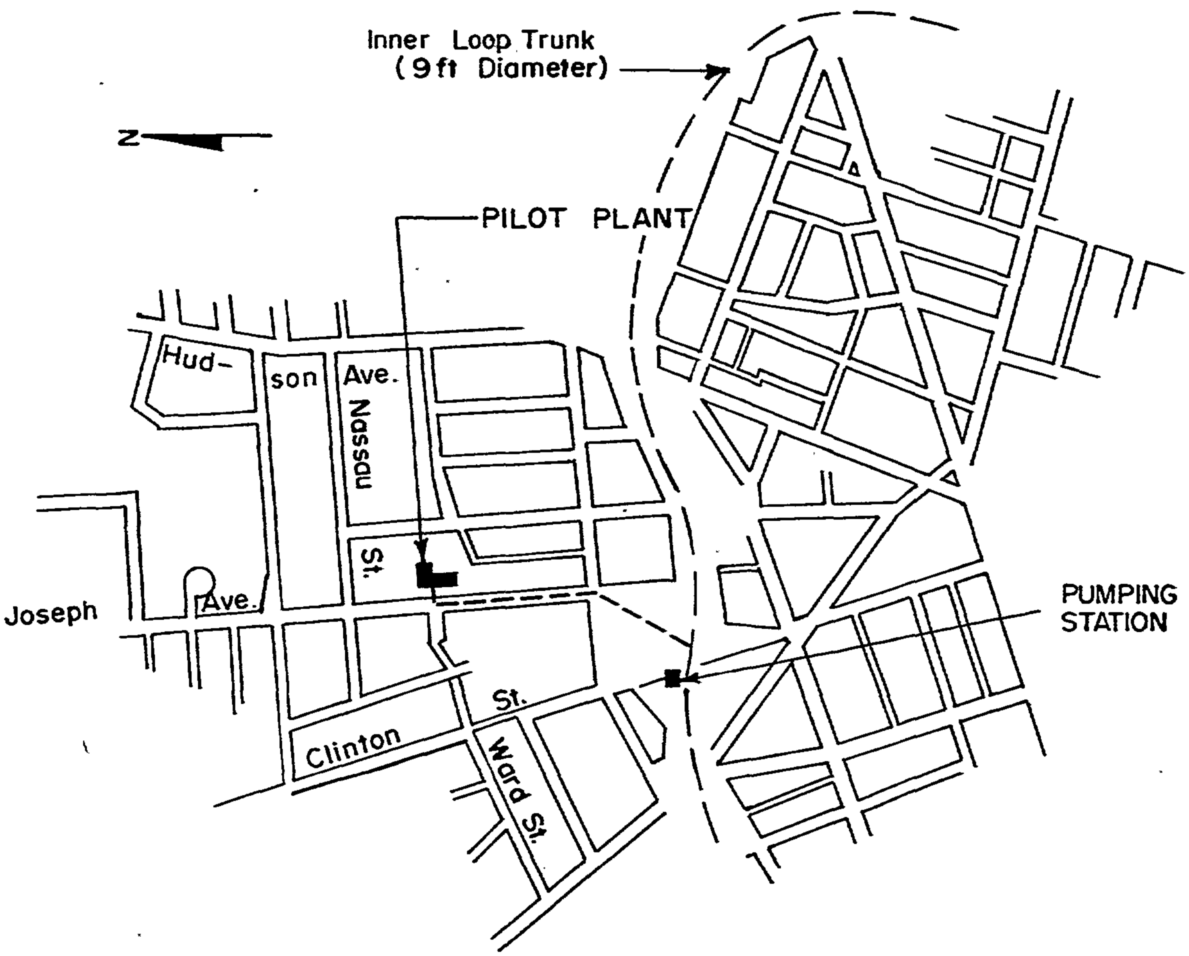


FIGURE 1. Pilot Plant and Pumping Station Locations

Three types of treatment processes were investigated at the Rochester pilot plant: (1) primary solids separation; (2) chemical precipitation to achieve a greater degree of fine solids removal along with phosphorus reduction below the 1 mg/l level; and (3) final polishing and high-rate disinfection to achieve a secondary quality effluent with respect to BOD_5 and bacterial contamination. The primary solids removal processes tested and evaluated included high-rate sedimentation, microscreening, high-rate filtration, and swirl concentrators. The phosphorus removal processes tested and evaluated included chemical addition and flocculation prior to the high-rate sedimentation process and chemical addition prior to application on high-rate, dual-media filter beds. Polishing and high-rate disinfection included carbon filters to study the effect of providing the equivalent of secondary treatment to wet-weather discharges. The disinfection process was directed towards applying conclusions of earlier studies of chlorine and chlorine dioxide (42) and testing several mixing concepts to evaluate methods for achieving bacterial reductions within very short detention periods (five minutes or less).

Physical dimensions and design parameters of the pilot plant facilities are listed in Table 1. Figures 2 and 3 show photographs of the pilot plant facilities.

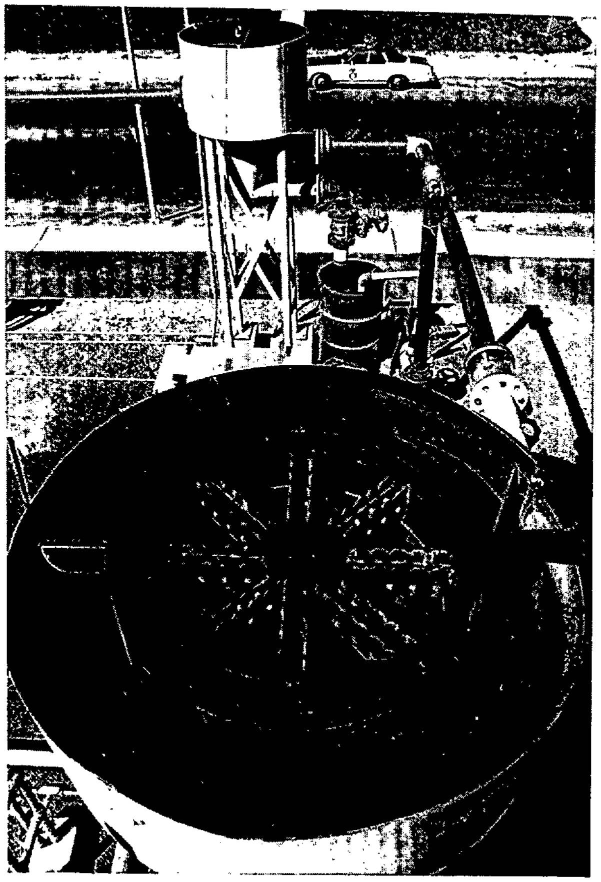
PUMPING STATION

The pumping station which provided the influent to the pilot plant was located upstream of the Central Avenue overflow in a section of the 3.66 m (12 ft) tunnel. The pumping station location, although not at the actual overflow site, collected runoff as part of the combined sewage from more than 95 percent of the drainage area. Pumping of flow to the pilot plant was accomplished through the use of two 10.2 cm (4 in) submersible high-head pumps. Each pump was capable of delivering 25.2 l/s (400 gpm) under a total head of 26 m (85 ft).

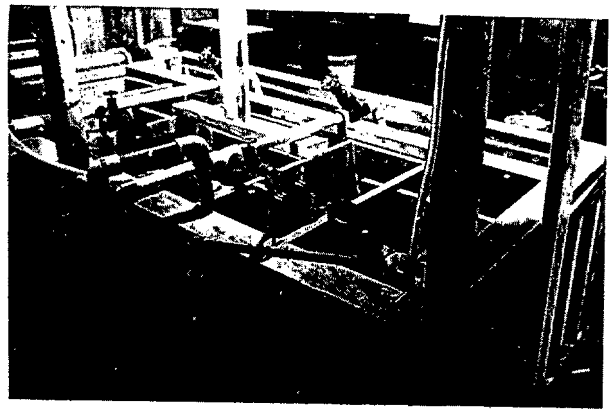
Immediately downstream of the pumps a 0.6 m (2 ft) weir was constructed in order to maintain a minimum level of flow around the pumps. This made it possible to operate the pumps under both dry and wet-weather conditions. A removable gate was installed in the weir which permitted the areas behind the weir and around the pumps to be cleaned periodically.

The pumps were controlled from the pilot plant by two alternative modes of operation. The pumps could be started manually and independent of flow conditions in the tunnel, or the pumps could be started inside the tunnel. An ultrasonic head probe and continuous recorder were used to monitor and record the amount of overflow produced with each storm occurrence.

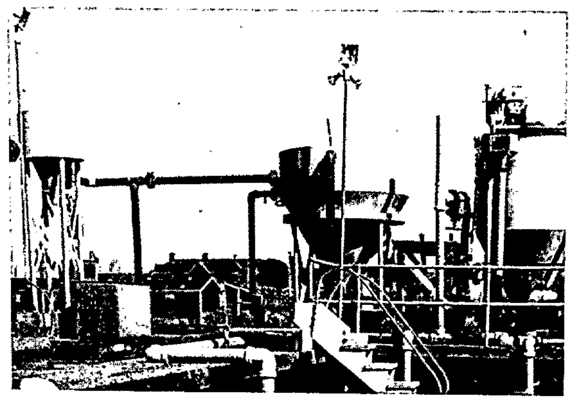
Conveyance of flow to the pilot plant was provided through the use of a 15 cm (6 in) diameter pipe, approximately 457 m (1500 ft) long. A bypass valve controlled the flow of CSO into the pilot plant. Gate valves were used to control the flow into each of the treatment units. Flow measurements were made with magnetic flowmeters with direct reading indicators installed in the vicinity of the gate valves to monitor incoming flows.



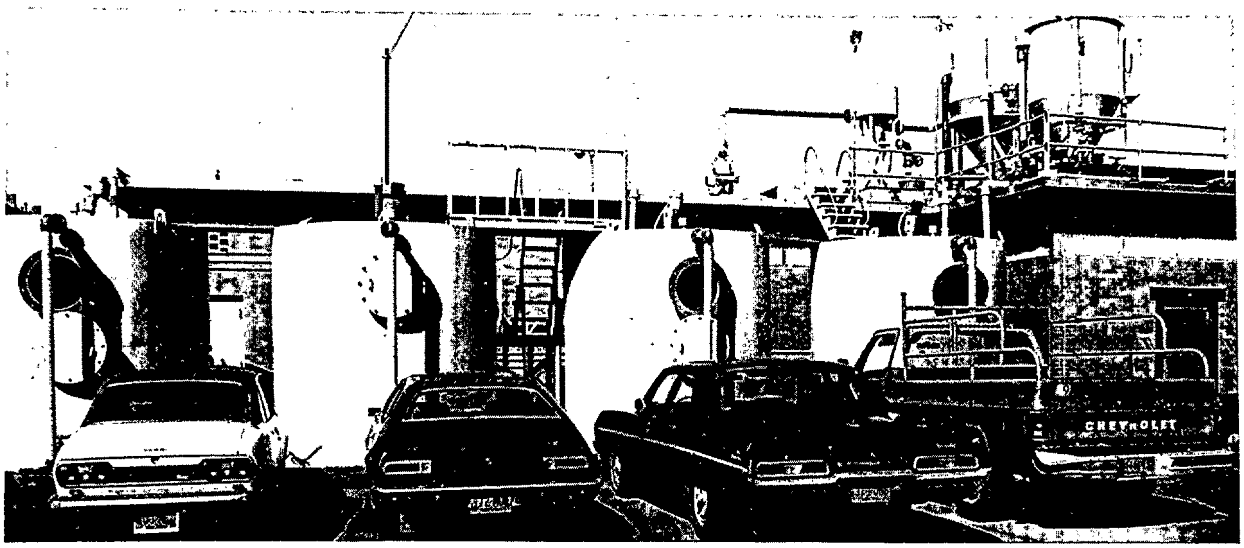
Swirl Primary Separator (foreground) and Swirl Degritter (background)



Cl_2 and ClO_2 High Rate Disinfection Tanks

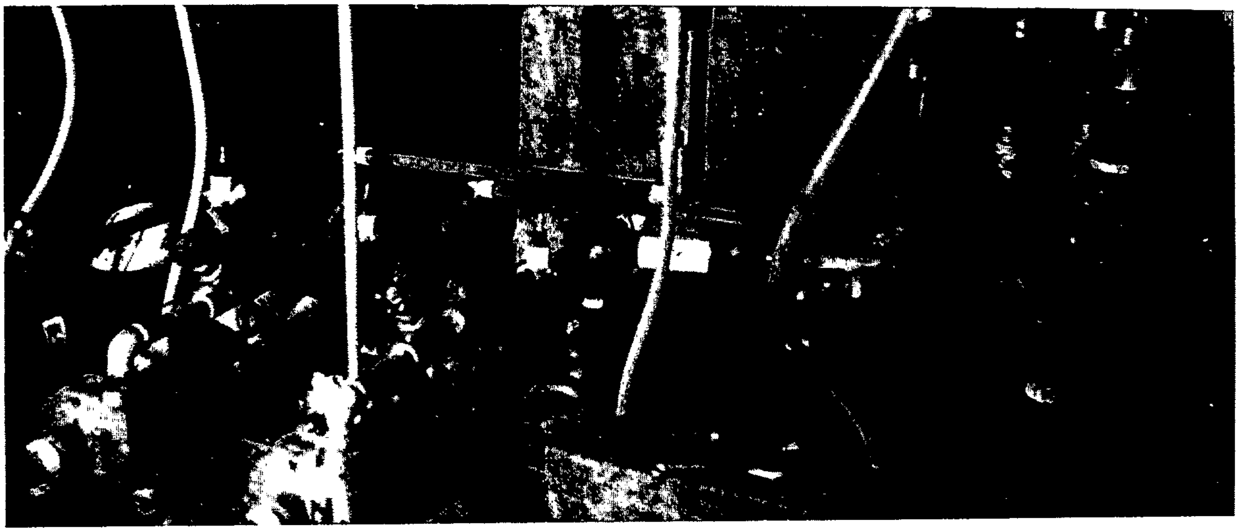


From left: Swirl Degritter, Swirl Primary Separator and Microscreen Unit



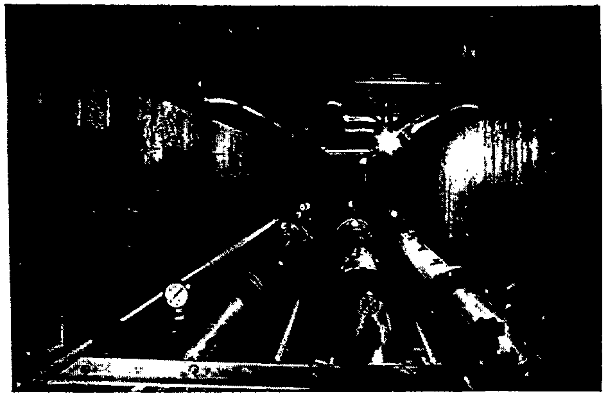
Storage Tanks (on ground)

FIGURE 2. Rochester Pilot Plant Facilities

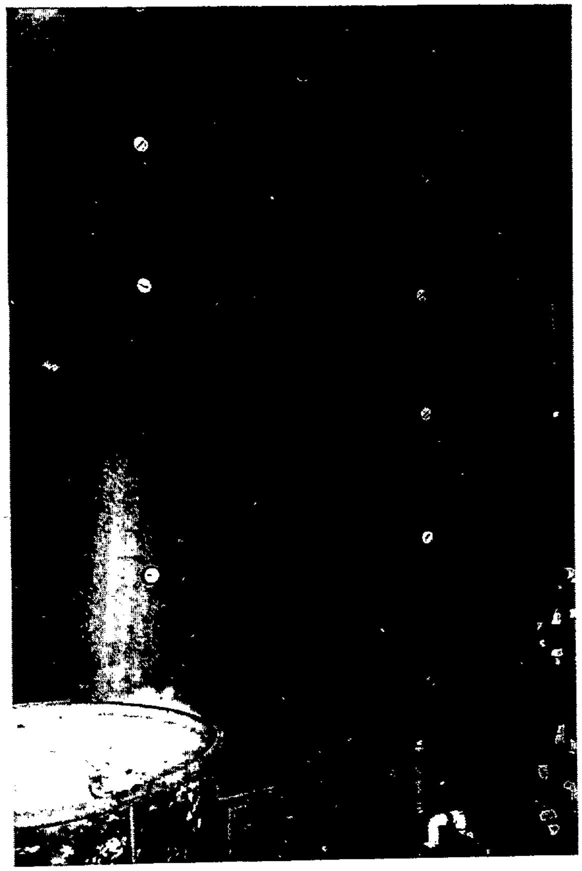


Influent and Effluent Pumps Associated with Dual Media Filter Columns

Flocculation--Sedimentation Basin



Dual Media Filter Columns for High Rate Filtration



Activated Carbon Columns

FIGURE 3. Rochester Pilot Plant Facilities

TABLE 1. PILOT PLANT DESIGN PARAMETERS

A. Flocculation Basin	
1. dimensions	2.1 m x 0.9 m x 1.98 m deep (7 ft x 3 ft x 6.5 ft)
2. surface area	1.95 m^2 (21.0 ft^2)
3. volume	3864 l (1021 gal)
4. flow rates	4.5-11.2 l/s (71-177 gpm)
5. detention times	5.1-10.1 min
6. velocity gradient	120/sec
7. mixing intensity (GT)	42000-104000
B. Sedimentation Basin	
1. dimensions	6.1 m x 2.1 m x 1.98 m deep (20 ft x 7 ft x 6.5 ft)
2. surface area	11.8 m^2 (127.3 ft^2)
3. volume	21900 l (5790 gal)
4. flow rates	4.5-11.2 l/s (71-177 gpm)
5. overflow rates	32.6-81.6 m^3/day m^2 (800-2000 gpd/ft^2)
6. detention times	33-81 min
C. Microscreen	
1. dimensions	1.5 m dia. x 2.3 m (5 ft dia. x 7.5 ft)
2. tank volume	3452 l (912 gal)
3. screen surface area	0.56 m^2 (6.0 ft^2)
4. flux	610-1221 l/min m^2 (15-30 gpm/ft^2) at full screen submergence
5. flow rates	6-11 l/s (90-180 gpm)
6. detention time	5.1 - 10.1 min
7. maximum rotation	136 rpm
8. screen aperture	10 or 70 microns
D. Swirl Degritter	
1. dimensions (overall)	0.9 m dia. x 1.2 m (3 ft dia. x 4 ft)
2. D_2/D_1 ratio	6.0
3. H_1/D_2 ratio	0.40
4. chamber volume	214 l (56.5 gal)
5. grit cone volume	61 l (16.0 gal)
6. surface area	0.64 m^2 (6.87 ft^2)
7. tested flow range	0.95-4.4 l/s (15 - 70 gpm)
8. operating N_F	0.0018 - 0.0392
9. detention time	1.04 - 4.83 min
E. Swirl Primary Separator	
1. dimensions (overall)	1.8 m dia x 1.8 m (6 ft dia. x 6 ft)
2. D_2/D_1 ratio	18.0
3. H_1/D_2 ratio	0.27
4. chamber volume	1173 l (310 gal)
5. sludge cone volume	1181 l (312 gal)

(continued)

TABLE 1. (continued)

6.	surface area	2.6 m^2 (28 ft^2)
7.	tested flow range	0.95 - 4.4 l/s (15 - 70 gpm)
8.	operating N_F	0.0137 - 0.298
9.	detention time	8.9 - 4.5 min
10.	equivalent OR	31.6 - 146.2 m^3/day m^2 (771-3600 gpd/ft^2)
F.	Dual-Media High-Rate Filters	
1.	dimensions	15 mm dia. x 5.5 m (0.5 ft x 18 ft)
2.	surface area	0.02 m^2 (0.196 ft^2)
3.	design flux	407 - 1018 l/min m^2 (10-25 gpm/ft^2)
4.	flow rates	7.6-18.9 l/min (2-5 gpm)
5.	media	1.5 m (5 ft) of No. 2 anthracite 0.9 m (3 ft) of No. 1220 sand
G.	Carbon Columns	
1.	dimensions	0.9 m dia. x 2.9 m (3 ft x 9.5 ft)
2.	surface area	0.66 m^2 (7.07 ft^2)
3.	operating flow range	0.19 - 0.63 l/s (3 - 10 gpm)
4.	detention time	13.5 - 45 min
5.	flux	17.3 - 57.3 l/min m^2 (0.42-141 gpm/ft^2)
6.	media	2.1 m (6.8 ft) of Filtrasorb 400
H.	Disinfection Tanks	
1.	dimensions	0.61 m x 0.61 m (2 ft x 2 ft)
2.	operating depths	15-37 mm (0.5 - 1.2 ft)
3.	volume	57 - 136 l (15 - 36 gal)
4.	operating flow rates	0.13 - 0.63 l/s (2 - 10 gpm)
5.	detention time	3.4 - 8.4 min
6.	mixing intensities (GT)	41400 - 179000

FLOCCULATION/SEDIMENTATION SYSTEM

The dimensions of the pilot flocculation/sedimentation system, shown in Figure 4, are listed in Table 1. The elevation of the overflow weir was adjustable so that both overflow rate and flow-through velocity could be varied. Overflow from the flocculation basin was directed by a baffle to the bottom of the sedimentation basin.

Chemicals were added to the flocculation basin using positive displacement pumps equipped with either 25 mm (1 in) or 12.7 mm (0.5 in) Viton pump heads. Alum was introduced as far back in the influent line as possible to ensure adequate mixing with the influent before coming into contact with the polymer. The polymer was fed at the point of influent discharge to the flocculation basin. Additional mixing in the flocculation basin was accomplished using a 2.67 kg-Cal/min (0.25 hp) mixer equipped with two 13 mm

(5.2 in) and one 20 mm (7.7 in) propellers on a 1.52 m (5 ft) shaft.

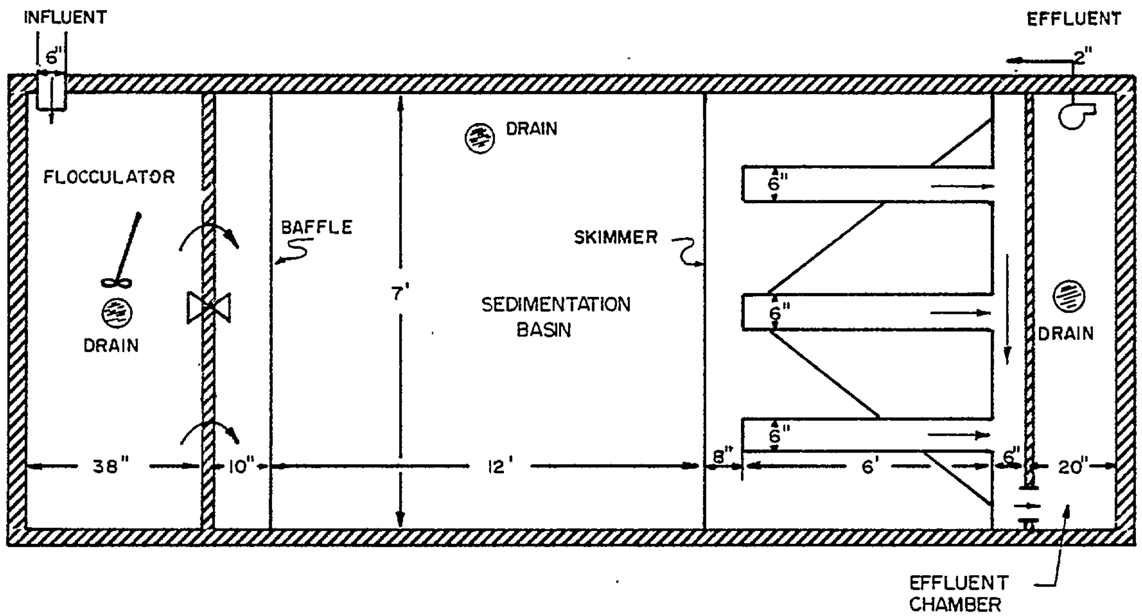


FIGURE 4. Flocculation/ Sedimentation Tank (Pilot Unit)

The major portion of the flocculation/sedimentation effluent was returned to the main sewer system. A portion of this effluent was capable of being directed into the carbon columns, the dual-media filters and disinfection bays. Grab samples were taken from 12.7 mm (0.5 in) taps located on the influent and effluent lines.

SWIRL CONCENTRATORS

The pilot facilities included a swirl degritter and a swirl primary separator connected in series. Dimensions of the swirl degritter, shown on Figure 5, are listed in Table 1. During normal operations the overflow from the swirl degritter (Figure 5) became the influent for the swirl primary separator (Figure 6). Provisions were also made, however, to allow the plant influent to bypass the swirl degritter and go directly into the swirl primary separator.

Both the inlet and outlet pipe diameters associated with the swirl degritter were 15.2 cm (6 in); each was fitted with 12.7 mm (0.5 in) sample taps. Installation of a 10.2 cm (4 in) gate valve on the swirl degritter solids drawoff line permitted the intermittent discharge of any solids which accumulated in the unit.

The dimensions of the swirl primary separator, shown in Figure 6, are listed in Table 1. The inlet pipe diameter, D_1, was 10.2 cm (4 in) and the outlet diameter was 7.6 cm (3 in). Sample taps were located on

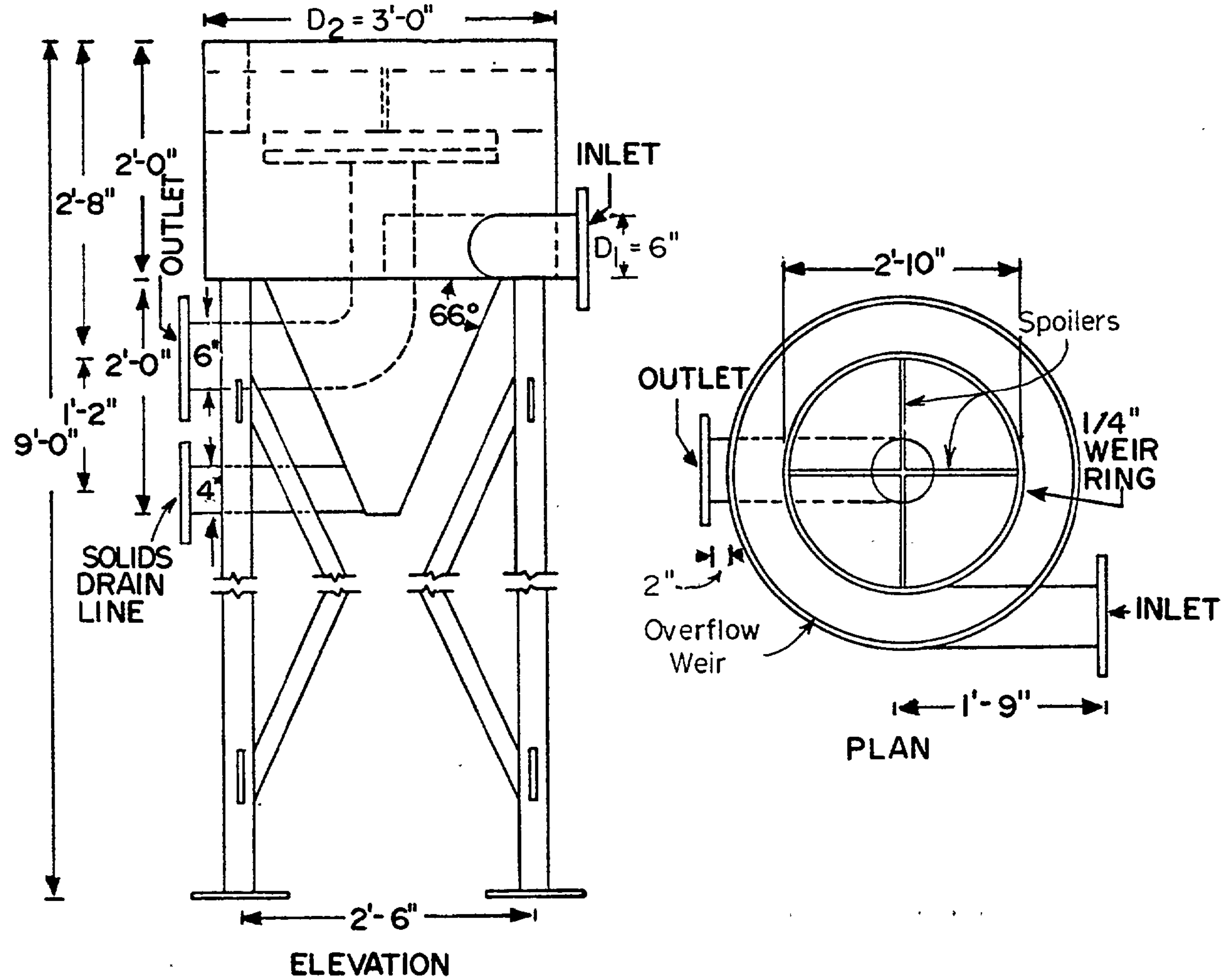


FIGURE 5. Swirl Degritter (Pilot Unit)

both the influent and effluent lines.

Two methods of sludge drawoff were provided for the swirl primary separator unit: intermittent and continuous. Installation of a 12.7 mm (0.5 in) ball valve on the solids drain line permitted accumulated sludge to be withdrawn intermittently. Continuous drawoff was achieved through a 2.54 cm (1 in) line using the head differential between the swirl unit and the outlet.

Chemical treatments to the swirl primary unit were added using positive displacement pumps. Alum was introduced to the swirl degritter effluent immediately as it exited the overflow weir. Anionic polymer was introduced approximately 1.8 m (6 ft) downstream from the point of alum addition and 2.4 m (8 ft) upstream of the swirl primary unit. A second mode of chemical addition was tested during Storm No. 19. It was attempted to gain enhanced mixing and contact time by adding alum upstream of the swirl degritter--

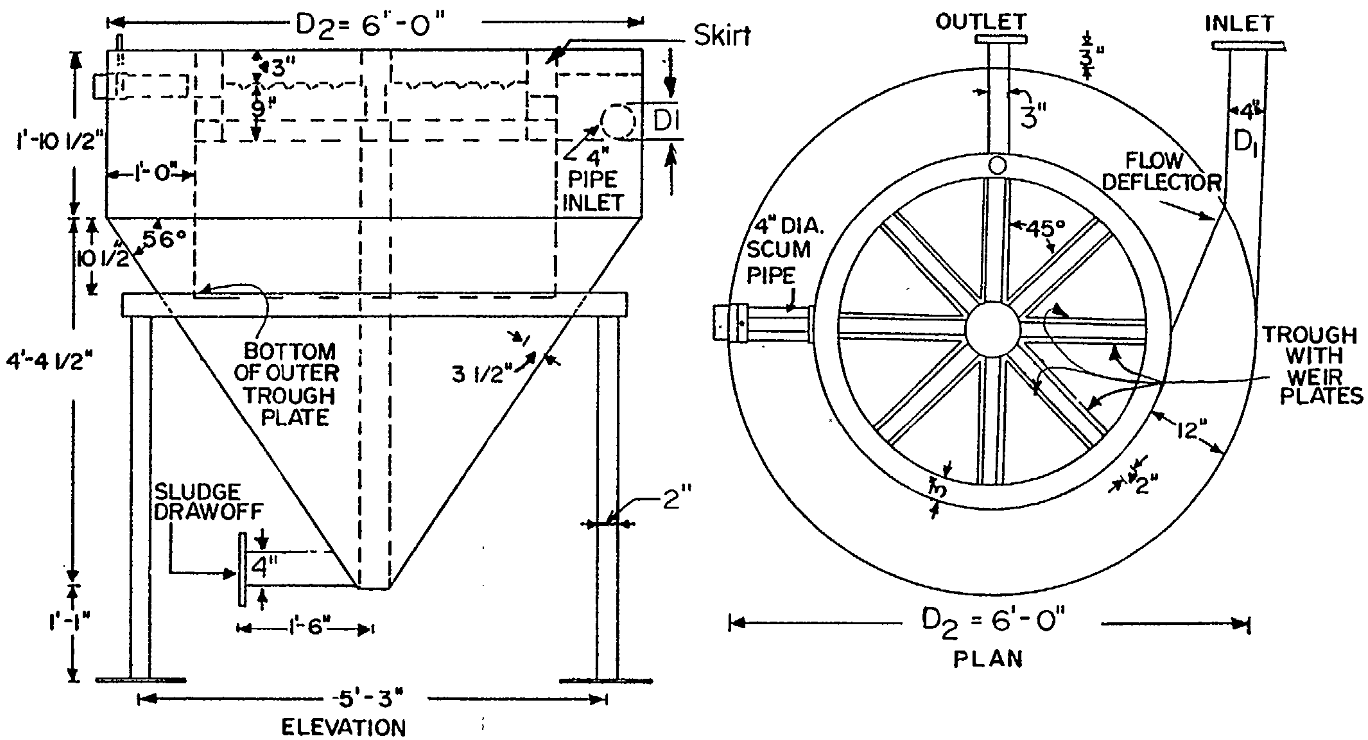


FIGURE 6. Swirl Primary Separator (Pilot Unit)

converting the degritter to a flocculation basin by installing a mixer.

MICROSCREENING SYSTEM

The microscreening system* used at the pilot plant employed a sonic cleaning mechanism. Figure 7 shows an elevation view of the microscreen and the sonic cleaner. Used in conjunction with the rotating strainer drum, the sonic cleaner provided continuous cleaning of the screen area of 1.83 m^2 (6 ft^2) with a peak hydraulic loading rate of 1221 l/min m^2 (30 gpm/ft^2). This represented a maximum flow rate of approximately 11.4 l/s (180 gpm).

Determination of the headloss across the screens was accomplished through the use of two manometers attached to the outside of the unit.

Both influent and effluent lines were 10.2 cm (4 in) in diameter. Effluent from the unit could be directed back into the main sewer system or into any of the four storage tanks. To prevent the accumulation of solids in the unit during operation, a 25 mm (1 in) flexible hose and ball valve were connected to the solids concentrate drain line. This permitted the drawoff of solids on an intermittent basis in lieu of continuous drawoff.

STORAGE TANKS

The effluents from both the microscreen system and the swirl separators were capable of being stored in quantities of 37.9 m^3 (10,000 gal) each. Four steel tanks, each having a capacity of 18.95 m^3 (5000 gal), were used to provide this storage. This storage permitted the operation of the secondary treatment units for four to five days following the wet-weather event. Figure 8 shows dimensions of the storage tanks used at the plant facilities.

Mixing of the stored CSO in each tank was provided with a 10.68 kg-cal/min (1 hp) mixer to keep the solids in suspension and maintain the D.O. levels above 2 mg/l.

DUAL-MEDIA HIGH-RATE FILTERS

Pilot filter studies were conducted using one PVC and two plexiglass columns. These filter columns were operated in parallel. Each column was 15 cm (6 in) in diameter and 5.5 m (18 ft) in depth. Filter media consisted of 1.5 m (5 ft) of No. 2 anthracite over 0.9 m (3 ft) of No. 1220 sand. Influent to the filter was from the storage tanks containing the effluent from either the microscreen or the swirl separator systems and was delivered through 25 mm (1 in) diameter pipes using 16.02 kg-cal/min (1.5 hp) centrifugal pumps. Similar pumps were employed in transferring the filter effluent to subsequent pilot operations. Flow measurements for both the influent and effluent were obtained using 19 mm (0.75 in) rotameters having a range of 0.13 to 0.63 l/s (2 to 10 gpm). Installation of a float-valve mechanism on the filter discharge facilitated the operation of the filter units. Figure 9 shows dimensions of the filter columns.

* supplied by FMC Corporation

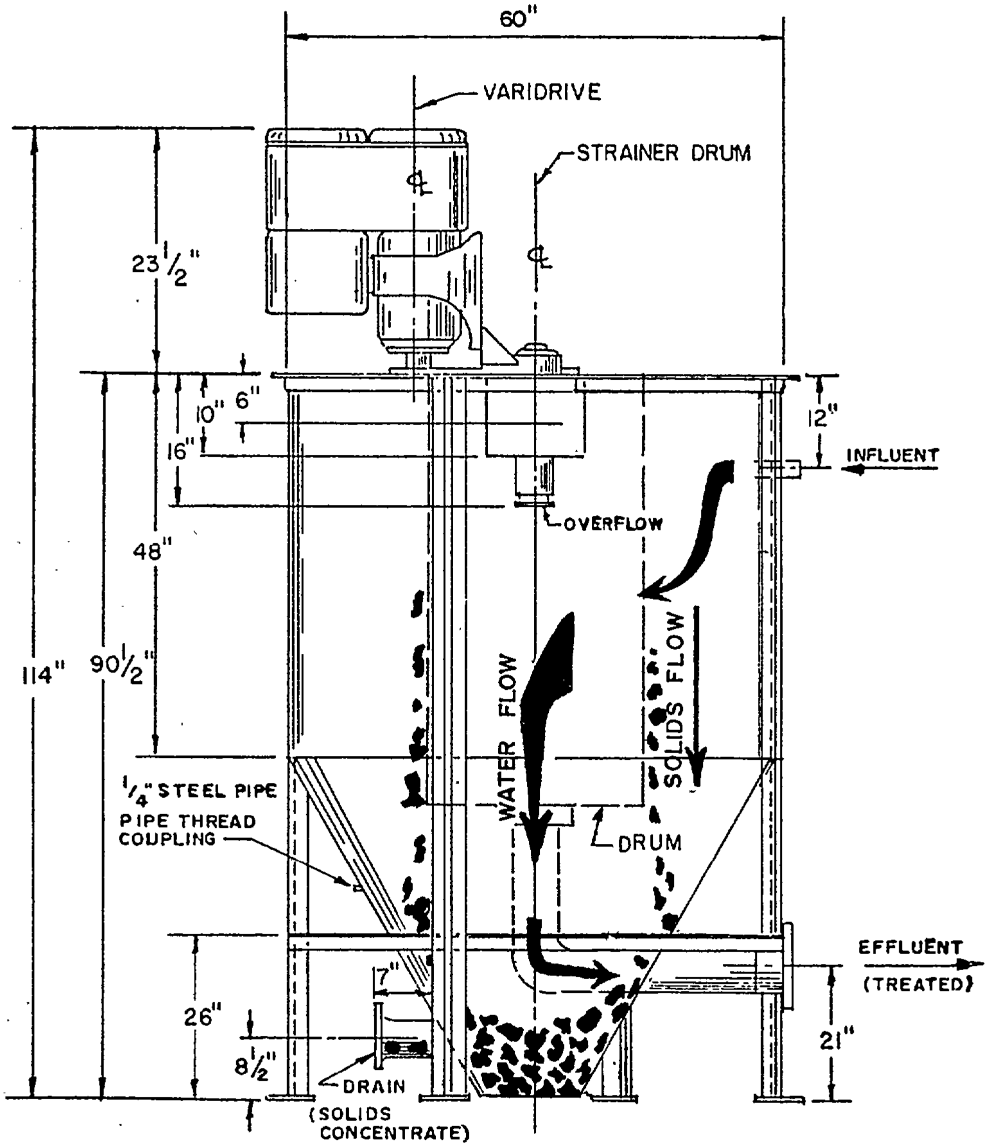


FIGURE 7. The FMC Sonic Cleaner Microscreen (Pilot Unit)

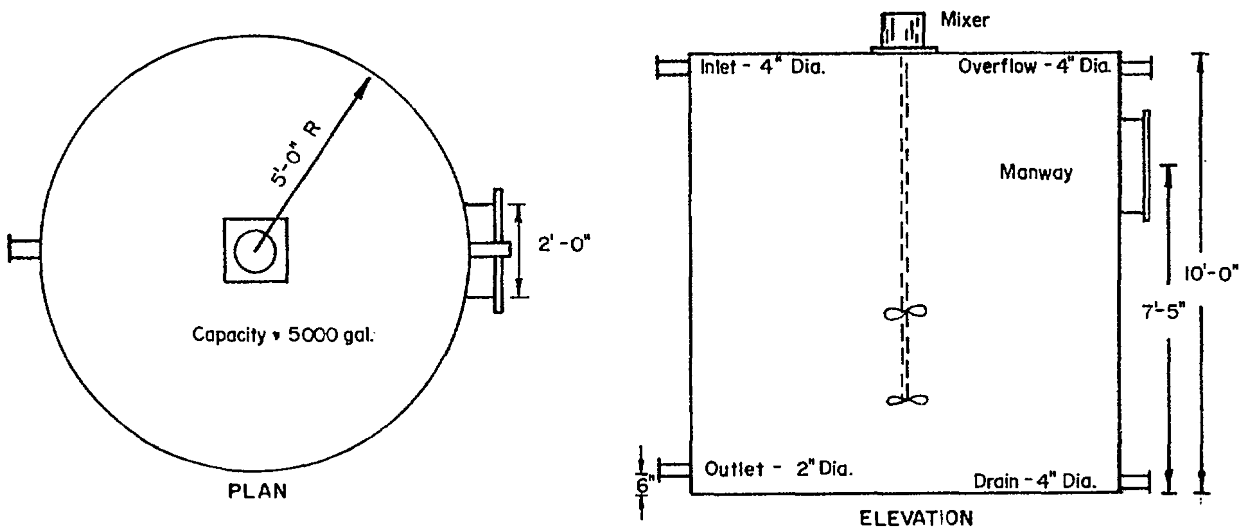


FIGURE 8. Storage Tank

Samples were taken at the influent and effluent ends of the filters and at depths of 0.6 and 1.5 m (2 and 5 ft) below the surface of the filter beds. Headloss measurements across the filters were obtained at depths of 0, 0.6, 1.5, and 2.4 m (0, 2, 5, and 8 ft) below the surface of the filter beds. Upflow backwash of the filters was accomplished by feeding tap water to the bottom of each column. Air scouring was also provided.

Chemical addition to the filter influent was accomplished by utilizing positive displacement pumps. Alum was introduced upstream of the filter feed pumps. Polymer was introduced immediately downstream of the feed pumps.

CARBON ADSORPTION

Three carbon columns were installed at the pilot plant site. Figure 10 shows dimensions of these facilities. The units were sized to accept a portion of the effluent from the flocculation/sedimentation system or the total flow from the dual media filters. The three columns could be arranged in either parallel or series to allow flexibility in testing. Piping following the columns was arranged to allow the effluent to be directed into any of the disinfection bays.

The units were filled with 2.1 m (6.8 ft) of Calgon Filtrasorb 400 granular carbon. This media has an effective size of 0.55 - 0.65 mm, a uniformity coefficient of 1.9 or less, and a bulk density of 400 kg/m^3 (25 lb/ft^3). Backwash facilities were provided by connecting a water line to the bottom of each of the columns.

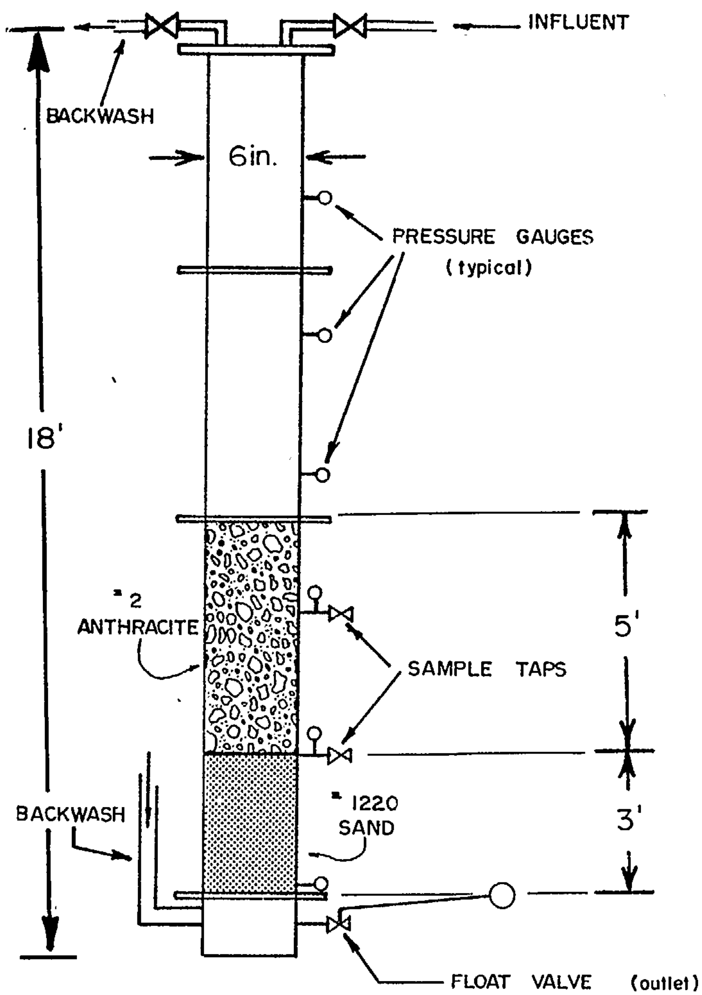


FIGURE 9. Dual-Media High-Rate Filter (Pilot Unit)

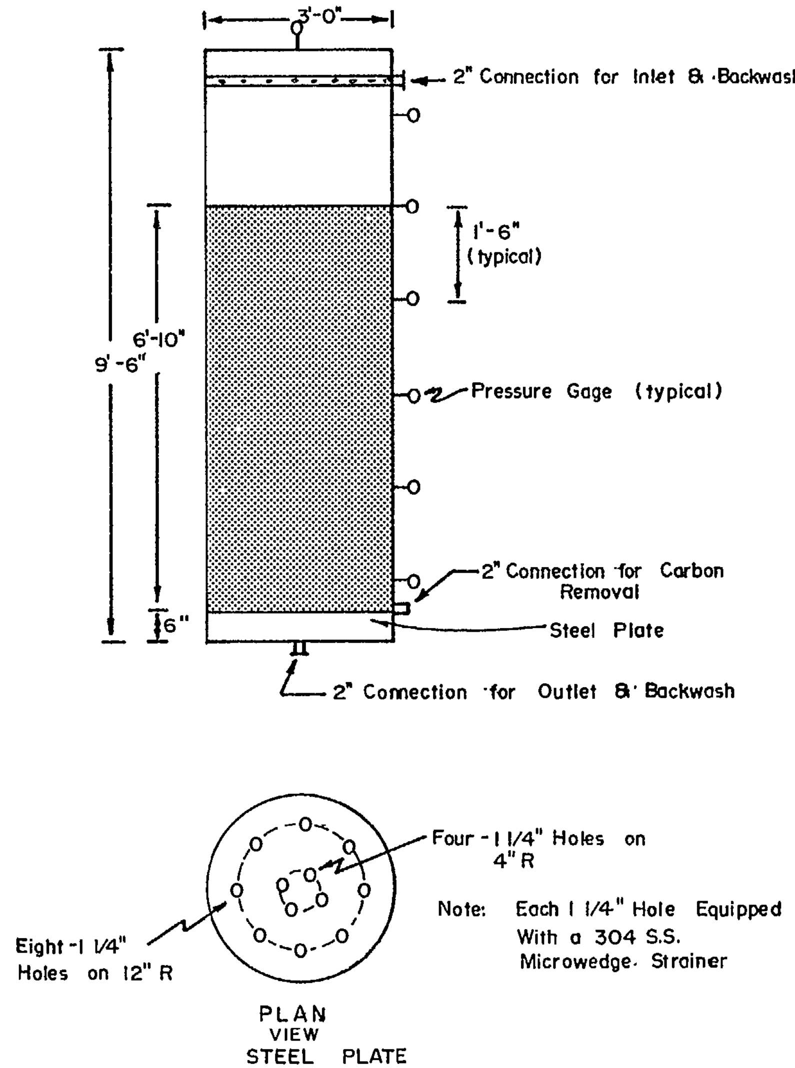


FIGURE 10. Activated Carbon Column (Pilot Unit)

DISINFECTION SYSTEM

Three parallel, high-rate pilot tanks were provided to study disinfection optimization by mixing methods. The mixing techniques included parallel corrugated baffling, sequential flash mixing and single flash mixing at the point of application. These are outlined along with the tank dimensions in Figure 11. Provisions were made to allow each mixing technique to be evaluated in each of the three bays. Flash mixing was furnished by 2.53 kg-cal/min (0.05 hp) mixers equipped with 0.46 m (18 in) shafts and 5 cm (2 in) diameter props. Each mixer delivered a water hp of approximately 0.02. G values were calculated for three components: walls, baffles, and mixers (58). The system G value was defined as $\Sigma GT/\Sigma T$ using the zone of influence for each component. A number of different weir heights were made available for the purpose of evaluating different detention times.

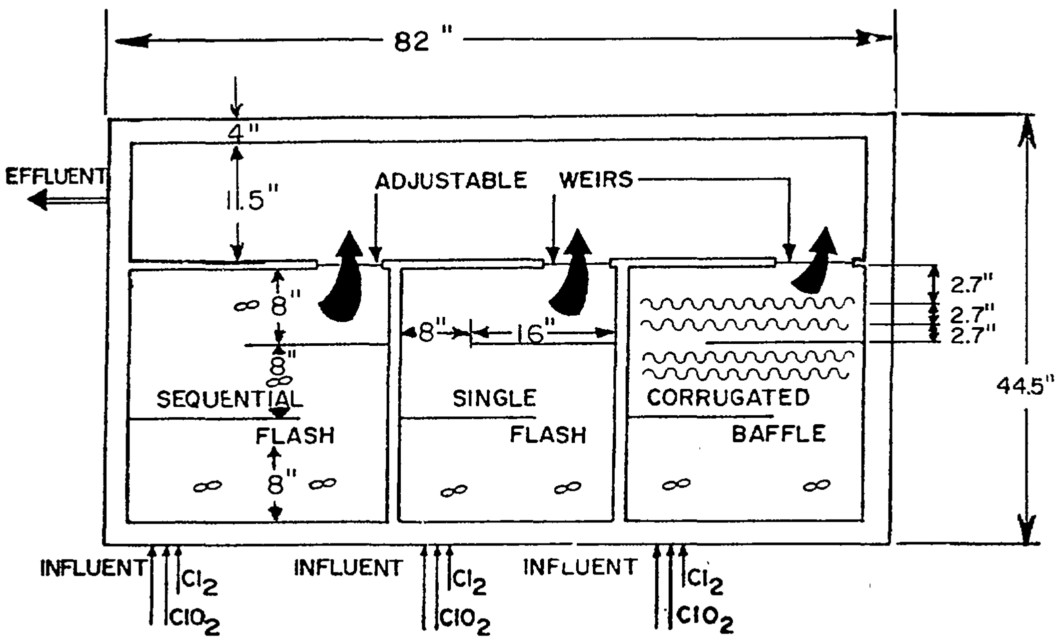


FIGURE 11. Pilot Disinfection Tank and Mixing Concepts Plan View

The disinfectants used were chlorine and chlorine dioxide. Chlorine was supplied in cylinders and chlorinators were used to disperse the chlorine in water prior to dosing. The portion of the chlorine solution applied to the bays was measured manually and samples were withdrawn hourly for determination of solution strength by Iodometric back titration methods (77).

Chlorine dioxide was initially prepared through two chlorine dioxide generators (supplied by Chemical Generators, Inc.). Laboratory testing of chlorine dioxide revealed that low concentrations of the solution would remain relatively stable for a period of 3-4 days if kept in a closed container. This made it possible to manually prepare sufficient quantities of the solution in advance of any disinfection testing. The chlorine dioxide was fed into the bays using pumps having a capacity of 17 ml/min (0.004 gpm). Application rates were measured volumetrically. Strength of the chlorine dioxide solution was determined using Starch-Iodide (77) or DPD titration techniques (50).

SECTION 5

PROJECT PLAN

PROGRAM DEVELOPMENT AND APPLICATION OF RESULTS

The Rochester CSO study program included overflow sampling and monitoring, sewer network modeling, and pilot plant testing of the CSO treatment alternatives. The pilot plant studies were designed to interface with the mathematical modeling for evaluation of abatement alternatives.

The system modeling generally employed the EPA-developed Stormwater Management Model (SWMM). One of the components of this model is a Storage-Treatment block which provides estimates of treatment efficiency for time-variable storm flows for specified process train selections and design conditions.

The test programs and development of performance equations were directed toward evaluating the effects of varying hydraulic loadings and influent quality on the performance of the treatment systems. The effects of chemical treatments are also included, where applicable. The performance models, coupled with cost developments were used to compile cost/benefit comparisons and design optimizations of some of the alternatives. Opportunities for such optimizations generally arise because of the relative infrequent use of the wet-weather treatment facilities. These optimizations may indicate the possibilities of achieving greater economies by employing procedures that may increase the operating cost (e.g. high chemical doses or high energy mixing) by permitting great reductions in sizing of facilities and the capital costs. The operating costs for wet-weather facilities represent a much lower fraction of total yearly costs than the cost for dry-weather plants. These optimizations are highly dependent on site-specific factors such as number of overflows and the total quantity of overflows to be treated per year.

The cost and performance relationships were also used to evaluate a number of area-wide alternatives. These alternatives are presented in Volume I of this report (3). The alternatives included: a) optimizations of storage versus treatment sizing, b) use of local satellite treatment plants versus centralized treatment, c) alternative locations of centralized treatment, and d) use of satellite treatment for first-flush overflows only, with collection of remaining flows.

SCOPE OF WORK

Pilot operations covered nineteen overflow events during the period of September 1975 through June 1976. Storm characteristics associated with these storms are listed in Table 2. The piloted processes included flocculation/sedimentation, swirl degritter and swirl primary separator, microscreening, dual-media high-rate filtration, activated carbon adsorption and high-rate disinfection. While these include some of the major processes generally considered for CSO treatment, there are other alternatives that were not piloted. For example, dissolved air flotation, biological lagoons, and rotating biological discs have been studied by others for application to CSO treatment. It was also not intended to comprehensively evaluate all design parameters associated with each system. The sampling and operation schedules were established to permit evaluations of variable influent quality and the effects of the selected operating conditions. Analyses included evaluations of BOD_5, SS, VSS, total solids, volatile solids, setteable solids, COD, TOC, total inorganic phosphorus, TKN, oil and grease, temperature, metals, and fecal coliforms. All analyses were conducted in accordance with Standard Methods (77) and/or Methods for Chemical Analysis of Water and Wastes (78).

In addition to the pilot plant process operations, a number of support studies were included throughout the program. These included dry weather testing of the unit processes, determination of reaction rates in the ClO_2 generator, determinations of alum and polyelectrolyte dosage requirements, sludge thickening and dewaterability testing, particle size distributions and specific gravities, and analyses of heavy metals content of influents, treated effluents, and sludges.

TABLE 2. STORM CHARACTERISTICS

Storm No.	Date	Rainfall Start Time	Rainfall Duration (hrs.)	Total Rainfall (inches)	Pilot Plant Startup Time	Overflow Duration (hrs.)	Peak Overflow Rate (MGD)
1	09/25/75	1600	6.0		1840	5.25	
2	10/09/75	1345	6.6		1810	2.7	
3	10/17/75	1815	7.2		2100	6.75	
4	11/10/75	0630 1255	4.0 0.7	0.22 0.30	0830 1310	3.0 1.6	7.0 12.1
5	11/21/75	0400	5.8	0.50	0815	3.7	7.0
6	12/06/75	0715	2.5	0.60	0830	2.25	10.6
7A	12/09/75	1130	2.3	0.25	1255	1.1	5.7
7B	12/09/75	2100	9.0		2255	7.5	6.8
8	01/26/76	0400	8.5		0930	14.0	
9	02/18/76	0200	7.0		0730	5.0	
10	02/18/76	2030	2.25	0.15	2115	2.4	30.0
11	02/21/76	1230	4.5		1315	2.0	30.0
12	03/03/76	0315	6.25	0.45	0530	11.75	30.0
13	03/12/76	1400	2.25	0.30	1500	2.0	10.0
14	03/19/76				0920	7.7	10.0
15	03/31/76	1140	3.2	0.60	1215	3.9	50.0
16	04/21/76	1620	2.6	0.50	1615	2.7	50.0
17	05/11/76	1130	4.5	0.25	1335	3.5	12.0
18	05/19/76	1145	13.5	1.51	1250	14.5	30.0
19	06/21/76	1830	2.0		1900	1.8	

SECTION 6

FLOCCULATION/SEDIMENTATION

BACKGROUND

Primary sedimentation of raw municipal wastewater has been applied conventionally at overflow rates (OR) of 24 to 41 m^3/day m^2 (600 to 1000 gpd/ft^2). Typically, suspended solids removal rates of 30 to 60 percent are attained in this process.

The OR is the single most important design criteria for sizing of sedimentation basins (6, 7, 8). Theoretically, depth and detention time have minor influence on determining removal efficiencies for discrete particles. However, for flocculent particles, detention time plays a more important role since settling velocity increases with time of particle agglomeration. In practice, minimum depths and detention times are employed based on experience.

OR is an expression of the upflow hydraulic velocity created in the basin. Particles with settling velocities greater than the upflow velocity will be removed. In combined sewer overflows the particle size distribution is considerably coarser than in typical dry weather flow, since the high scour velocities created in the sewer suspend larger particles. It would be expected, then, that OR's applicable to treatment of CSO might be considerably higher than those applied to dry-weather flow.

The effects of OR on SS removals from municipal wastewater have been evaluated by several investigators. The ASCE Manual of Engineering Practice Number 36 (71) includes a design curve for selecting OR for a desired removal efficiency. This is shown on Figure 18. Smith (72) presented a similar evaluation from analysis of field data and developed the performance function:

$$\text{SS Removal Efficiency (\%)} = 82\ e^{-(OR/2780)}$$

This equation shown on Figure 18 closely approximates the ASCE curve. Both relationships above were basically developed for municipal dry-weather flows.

An analysis of operating data for primary facilities at Los Angeles (9) evaluated OR's as high as 163 m^3/day m^2 (4000 gpd/ft^2). These results indicated that major losses in performance were not experienced until OR was increased beyond about 82 m^3/day m^2 (2000 gpd/ft^2) (see Figure 18). One of the major reasons why such high OR's were attainable might have been the relatively high influent SS concentration (average 500 to 600 mg/l) in the raw wastewater. This might indicate a relatively coarse solids size distribution. This study also indicated that performance was not influenced by flow-through velocities, v, less than 1.2 m/min (4 fpm), but sludge resuspension became significant at levels above 1.2 m/min (4 fpm). Camp (7) has stated that velocities up to 5.5 m/min (18 fpm) may not cause resuspension, however, designs should incorporate velocities substantially under 5.5 m/min (18 fpm). Other tests at Los Angeles (10) showed that velocities above 1.8 m/min (6 fpm) did not hinder removals when alum and polyelectrolyte were employed. The selected velocity influences the configuration of the basin, high velocities being associated with shallow and narrow basins. Below the scour velocity, high velocities tend to enhance velocity gradient flocculation (11).

Data from full-scale primary facilities treating sanitary and wet-weather combined sewage at Toronto, Canada, has also been published (12). These data, covering a range of influent SS from 287 to 627 mg/l, show significant removals at OR's up to 82 m^3/day m^2 (2000 gpd/ft^2). Removals are shown to be related to influent SS concentration, indicating the impact of the coarser particle size distribution associated with the higher SS levels.

OUTLINE OF EXPERIMENTS

A high-rate sedimentation system has been designed for treatment of wet-weather flows from the Rochester Pure Waters District (13). The facility is proposed to consist of four units with a total capacity of 1041 m^3/day (275 mgd). Dimensions of each unit are 117 m (384 ft) x 32.5 m (106.5 ft) x 4.7 m (15.5 ft) deep. Design parameters included maximum OR of 81.6 m^3/day m^2 (2000 gpd/ft^2), detention time of 75 min and flow-through velocity of 1.22 m/min (4.0 ft/min).

The primary sedimentation basin at the pilot plant was intended to evaluate the chemicals necessary to achieve phosphorous removal through the flocculation/sedimentation process. However, due to the detergent ban in New York State, the levels of phosphorous observed in Rochester CSO have generally been less than 1 mg/l as P even under peak conditions. These low levels of phosphorous preclude the need for phosphorous removal as applied to the Rochester CSO.

Alum treatment is incapable of producing phosphorous levels significantly below those observed. Therefore, chemical treatment (alum and/or polymers) was evaluated mainly from the standpoint of enhancement of suspended solids removal. However, a limited amount of testing was included whereby the influent was spiked with phosphate and the alum dosage adjusted for phosphorous removal.

The matrix of tests employed in the program is outlined in Table 3.

The pilot plant tests included evaluations of the effect of OR under four chemical treatment programs. The chemical treatments included: no chemical addition, polyelectrolyte only, alum + polyelectrolyte, and phosphorous spiking accompanied by higher alum and polyeletrolyte doses. Selection of the chemical treatments is discussed in subsequent pages.

TABLE 3. FLOCCULATION/SEDIMENTATION SYSTEM TEST MATRIX

Storm No.	Pilot Flowrate (gpm)	OR (gpd/ft^2)	d.t. (min.)	v (fpm)	P-Spike (mg/l)	Alum (mg/l)	Polymer (mg/l)
1	71	800	38.8	0.8			
2	71	800	38.8	0.8			
3	133	1500	15.7	2.3			
4	124	1407	16.7	2.3			
5	165	1870	15.2	2.2			
6	165	1870	15.2	2.2			
7A	177	2000	14.2	2.2			
7B	162	1830	15.6	2.0			
8	71	800	78.0	0.24			
9	133	1500	42.0	0.45			
10	177	2000	31.0	0.59			
11	71	800	78.0	0.24			1.0
12	133	1500	42.0	0.45			1.0
13	177	2000	31.0	0.59			1.0
14	177	2000	31.0	0.59			
15	71	800	78.0	0.24		40	1.0
16	133	1500	42.0	0.45		40	1.0
17	177	2000	31.0	0.59		40	1.0
18	71	800	78.0	0.24	2.13	105	1.0
19	177	2000	31.0	0.59	0.85	105	1.0

The matrix of tests also included evaluations of OR's of 33, 61 and 82 m^3/day m^2 (800, 1500 and 2000 gpd/ft^2). OR was held constant throughout the duration of each storm to study the system efficiency under variable influent solids concentrations. It was considered necessary to evaluate the performance relative to CSO quality, since some of the area-wide abatement alternatives considered the use of facilities for treatment of the first-flush storm component only.

Sludge withdrawal was not employed with any of the tests. Calculations indicated that sludge accumulation for an average storm of 4 hours duration would result in an accumulation of less than two inches of sludge. The sludge layer was sampled at the termination of each test.

Weir overflow rates (WOR) of 84, 63 and 33 m^3/day m^2 (6800, 5100 and 2700 gpd/ft) of weir were employed at OR's of 33, 61 and 82 m^3/day m^2 (800, 1500 and 200 gpd/ft^2) respectively, which were low enough to prevent exit losses of suspended particles.

The 2.67 kg-cal/min (0.25 hp) agitator employed in the flocculation basin imparted a velocity gradient (G) of approximately 120 sec^{-1}. This resulted in mixing intensities (GT) of 42,000 to 104,000, values typically associated with flocculation systems.

CHEMICAL TREATMENT REQUIREMENTS

In order to select the types and dosages of chemicals to be employed in the pilot tests, a number of laboratory jar tests were conducted using Rochester CSO. A range of polyelectrolyte types were tested in conjunction with an alum dosage of 50 mg/l. Figure 12 indicates the comparison of the performance of several polyacrylamides based on the charged functional groups. These data indicate increasing performance with increasing anionic content of the polyelectrolyte. A highly anionic polyacrylamide (Nalcolyte 676) was selected for use in all testing at the pilot facilities.

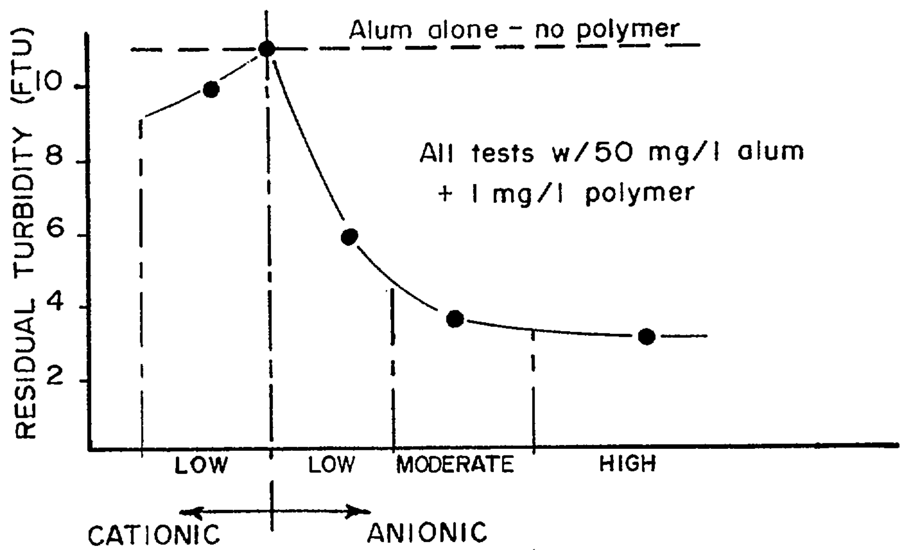


FIGURE 12. Comparison of Polyelectrolyte Types

The same trend was verified when the data of Nebolsine, et al. (14) were evaluated. That report presented the results of filtration of CSO when employing a variety of polyelectrolytes from many suppliers. When compared on the basis of charged functional groups it was again noted that flocculation of CSO responded best to highly anionic polyelectrolytes.

The effect of polyelectrolyte dosage is indicated on Figure 13. A typical dosage of 1.0 mg/l was anticipated to provide optional flocculation, and was verified by this test.

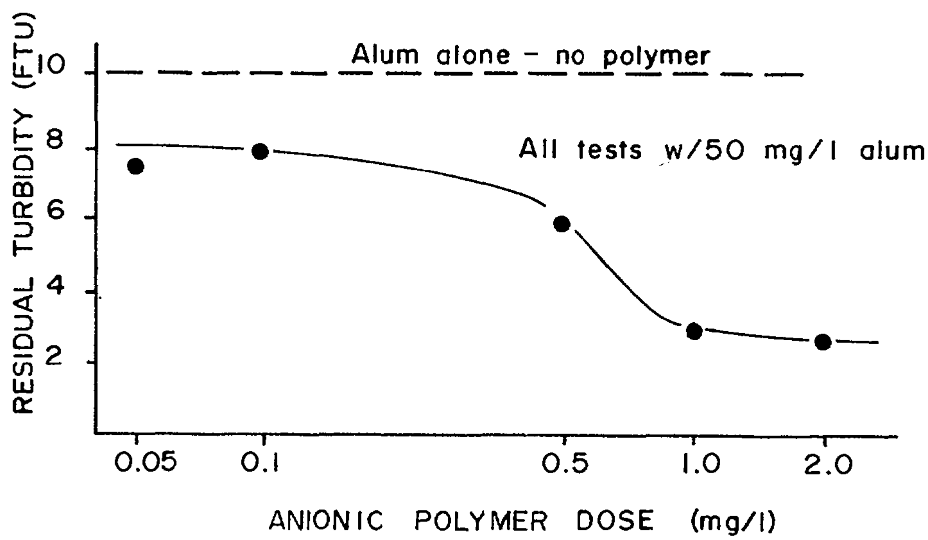


FIGURE 13. Selection of Polyelectrolyte Dosage

Alum dosage requirements were established by testing samples of CSO taken during several intervals throughout a storm. Figure 14 shows test results when several alum doses were tested on each CSO sample. It is noted that for all portions of the storm, optimal results were attained with an alum dosage of approximately 40 mg/l.

SUSPENDED SOLIDS REMOVAL

Appendix B presents the results of the SS analysis of influent and effluent data for the flocculation/sedimentation basin. These plots indicate results as the samples were taken, and are not adjusted for the detention time in the unit. From these curves, influent data were lagged by the theoretical detention time in the treatment unit and SS removal rates were calculated for each 20 minute increment. Multiple regression analysis was then conducted between the SS removal rates, surface overflow rate, and the concentration of influent suspended solids for three chemical treatment conditions. A statistical fit to the pilot plant data was obtained in the form of the following equation:

$$\text{Log } (c_e/c_o) = K_1 + K_2 \log Q + K_3 \log c_o$$

where

c_e/c_o = fraction of SS remaining
Q = flow through the flocculation/sedimentation basin (gpm)
c_o = influent suspended solids concentration in the unit (mg/l)
K_1, K_2, K_3 = regression coefficients representing different chemical treatments

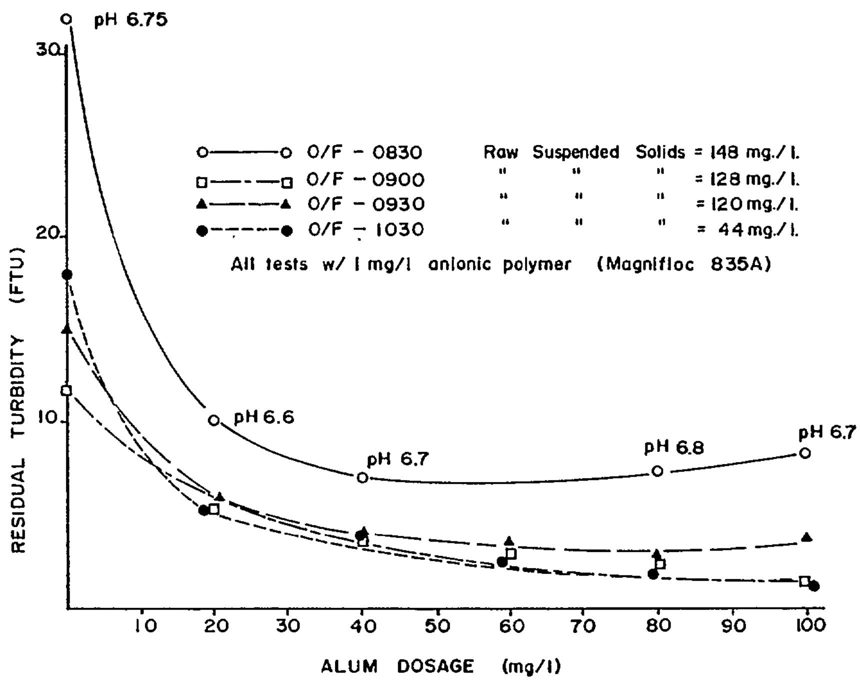


FIGURE 14. Variation in Alum Demand

Results of the regression analyses are indicated in Tables 4, 5, and 6. In all three cases the regression coefficients indicated the following trends: (a) percent removal of SS decreases as the hydraulic loading to the system increases and (b) percent removal of SS increases as the influent SS concentration increases. The magnitude of the regression coefficients associated with hydraulic loadings in all cases indicate a fairly minor effect of applied flowrate within the test range on SS removals; 'T' values (measure of the statistical significance of the regression coefficients) associated with the flowrate data indicate degrees of confidence of > 99, 75 and 55 percent, respectively, for treatments of no chemicals, polymer only and alum plus polymer. The influent concentration of SS has a major effect on the percentage removal of SS; 'T' values associated with the influent SS data in all cases represent degrees of confidence greater than 99 percent.

The performance equations were derived from the regression analysis by providing the conversion OR = Q x 11.3.

For no chemical treatment:

$$\log (c_e/c_o) = 1.71 + 0.072 \log Q - 0.836 \log c_o$$

$$c_e/c_o = 43.4 \, (OR)^{0.072} \, (c_o)^{-0.836}$$

For treatment with anionic polymer:

$$\log (c_e/c_o) = 1.20 + 0.175 \log Q - 0.806 \log c_o$$

$$c_e/c_o = 10.3 \, (OR)^{0.175} \, (c_o)^{-0.806}$$

For treatment with alum plus anionic polymer:

$$\log (c_e/c_o) = 0.765 + 0.193 \log Q - 0.775 \log c_o$$

$$c_e/c_o = 3.63 \, (OR)^{0.193} \, (c_o)^{-0.775}$$

where c_e = effluent SS concentration (mg/l), c_o = influent SS concentration (mg/l), Q = applied pilot plant flowrate (gpm) and OR = overflow rate (gpd/ft^2).

TABLE 4. MULTIPLE REGRESSION ANALYSIS OF FLOCCULATION/SEDIMENTATION DATA: NO CHEMICAL TREATMENT

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log Q	1.07	1.054	-0.131	0.072	0.010	7.08
Log c_o	2.45	0.225	-0.855	-0.836	0.048	-17.4
Dependent						
Log (c_e/c_o)	-0.260	0.173				
Intercept		1.71				
Multiple Correlation		0.934				
Std. Error of Estimate		0.063				

Analysis of Variance for the Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	2	1.23	0.618	154.8
Deviation from Regression	45	0.179	0.0039	
Total	47	1.41		

TABLE 5. MULTIPLE REGRESSION ANALYSIS OF FLOCCULATION/SEDIMENTATION DATA: TREATMENT WITH ANIONIC POLYMER

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log Q	2.16	0.118	0.496	0.175	0.146	1.19
Log c_o	2.42	0.220	-0.908	-0.908	0.078	-10.2
Dependent						
Log (c_e/c_o)	-0.373	0.206				

Intercept	1.20
Multiple Correlation	0.912
Std. Error of Estimate	0.086

Analysis of Variance for the Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	3	1.13	0.566	74.9
Deviation from Regression	30	0.226	0.0075	
Total	32	1.36		

TABLE 6. MULTIPLE REGRESSION ANALYSIS OF FLOCCULATION/SEDIMENTATION DATA: TREATMENT WITH ALUM AND ANIONIC POLYMER

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log Q	2.00	0.172	0.197	0.193	0.244	0.792
Log c_o	2.443	0.253	-0.675	-0.775	0.166	-4.667
Dependent						
Log (c_e/c_o)	-0.741	0.298				

Intercept	0.765
Multiple Correlation	0.684
Std. Error of Estimate	0.225

Analysis of Variance for the Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	2	1.20	0.603	11.8
Deviation from Regression	27	1.37	0.050	
Total	29	2.57		

The regression equations are plotted on Figures 15, 16 and 17. Also plotted on these Figures are the experimental results for the test series at hydraulic loadings of 33, 61 and 82 m^3/day m^2 (800, 1500 and 2000 gpd/ft^2). It is noted that the chemical treatments result in significantly enhanced SS removals at all influent SS concentrations. It is also noted that only minor performance losses are incurred by raising the overflow rates from 33 to 82 m^3/day m^2 (800 to 2000 gpd/ft^2). This indicates that overflow rates greater than 82 m^3/day m^2 (2000 gpd/ft^2) should be evaluated, especially with the chemical treatments. It should be emphasized that the performance equations apply to only OR's up to 82 m^3/day m^2 (2000 gpd/ft^2) and influent SS concentration up to 800 mg/l. Results outside of these ranges should not be extrapolated.

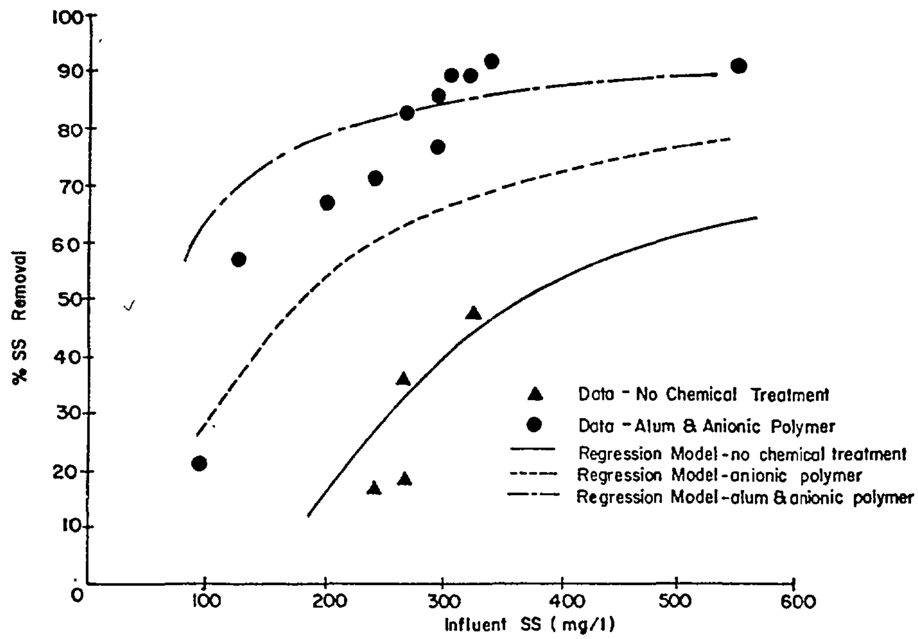


FIGURE 15. Performance of Flocculation-Sedimentation System @ 800 gpd/ft^2

SCALEUP CONSIDERATIONS

Camp (7, 47) has presented a comprehensive consideration of factors involved in scaleup of the design of sedimentation systems. While overflow rate is the most important design parameter, a number of other design factors affect performance, particularly when dealing with flocculent suspensions. For example, flocculation is affected by detention time, differences in particle settling velocities, and velocity gradients in the liquid. Turbulence due to density currents or high velocities can retard settling or result in scour from the bottom. Entrance and exit designs also affect performance. Camp (7) has demonstrated that the degree of short-circuiting in a basin is a function of the Froude number of the horizontal flow. Thus there may be some rationale for the application of Froude Law scaling relationships. However, neither scaleup by

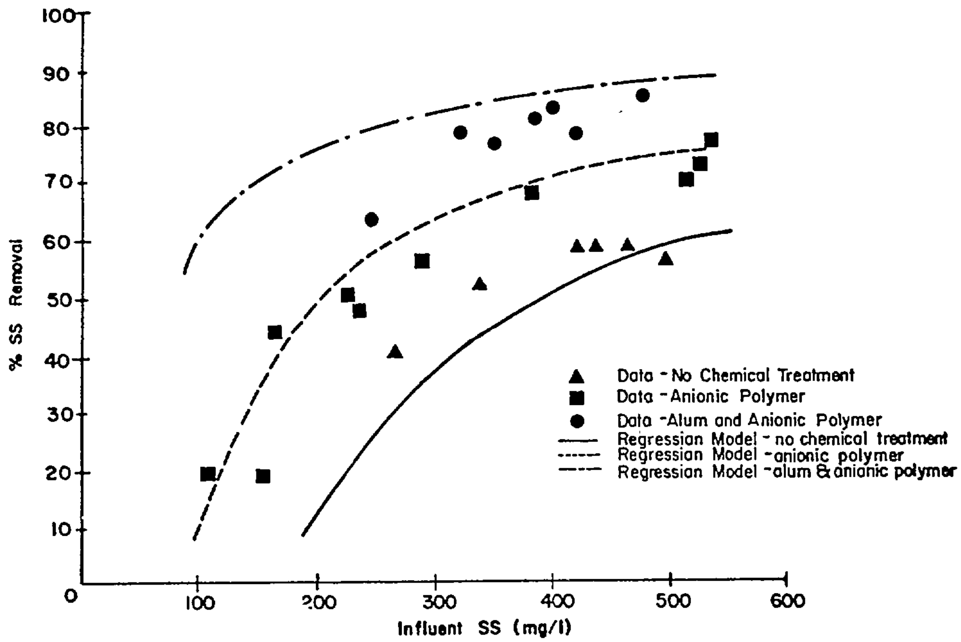


FIGURE 16. Performance of Flocculation/Sedimentation System @ 1500 gpd/ft^2

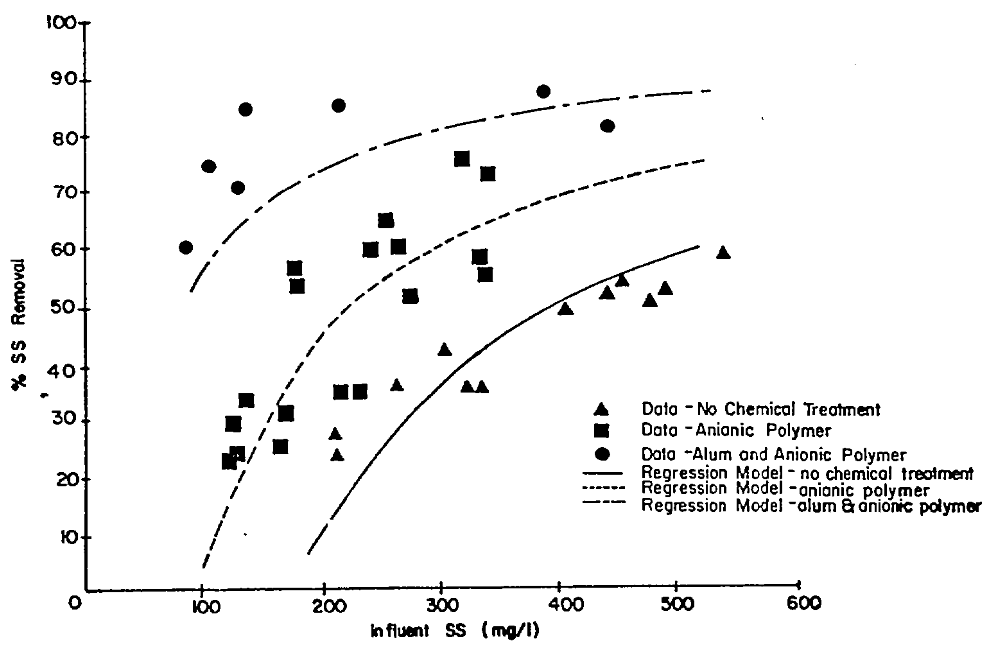


FIGURE 17. Performance of Flocculation/Sedimentation System @ 2000 gpd/ft^2

overflow rate nor Froude Law take into account the effect of detention time on flocculation.

Figure 18 presents a comparison of loading-performance relationships derived from several sources. Some commonly accepted relationships for domestic sewage are illustrated for comparison. Results of treatment of CSO at the Humber plant in Toronto (12) are shown (six primary tanks 34 ft x 327 ft x 10 ft deep). Results were presented for several OR's and for different storm intervals. The influent SS concentrations covered a range from 287 to 627 mg/l. Removals predicted by regression analysis of the Rochester data are presented for the same range of influent SS concentration. All data apply to treatment without chemicals. At the higher loading rates, performance results in Toronto and Rochester were similar, while treatment at the lower loading rates were slightly better for Toronto CSO.

Also indicated on Figure 18 are removals predicted from Rochester CSO particle size analyses (see Section 6). Actual SS removals are in agreement with the removals expected from the calculated particle settling velocities.

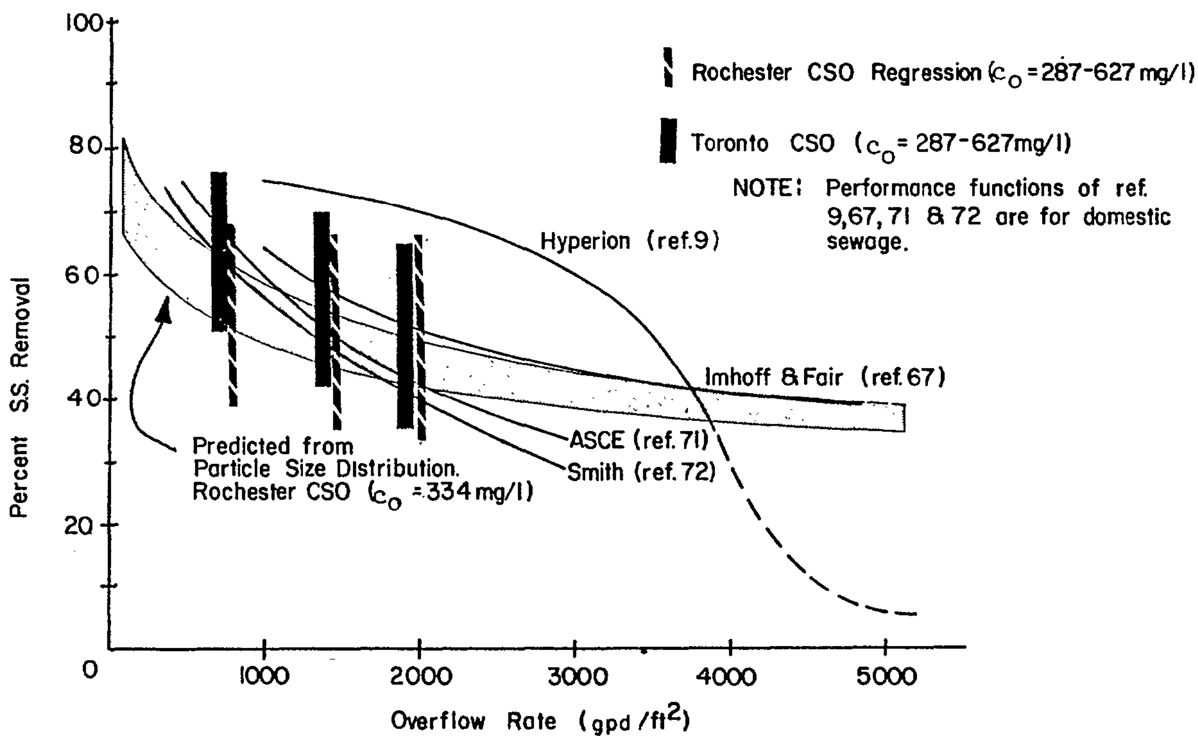


FIGURE 18. Loading-Performance Relationships: Flocculation/Sedimentation System

REMOVAL OF OTHER CONSTITUENTS

Removals of other parameters were evaluated on a storm-average basis. Listings of minimum, maximum, arithmetic means, geometric means and standard deviations of influent and effluent data are included in Appendix B. Table 7 represents the geometric mean or median data for each storm and parameter tested in Rochester, N.Y.

VSS removals were generally higher than the corresponding SS removals. Average VSS removals were 37 percent without chemical treatment, 47 percent with the addition of polymers and 79 percent with alum and polymers. Settleable solids removals were 52, 58 and 94 percent for no chemical treatment, polymer addition, and alum + polymer treatment, respectively.

BOD_5 removals also showed an increase with chemical addition. Median removals were 21 percent for no chemical treatment, 37 percent with polymer addition, and 61 percent for alum + polymer treatment. Average TOC removals were 11, 29 and 47 percent for the above three chemical treatments respectively. Oil and grease removals were 27 percent without chemicals and 35 percent with the addition of alum plus polymer. The effluent pH values ranged from 5.9 to 7.8 without alum, and 5.4 to 7.5 when alum was used.

No appreciable TKN removals were observed in the F/S system under each of the three treatment conditions. TIP removals average 8 percent with no chemical treatment, 11 percent with polymer addition, 71 percent with alum (40 mg/l) and polymer, and 71 percent when phosphorous was spiked (1-2 mg/l as P) and an alum dose of 105 mg/l was used in conjunction with polymer.

Table 8 shows the percent VSS of SS for influent and effluent samples from the F/S system. Mean percentage of VSS in the CSO for all storms was 48.6 and 38.6 percent for effluent samples; 84 percent of the storms showed a decrease in percent VSS for the effluent samples.

TABLE 7. FLOCCULATION/SEDIMENTATION SYSTEM: MEDIAN REMOVALS

Storm No.	SS Data (mg/1) Median Infl.	Median Effl.	% Removal	VSS Data (mg/1) Median Infl.	Median Effl.	% Removal	SETTS Data (mg/1) Median Infl.	Median Effl.	% Removal	BOD_5 Data (mg/1) Median Infl.	Median Effl.	% Removal
1	132.29	236.16	-78.52	24.98	32.00	- 28.10				7.82		
2												
3	137.72	122.49	11.06	58.98	48.43	17.89	2.64	94	64.39	29.63	35.68	- 20.42
4	164.65	194.13	-17.90	92.09	75.11	18.44						
5	71.13	93.98	-32.12	31.44	82.41	-162.12				340.97	500.07	- 46.66
6	87.75	123.36	-40.58	49.84	46.34	5.02	1.83	1.61	12.02	20.58	13.86	32.65
7A	262.38	223.14	14.96	158.19	87.59	44.63	5.36	2.81	47.57	82.47	78.63	4.66
7B	74.42	50.33	32.37	46.44	15.89	65.78	.41	.24	41.46	21.74	19.96	8.19
8	189.12	197.30	- 4.33	105.67	57.51	45.58	2.13	1.04	51.17	71.46	88.58	- 23.96
9	302.58	180.10	40.48	158.54	80.53	49.21	1.71	.15	91.23	30.18	23.38	22.53
10	190.48	229.44	-20.45	83.65	86.46	- 3.36	1.24	.54	56.45	51.32	42.25	17.67
11	171.35	120.88	29.45	85.84	57.99	32.44	1.55	.92	40.65	37.27	25.86	30.61
12	266.01	112.06	57.87	146.04	54.40	62.75	2.52	.81	67.86	77.82	32.52	58.21
13	195.49	119.97	38.63	132.12	70.08	46.96	4.00	1.41	64.75	102.25	79.97	21.79
14	330.72	199.71	39.61	133.59	67.89	49.18	6.73	1.76	73.85	135.12	83.92	37.89
15	449.56	34.67	92.29	162.15	6.65	95.90	7.10	.13	98.17	121.37	30.40	74.95
16	445.37	74.50	83.27	155.25	26.64	82.84	1.40	.26	81.43	48.71	27.73	43.07
17	162.52	50.98	68.63	79.20	17.60	77.78	8.45	.19	97.75	126.26	64.76	48.71
18	151.82	55.60	63.38	74.12	13.40	81.92	5.88	.10	98.30	71.43	19.74	72.36
19	183.59	59.21	67.75	41.05	17.55	57.25	2.24	.10	95.54	35.58	11.24	68.41

(continued)

TABLE 7. (continued)

Storm No.	COD Data (mg/l) Median Infl.	Median Effl.	% Removal	TOC Data (mg/l) Median Infl.	Median Effl.	% Removal	O&G Data (mg/l) Median Infl.	Median Effl.	% Removal	pH Data Median Infl.	Median Effl.
1	7.93	10.23	- 29.00	16.87	20.07	- 18.97	9.34	21.00	-124.84	6.18	6.04
2	28.23	32.74	- 15.98	48.22	42.93	10.97	28.92	9.90	65.77	5.72	5.90
3	97.00			20.45	19.99	2.25	24.19	24.04	.62	5.90	6.02
4											
5		37.65		109.67	94.53	13.81	20.36	6.86	66.31	6.21	6.63
6	25.41	27.95	- 10.00	30.55	29.12	4.68	1.27	1.33	- 4.72	6.80	6.19
7A	54.04	55.53	- 2.76	61.66	60.91	1.22				7.07	7.26
7B	25.42	24.77	2.56	14.15	14.25	- .71				7.02	7.13
8	86.49	155.79	- 80.12	48.31	48.36	- .10				6.51	6.44
9	11.04	12.99	- 17.66	31.39	28.55	9.05				7.17	7.40
10	15.69	24.35	- 55.19	44.01	39.75	9.68				7.16	7.04
11				26.27	16.72	36.35				8.09	7.85
12				30.59	21.44	29.91				6.68	6.76
13				60.46	48.66	19.52	64.17	63.96	.33	7.00	7.00
14				114.47	72.70	36.49	46.67	33.33	28.58	7.63	7.78
15				55.94	30.88	44.80	41.55	8.64	79.21	7.20	7.50
16				47.71	26.87	43.68	27.41	14.07	48.67	7.12	6.99
17				67.29	28.75	57.27	38.48	76.39	- 98.52	6.86	7.09
18				44.90	26.56	40.85	50.87	51.54	- 1.32	6.97	5.41
19				19.16	11.70	38.94	54.39	51.94	4.50	7.61	6.82

(continued)

TABLE 7. (continued)

Storm No.	TKN Data (mg/l) Median Infl.	Median Effl.	% Removal	TIP Data (mg/l) Median Infl.	Median Effl.	% Removal	Aluminum Data (mg/l) Median Infl.	Median Effl.	% Removal
1	.29	.63	-117.24	.10	.12	- 20.00			
2	2.63	3.18	- 20.91	.24	.33	- 37.50			
3	1.10	1.44	- 30.91	.26	.24	7.69			
4									
5	6.20	5.98	3.55	1.49	1.29	13.42	1.67	2.16	- 29.34
6	2.50	2.29	8.40	.55	.55	.00	2.28	2.11	7.46
7A	4.57	5.16	- 12.91	.63	.71	- 12.70	.60	1.45	-141.67
7B	1.22	1.36	- 11.48	.18	.23	- 27.78	.50	.46	8.00
8	3.05	3.85	- 26.23	.42	.84	-100.00	1.09	1.27	- 16.51
9	.77	1.21	- 57.14	.22	.21	4.55	5.67	4.23	25.40
10	.81	1.16	- 43.21	.26	.33	- 26.92	4.76	4.47	6.09
11	2.45	2.67	- 8.98	.29	.31	- 6.90	.61		
12	3.39	3.06	9.73	1.16	1.03	11.21	.75	.33	56.00
13	5.42	5.59	- 3.14	.62	.64	- 3.23	.05		
14	4.12	4.56	- 10.68	.82	.79	3.66	3.06	1.62	47.06
15	4.17	3.98	4.56	.86	.19	77.91	1.26	1.33	- 5.56
16	2.25	2.99	- 32.89	.31	.35	- 12.90	2.94	2.57	12.59
17	3.47	4.87	- 40.35	.56	.21	62.50	1.12	2.93	-161.61
18	2.70	3.71	- 37.41	2.63	.81	69.20	1.77	14.10	-696.61
19	1.33	1.20	9.77	1.05	.29	72.38	6.96	9.85	- 41.52

TABLE 8. PERCENT VSS OF SS-FLOCCULATION/SEDIMENTATION SYSTEM

Storm No.	Inf. SS	Inf. VSS	Inf. % Vol.	Eff. SS	EFF. VSS	Eff. % Vol.
1	132.29	24.98	18.88	236.16	32.00	13.55
2						
3	137.72	58.98	42.83	122.49	48.43	39.54
4	164.65	92.09	55.93	194.13	75.11	38.69
5	71.13	31.44	44.20	93.98	82.41	87.69
6	87.75	49.84	56.80	123.36	47.34	38.38
7A	262.38	158.19	60.29	223.14	87.59	39.25
7B	74.42	46.44	62.40	50.33	15.89	31.57
8	189.12	105.67	55.87	197.30	57.51	29.15
9	302.58	158.54	52.40	180.10	80.53	44.71
10	190.48	83.65	43.92	229.44	86.46	37.68
11	171.45	85.84	50.10	120.88	57.99	47.97
12	266.01	146.04	54.90	112.06	54.40	48.55
13	195.49	132.12	67.58	119.97	70.08	58.41
14	330.72	133.59	40.39	199.71	67.89	33.99
15	449.56	162.15	36.07	34.67	6.65	19.18
16	445.37	155.25	34.86	74.50	26.64	35.76
17	162.52	79.20	48.73	50.98	17.60	34.52
18	151.82	74.12	48.82	55.60	13.40	24.10
19	183.59	41.05	22.36	59.21	17.55	29.64

SECTION 7

SWIRL CONCENTRATORS

BACKGROUND

The swirl concentrator has been developed following demonstration of a vortex regulator by Smisson (15) who noted that the device permitted solids separation in addition to functioning as an overflow regulator. Swirl concentrators achieve removals of suspended solids by rotationally induced forces causing inertial separation in addition to vertical gravity sedimentation during relatively short detention times. Originally developed as a CSO regulator (16, 17) the concept has been refined and extended to selective grit removal (18) and attainment of primary removal efficiencies (12).

Mathematical and hydraulic modeling have been conducted in the studies cited above. These models were developed using synthetic materials simulating the particle size distributions and specific gravities of grit and organics found in domestic sewage and CSO. The models are also being verified by testing in prototype and pilot facilities using actual sanitary wastewater and CSO at Lancaster, PA. (U.S. EPA Grant No. S-802219), Denver, CO. (64), Toronto, Ont. (12), and Syracuse, NY (22). Original development work (12, 16, 17, 18) has presented a series of design curves relating anticipated performance to design capacity and other design parameters.

Structurally, swirl regulators/concentrators, swirl degritters, and swirl primary separators incorporate distinctly different features. Some of these differences are illustrated on Figures 19, 20 and 21. The selected configuration for each application is a result of consideration of hydraulic principles and testing on a variety of physical models. Distinct differences are noted in weir configurations, baffling and floor layouts. The units also differ in design features such as inlet velocities, D_2/D_1 (unit diameter/inlet dimension) ratios, and H_1/D_1 (weir height/inlet dimension) ratios. The swirl regulator and degritter studies have presented results for units with D_2/D_1 ratios of 6, 7.2, 9 and 12. The swirl primary separator study employed a unit with D_2/D_1 ratio of approximately 15.

Performance results in each of the above studies were scaled from model results to predicted prototype results by using Froude Law scaling relationships. Model to prototype conversion used the Froude number

$$N_F = \frac{v^2}{gs}$$

for scaling of unit dimensions, where N_F = Froude number, v = velocity,

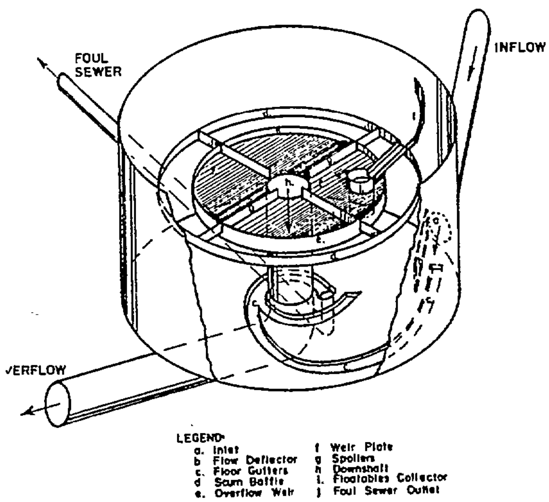


FIGURE 19. Swirl Regulator/ Concentrator

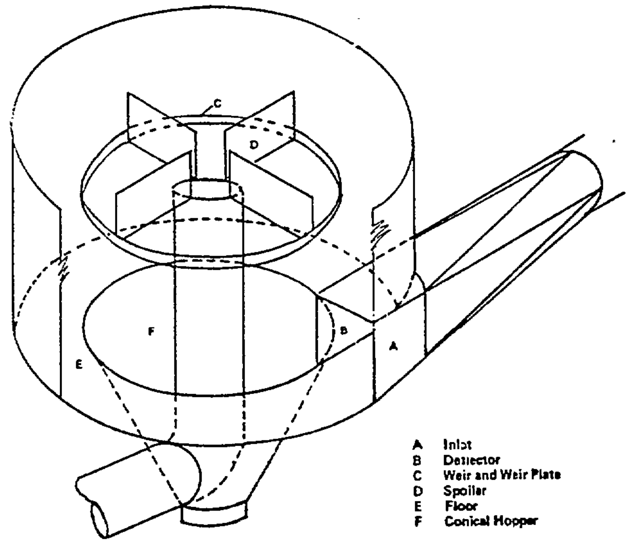


FIGURE 20. Swirl Degritter

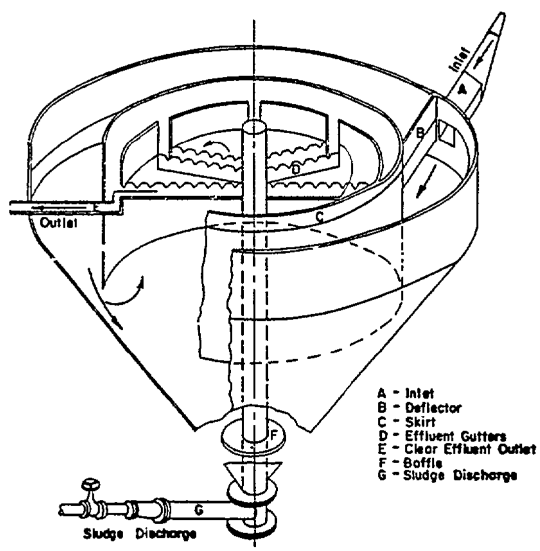


FIGURE 21. Swirl Primary Separator

g = acceleration due to gravity and s = reference length.

Since v = Q/A and area, A, is a function of the square of the inlet diameter D_1

therefore, $N_F = [\frac{Q^2}{D_1^5}]$

Froude number scaling thus employs the relationship:

$$\frac{Q\ \text{model}}{Q\ \text{prototype}} = [\frac{D_1\ \text{model}}{D_1\ \text{prototype}}]^{5/2}$$

for scaling of hydraulic flows. Geometric similarity must be maintained between model and prototype. In addition, foul fraction (percent of flow which is wasted) must be the same in prototype as in the model.

In a similar manner, particle settling velocities were also scaled in the above studies using Froude Law relationships. Since

$$N_F = f\ (\frac{v^2}{s})$$

scaling of settling velocities employs the relationship

$$\frac{v^2\ \text{prototype}}{v^2\ \text{model}} = \frac{D_2\ \text{prototype}}{D_2\ \text{model}} = \lambda$$

where λ = scale factor.

Since settling velocity is dependent on particle diameter and specific gravity, the above studies employed synthetic materials to represent settling velocities in the model studies. These represented scaled-down settling velocities from prototype scale for expected particle size distributions and specific gravities. The regulator studies used gilsonite and polythene, the degritter studies used sand, gilsonite and pumice, and the primary separator studies used petrothene and IRA-93 anion exchange resin to simulate, respectively, solids in CSO, grit in domestic sewage, and organics in domestic sewage.

The swirl regulator and the degritter studies reported effects of varying the H_1/D_1 ratio. Although results showed some impact on the performance within the range tested, the effect was minor in comparison to other design parameters. Selection of other unit dimensions is in conformity with maintaining geometric similarity between model and prototype.

The early work of Smisson on regulators/concentrators employed foul fractions of 30 percent using a vortex device. Later studies (12, 16, 17, 18) demonstrated removals using foul fractions in the range of 2 to 3 percent. The regulator study (16) presented results indicating that removal efficiency improved as foul fraction was increased from 3 to 30 percent. Foul fractions employed in the Rochester work are discussed in the subsections below.

OUTLINE OF EXPERIMENTS

Testing of the swirl degritter and primary separator was directed toward evaluating the effects of hydraulic loading and variable influent quality on removal efficiencies when treating Rochester CSO.

A matrix of tests was established whereby the swirl degritter and primary separator units were evaluated at five flowrates from 0.95 to 4.4 l/s (15 to 70 gpm) without chemical treatment. Flowrate was held constant throughout the duration of each storm to observe the system efficiency under variable influent solids concentrations.

Several of these tests were repeated in the program employing chemical treatments (polymer alone and alum plus polymer with and without phosphorous spiking). Selection of chemicals and dosages is described in Section 5.

Table 9 lists the matrix of tests conducted for the swirl degritter and primary separator units. Also shown on this Table is the foul percentage employed during each test. Grit withdrawal from the swirl degritter was conducted intermittently at 20 minute intervals. Sludge withdrawal for the swirl primary separator was carried out on both an intermittent and continuous basis. For intermittent withdrawal, the sludge was extracted at 20 minute intervals. Continuous sludge withdrawal was conducted utilizing hydraulic pressure differentials which forced the sludge through a 2.54 cm (1 in) line at rates ranging up to 0.3 l/s (5 gpm).

TABLE 9. SWIRL DEGRITTER AND PRIMARY SEPARATOR TEST MATRIX

Storm No.	Flowrate (gpm)	Foul Percentage Degritter	Foul Percentage P/S*	P/S* Chemical Addition P (mg/l)	P/S* Chemical Addition Alum (mg/l)	P/S* Chemical Addition Polymer (mg/l)
1	30					
2	30					
3	40					
4	50	0.26	0.53			
5	30	0.46	0.92			
6	30	0.44	0.88			
7A	30	0.33	0.67			
7B	50	0.26	0.53			
8	30	0.47	0.87			1.0
9	50	0.30	0.44			1.0
10	50	0.39	0.48			1.0
11	40	0.58	0.63		40	1.0
12	50	0.52	0.46		40	1.0
13	30	0.73	0.90	1.55	105	1.0
14	50	0.72	0.52			
15	40	1.12	1.26	1.37	105	1.0

(continued)

TABLE 9. (continued)

Storm No.	Flowrate (gpm)	Foul Percentage Degritter	P/S*	P/S Chemical Addition P (mg/l)	Alum (mg/l)	Polymer (mg/l)
16	50	0.22	2.4**	1.37	105	1.0
17	70	0.34	2.7**			
18	15	0.43	9.6**			
19	50				40	1.0

* P/S - Swirl primary separator ** - Sludge continuously drawn

Scaling of hydraulic flows from model to prototype uses Froude Law relationships as discussed earlier. The inlet pipe diameters, (D_1), for the degritter and primary separator swirl units were 15 and 10 cm. (6 and 4 in), respectively. The unit diameters, (D_2), were 0.91 and 1.83 m (3 and 6 ft), respectively. Thus the D_2/D_1 ratios employed in these designs were 6 and 18, respectively. Table 10 shows the flowrates tested in the pilot plant and indicates the Froude number and flowrate for a 11 m (36 ft) diameter prototype unit, corresponding to each model flowrate. This Table also indicates the detention time in the model at each flowrate.

TABLE 10. SWIRL DEGRITTER AND PRIMARY SEPARATOR: MODEL AND PROTOTYPE FLOWRATES

Model Flowrate (gpm)	(mgd)	D.T. in Model (min)	Influent Froude Number	Prototype Flowrate (mgd)	D.T. in Prototype (min)
Swirl Degritter					
3 ft dia model				6 ft dia prototype	
15	0.022	4.7	0.0018	0.12	7.8
30	0.043	2.4	0.0072	0.24	3.9
40	0.058	1.8	0.0128	0.33	2.8
50	0.072	1.4	0.0200	0.41	2.3
70	0.101	1.0	0.0392	0.57	1.6
Swirl Primary Separator					
6 ft dia model				36 ft dia prototype	
15	0.022	41.3	0.0137	1.9	105.3
30	0.043	20.7	0.0547	3.8	52.6
40	0.058	15.5	0.0972	5.1	39.2
50	0.072	12.4	0.1518	6.3	31.8
70	0.101	8.8	0.2977	8.9	22.5

Particle size distributions for Rochester CSO were measured for several samples following storms 14, 15 and 17. These samples included composites of influent CSO for the first and second half of each storm and full-storm composites of effluents from the swirl degritter and swirl primary systems.

Particle size distributions were determined by passing wet samples across individual screens ranging in size from 74 to 1000 microns. SS determinations were conducted before and after screening. A small sample volume was applied per surface area of screen to prevent matte formation. The sample was initially deflocculated by adding 10 mg/l of detergent. Results of the screen analysis are presented in Table 11. Results of the influent CSO analyses are plotted on Figure 22 as a log-probability plot of percent finer versus particle size. Figure 22 also shows CSO particle size distributions presented in the APWA studies (18,64)for samples from Lancaster, PA, and San Francisco, CA. It is noted the the Rochester samples exhibited size distributions slightly finer than the other locations.

TABLE 11. PARTICLE SIZE DISTRIBUTIONS*

Size Range (microns)	Storm No.	CSO 1st Half	CSO 2nd Half	Swirl Degritter Effl. Compos.	Swirl Primary Separator Effl. Compos.
>1000	14	0	54	]	]
841-1000		27	0		
595-841		1	0	16	0
420-595		6	8	]	]
180-420		6	10	2	0
149-180		0	8	2	22
74-149		74	18	54	8
<74		280	192	208	148
		394	290	282	178
>1000	15	0	10	]	]
841-1000		30	10		8
595-841		20	10	0	
420-595		50	0	]	]
180-420		10	5	20	20
149-180		30	5	16	0
74-149		60	70	40	0
<74		480	150	254	68
		680	260	330	96
>1000	17	36	0	]	]
841-1000		10	2		
595-841		20	5	41	0
420-595		10	0	]	]
180-420		30	14	14	4
149-180		0	2	0	8
74-149		20	15	5	4
<74		170	48	135	80
		296	86	195	96

* Results as SS (mg/l)

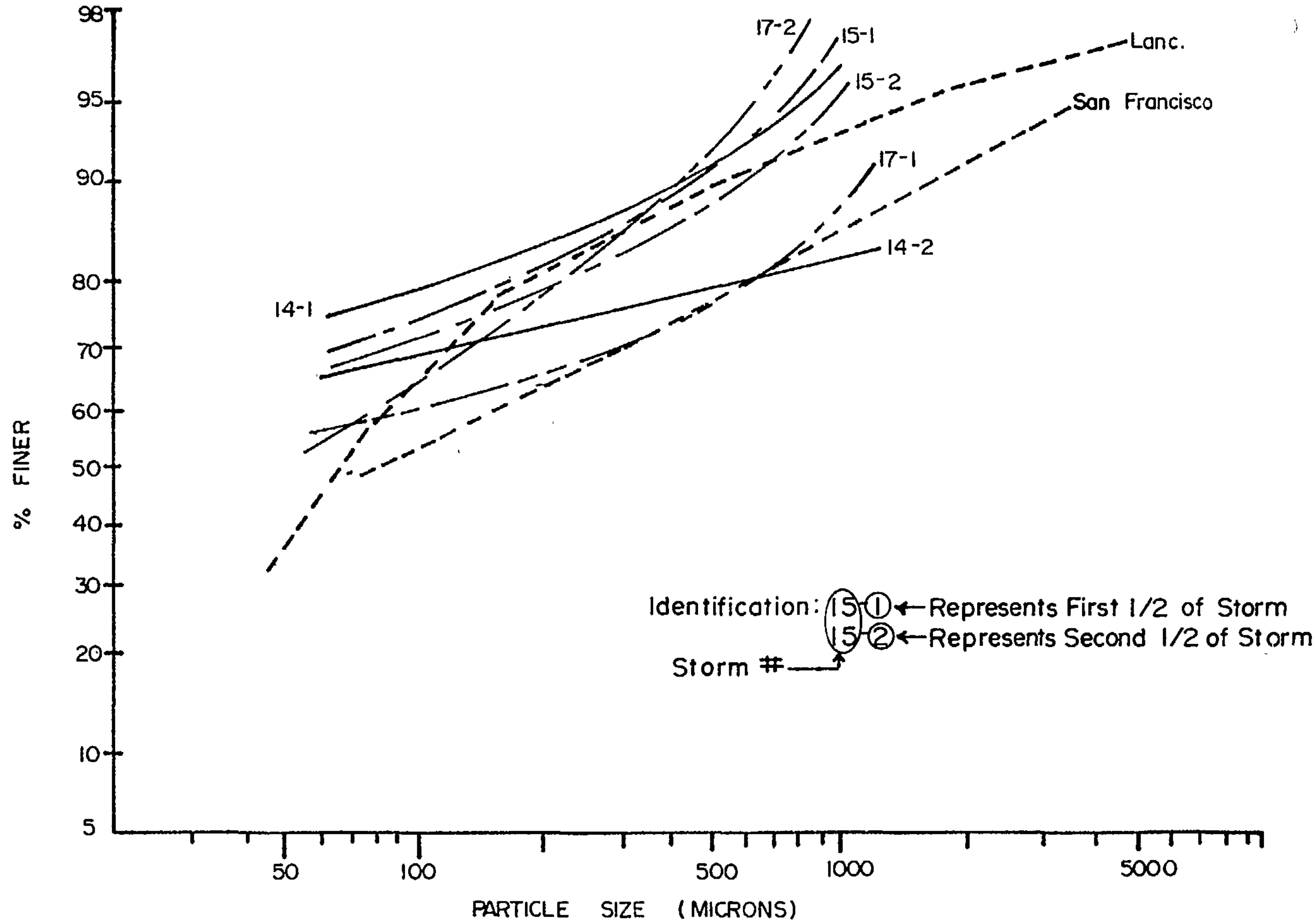


FIGURE 22. Combined Sewer Overflow Particle Size Distributions.

Specific gravity of dried sludge solids was determined following Storm No. 14 for a composite of swirl degritter and swirl primary separator sludges. The specific gravity of the combined grit and organic solids was determined as 1.70.

SWIRL DEGRITTER

Denver (64) and LaSalle (18) swirl degritter performance studies were conducted on a 1.83m (6 ft) diameter prototype unit and a 0.9m (3 ft) diameter pilot scale unit, respectively. Both studies concluded that the swirl degritter could be effectively used to remove grit solids from all wastewater flows at application rates higher than those employed in conventional aerated grit chambers.

The LaSalle study (18) was conducted to determine a design procedure for the removal of grit solids using the swirl concentrator concept. The pilot scale model consisted of a 0.9m (36 in) diameter separation chamber with a height of 1.02m (40 in). The influent pipe diameter was varied to test the model at different operating conditions. Simulated materials such as Gilsonite, pumice and fine sand were used to simulate grit material found in combined sewage. The model was scaled up to a prototype unit by using Froude Law relationships for both mass flow and particle settling velocity.

The Denver (64) study was essentially an extension of the LaSalle study (18), but conducted on a prototype scale using real sewage. The performance of this unit was also compared to the efficiency of a conventional aerated grit chamber (AGC). The swirl degritter unit consisted of a 1.83m (6 ft) diameter separation chamber with a 30.4 cm (1 ft) diameter influent pipe. The grit was defined as that component having a diameter greater than 0.20 mm and a specific gravity greater than 2.65. Chasick samplers were installed at the influent and effluent ends of the swirl degritter to measure grit greater than 0.2 mm in size.

The LaSalle report (18) calculated the grit removal efficiencies of various grit chamber diameters at different scaled-up flowrates. This report also presented a design curve for 80 to 95 percent range of grit removal efficiencies of the swirl degritter.

In the Denver (64) study, two series of tests were conducted. In the first series, only real sewage was applied to the swirl degritter, whereas in the second series of tests, dry blasting sand, size 0.25 mm, was added to the sewage after it was pumped from the influent channel. Grit removal was measured as the weight of dry grit recovered and the weight of grit ash recovered. The percentage removal of grit ash in the swirl degritter ranged from 68 to 84 percent during the first series of tests. The grit removals in the second series of tests were higher and uniform for the lower applied flows. However, the removals at the higher flow rates (2.0 and 3.0 mgd) were erratic and at times indicated negative removals.

Grit Definition

Grit is generally defined as particles greater than or equal to 0.2 mm with a specific gravity of 2.65, thus possessing a settling velocity of 2.6 cm/sec (0.085 ft/sec) or greater. The specific gravity of CSO solids measured for Storm No. 14 was 1.70. Therefore, particles of 0.3 mm size or above would have a settling velocity of 2.6 cm/sec (0.085 ft/sec) or greater. For the particle size distributions measured during Storm numbers 14, 15 and 17, the percentage of solids with particle size greater than 0.3 mm was calculated. These are shown in Table 12.

TABLE 12. GRIT SOLIDS DISTRIBUTION

Storm	Duration	Wt. % of Particles > 0.3 mm
14	1st half	8.6
14	2nd half	22.0
15	1st half	14.7
15	2nd half	11.5
17	1st half	25.7
17	2nd half	8.1

The percentage of particles greater than 0.3 mm has been defined here as the percentage of grit in the influent CSO. It was attempted to correlate percentage of grit with the influent SS level, but no strong correlation was observed. Therefore, the arithmetic mean value of grit in the influent CSO has been used as a measure of the concentration of grit in untreated CSO.

Prototype Swirl Degritter Performance

The particle size distributions tested in the model translate to a different size distribution when scaled to prototype. Figure 23 shows the mean particle size distribution of the influent to the swirl degritter for three overflow events.

Particle settling velocities are scaled from model to prototype by multiplying by the square root of the scale factor λ. A new particle size distribution is thus obtained for the prototype by entering a chart of settling velocity versus particle size and specific gravity such as those found in the APWA reports (18, 64). The results of these calculations are presented on Table 13 for the particle size distributions measured in the Rochester work. The 1.8 m (6 ft) diameter prototype size distributions are shown on Figure 23. It is noted that the particle size distribution for the prototype swirl degritter does not differ greatly from that of the pilot scale model. Therefore, the prototype swirl degritter performance equations have been developed by assuming the same particle size distribution as was observed in the pilot scale unit.

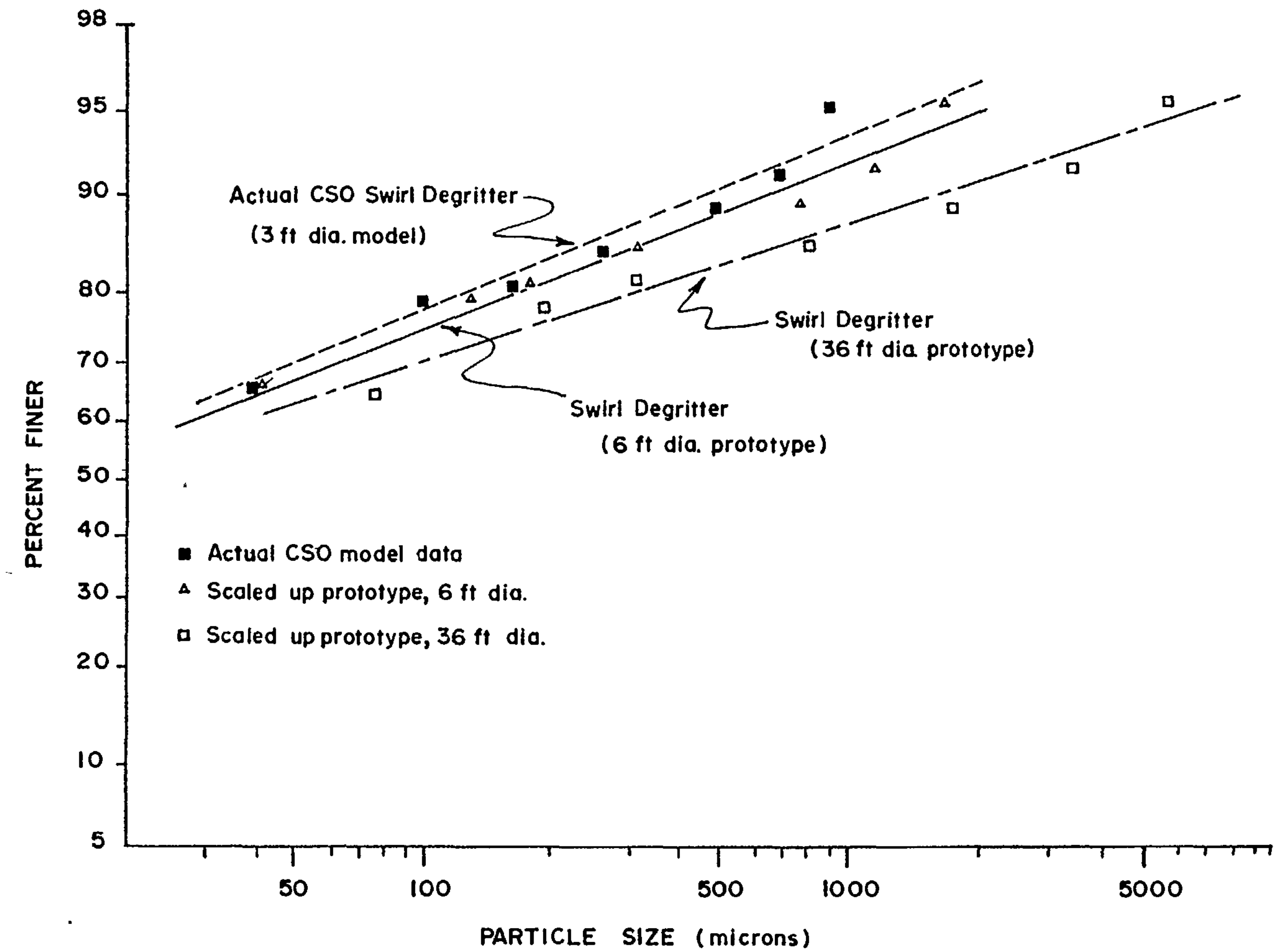


FIGURE 23. Swirl Degritter Model and Prototype Particle Size Distributions

TABLE 13. SWIRL DEGRITTER MODEL TO PROTOTYPE SCALING OF PARTICLE SIZES; S.G. = 1.70

Model Size Range (microns)	Assumed Model Size (mm)	Ave. Infl. Distrib. (%)	Settling Velocity (cm/sec) Model	Settling Velocity (cm/sec) Proto.	Prototype Size (mm)
Model dia. = 3 ft, Prototype dia. = 6 ft, $\lambda = 2$					
>1000	1.4	5.0	9.0	12.7	2.8
841-1000	0.92	3.9	7.0	9.9	1.7
595-841	0.71	2.8	5.8	8.2	1.1
420-595	0.50	3.7	4.2	5.9	0.75
180-420	0.27	3.7	2.0	2.8	0.31
149-180	0.16	2.2	0.8	1.1	0.18
74-149	0.10	12.8	0.4	0.6	0.13
<74	0.04	65.8	0.07	0.1	0.04

Results and Performance

In the Rochester CSO analysis, it has been assumed that changes in particle settling velocity distributions are reflected in the influent grit solids concentration. That is, conditions such as high sewer velocities which tend to scour heavier particles also result in higher influent grit solids concentrations. Performance of the degritting unit was thus related to influent grit solids concentration levels and the flow through the swirl degritter. Influent and effluent SS results across the swirl degritter are plotted in Appendix A. The pilot scale model was scaled from a 0.91 m (3 ft) diameter unit to a 1.83 m (6 ft) diameter unit to compare performance with the data obtained from the LaSalle and Denver studies.

Multiple regression analysis was conducted to statistically fit an equation to the pilot plant data. The following equation was obtained from the analysis:

$$g_e/g_o = k_1 + K_2 \text{ Log } Q + K_3 \text{ Log } c_o$$

where g_e/g_o = Fraction of grit remaining
Q = Flow through the swirl degritter (gpm)
c_o = Influent suspended solids concentration in the unit (mg/l)
K_1, K_2, K_3 = Regression coefficients

It was assumed that grit loading to the unit varied with the measured influent SS concentration and that grit solids represented approximately 15 percent of the influent SS concentration (Table 12).

The developed regression coefficients of flow and influent SS indicated that the performance decreases with increase in flow through the swirl degritter and increases with increasing concentration of SS. The results obtained from the above regression analysis are shown in Table 14. The 'T' Values associated with the flow and influent SS represent degrees of confidence above 70 percent and 99 percent, respectively. The 'F' value gives an indication of the statistical significance of the regression expression. In the above analysis, the 'F' value represents a degree of confidence greater than 99 percent. The final regression equation obtained for the 3 ft diameter pilot system is as follows:

$$g_e/g_o = 1.36 + 0.217 \log Q - 0.653 \log c_o$$

Results of the regression analysis are indicated on Figure 24 after scaling flowrates to a 1.8 m (6 ft) diameter prototype. Figure 24 indicates that performance is affected not only by hydraulic loading but also by influent grit concentrations. The dotted line on Figure 24 indicates anticipated grit removals for the median concentration of solids in CSO at the Rochester pilot plant location.

TABLE 14. REGRESSION ANALYSIS OF PILOT PLANT SWIRL DEGRITTER DATA

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log Q	1.57	.161	.142	.217	.198	1.09
Log c_o	2.28	.261	-.400	-.653	.122	-5.32
Dependent						
g_e/g_o	.215	.440				
Intercept			1.36			
Multiple Correlation			.408			
Std. Error of Estimate			.404			

Analysis of Variance for the Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	2	5.26	2.63	16.1
Deviation from Regression	161	26.3	.163	
Total	163	31.5		

Study Comparisons

Figure 24 indicates results of the swirl degritter studies at LaSalle and Denver, both for a 1.8 m (6 ft) diameter unit. The LaSalle design curve is based on hydraulic modeling using sand, gilsonite and pumice. The Denver results express removals for grit in domestic sewage and also include some tests with sand added to domestic sewage. It is noted that the Denver data indicate grit removals significantly lower than removals predicted by the LaSalle modeling. The Rochester CSO data illustrate a trend

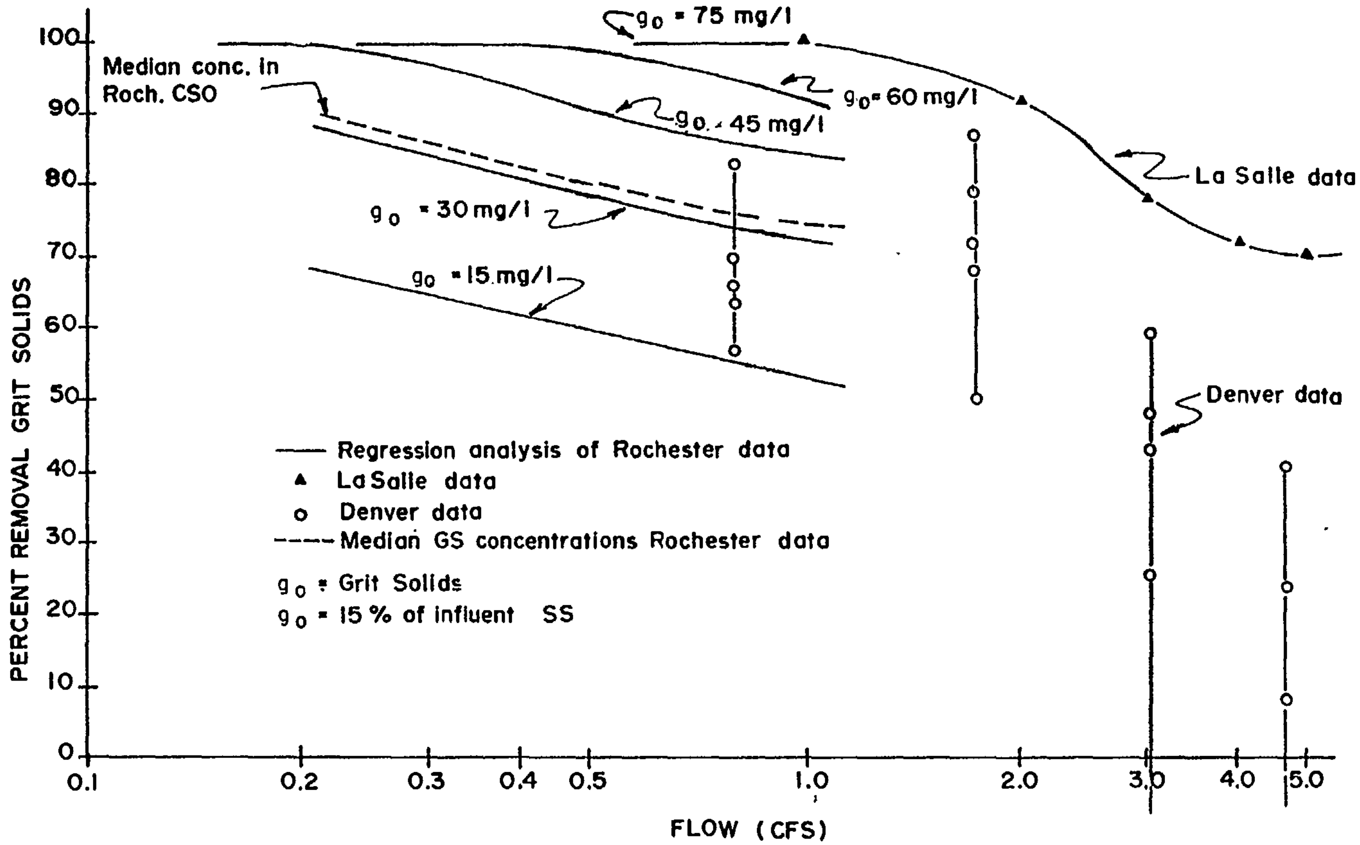


FIGURE 24. Performance of Swirl Degritter (6 ft dia. unit)

more consistent with the Denver data than that indicated by the LaSalle model.

SWIRL PRIMARY SEPARATOR

Primary treatment of CSO and municipal wastewater by the swirl primary separator principle was developed in a series of hydraulic (using synthetic sewage) and mathematical model studies (12). The developed design configuration was then tested on a pilot installation in Toronto, Canada. The purpose of the Toronto study was to verify the design when treating municipal wastewater.

The hydraulic and mathematical model studies developed a series of design curves for different size units. This study was conducted on a 0.9m (3 ft) diameter unit and was scaled to prototype sizes using Froude Law relationships. The Toronto pilot study was conducted on a 3.7 m (12 ft) diameter unit. The Toronto tests were carried out at flow rates of 1,137 m^3/day (0.3 mgd) and 1,700 m^3/day (0.45 mgd). Figure 26 shows a comparison of the predicted performance by the LaSalle design curves and the arithmetic mean of the SS removal results obtained at Toronto.

Pilot Plant Results

Data from operation of the 1.8 m (6 ft) diameter swirl primary separator at Rochester are indicated in Appendix A. These curves represent analyses corresponding to actual sampling times. Removal rates were calculated after lagging the effluent analyses by the theoretical detention time in the unit. Hydraulic loading to the unit was held constant for each storm. For each storm it was noted that SS removal rates fluctuated as a function of the influent SS concentration (c_o). It was furthermore noted that an approximately straight line relationship was developed for each storm when log (c_e/c_o) was plotted versus log c_o. Since the suspended solids concentration in CSO fluctuates in response to scouring velocities in the sewer line, c_o was viewed as a gross indicator of the particle settling velocity distribution. Thus, wastewaters during the first-flush, when c_o is highest, tend to have a greater proportion of solids of larger size and specific gravity.

The SS removal rate is also a function of hydraulic loading to the unit. In order to account for both influences, the pilot plant data were statistically fit using a multiple regression analysis to an equation of the form:

$$\log (c_e/c_o) = K_1 + K_2 \log Q + K_3 \log c_o$$

where Q = hydraulic flow applied to the unit and K_1, K_2 and K_3 are regression coefficients.

Results of the regression analysis are shown on Table 15. The signs associated with the regression coefficients indicate that SS removals generally increased with an increase in c_o and a decrease in Q. 'T' values associated with Q and c_o indicated degrees of confidence of >99 percent for the overall expression.

TABLE 15. REGRESSION ANALYSIS OF PILOT PLANT SWIRL PRIMARY SEPARATOR DATA

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log Q	1.52	.236	.351	.447	.129	3.46
Log c_o	2.17	.279	-.215	-.239	.109	-2.18
Dependent						
Log c_e/c_o	-2.46	.297				
Intercept			-.409			
Multiple Correlation			.416			
Std. Error of Estimate			.273			

Analysis of Variance for the Regression

Souce of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	2	1.22	.613	8.20
Deviation from Regression	78	5.83	.074	
Total	80	7.06		

The final regression equation was thus obtained as

$$c_e/c_o = 0.389\ Q^{.447}\ c_o^{-0.239}$$

The trends indicated by the regression equation are shown on Figure 25. Using this model it is possible to predict the performance of the swirl primary separator for simultaneously varying flows and influent quality such as that which occurs during an overflow event. It should be emphasized that the above equation was developed for a 0.9 m (3 ft) diameter model tested up to the flowrate of 4.4 l/s (70 gpm) and influent SS concentrations range of 100 to 800 mg/l.

On Figure 26 the Rochester regression model is compared to performance predicted by the LaSalle design curves. It is noted that for a range of c_o between 100 to 500 mg/l, the Rochester data generally support the LaSalle curve, except at the lower flowrates. It is recognized, however, that the LaSalle curves were developed for a material synthesizing the settling velocity distribution of municipal sewage while the Rochester work used actual CSO. Figure 26 also shows a comparison of results of the Toronto study (12) with the design predictions from the LaSalle study (12).

All of the analyses above used only the data from runs in which no chemical treatment was employed. In general, it was observed that chemical treatments (anionic polymer alone or alum plus anionic polymer) produced no significant improvement beyond that observed without chemicals. It is speculated that the mode of chemical addition was responsible for the lack of improvement. Because of inadequate velocity gradients and/or contact time, in-line mixing of chemicals may not have provided efficient floc development. It cannot be stated that the swirl primary separator is ineffective for separation of chemical floc.

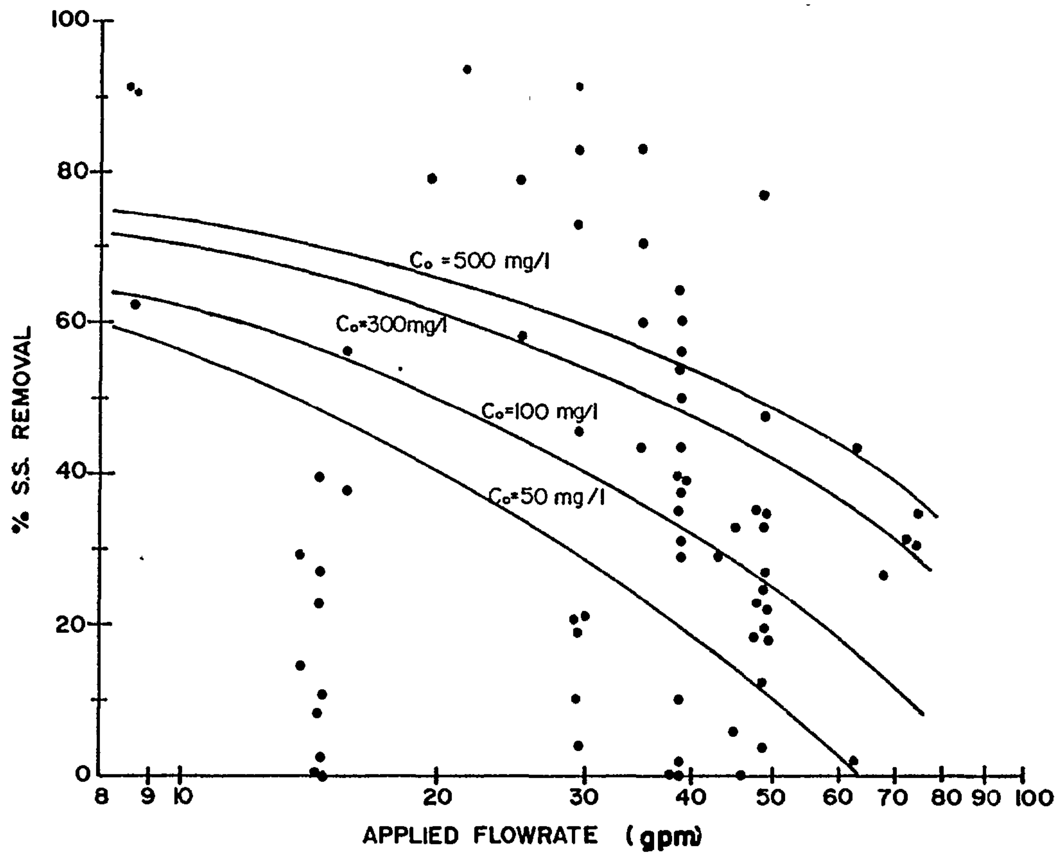


FIGURE 25. Swirl Primary Separator Regression Model and Performance Data

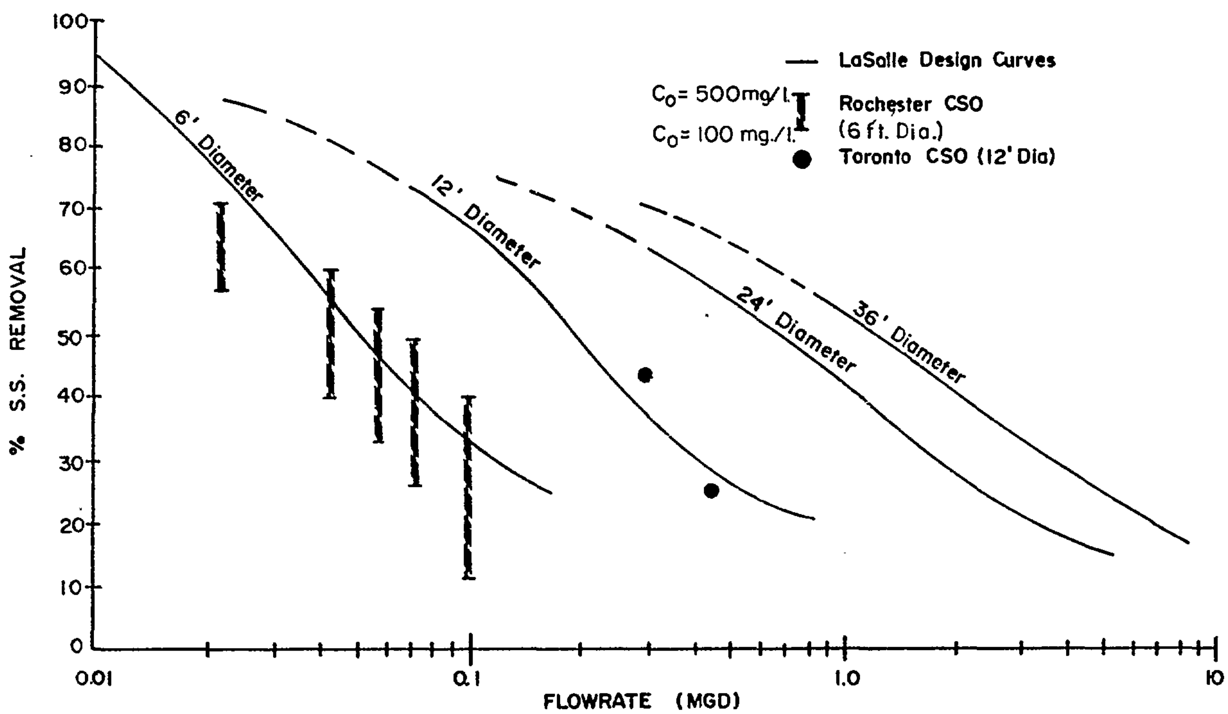


FIGURE 26. Swirl Primary Separator Loading-Performance Relationship

Scale-Up Considerations

Figure 26 illustrates the trend attained by scaling of flows and particle settling velocities as proposed by the LaSalle work. It is noted that scaling of particle settling velocities results in lower removal efficiencies for larger size prototypes at equivalent scaled hydraulic loads.

It is noted that scale-up by Froude Law results in a prototype size significantly different from that which would be obtained by traditional scale-up using OR. A rationale for the use of Froude Law scaling may perhaps be seen in data presented by Camp (7, 47) for narrow and wide rectangular sedimentation basins and circular, radial-flow basins. In evaluating the results of dye tracer studies, Camp showed that the degree of short-circuitng in the basin was related to the Froude number of the horizontal flow through the basin. Thus, by scaling based on Froude Law relationships it would be expected that the model and prototype would both display the same degree of short-circuiting.

When dealing with primary separators in which flocculent particles are removed, it may not be entirely appropriate to apply Froude Law scaling to particle settling velocities. It was noted on Table 10 that Froude Law scaling of hydraulic flows results in greater detention times in the prototype than in the model. While separation of discrete particles is theoretically independent of detention time, there are aspects of flocculent agglomeration that are affected by detention time. As flocculent particles collide, the combined particle size is increased and the settling velocity increases. This flocculation process is affected by detention time, differences in particle settling velocities,and velocity gradients in the liquid. Thus, it is possible that the loss in removal efficiency predicted by particle scaling is partially offset by increased flocculation in the larger prototype units.

Figure 27 shows the mean particle size distribution of the influent SS to the swirl primary separator for three overflow events. For scale up from model to prototype, particle settling velocities have been scaled by multiplying by the square root of the scale factor λ. Table 16 presents the prototype particle size distributions for the data obtained in Rochester.

TABLE 16. SWIRL PRIMARY SEPARATOR-MODEL TO PROTOTYPE SCALING OF PARTICLE SIZES, S.G. = 1.70

Model Size Range (microns)	Assumed Model Size (mm)	Ave. Infl. Distrib. (%)	Settling Velocity (cm/sec) Model	Settling Velocity (cm/sec) Proto.	Prototype Size (mm)
Model dia. = 6 ft, prototype dia. = 36 ft; λ = 6					
1000	0.60	7.1	5.1	12.5	2.5
180-420	0.27	4.5	2.0	4.9	0.55
149-180	0.16	2.2	0.8	2.0	0.26
74-149	0.10	12.3	0.4	1.0	0.17
<74	0.04	73.9	0.07	0.17	0.065

Figure 27 shows the particle size distributions for the 1.83 m (6 ft) diameter pilot scale model and the 11.0 m (36 ft) diameter prototype unit. If Froude Law scaling of particle settling velocities is to be employed, it may be necessary to adjust removal rates to account for the coarser size distribution represented in the prototype. However, as discussed above, this may be offset by the longer detention times in the prototype.

REMOVALS OF OTHER CONSTITUENTS

Removals of pollutants other than SS were evaluated on a storm-average basis. Listings of minimum, maximum, arithmetic means, geometric means, and standard deviations of influent and effluent data are included in Appendix C. For each of the parameters the geometric mean or median data were compiled for each storm and median removal rates were determined (see Tables 17 and 18).

Tables 19 and 20 show the percent VSS of SS for the influent and effluent samples for the swirl degritter and the swirl primary separator systems. Mean percent VSS of SS in the raw CSO for all storms was 48.6 percent.

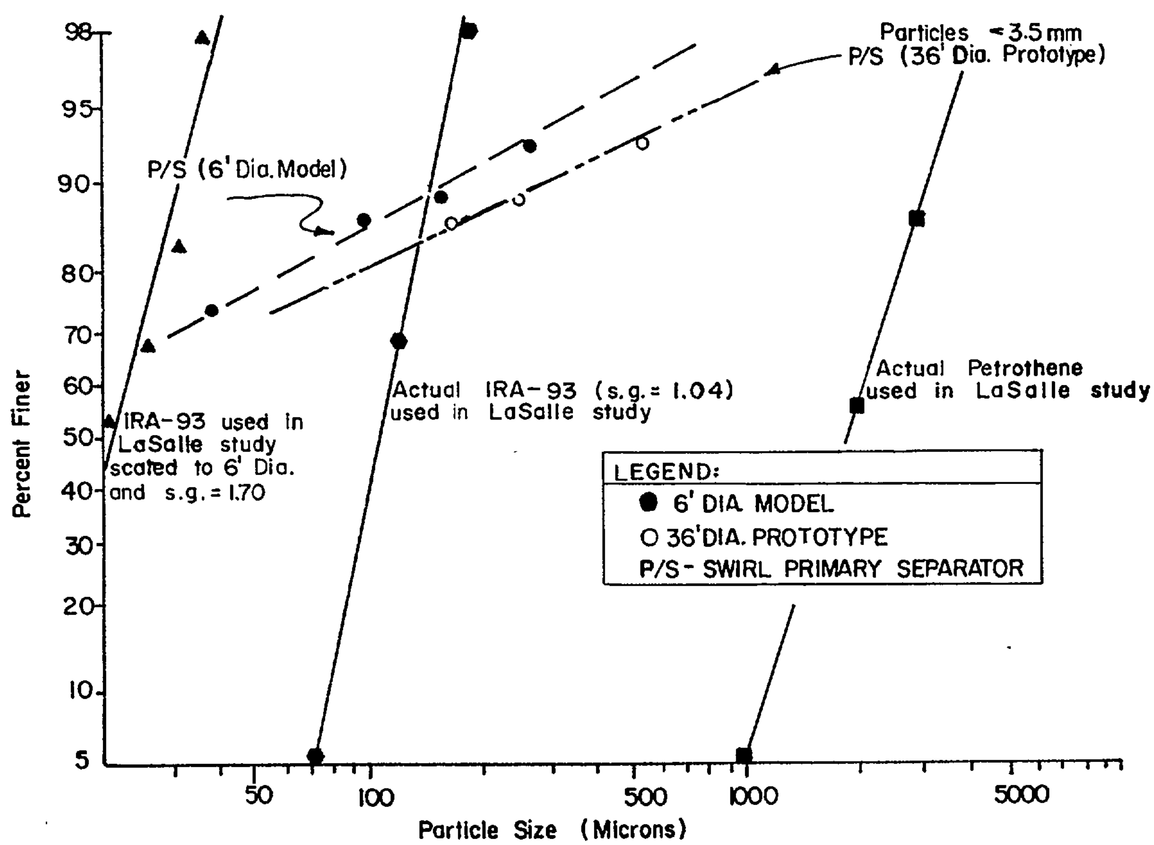


FIGURE 27. Swirl Primary Separator Model and Prototype Particle Size Distributions (specific gravity = 1.70).

TABLE 17. SWIRL DEGRITTER SYSTEM

Storm No.	SS Data (mg/l) Median Infl.	Median Effl.	% Removal	VSS Data (mg/l) Median Infl.	Median Effl.	% Removal	SETTS Data (mg/l) Median Infl.	Median Effl.	% Removal	BOD_5 Data (mg/l) Median Infl.	Median Effl.	% Removal
1	132.29	134.58	- 1.73	24.98	24.39	2.36				7.82	10.35	- 32.35
2												
3	137.72	112.27	18.48	58.98	50.14	14.99	2.64	1.94	26.52	29.63	32.75	- 10.53
4	164.65	124.05	24.66	92.09	64.08	30.42						
5	71.13	124.84	- 75.51	31.44	112.96	-259.29				340.97	1302.0	-281.85
6	87.75	139.23	- 58.67	49.84	74.20	- 48.88	1.83	1.54	15.85	20.58	13.16	36.05
7A	262.38	245.31	6.51	158.19	120.32	23.94	5.36	5.66	- 5.60	82.47	75.09	8.95
7B	74.42	41.38	44.40	46.44	14.38	69.04	.41	0.36	12.20	21.74	15.79	27.37
8	189.12	249.75	- 32.06	105.67	75.14	28.89	2.13	2.72	- 27.70	71.46	72.02	- 0.78
9	302.58	184.56	39.00	158.54	84.74	46.55	1.71	1.23	28.07	30.18	20.74	31.28
10	190.48	259.85	- 36.42	83.65	102.34	- 22.34	1.24	0.88	29.03	51.32	32.98	35.74
11	171.35	149.35	12.84	85.84	76.99	10.31	1.55	1.37	11.61	37.27	36.05	3.27
12	266.01	164.06	38.33	146.04	42.56	70.86	2.52	2.09	17.06	77.82	45.72	41.25
13	195.49	249.69	- 27.73	132.12	116.44	11.87	4.00	3.69	7.75	102.25	54.59	46.61
14	330.72	336.95	- 1.88	133.59	143.41	- 7.35	6.73	6.22	7.58	135.12	97.08	28.15
15	449.56	302.16	32.79	162.15	97.07	40.14	7.10	11.00	- 54.93	121.37	60.95	49.78
16	445.37	239.85	46.15	155.25	62.60	59.68	1.40	6.60	-371.43	48.71	25.68	47.28
17	162.52	148.09	8.88	79.20	101.54	- 28.21	8.45	7.40	12.43	126.26	113.28	10.28
18	151.82	109.29	28.01	74.12	46.76	36.91	5.88	2.66	54.76	71.43	56.46	20.96
19	182.59			41.05			2.24			35.58		

(continued)

TABLE 17. (continued)

Storm No.	COD Data (mg/l) Median Infl.	Median Effl.	% Removal	TOC Data (mg/l) Median Infl.	Median Effl.	% Removal	O&G Data (mg/l) Median Infl.	Median Effl.	% Removal	pH Data Median Infl.	Median Effl.
1	7.93	5.48	30.90	16.87	18.62	-10.37	9.34	12.50	-33.83	6.18	6.03
2	28.23	21.13	21.61	48.22	44.98	6.72	28.92	29.06	-.48	5.72	5.78
3	97.00			20.45	17.90	12.47	24.19	24.82	-2.60	5.90	5.92
4											
5		41.00		109.67	82.21	25.04	20.36			6.21	
6	25.41	26.18	-3.03	30.65	34.04	-11.42	1.27			6.80	
7A	54.04	51.01	5.61	61.66	52.44	14.95		31.00		7.07	
7B	25.42	21.34	16.05	14.15	13.38	5.44		7.00		7.02	
8	86.49			48.31	51.74	-7.10		28.00		6.51	7.81
9	11.04	18.15	-64.40	31.39	31.89	-1.59		20.00		7.17	7.33
10	15.69	15.48	1.34	44.01	30.33	31.08		42.00		7.16	7.65
11				26.27	26.28	-.04		24.00		8.09	
12				30.59	31.34	-2.45		18.50		6.68	
13				60.46	63.52	-5.06	64.17	88.00	-37.18	7.00	
14				114.47	99.44	13.13	46.67	32.00	31.43	7.63	
15				55.94	87.45	-56.33	41.55	56.00	-34.78	7.20	
16				47.71	40.36	15.41	27.41	18.00	34.33	7.12	
17				67.29	67.07	.33	38.48	100.00	-159.88	6.86	
18				44.90	33.49	25.41	50.87	66.00	-29.74	6.97	
19				19.16			54.39			7.61	

(continued)

TABLE 17. (continued)

Storm No.	TKN Data (mg/l) Median Infl.	Median Effl.	% Removal	TIP Data (mg/l) Median Infl.	Median Effl.	% Removal
1	.29	.27	6.90	.10	.08	20.00
2	2.63	2.19	16.73	.24	.25	- 4.17
3	1.10	.87	20.91	.26	.20	23.08
4						
5	6.20	4.96	20.00	1.49	1.15	22.82
6	2.50	2.33	6.80	.55	.52	5.45
7A	4.57	4.84	- 5.91	.63	.60	4.76
7B	1.22	.81	33.61	.18	.18	.00
8	3.05	.18	94.10	.42	.94	-123.81
9	.77	1.34	- 74.03	.22	.31	- 40.91
10	.81	1.21	- 49.38	.26	.17	34.62
11	2.45	2.24	8.57	.29	.26	10.34
12	3.39	2.34	30.97	1.16	.09	92.24
13	5.42	6.62	- 22.14	.62		
14	4.12	4.59	- 11.41	.82	.71	13.41
15	4.17	2.49	40.29	.86		
16	2.25	2.05	8.89	.31		
17	3.47	4.42	- 27.38	.50	.61	- 8.93
18	2.70	2.51	7.04	.50	.41	18.00
19	1.33			.20		

TABLE 18. SWIRL PRIMARY SEPARATOR SYSTEM

Storm No.	SS Data (mg/l) Median Infl.	SS Data (mg/l) Median Effl.	SS Data % Removal	VSS Data (mg/l) Median Infl.	VSS Data (mg/l) Median Effl.	VSS Data % Removal	SETTS Data (mg/l) Median Infl.	SETTS Data (mg/l) Median Effl.	SETTS Data % Removal	BOD_5 Data (mg/l) Median Infl.	BOD_5 Data (mg/l) Median Effl.	BOD_5 Data % Removal
1	134.58	122.88	8.69	24.39	53.86	-120.83				10.35		
2												
3	112.27	80.67	28.15	50.14	27.93	44.30	1.94	.76	60.82	32.75	24.63	24.79
4	124.05	56.56	54.41	64.08	12.19	80.98						
5	124.84	135.25	-8.34	112.96	120.86	-6.99				1302.00	1739.00	-33.56
6	139.23	35.55	74.47	74.20	20.31	72.63	1.54	1.41	8.44	13.16	14.67	-11.47
7A	245.31	300.72	-22.59	120.32	147.87	-22.90	5.66	4.67	17.49	75.09	89.58	-19.30
7B	41.38	55.69	-34.58	14.38	23.24	-61.61	.36	.33	8.33	15.79	18.31	-15.96
8	249.75	198.70	20.44	75.14	63.19	15.90	2.72	1.55	43.01	72.02	64.02	11.11
9	184.56	209.35	-13.43	84.74	87.09	-2.77	1.23	1.07	13.01	20.74	22.87	-10.27
10	259.85	175.81	32.34	102.34	63.54	33.03	.88	1.13	-28.41	32.98	24.86	24.62
11	149.35	113.48	24.02	76.99	47.11	38.81	1.37	2.61	-90.51	36.05	24.35	32.45
12	164.06	121.79	25.76	42.56	58.39	-37.19	2.09	1.56	25.36	45.72	29.61	35.24
13	249.69	153.71	38.44	116.44	59.84	48.61	3.69	.22	94.04	54.54	39.63	27.40
14	336.95	260.12	22.80	143.41	104.00	27.48	6.22	2.62	57.88	97.08	79.07	18.55
15	302.16	109.85	63.65	97.07	32.10	66.93	11.00	1.75	84.09	60.95	31.76	47.89
16	239.85	135.90	43.34	62.60	41.81	33.21	6.60	3.77	42.88	25.68	18.19	29.17
17	148.09	121.58	17.90	101.54	79.65	21.56	7.40	4.49	39.32	113.28	110.44	2.51
18	109.29	88.32	19.19	46.76	37.15	20.55	2.66	.32	87.97	56.46	51.21	9.30
19	183.59	91.77	50.01	41.05	24.99	39.12	2.24	1.18	47.32	35.58	24.63	30.78

(continued)

TABLE 18. (continued)

Storm No.	COD Data (mg/l) Median Infl.	COD Data (mg/l) Median Effl.	COD Data (mg/l) % Removal	TOC Data (mg/l) Median Infl.	TOC Data (mg/l) Median Effl.	TOC Data (mg/l) % Removal	O&G Data (mg/l) Median Infl.	O&G Data (mg/l) Median Effl.	O&G Data (mg/l) % Removal	pH Data Median Infl.	pH Data Median Effl.
1	5.48	10.65	- 94.34	18.62	18.08	2.90	12.50	10.38	16.96	6.03	5.90
2	22.13	22.25	- .54	44.98	42.92	4.58	29.06	33.45	- 15.11	5.78	5.86
3				17.90	16.63	7.09	24.82	11.22	54.79	5.92	5.89
4											
5	41.00	39.72	3.12	82.21	73.19	10.97					
6	26.18	29.03	- 10.89	34.04	33.57	1.38					
7A	51.01	61.24	- 20.05	52.44	96.45	- 83.92	31.00	24.00	22.58		
7B	21.34	22.02	- 3.19	13.38	14.95	- 11.73	7.00	14.00	-100.00		
8		83.91		51.74	50.08	3.21	28.00	15.00	46.43	7.81	7.56
9	18.15	11.31	37.69	31.89	21.22	33.46	20.00	24.00	- 20.00	7.33	7.47
10	15.48	16.57	- 7.04	30.33	20.96	30.89	42.00	38.00	9.52	7.65	7.85
11				26.28	25.74	2.05	24.00	16.00	33.33		
12				31.34	26.06	16.85	18.50	15.00	18.92		
13				63.52	42.34	33.34	88.00	76.00	13.64		
14				99.44	68.20	31.42	32.00	30.00	6.25		
15				87.45	33.02	62.24	56.00	17.00	69.64		
16				40.36	31.80	21.21	18.00	15.00	16.67		
17				67.07	33.91	49.44	100.00	88.00	12.00		
18				33.49	32.92	1.70	66.00	67.00	- 1.52		
19				19.16	18.01	6.00	54.39	49.00	9.91	7.61	

(continued)

TABLE 18. (continued)

Storm No.	TKN Data (mg/l) Median Infl.	Median Effl.	% Removal	TIP Data (mg/l) Median Infl.	Median Effl.	% Removal	Aluminum Data (mg/l) Median Infl.	Median Effl.	% Removal
1	.27	.39	- 44.44	.08	.09	- 12.50			
2	2.19	2.90	- 32.42	.25	.33	- 32.00			
3	.87	1.26	- 44.83	.20	.31	- 55.00			
4									
5	4.96	4.29	13.51	1.15	1.10	4.35			
6	2.33	2.30	1.29	.52	.51	1.92			
7A	4.84	5.91	- 22.11	.60	.61	- 1.67			
7B	.81	.94	- 16.05	.18	.20	- 11.11			
8	.18	2.86	-1488.89	.94	.41	56.38			
9	1.34	1.31	2.24	.31	.10	67.74			
10	1.21	1.49	- 23.14	.17	.20	- 17.65	1.92		
11	2.24	1.58	29.46	.26	.02	92.31			
12	2.34	2.18	6.84	.09	.10	- 11.11			
13	6.62	7.40	- 11.78	1.55	2.04	- 31.61			
14	4.59	5.11	- 11.33	.71	.65	8.45			
15	2.49	2.30	7.63	1.37	1.50	- 9.49		134.00	
16	2.05	2.40	- 17.07	1.37	.68	50.36			
17	4.42	4.74	- 7.24	.61	.46	24.59			
18	2.51	2.84	- 13.15	.41	.47	- 14.63			
19	1.33	1.57	- 18.05	.20	.20	.00	6.96		

TABLE 19. SWIRL DEGRITTER - PERCENT VSS OF SS

Storm No.	- - - mg/l Inf. SS	- - - Inf. VSS	Inf. Vol. %	- - - mg/l Eff. SS	- - - Eff. VSS	Eff. Vol. %
1	132.29	24.98	18.88	134.58	24.39	18.12
2	137.72	58.98	42.83	112.27	50.14	44.66
3	164.65	92.09	55.93	124.05	64.08	51.66
4	164.65	92.09	55.93	124.05	64.08	51.66
5	71.13	31.44	44.20	124.84	112.96	90.48
6	87.75	49.84	56.80	139.23	74.20	53.29
7A	262.38	158.19	60.29	245.31	120.32	49.05
7B	74.42	46.44	62.40	41.38	14.38	34.75
8	189.12	105.67	55.87	249.75	75.14	30.09
9	302.58	158.54	52.40	184.56	84.74	45.91
10	190.48	83.65	43.92	259.85	102.34	39.38
11	171.35	85.84	50.10	149.35	76.99	51.55
12	266.01	146.04	54.90	164.06	42.56	25.94
13	195.49	132.12	67.58	249.69	116.44	46.63
14	330.72	133.59	40.39	336.95	143.41	42.56
15	449.56	162.15	36.07	302.16	97.07	32.13
16	445.37	155.25	34.86	239.85	62.60	26.10
17	162.52	79.20	48.73	148.09	101.54	68.57
18	151.82	74.12	48.82	109.29	46.76	42.79

TABLE 20. SWIRL PRIMARY SYSTEM - PERCENT VSS OF SS

Storm No.	- - - mg/l Inf. SS	- - - Inf. VSS	Inf. Vol. %	- - - mg/l Eff. SS	- - - Eff. VSS	Eff. Vol. %
1	134.58	24.39	118.12	122.88	53.86	43.83
2						
3	112.27	50.14	44.66	80.67	27.93	34.62
4	124.05	64.08	51.66	56.56	12.19	21.55
5	124.84	112.96	90.48	135.25	120.86	89.36
6	139.23	74.20	53.29	35.55	20.31	57.13
7A	245.31	120.32	49.05	300.72	147.87	49.17
7B	41.38	14.38	34.75	55.69	23.24	41.73
8	249.75	75.14	30.09	198.70	63.19	31.80
9	184.56	84.74	45.91	209.35	87.09	41.60
10	259.85	102.34	39.38	175.81	68.54	38.99
11	149.35	76.99	51.55	113.48	47.11	41.51
12	164.06	42.56	25.94	121.79	58.39	47.94
13	249.69	116.44	46.63	153.71	59.84	38.93
14	336.95	143.41	42.56	260.12	104.00	39.98
15	302.16	97.07	32.13	109.85	32.10	29.22
16	239.85	62.60	26.10	135.90	41.81	30.77
17	148.09	101.54	68.57	121.58	79.65	65.51
18	109.29	46.76	42.79	88.32	37.15	42.06
19	183.59	41.05	22.36	91.77	24.99	27.23

SECTION 8

MICROSCREENING

GENERAL

The microscreen is a liquid straining device that utilizes a micro fabric mesh to remove suspended materials from liquid-solid suspension. Although the use of the microscreen in the waste treatment field is not new, application of the units for the treatment of CSO has been very limited. Microscreen studies conducted by the Hydrotechnic Corporation (14) demonstrated suspended solids removals ranging from 17 to 40 percent and BOD_5 removals of 4 to 22 percent. The screens employed during these investigations had aperture sizes of 420 and 841 microns. NeKetin and Dennis (25), utilizing screens with a 105 micron aperture size, found suspended solids and COD removals equal to 26.6 and 15.5 percent, respectively. Microscreen experiments conducted by Glover and Herbert (26) exhibited suspended solids removals of 20 to 93 percent. The screen aperture size utilized during their investigations was 23 microns. Also, organic matter, as measured by COD and TOC, was found to be reduced by 25 to 40 percent. Glover and Herbert (26) also suggested that conventional microscreens employed in CSO treatment be operated at high headloss differentials of approximately 61 cm (24 in). They proposed that this differential would permit loading rates of 142 to 1831 l/min m^2 (35 to 45 gpm/ft^2) of screen area and produce an effluent quality of 40 mg/l suspended solids.

The microscreen used at the Rochester pilot plant was comprised of a vertically aligned cylindrical drum, the lower portion of which was covered with a woven micromesh filter fabric (See Figure 6). When in operation, the drum rotated about its vertical axis at peripheral speeds of 91 to 213 m/min (300 to 700 fpm) which corresponds to a rotational speed of 58 to 136 rpm. A sonic transducer was rigidly mounted on a stationary support inside the strainer drum and as the fabric-covered portion of the drum passed over the transducer, it was cleaned by the gas cavitation that was developed in the liquid at the surface of the drum as a result of the high-energy sound waves produced by the sonic transducer. Because the sonic transducer must be covered with liquid to effectively clean the fabric, the liquid (filtrate) inside the drum must be maintained at a level sufficient to keep the transducer submerged. The liquid outside the drum was maintained at a level greater than that of the filtrate so that a differential head was established, forcing the unfiltered liquid outside the drum through the filter fabric.

The microscreening process at the pilot plant was evaluated in comparison to swirl concentrators to establish primary solids removal prior to filtration. The purpose of this comparison was to investigate the type of pretreatment efficiency necessary (90 percent SS removal for microstraining or 50 to 70 percent SS removal for swirls) to optimize the performance of dual-media high-rate filtration.

OUTLINE OF EXPERIMENTS

Two of the more important variables that are relative to the microscreening process are hydraulic loading rates and screen aperture size. Since there are no historical data on the overall performance and efficiency of sonically-cleaned microscreens in treating combined sewer overflows, it was necessary to concentrate on hydraulic loading rates during the initial testing stages. The emphasis of operation during the initial investigations was concerned with establishing screen performance at hydraulic rates of 1000 to 1200 l/min m^2 (25 to 30 gpm/ft^2).

The microscreen was originally equipped with screens having an aperture size of 10 microns based on manufacturer's recommendation. Hydraulic loading rates greater than 400 l/min m^2 (10 gpm/ft^2) were unattainable without creating an overflow condition in the unit when using the 10 micron screens. This condition could have been due to the screen aperture size and/or to the ineffectiveness of the sonic cleaning mechanism. In an attempt to attain higher hydraulic loadings, the 10 micron screens were replaced with screens having an aperture size of 70 microns. However, subsequent testing of the microscreen, utilizing the larger aperture screens, failed to yield any improvement in performance.

Examination of the microscreen unit disclosed a faulty transducer in the sonic cleaning mechanism. The mechanism was returned to service only prior to Storm No. 13. Because of time limitations in the pilot plant program, subsequent testing of the microscreen unit was restricted to maximizing the hydraulic loading rate.

RESULTS AND PERFORMANCE

Evaluations of the microscreening process were fairly limited due to the problems encountered with the sonic cleaning mechanism. Results of the first dry weather test (Storm No. 67) conducted in the microscreen are presented in Figure 28. Suspended solids removals averaged 33 percent at a loading of 895 l/min m^2 (22 gpm/ft^2). Operating at a drum speed of 136 rpm, headloss in the unit stabilized at 30 cm (12 in).

During the next wet weather test, the microscreen unit reached a loading rate of approximately 407 l/min m^2, operating under a head differential of 25 cm (10 in). Drum speed during this investigation was maintained at 136 rpm. Figure 29 shows the suspended solids removal efficiency for this test. Mass balance calculations indicated that a very small fraction of the solids removed were present in the solids blowdown. The majority of solids accumulated upstream of the strainer.

Following the above tests, the screens were steam cleaned and a series of dry weather tests were conducted. Higher headlosses generally prevented operation beyond a hydraulic loading of 407 l/min m^2 (10 gpm/ft^2). The

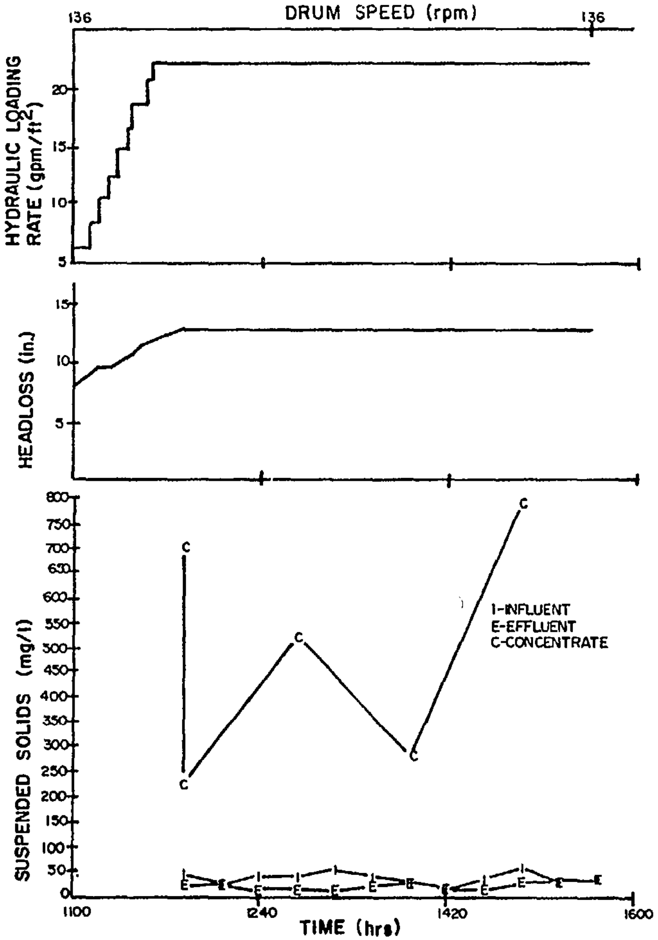


FIGURE 28. Microscreen System Performance
Storm No. 67 (2/25/76)
(dry-weather flow)

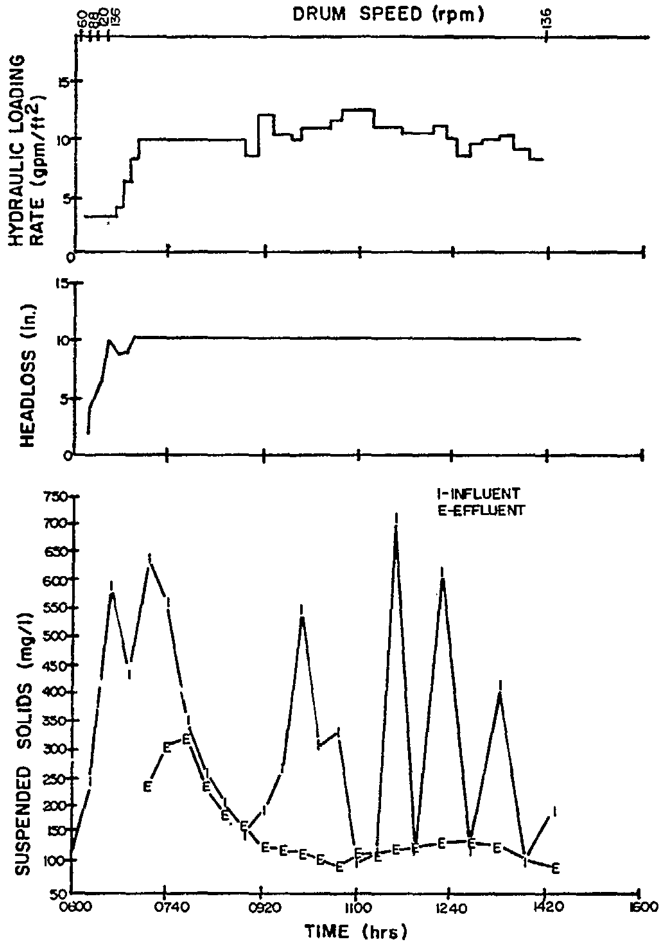


FIGURE 29. Microscreen System Performance
Storm No. 12 (3/2/76)
(wet-weather flow)

hydraulic loading and the drum speed were gradually increased to 407 l/min m^2 (10 gpm/ft^2) and 136 rpm, respectively. Headlosses associated with the higher loading rates were much smaller than the headlosses incurred by the sudden increase in loading rates as was done in the above tests. Figures 30 and 31 present suspended solids removal results for the two dry weather tests conducted under the above operating conditions. Figure 32 presents the SS removal efficiency of the unit at a maximum hydraulic loading of 598 l/min m^2 (14.7 gpm/ft^2) and a rotational speed of 136 rpm. The headloss incurred in this test was 44 cms (17.5 in). A final wet-weather analysis was conducted by increasing the rotational speed of the drum to 136 rpm at a hydraulic loading of 273 l/min m^2 (6.7 gpm/ft^2). Figure 33 presents the system performance results during the final wet-weather analysis.

From the above analysis, it appears that the rotational speed is a very important parameter in the operation of the unit. Results indicated that the microscreen performance improved considerably when the microscreen drum was rotated at the maximum speed. With the exception of one storm the maximum hydraulic loading attainable without producing overflow was 549 l/min m^2 (13.5 gpm/ft^2). This appeared to be the operating limit of the microscreen for both wet- and dry-weather flows at the Rochester pilot plant site. During wet-weather flows, operation of the unit was considerably more erratic and hydraulic loadings attainable were lower than those experienced during dry-weather investigations. This could have been due to the varying level of suspended solids present in the influent. Influent suspended solids averaged 240 to 317 mg/l during the wet-weather investigations and 40 to 60 mg/l during the dry-weather operations. However, the higher influent SS during wet-weather testing did not always result in higher SS removals as seen in Table 21.

A list of removal percentages for all the parameters analyzed during the microscreen investigations is presented in Table 21. A statistical analysis of this data for storm operations is presented in Appendix C.

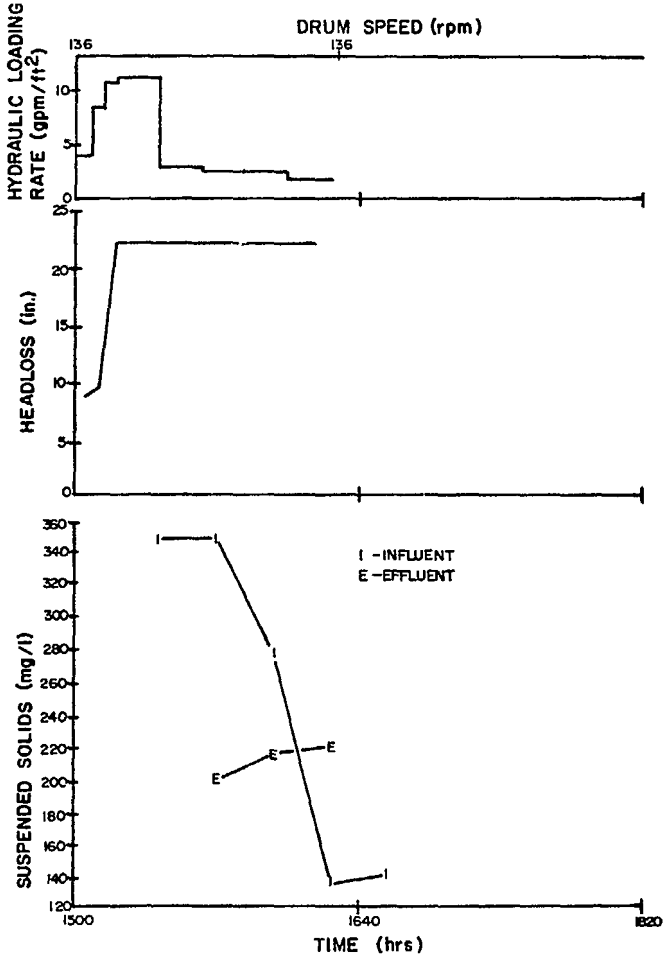


FIGURE 30. Microscreen System Performance Storm No. 13 (3/12/76) (wet-weather flow)

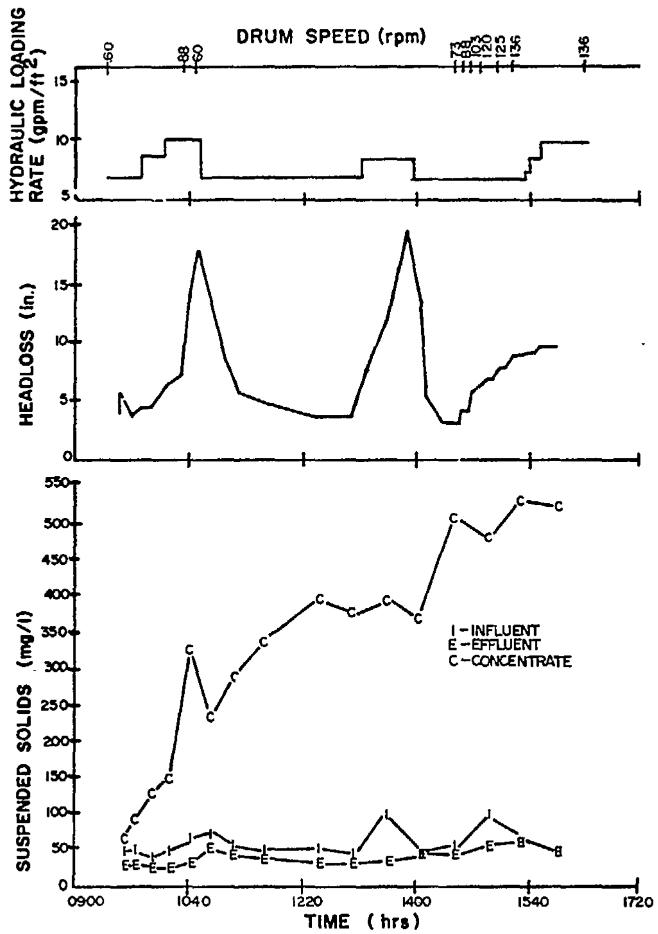


FIGURE 31. Microscreen System Performance Storm No. 71 (5/3/76) (dry-weather flow)

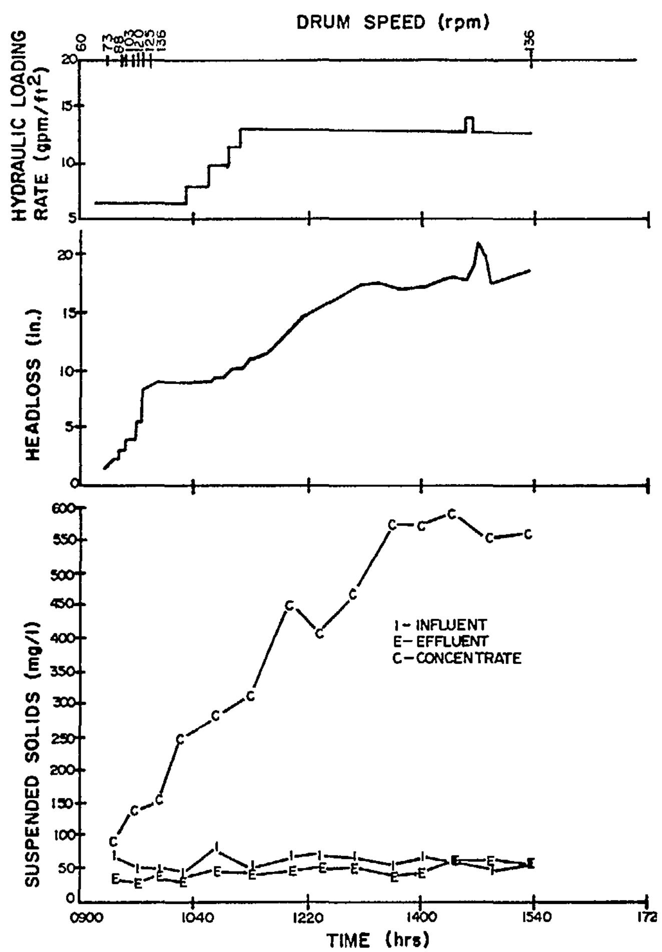


FIGURE 32. Microscreen System Performance
Storm No. 72 (5/4/76)
(dry-weather flow)

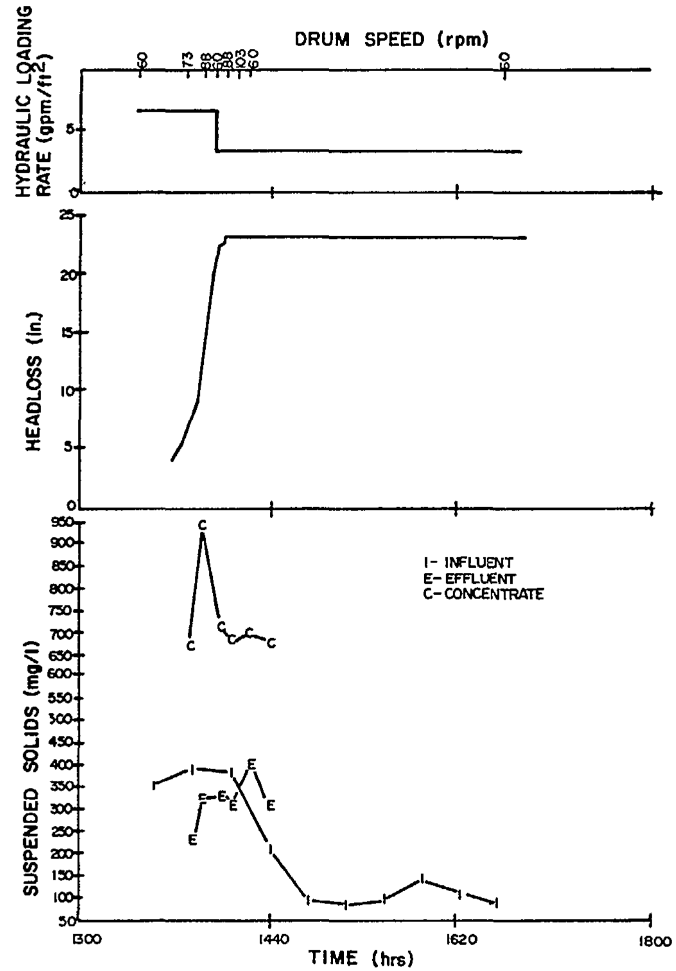


FIGURE 33. Microscreen System Performance
Storm No. 17 (5/11/76)
(wet-weather flow)

TABLE 21. MICROSCREENING ANALYTICAL DATA*

PARAMETER	WET WEATHER ANALYSIS			DRY WEATHER ANALYSIS		
Storm No.	12	13	17	67	71	72
Infl. SS (mg/l)	261.2	236.9	317.3	40.5	54.6	59.5
Effl. SS (mg/l)	147.6	212.1	314.5	27.3	36.7	45.6
% SS Removal	43.5	10.5	1.5	32.6	32.8	23.4
Infl. BOD_5 (mg/l)	82.6	107.9	209.6			
Effl. BOD_5 (mg/l)	42.6	109.0	201.4			
% BOD_5 Removal	48.4		3.9			
Infl. VSS (mg/l)	128.3	154.5	200.6	35.3		
Effl. VSS (mg/l)	62.3	114.0	188.4	22.8		
% VSS Removal	51.4	26.2	6.1	35.4		
Infl. SETTS (mg/l)	2.48	9.41	13.50			
Effl. SETTS (mg/l)	0.87	3.62	7.14			
% SETTS Removal	64.9	61.5	47.1			
Infl. TIP (mg/l)	7.27	0.63	1.01			
Effl. TIP (mg/l)	0.41	0.99	1.23			
% TIP Removal	94.4					
Infl. TKN (mg/l)	3.56	4.88	3.32			
Effl. TKN (mg/l)	3.42	6.49	6.74			
% TKN Removal	3.9					
Infl. TOC (mg/l)	29.6	62.9	107.4			
Effl. TOC (mg/l)	43.2	85.2	97.7			
% TOC Removal			9.0			
Infl. O & G (mg/l)		86.0	59.0			
Effl. O & G (mg/l)		76.0	52.1			
% O & G Removal		11.6	11.7			

* Results are geometric means of the values obtained

SECTION 9

DUAL-MEDIA HIGH-RATE FILTRATION

BACKGROUND

Studies of wastewater filtration have focused primarily on polishing of secondary effluents. In this application deep bed filters have been employed at hydraulic loading rates of 81 to 407 l/min m^2 (2 to 10 gpm/ft^2). Dual or multi-media filters are generally preferred in wastewater applications, as they allow more efflicient use of the filter depth.

In addition to removal efficiencies, the performance of filter units is characterized by the run lengths attainable as determined by the rate of headloss. Since run length is also affected by the hydraulic loading rate, a more appropriate measure of production is specific capture or the total kilograms of SS accumulated per m^2 of surface area per run.

When treating secondary effluent, Baumann and Huang (31) have indicated results showing up to 85 percent removal of SS when employing 30 cm (12 in) of 1.84 mm anthracite over 30 cm (12 in) of 0.55 mm sand. Specific captures of 3 to 3.6 kg/m^2 (0.62 to 0.73 lb/ft^2) per run were demonstrated when employing terminal headlosses of 3 m (10 ft) of water. Their work indicated that specific capture was basically unaffected by hydraulic loading and applied solids concentration, but was related mainly to filter media size. Tchobanoglous and Eliassen (32) developed a mathematical model for determining specific capture based on data for activated sludge effluent from Palo Alto, Cal. They indicated specific captures ranging from 1.95 to 12.7 kg/m^2 (0.4 to 2.6 lb/ft^2) per run as media size was increased from 0.4 to 1.5 mm diameter.

The filter performance equations employed in the EPA SWMM II model (34) are based partly on secondary effluent filtration studies at Chicago reported by Lynam et al. (33). These studies demonstrated SS removals of 65 to 78 percent for 0.58 mm sand with hydraulic loading (flux) rates of 102 to 244 l/min m^2 (2.5 to 6 gpm/ft^2). The filter results obtained at Washington, D.C. (35) using a synthetic storm overflow were also incorporated in the SWMM model. This report presented results for three filters. The first filter consisted of fiberglass media which demonstrated SS removals of 87 to 95 percent and BOD_5 removals of 60 to 75 percent for flux rates of 610 to 2035 l/min m^2 (15 to 50 gpm/ft^2). The second filter was comprised of 91 cms (36 in) of coarse garnet. Two-hour run lengths were attained at 407 l/min m^2 (10 gpm/ft^2) with SS removals of 80 to 95 percent and BOD_5 removals of 50 to 80 percent. The higher removals were attained with chemical treatment (150 mg/l alum + 4 mg/l flocculant aid). Flux rates of 814 l/min m^2 (20 gpm/ft^2) resulted in one-half hour runs. The third filter consisted of 1.2 m (48 in) of medium garnet and 23 cm (9 in) coarse garnet operated in an upflow mode. This filter maintained flux rates of 204 to 610 l/min m^2 (5 to 15 gpm/ft^2) with SS removals of 60 percent and BOD_5 removals of 45 percent. Efficiency dropped sharply for flux rates above 610 l/min m^2 (15 gpm/ft^2).

Filtration of CSO was studied at Cleveland, Ohio by Nebolsine et al. (14), where the filtration was preceeded by fine mesh screening (40 mesh). After testing anthracite sizes of Numbers 2, 3, and 4, a filter media configuration of 1.5 m (5 ft) of No. 3 anthracite (4.0 mm e.s.)over 0.9 m (3 ft) of No. 612 sand (2.0 mm e.s.) was chosen. Results without chemical treatment indicated average SS removals of 65 percent. The performance of the system decreased as the flux increased from 407 to 1628 l/min m^2 (10 to 40 gpm/ft^2). SS removal efficiencies of 90 and 95 percent were attained for respective flux rates of 1017 and 326 l/min m^2 (8 and 25 gpm/ft^2) with the addition of 1 mg/l of polyelectrolyte. Typical filter influent SS ranged from 114 to 301 mg/l. BOD_5 removals ranged from 23 to 62 percent without chemical and 54 to 72 percent with the addition of polyelectrolyte. Phosphorus removals averaged 26 to 52 percent with influent P concentration of 0.71 to 0.76 mg/l. Oil and grease removals ranged from 32 to 50 percent. Results were also presented for treatment with alum and polyelectrolyte. Typical run lengths were 6 to 10 hours at 977 l/min m^2 (24 gpm/ft^2) with no chemicals and 3 to 6 hours with polyelectrolyte. The filtration tests without chemical addition were terminated by headloss development while the polyelectrolyte runs generally resulted in termination due to solids breakthrough.

Filtration studies of CSO at Syracuse (36) used filtration through No. 3 anthracite, -16 +50 mesh clinoptilolite, and 3.2 mm (0.125 in) plastic pellets (37). When employing alum and polymer treatment, SS removal rates of 90 to 100 percent were achieved at application rates of 407 to 529 l/min m^2 (10 to 13 gpm/ft^2). Phosphorus removal increased from 30 to 98 percent as the Al:P molar ratio was increased from 0.5 to 3.5.

Backwash water requirement is a function of the filter media used. The Cleveland study (14) showed backwash requirements of 1.9 to 8.6 percent of filtered flow with a median value of approximately 4 percent. Backwash rates of 1261 to 3663 l/min m^2 (31 to 90 gpm/ft^2) were used with durations of 4 to 25 minutes. It is generally agreed that filters designed for wastewater treatment should incorporate both air scour and surface wash facilities. The Syracuse studies using No. 3 anthracite recommended 5 minutes of air scour at 1.2 m^3/min m^2 (4 scfm/ft^2), 3 minutes of scour-backwash at 1.2 m^3/min m^2 (4 scfm/ft^2) and 814 l/min m^2 (20 gpm/ft^2), respectively, followed by 12 minutes of backwashing at 814 l/min m^2 (20 gpm/ft^2).

OUTLINE OF EXPERIMENTS

The dual-media high-rate filter (DMHRF) experiments included evaluations of the effects of hydraulic loading and chemical treatment on performance. Flux rates of 407, 610, 814 and 1017 l/min m^2 (10, 15, 20 and 25 gpm/ft^2) were employed. Chemical treatments included: no chemicals, polyelectrolyte only (1 mg/l - Nalcolyte 676) and alum (30 mg/l) plus polyelectrolyte (1 mg/l).

The swirl separator effluent was used as influent to the DMHRF. Since several chemical treatments were employed on the swirl separator system, DMHRF performance is related to the upstream swirl treatment as well as the chemicals applied to the filter influent. Table 22 is a summary of the flux rates and chemical treatments associated with each filter run.

TABLE 22. DMHRF OPERATING CONDITIONS

Run No.	Filter No.	Flux (gpm/ft^2)	Chemicals On Swirl Separator*	Chemicals On DMHRF*
5-1	1	25	None	None
"	2	10	"	"
"	3	20	"	"
6-1	1	25	"	"
"	2	10	"	"
"	3	20	"	"
6-2	1	20	"	"
"	2	15	"	"
"	3	10	"	"
7-1	1	25	"	"
"	2	10	"	"
"	3	20	"	"
7-2	1	20	"	"
"	2	15	"	"
"	3	10	"	"
7-3	1	10	"	"
"	2	25	"	"
"	3	15	"	"
7-4	1	15	"	"
"	2	15	"	"
"	3	15	"	"
8-1	1	25	Polymer	"
"	2	10	"	"
"	3	20	"	"
8-2	1	20	"	"
"	2	15	"	"
"	3	10	"	"
8-3	1	10	"	"
"	2	25	"	"
"	3	15	"	"
9-1	1	25	"	"
"	2	20	"	"
"	3	10	"	"
9-2	1	10	"	"
"	2	15	"	"
"	3	25	"	"
9-3	1	20	"	"
"	2	10	"	"
"	3	15	"	"
9-4	1	25	"	Polymer
"	2	20	"	"
"	3	10	"	"

(continued)

TABLE 22. (continued)

Run No.	Filter No.	Flux (gpm/ft^2)	Chemicals Swirl Separator*	Chemicals On DMHRF*
9-5	1	25	Polymer	Alum + Polymer
"	2	20	"	"
"	3	10	"	"
11-1	1	15	Alum + Polymer	"
"	2	15	"	"
"	3	15	"	"
12-1	1	15	"	None
"	2	15	"	Polymer
"	3	25	"	"
12-2	1	15	"	Alum + Polymer
"	2	15	"	None
"	3	15	"	"
13-1	1	25	Phos. + Alum + Polymer	Alum + Polymer
"	2	25	"	Polymer
"	3	25	"	None
13-2	1	20	"	Alum + Polymer
"	2	20	"	Polymer
"	3	20	"	None
13-3	1	15	"	Alum + Polymer
"	2	15	"	Polymer
"	3	15	"	None
15-1	1	25	"	Polymer
"	2	25	"	"
"	3	25	"	None
15-2	1	15	Phos. + Alum + Polymer	Polymer
"	2	15	"	"
"	3	15	"	None
16-1	1	25	"	"
"	2	25	"	"
"	3	25	"	"
16-2	1	25	"	Polymer
"	2	25	"	"
"	3	25	"	"
17-2	1	15	None	"
"	2	15	"	"
"	3	15	"	"
17-3	1	15	"	"
"	2	15	"	"
"	3	15	"	"
17-4	1	15	"	None
"	2	15	"	"
"	3	15	"	"

*Chemical dosages: alum, 30 mg/l; polymer, 1 mg/l

The filter media consisted of 0.9 m (3 ft) of No. 2 anthracite over 1.5 m (5 ft) of No. 1220 sand. Following storm No. 8, the filters were regraded by hydraulically scalping the fines from the surface in an attempt to attain longer run lengths. Sieve analyses indicated size distributions of No. 2 anthracite (effective sizes and uniformity coefficients) for samples taken from the top of the filters as shown on Table 23.

TABLE 23. SIEVE ANALYSIS OF FILTER MEDIA

	Filter No.	Effective * Size (mm)	Uniformity Coefficient
No. 2 Anthracite		2.7	1.30
a. before regrading			
	1	1.7	1.69
	2	1.4	1.61
	3	1.3	1.52
b. after regrading			
	1	2.1	1.48
	2	1.8	1.39
	3	1.7	1.35

*Since the samples were taken from the top of the hydraulically classified bed, the effective size would be expected to be slightly finer than the unclassified media.

Filter runs were terminated upon headloss development of approximately 0.145 N/mm^2 (21 psi), 14.8 m of water (48.5 ft water). Headlosses were determined from pressure gauge readings taken at the top of the bed, and at the locations of 61, 152, and 244 cm (24, 60 and 96 in) below the top of the bed. Headlosses were corrected for static pressures at each location.

OPERATING PROCEDURES

The filter units were prepared for service by backwashing at 80 to 90 percent bed expansion. Backwash was preceeded by air scour at 0.6-1.5 m^3/min m^2 (2-5 ft^3/min ft^2) plus backwash at 2279 1/min m^2 (56 gpm/ft^2) for five minutes followed by an additional 10 minute backwash at 2890 1/min m^2 (71 gpm/ft^2).

Three parallel filters were operated with each run set. The units initially contained clean water to prevent channel formation on start-up. Flowrate was controlled by regulating a pump drawing wastewater from an effluent sump. A float valve on the column effluent thus regulated flow through the filter equal to the rate of sump withdrawal. Applied flowrate was constant throughout each entire run.

Pressure readings at each of four locations were taken every 15 minutes. Grab samples of influent, effluent and intermediate locations were taken at 15 to 30 minute intervals. Intermediate samples were taken at depths of 24 and 60 inches from the top of the media.

RESULTS

Figure 34 is a typical performance plot of data from the DMHRF system. Headloss and SS data are shown versus time. It is noted that the majority of the headloss occurred within the top 61 cm (24 in) of media. It is also noted that a gradual deterioration of effluent quality was obtained toward the end of this run. This is typical of the trend reported in the Cleveland study (14) for treatment with polyelectrolyte.

Run Lengths

Figures 35 through 37 show run lengths versus applied flux for several chemical treatment cases. In general, the results indicate the classical trend of reduced run lengths at higher flux rates. It is noted, however, that the upstream treatment (swirl separator) had a definite impact on the run lengths attained. Use of polymer and alum + polymer on the swirl separator unit tended to result in longer run lengths on the DMHRF. There may be two reasons for the longer runs. First, longer runs would be expected when lower SS concentrations are applied to the filters. However, as noted in Section 6, the chemical treatments on the swirl unit generally did not result in imporved performance across that unit. More likely, the longer filter runs were associated with the effluent solids from the swirl unit being chemically conditioned further ahead of the filter units.

Specific Capture

Measurements of filter run lengths do not allow assessment of the effects of changes in influent SS concentrations and the effects of attaining greater removal efficiencies. For these reasons the use of specific capture is a better indicator of performance.

Specific captures were determined by summing the incremental SS removals across the DMHRF for the duration of the filter runs. Results were calculated as total kg (or lb) of SS accumulated per m^2 (or ft^2) of surface area per run. Although the capture is expressed per unit of surface area, this does not necessarily imply that solids are only captured at the surface of the bed.

Figures 38 and 39 show specific captures versus flux rates. The most significant point immediately evident from these figures is that specific capture generally increases in most cases as flux rate is increased. It is characteristic of deep-bed filters that higher flux rates promote deeper penetration of solids into the interior of the bed and permit fuller utilization of the filter volume. However, as demonstrated below, higher flux rates also result in a greater rate of solids contamination of the effluent, so that tradeoffs must be evaluated.

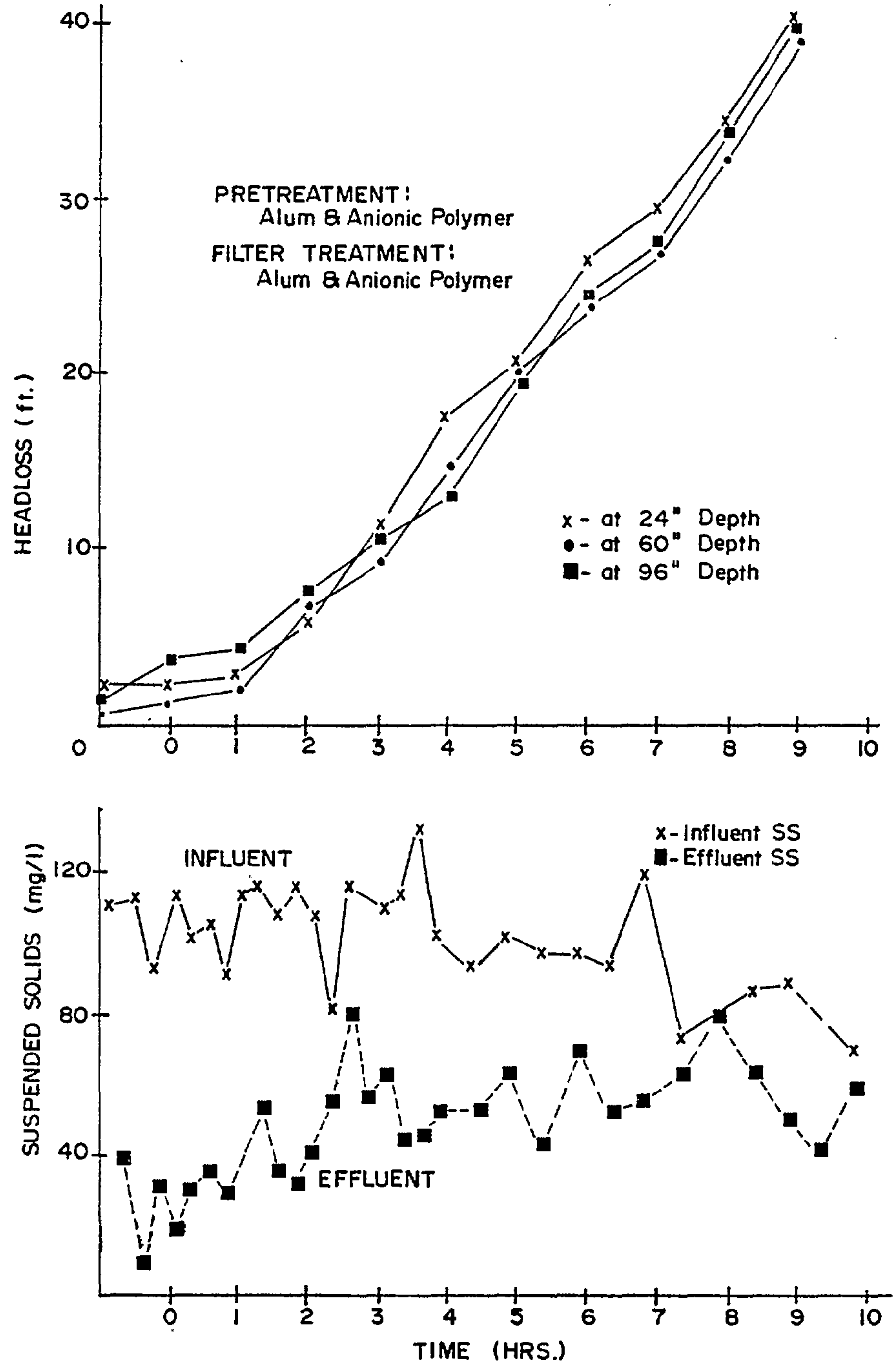


FIGURE 34. TYPICAL FILTER (DMHRF) PERFORMANCE CURVES
Run No. 11-2-2. Flux = 15 gpm/ft^2

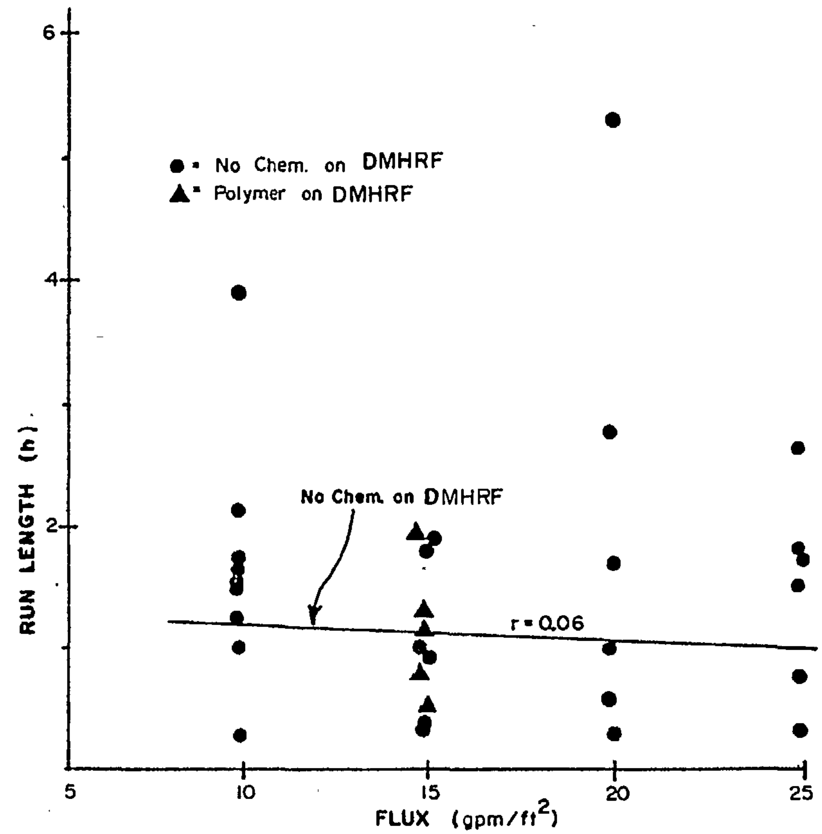


FIGURE 35. DMHRF Run Lengths. No chemical treatment on Swirl Primary Separator

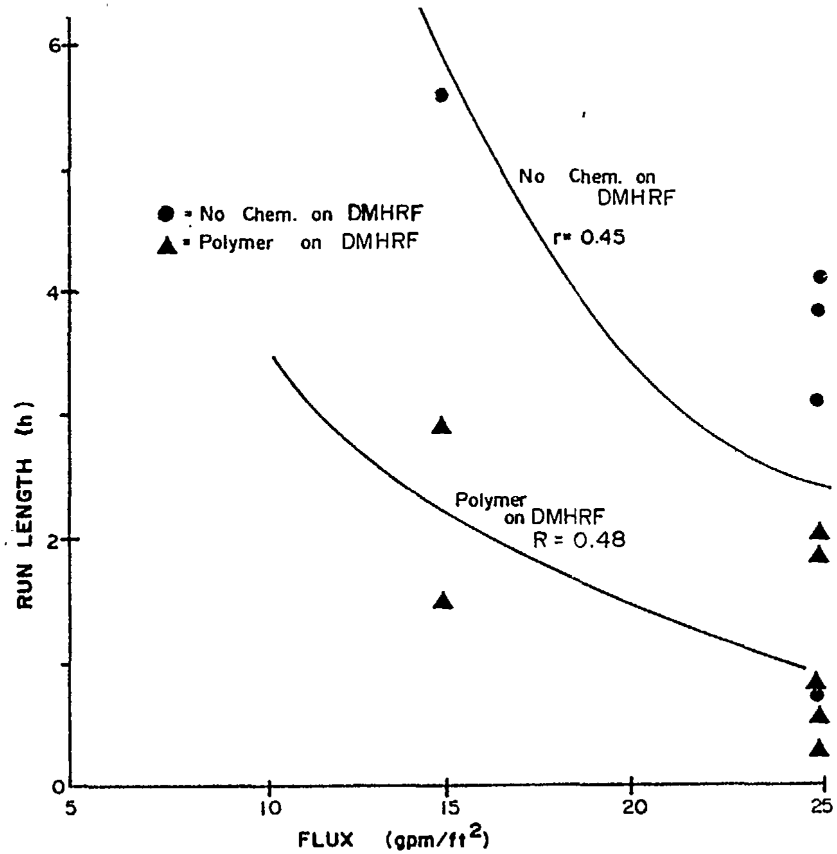


FIGURE 36. DMHRF Run Lengths. Alum + Polymer Treatment on Swirl Primary Separator

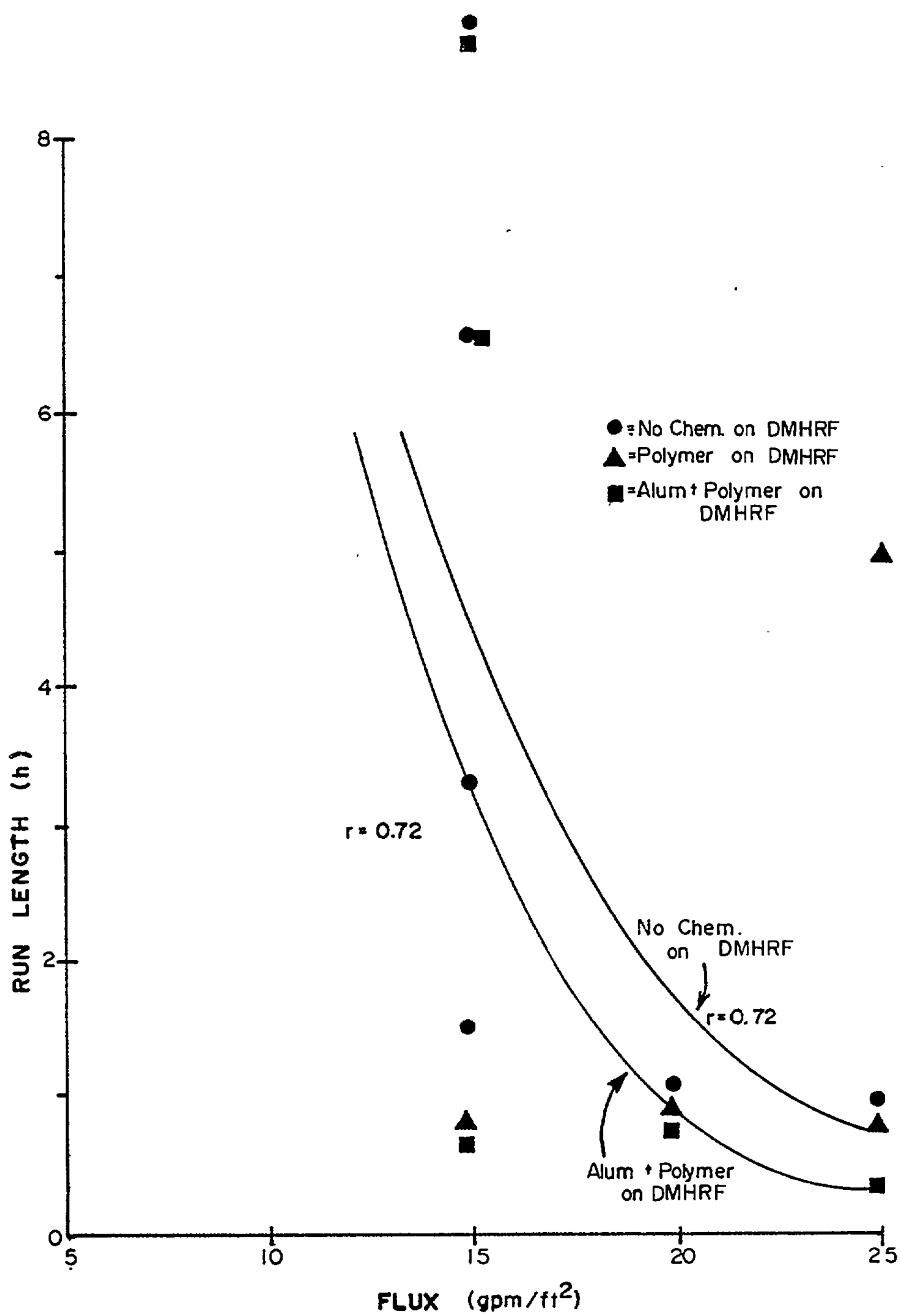


FIGURE 37. DMHRF Run Lenths. Polymer on Swirl Primary Separator

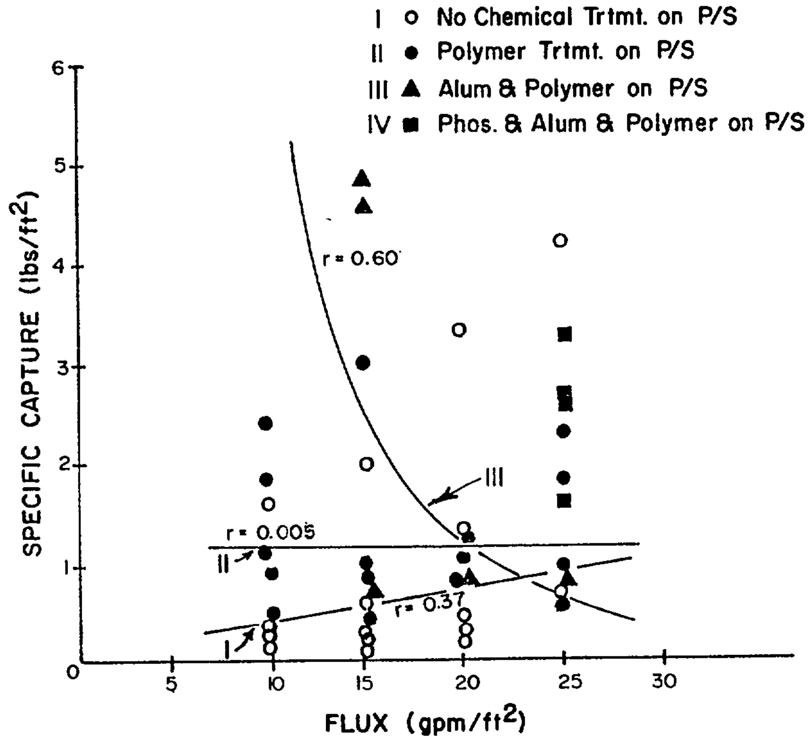


FIGURE 38. DMHRF Specific Capture. No Chemical Treatment on DMHRF.

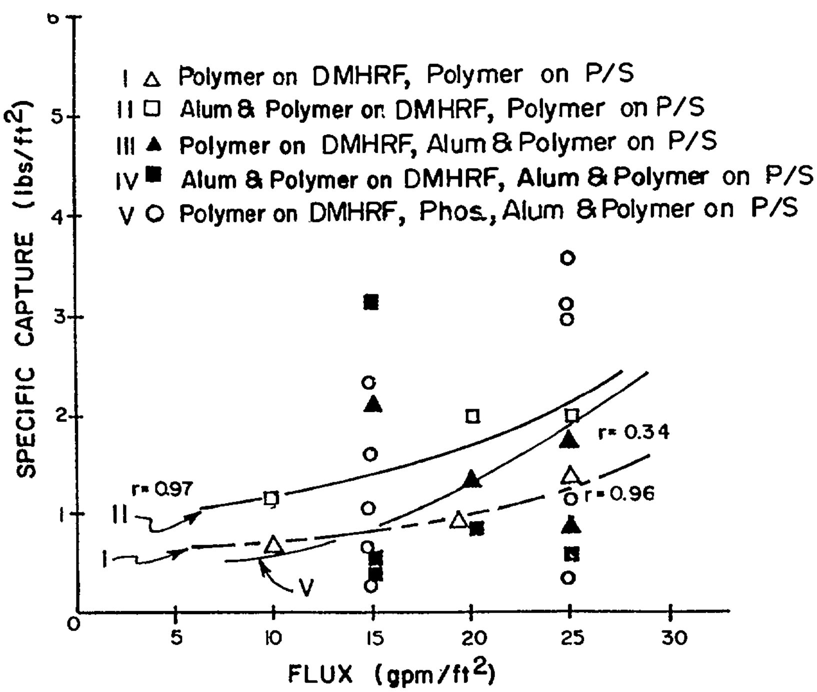


FIGURE 39. DMHRF Specific Capture. Chemical Treatment on DMHRF.

Figures 38 and 39 demonstrate the impact of the chemical treatments employed in the upstream swirl primary separator. Specific captures on the order of 9.8 kg/m^2 (2 lb/ft^2) per run were attained when alum + polymer were employed upstream. Comparison of Figure 38 to Figure 39 suggests that upstream chemical treatment had more impact on DMHRF performance than the chemicals applied directly ahead of the DMHRF. This points out the importance of contact time for chemical conditioning of CSO solids.

SS Removal Rates

Figures 40 and 41 show the effect of flux rate on percent removals of SS. In general, average percent SS removals decrease as the flux rate is increased. Figure 40 represents results for DMHRF runs where no chemicals were applied to the DMHRF. Figure 41 includes results for DMHRF runs employing chemical treatment. Again, the upstream chemical treatment on the swirl unit shows more significant effect on DMHRF performance than the chemicals applied to the DMHRF. SS removals generally ranged from 60 to 85 percent at 408 l/min m^2 (10 gpm ft^2) to 40 to 80 percent at 1018 l/min m^2 (25 gpm/ft^2). Best removals were attained when alum plus polyelectrolyte were applied to the swirl unit and/or the DMHRF.

Removal of Other Constituents

Statistical analyses of other parameters tested during the DMHRF runs are included in Appendix D for influent and effluent samples. Results of all tests of similar flux and chemical treatment (both swirl unit and DMHRF) were grouped for this analysis. Appendix D includes minimum, maximum, average, geometric mean,and standard deviation for each data set. The influent and effluent geometric mean (or median) data are compiled on Table 24 and median removals are listed for each set of flux and chemical treatment employed.

VSS removals ranged from 30 to 61 percent without chemicals and 43 to 96 percent when chemicals were employed. BOD_5 removals ranged from 32 to 56 percent without chemicals and 20 to 92 percent with chemicals. TOC removals were generally higher than COD removals. TOC removals ranged from 19 to 50 percent without chemicals and 23 to 68 percent with chemical treatment. COD removals averaged 13 percent without chemicals and 42 percent with chemicals.

Oil and grease removals were less than 4 percent without chemicals and ranged from 5 to 56 percent when chemical treatments were employed. TKN removals ranged from 8 to 13 percent without chemicals and 1 to 49 percent with chemicals. TIP removals of 7 to 34 percent were attained without chemicals, while chemical treatments generally resulted in TIP removals of 20 to 89 percent. Effluent pH ranged from 6.8 to 7.2 when chemicals were not employed and from 3.6 to 7.4 when chemicals were employed. Aluminum reductions were 10 to 93 percent without chemicals and 12 to 94 percent with chemical addition.

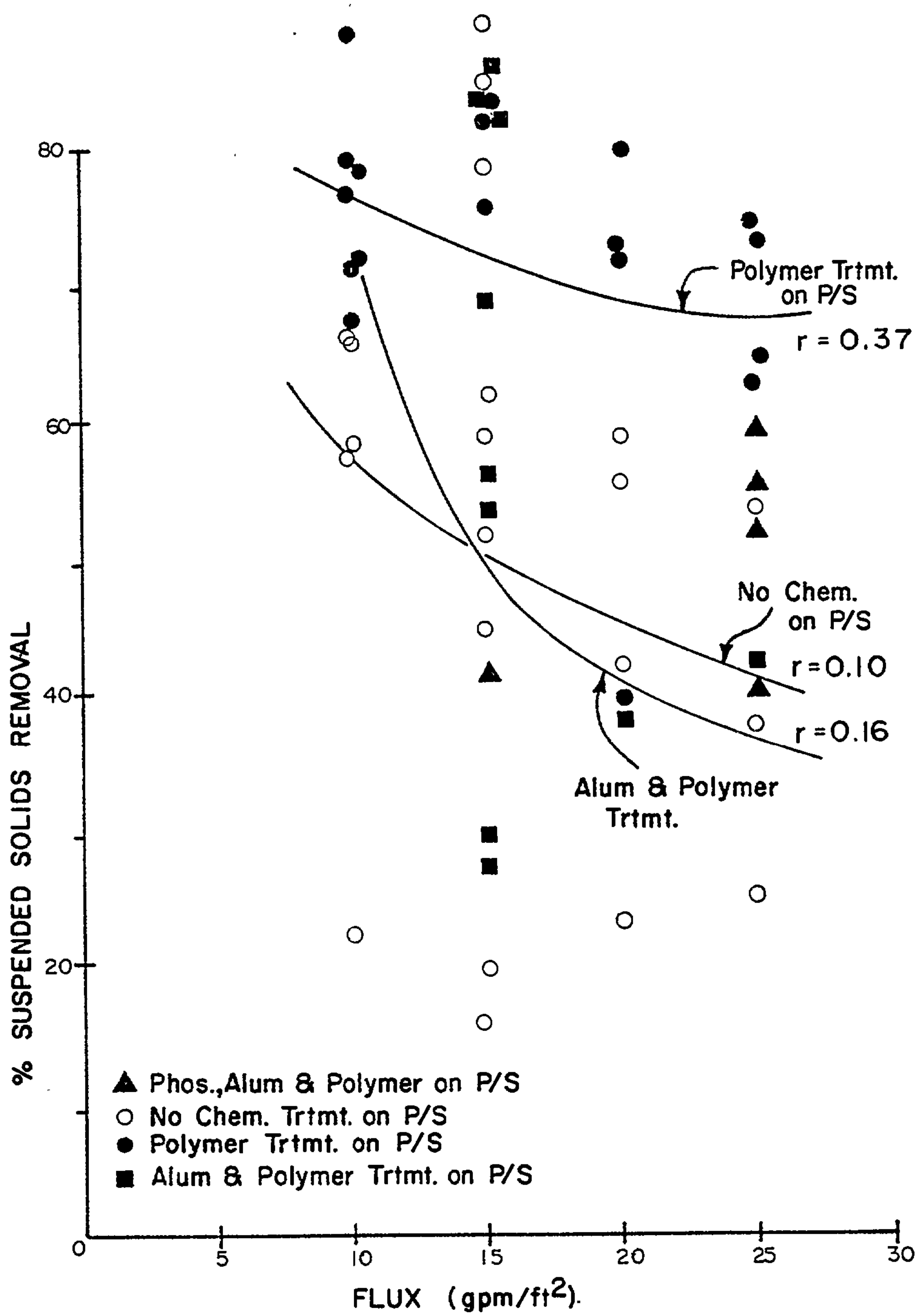


FIGURE 40. DMHRF Performance. No Chemical Treatment.

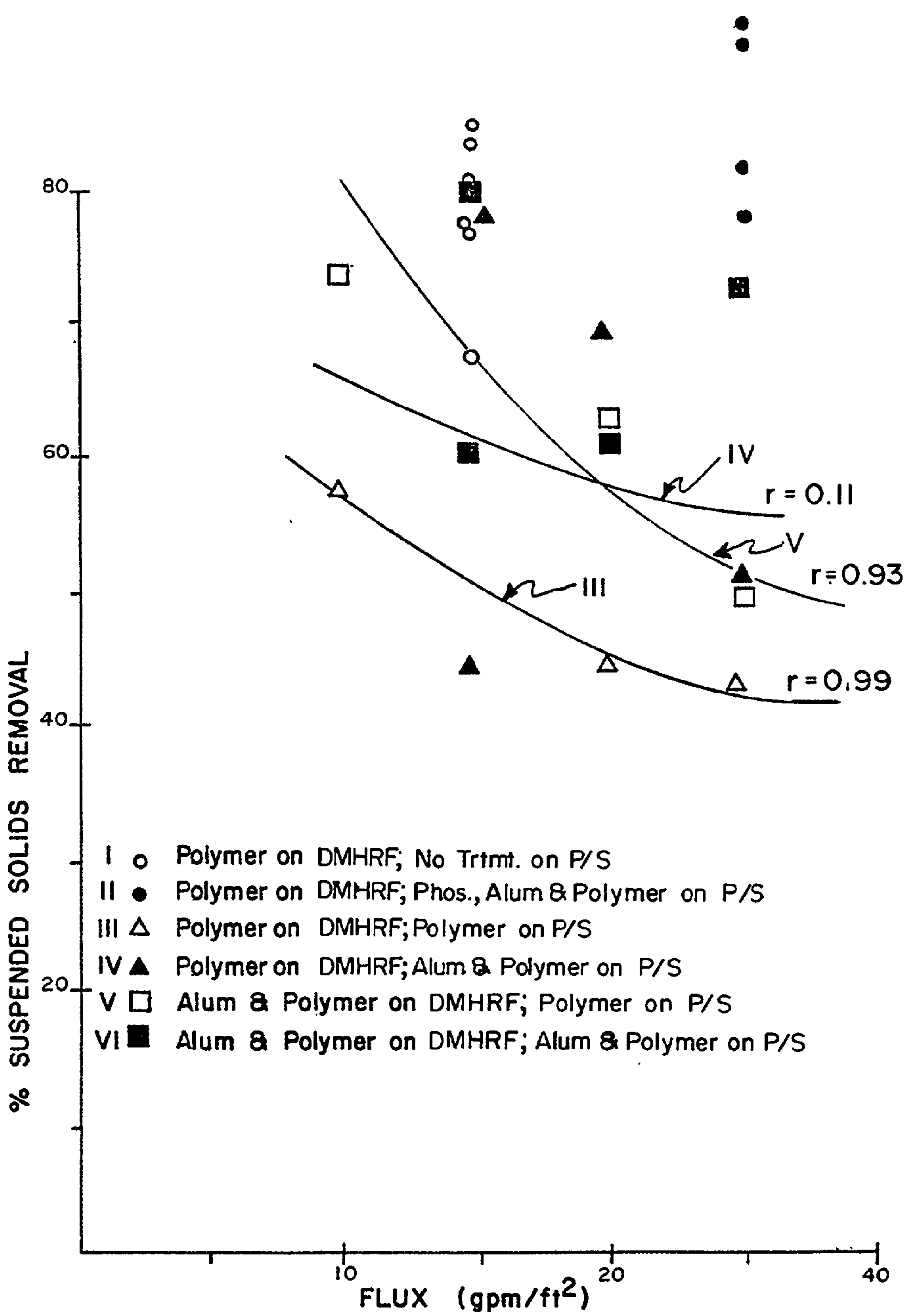


FIGURE 41. DMHRF Performance with Chemical Treatment.

TABLE 24. MEDIAN PERFORMANCE OF DMHRF

Treatment* On P/S	Treatment* On DMHRF	Flux gpm/ft^2	SS Inf. mg/l	SS Eff. mg/l	SS % Rem.	VSS Inf. mg/l	VSS Eff. mg/l	VSS % Rem.	BOD$_5$ Inf. mg/l	BOD$_5$ Eff. mg/l	BOD$_5$ % Rem.	TOC Inf. mg/l	TOC Eff. mg/l	TOC % Rem.
NC	NC	10	58.8	25.3	56	26.6	10.5	61	15.3	6.67	56	18.8	13.4	29
NC	NC	15	56.1	24.5	56	26.6	13.2	50	16.0	10.90	32	17.8	12.6	29
NC	NC	20	70.5	38.9	45	30.9	16.9	45	17.7	10.00	44	20.7	10.3	50
NC	NC	25	53.6	31.3	42	25.1	17.5	30	12.5	7.50	40	19.5	15.7	19
NC	PO	15	142.7	28.2	80	82.4	18.4	78	76.5	6.00	92	35.7	18.0	50
PO	NC	10	203.4	45.8	77	61.9	14.3	77	26.7	7.70	71	32.5	11.3	65
PO	NC	15	187.4	31.9	83	54.6	11.1	80	24.9	5.80	77	29.8	9.4	68
PO	NC	20	240.3	85.5	64	80.5	30.1	63	24.0	19.10	20	42.4	17.2	59
PO	NC	25	196.5	57.8	71	57.9	17.6	70	28.9	6.80	76	30.4	11.9	61
PO	PO	10	229.2	78.7	66	71.4	21.3	69	12.6			37.2	17.1	54
PO	PO	20	217.4	117.1	46	70.1	39.9	43	12.2			37.4	22.3	40
PO	PO	25	217.4	119.5	45	70.1	34.0	51	11.5			37.4	24.1	36
PO	AP	15	185.6	39.8	79	35.9	6.8	81	11.5			33.1	15.1	54
PO	AP	20	185.6	66.1	64	35.9	9.1	75	11.5			33.1	20.3	39
PO	AP	25	185.6	80.1	57	35.9	18.9	47	27.6			33.1	19.4	41
AP	NC	15	104.6	40.1	62	40.2	15.5	61	21.4	17.40	37	34.1	24.8	27
AP	NC	20	192.6	114.1	41	79.8	42.9	46	27.9			53.0	39.6	25
AP	NC	25	87.9	52.4	40	31.3	14.3	54	27.6	19.50	30	26.8	20.2	25
AP	PO	15	98.4	7.7	92	38.4	2.3	94	27.6	17.10		31.4	12.3	61
AP	PO	20	192.6	47.7	75	79.8	17.0	79	21.4			53.0	29.1	45
AP	PO	25	161.1	8.1	95	54.0	2.3	96	29.5	24.30		39.7	14.0	65
AP	AP	15	152.6	42.9	72	54.4	15.6	71	23.1	17.20		46.2	19.0	59
AP	AP	20	192.6	62.5	68	79.8	23.5	71	21.4			53.0	31.2	41
AP	AP	25	205.7	82.3	60	85.6	35.8	58	34.7			43.0	33.0	23

(continued)

*NC - no chemical treatment
PO - polymer treatment only
AP - alum + polymer treatment

TABLE 24. (continued)

Treatment* P/S	On DMHRF	Flux gpm/ft^2	COD Inf. mg/l	COD Eff. mg/l	COD % Rem.	O & G Inf. mg/l	O & G Eff. mg/l	O & G % Rem.	TKN Inf. mg/l	TKN Eff. mg/l	TKN % Rem.	TIP Inf. mg/l	TIP Eff. mg/l	TIP % Rem.
NC	NC	10	18.7	17.5	5				0.95	1.10		0.14	0.13	7
NC	NC	15	17.3	13.4	23	58.0	55.8	4	0.91	2.10		0.12	0.17	
NC	NC	20	20.7	18.2	12				1.19	1.03	13	0.16	0.10	34
NC	NC	25	18.5	18.8					1.03	1.38		0.15	0.15	
NC	PO	15				55.6	53.4	5	4.10	3.40	17	0.29	0.23	22
PO	NC	10	20.4	17.0	17				2.80	1.80	35	0.56	0.33	41
PO	NC	15	15.2	13.7	10				2.80	1.42	49	0.61	0.22	64
PO	NC	20	53.5	30.9	42				2.20	1.80	18	0.67	0.30	55
PO	NC	25	20.4	22.4					2.80	1.68	40	0.51	0.20	60
PO	PO	10							2.03	1.72	15	1.34	0.37	72
PO	PO	20							1.83	1.69	8	1.34	0.22	84
PO	PO	25							1.83	1.82	1	1.34	0.75	44
PO	AP	15							2.23	1.81	19	1.49	0.58	61
PO	AP	20							2.23	1.78	20	1.49	0.19	87
PO	AP	25							2.23	1.75	22	1.49	0.23	85
AP	NC	15				27.6	24.4	12	3.94	3.50	11	0.45	0.32	29
AP	NC	20				40.8	26.8	34	8.91	7.82	12	2.27	1.50	34
AP	NC	25				31.6	18.0	43	2.90	2.06	29	0.20	0.27	
AP	PO	15				27.6	12.1	56	4.03	3.36	17	0.42	0.09	79
AP	PO	20				40.8	20.0	51	8.91	7.90	12	2.27	0.67	70
AP	PO	25				30.8	15.6	50	2.76	2.40	13	0.85	0.23	73
AP	AP	15				37.4			4.82	2.80	42	0.89	0.10	89
AP	AP	20				40.8	24.0	41	8.9	8.30	7	2.27	0.99	56
AP	AP	25				86.0	40.8	53	8.2	8.05	2	1.60	1.28	20

(continued)

*NC - no chemical treatment
PO - polymer treatment only
AP - alum + polymer treatment

TABLE 24. (continued)

Treatment* On P/S	Treatment* On DMHRF	Flux gpm/ft²	pH Inf.	pH Eff.	Al Inf. mg/l	Al Eff. mg/l	Al % Rem
NC	NC	10	7.01	7.03	0.70	0.52	26
NC	NC	15	7.16	7.20	0.45	0.03	93
NC	NC	20	6.89	7.08	0.86	0.51	41
NC	NC	25	6.94	6.80	0.72	0.65	10
NC	PO	15	6.92	7.00	0.60	0.05	92
PO	NC	10	7.16	7.25	2.53	0.71	72
PO	NC	15	7.20	7.14	3.10	1.90	39
PO	NC	20	7.16	7.28	1.52	0.82	49
PO	NC	25	7.10	6.95	2.60	0.16	94
PO	PO	10	7.35	7.40	2.53	0.85	66
PO	PO	20	7.30	7.42	2.70	1.55	43
PO	PO	25	7.30	7.28	2.70	1.56	42
PO	AP	15	7.19	7.11	1.83	0.77	58
PO	AP	20	7.19	7.37	1.83	1.83	
PO	AP	25	7.19	7.41	1.83	2.23	
AP	NC	15	6.23	6.38	16.55	12.10	27
AP	NC	20	4.07	4.15	96.00	80.50	16
AP	NC	25	6.53	6.51	10.82	6.97	38
AP	PO	15	6.08	6.57	12.17	4.63	76
AP	PO	20	4.07	4.15	96.00	67.10	30
AP	PO	25	6.18	6.42	12.88	7.56	41
AP	AP	15	5.51	6.64	33.63	3.97	88
AP	AP	20	4.07	4.10	96.00	76.20	21
AP	AP	25	3.40	3.60	98.90	87.00	12

*NC - no chemical treatment
PO - polymer treatment only
AP - alum + polymer treatment

SECTION 10

ACTIVATED CARBON ADSORPTION

BACKGROUND

The polishing of the effluent from the flocculation/sedimentation (F/S) and dual-media high-rate filtration (DMHRF) processes may be desirable and necessary to provide a secondary quality overflow effluent with respect to BOD_5 during wet-weather periods. Polishing of dry-weather flows at the VanLare plant may also be a direct benefit of having facilities designed to serve a dual purpose. The carbon facilities would be available to provide additional BOD_5 removal capability for dry-weather flows. During wet-weather conditions the carbon facilities could be switched over to provide treatment of the effluent directly related to either the CSO treatment tanks (flocculation/sedimentation basins) or, in the event of future plant expansion, the high-rate filtration process.

OUTLINE OF EXPERIMENTS

Evaluations of the carbon adsorption system were very limited. An outline of the experiments is presented in Table 25.

TABLE 25. ACTIVATED CARBON OPERATING CONDITIONS

Storm No.	Influent Origin	Detention Time (min)
13	DMHRF	45.0
16	F/S	13.5, 19.3, 30.0
17	F/S	13.5, 19.3, 30.0

Investigations conducted during Storm No. 13 were performed on filter effluent applied to the carbon columns at a rate of 0.19 l/s (3 gpm), which provided a detention time of 45 min at a surface flux of 57.4 l/min m^2 (1.41 gpm/ft^2). BOD_5 removal rates were evaluated for Storm No. 16 over a lower range of detention times (13.5, 19.3 and 30.0 min) with surface flux at 17.1-38.3 l/min m^2 (0.42-0.94 gpm/ft^2). These investigations were performed on the effluent from the F/S basin operating at 61.2 m^3/day m^2 (1500 gpd/ft^2) and chemically treated with alum and polymer.

BOD removal rates for Storm No. 17 were also evaluated over the same range of detention times and surface flux for Storm No. 16 and at a hydraulic loading rate of 81.6 m^3/day m^2 (2000 gpd/ft^2) on the F/S basin.

RESULTS

The major goal of pilot testing of the carbon adsorption system was to compare BOD_5 removal rates with detention time. BOD_5 removal results associated with Storm Nos. 16 and 17 are presented in Figures 42 and 43, respectively. Figure 42 showed a significant improvement in the removal of BOD_5 when the detention time was increased from 13.5 to 19.3 minutes. No improvement, however, was experienced when the detention time was further increased to 30 minutes.

The results depicted in Figure 43 suggest that for Storm No. 17, within the range of detention times investigated, variation in the detention time had minimal effect on the BOD_5 removal efficiency of the carbon facilities. The disparity between these results and those attained for Storm No. 16 may be attributed to the different influent BOD_5 levels experienced in each storm. Influent BOD_5 in Storm No. 16 ranged from 16 to 46 mg/l while those associated with Storm No. 17 ranged from 52 to 79 mg/l.

BOD_5 removal results for Storm No. 13 are shown in Figure 44. Influent BOD_5 experienced during this investigation were similar to those experienced in Storm No. 16. A comparison of the results from these two storms indicates that there was no enhancement in the BOD_5 removal efficiency when the detention time was increased beyond 30 minutes. This shows that for an influent BOD_5 range of approximately 15 to 50 mg/l, there appears to be an optimum detention time for BOD_5 removal between 13.5 and 30.0 minutes.

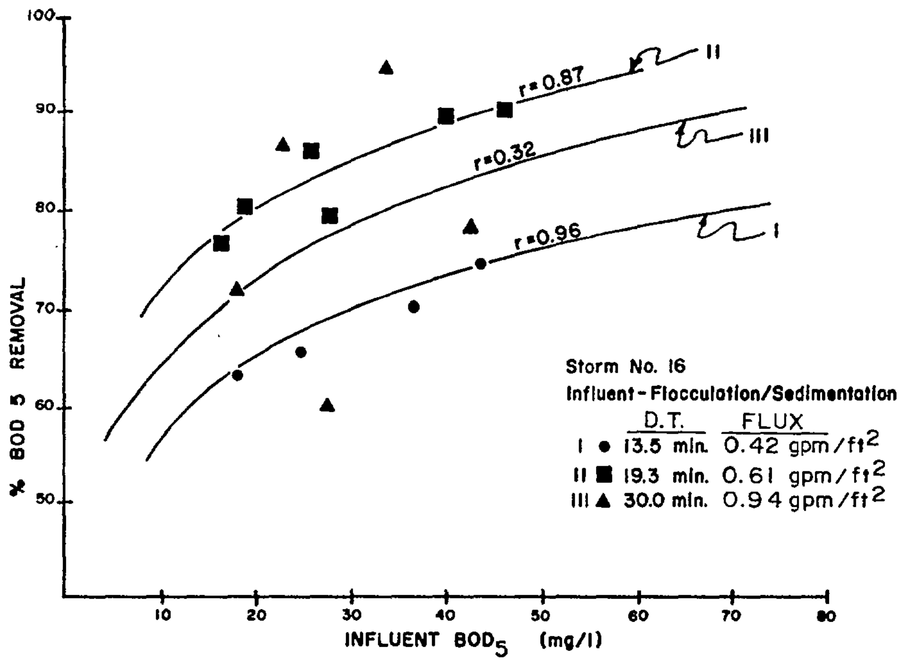


FIGURE 42. BOD_5 Removal with Carbon Adsorption. Low Influent BOD_5 concentration

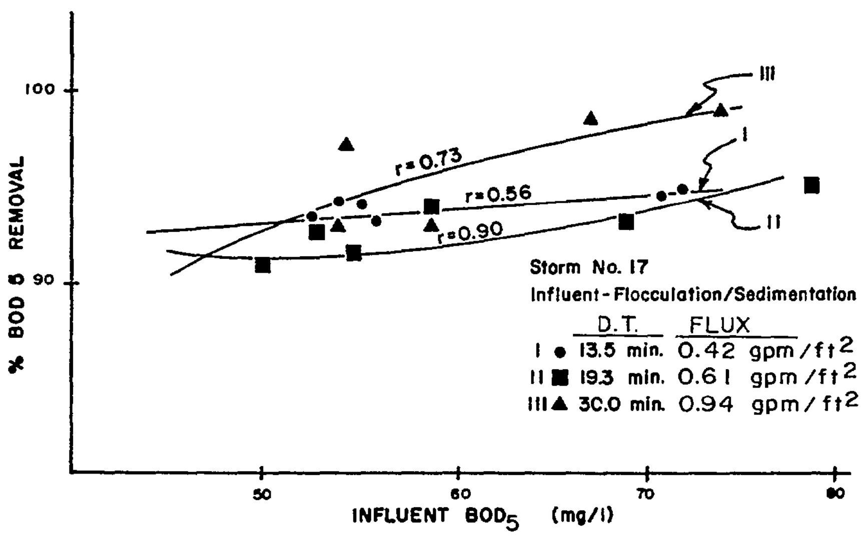


FIGURE 43. BOD_5 Removal with Carbon Adsorption. Higher Influent BOD_5 concentration

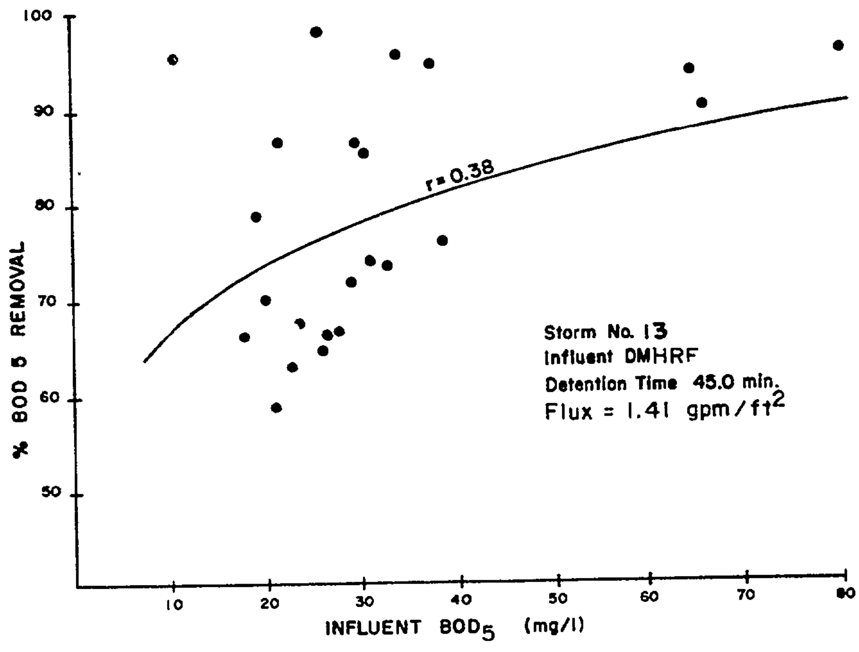


FIGURE 44. BOD_5 Removal With Carbon Adsorption

SECTION 11

HIGH-RATE DISINFECTION

BACKGROUND

Studies on disinfection of simulated combined sewer overflow (SCSO) in Syracuse, N.Y. (42) indicated that bacterial reductions occur rapidly in the presence of free chlorine (Cl_2). As the level of chlorine demanding substances in wastewater increases, the amount of free Cl_2 available as a bactericide significantly reduces. Ridenaur and Ingols (43) have hypothesized that chlorine dioxide (ClO_2) has an advantage over Cl_2 as a bactericide since it is less reactive with reduced substances present in wastewater.

The Syracuse studies (42) stated that the time of existence of free Cl_2 in the SCSO was very limited. They also reported that following the initial steep bacterial reduction brought about by the free Cl_2, there followed a gradual decrease in the bacterial population over an extended period of time. This second and lower rate of disinfection has been attributed to the combined form of Cl_2, which is considerably less powerful as a disinfection agent than free Cl_2. The work involving ClO_2 revealed that rapid bacterial kills were obtained within the first 30 seconds with little kill attained upon additional contact. It was concluded that ClO_2 itself is the disinfection species and its decomposition product ClO_2^- has very little disinfecting capability. It was also concluded that on a weight basis, ClO_2 is approximately twice as effective as Cl_2 in reducing bacterial populations to target levels. The Syracuse study (42) also observed an enhancement in the disinfection process with a two-stage (sequential) addition involving the application of Cl_2 followed by ClO_2 after an initial contact time of 15 to 30 seconds. It was hypothesized that this may be due to the regeneration of ClO_2 through the interaction of chlorite ion (ClO_2^-) and Cl_2.

Mixing has been shown to be a significant parameter in all disinfecting practices. In his report on a survey of a number of treatment plants in the San Francisco Bay area, White (44) found that all of the plants exhibiting good disinfection had good mixing.

The influence of mixing intensity on bacterial kills with Cl_2 has been demonstrated by Collin (45) and Kruse (46). The use of the velocity gradient (G) as a measure of the mixing intensity was first proposed by Camp and Stein (47) in 1943. More recently, the non-dimensional expression, GT, has been associated with the effective mixing intensity. In this expression, G represents the velocity gradient and T is the nominal contact time in the disinfection chamber. Glover (26,49) reported that disinfection performance can be considered a function of the GT parameter and suggested that as the value of GT increases, disinfection is enhanced. Glover (49) also proposed the use of initial flash mixing and corrugated baffles in the disinfection chamber as an inexpensive means of increasing the GT value.

TEST PROGRAM

The intent of the disinfection program was to evaluate the performances of Cl_2 and ClO_2 in a high-rate disinfection application. Since CSO treatment involves capital facilities that are not operated full-time, it may be desirable to reduce the capital cost of the facilities at the expense of operating and chemical costs. If ClO_2 reacts faster and more effectively than Cl_2, as has been experienced in previously mentioned studies, the higher applied chemical cost associated with ClO_2 may be offset by lower capital costs.

As a result of the bench-scale studies on high-rate disinfection conducted in Syracuse, N.Y. (42), two-stage disinfection with Cl_2 and ClO_2 was evaluated in the Rochester pilot plant. It was considered possible that a more cost-effective alternative to single-stage disinfection could be developed if there were an improvement in the level of disinfection realized by two-stage application using Cl_2 and ClO_2.

The disinfection program also sought to define the type and level of mixing which is necessary to optimize the disinfection process. It was anticipated that if an optimum level of mixing could be established, it might prove advantageous to reduce capital costs by lowering process contact times.

The equipment involved in performing the disinfection studies is presented in Section 4. Testing was conducted in three parts. During storm events, the three disinfection systems were operated at three different dosage rates with all other conditions being identical. This allowed for the evaluation of the effect of the changes in chemical demand during the storm which could be attributed to organic and nitrogenous substances. This type of evaluation was conducted for both single-stage and two-stage disinfection. The latter part of the test program included the evaluation of different mixing conditions.

Following each storm, the disinfection systems were run using swirl primary separator and/or microscreen effluents collected prior to and following filtration. This allowed for further evaluations of the effects of solids levels on disinfection. In addition, the post-storm disinfection allowed for the evaluation of a larger array of dosages, detention times, and mixing conditions. During the holding period the quality of the stored wastewater remained relatively stable.

Part three of the disinfection studies included a number of tests utilizing dry-weather flow. These permitted the supplementary evaluation of the effect of chemical demand and solids loadings on the disinfection process.

Operating conditions for the wet- and dry-weather tests are outlined in Tables 26 and 27. The variables controlled in these tests were dosage, detention time, and mixing intensity.

TABLE 26. SUMMARY OF WET-WEATHER DISINFECTION OPERATING CONDITIONS

Storm No.	Influent Origin	D.T.††† (min)	Mixing	Cl_2 Dose (mg/l)	ClO_2 Dose (mg/l)
1-5	F/S*	1.8-5.6	CORR**	0	
6	F/S	1.8-5.6	CORR	0	2-12
	DMHRF	1.1-8.4	CORR	0	3-10
7	F/S	1.8-5.6	CORR	0	3-10
	DMHRF	1.1-8.4	CORR	0	2-9
8	F/S	1.8-5.6	CORR	0	2-9
	DMHRF	1.1-8.4	CORR	0	2-8
9	F/S	1.8-5.6	CORR	2-19	0
	DMHRF	1.1-8.4	CORR	6-19	0
10	F/S	1.8-5.6	CORR	4	0
11	F/S	1.8-5.6	CORR	4-14	0
12	F/S	1.8-5.6	CORR	6-15	0
	DMHRF	1.1-5.6	CORR	6-15	0
13	F/S	1.8-5.6	FM††,SFM§§,CORR	4	0
	DMHRF	1.8-5.6	FM SFM ,CORR	4	0
15	F/S	1.8-5.6	CORR	2	1,2,3
	DMHRF	1.1-5.6	CORR	2	1,2,3(Cl_2 First)
	DMHRF	1.8-5.6	FM,SFM,CORR	2	2
16	CC §	1.3-3.8	CORR	0	2,4,6
	DMHRF	1.1-3.4	FM,SFM,CORR	0	0
				4,6,8	4,6,8
17	CC	1.3-3.8	FM	4,6,8	0
	DMHRF	1.8-5.6	FM	0-12	0-6(Cl_2 First)

(continued)

TABLE 26. (continued)

Storm No.	Influent Origin	D.T. (min)	Mixing	Cl_2 Dose (mg/l)	ClO_2 Dose (mg/l)
18	F/S	1.8-5.6	FM,SFM,CORR	0	5
	P/S***	1.8-5.6	FM,SFM,CORR	0	4,6,8
				2,4,6	0
19	F/S	1.8-5.6	FM,SFM,CORR	1,2,3	1,2,3 (Cl_2 First)
	P/S	1.8-5.6	FM,SFM,CORR	1,2,3	1,2,3 (ClO_2 First)

*F/S - Flocculation/Sedimentation
†DMHRF - Dual-Media High-Rate Filter
§CC - Activated Carbon Columns
**CORR - Corrugated Baffles
††FM- Single Flash Mix
§§SFM - Sequential Flash Mix
***P/S - Swirl Primary Separator
†††D.T. - Detention Time

TABLE 27. SUMMARY OF DRY-WEATHER DISINFECTION OPERATING CONDITIONS

Storm No.	Influent Origin	D.T. (min)	Mixing	Cl_2 Dose (mg/l)	ClO_2 Dose (mg/l)
65	F/S	1.8-5.6	CORR	4,6,8	0
66	F/S	1.8-5.6	CORR	4,6,8	2,4,6
69	P/S	1.8-5.6	CORR	4,6,8	0
			FM,SFM,CORR	1-4	1-4 (Cl_2 First)
70	P/S	1.8-5.6	FM,SFM,CORR	1,2,3	1,2,3 (ClO_2 First)
76	P/S	1.8-5.6	FM	0	4,6
				6,8	0

SINGLE STAGE TREATMENT: CHLORINE VERSUS CHLORINE DIOXIDE

Multiple Regression Analysis

In order to evaluate the effects of the operating conditions and variable wastewater quality it was considered desirable to develop a mathematical model from the disinfection data. Multiple regression analysis was thus conducted to statistically fit an equation to the pilot plant data and to develop an optimal design configuration for treating CSO.

The final equation selected for the multiple regression analysis was:

$$\log \text{kill} = K_1 (C)^{K_2} (G)^{K_3} (DT)^{K_4} (10)^{K_5 \, TKN + K_6 BOD} \qquad (1)$$

where log kill = log Influent F. Coli-log Effluent F. Coli

C = concentration of disinfectant, mg/l

G = velocity gradient, min^{-1}

D.T. = detention time, min

TKN = concentration of TKN, mg/l

BOD = concentration of BOD_5, mg/l

K_1 through K_6 = constants

The relation between D.T. and log kill was based on the first-order relationship normally referred to as Chick's law (51), i.e.:

$$\frac{dN}{dt} = -kN \qquad (2)$$

where dN/dt = time rate of kill

k = rate constant

N = number of living microorganisms

Equation 2 may be rearranged (11) to yield:

$$t = \frac{2.3}{K} \log \frac{N_1}{N_2} \qquad (3)$$

where N_1 and N_2 = number of microorganisms living initially and at time, t, respectively.

Equation 3 suggested a linear relationship between the contact time and the log kill.

The relationship between the concentration of the disinfectant and the time required for the disinfection process has been suggested (52) as follows:

$$t = \frac{k''}{C^n} \qquad (4)$$

where t = time required to kill a given percentage of microorganisms

C = concentration of disinfectant

n = coefficient of dilution

k" = constant.

Equation 4 suggested the use of the factor C^K in the regression model (equation 1).

Use of the term, G, in equation 1 was based on a review of Glover's (49) work with high-rate disinfection of CSO. Examination of Figure 2 presented in reference 49 indicated a straight line relationship between the log (log kill) and the log GT:

$$\log(\log \text{kill}) = m \log GT \qquad (5)$$

where m = slope

GT = measure of mixing intensity, unitless.

Equation 5 can be further reduced to:

$$\log \text{kill} = (GT)^m = G^m T^m$$

where G = velocity gradient, t^{-1}

T = contact time

Most relationships developed in the literature between disinfectant dosage and kill are presented in terms of disinfectant residual. Disinfectant residual is a function of dosage as well as contact time and concentrations of reduced substances present in the wastewater (53). In order to develop a mathematical relationship between kill and dosage it was therefore necessary to include BOD_5 and TKN data, as these parameters affect the ability to maintain a disinfectant residual.

In addition to the variables presented in Equation 1, a number of other possible variables were tested in the multiple regression analysis. Changes in pH, temperature, suspended solids concentrations, and volatile solids concentrations did not show statistically significant effects with the disinfection system performance data.

Tables 28 and 29 present the results obtained from the regression analysis conducted on the Rochester pilot plant data. The regression coefficient values correspond to the exponential K values in equation 1. The value of K_1 in equation 1 is equal to 10^i where i is equal to tne intercept value. The magnitude of the regression coefficient gives an indication of the relative importance of this term in the regression expression. In the case of disinfection by Cl_2, positive regression coefficients associated with the dosage, detention time, and velocity gradient signify that as these values increase, the value of the log kill also increases. The negative signs associated with the TKN and BOD indicate that as these values increase the value of the log kill decreases.

TABLE 28. MULTIPLE REGRESSION ANALYSIS RESULTS FOR DISINFECTION BY Cl_2

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log C_1	0.820	0.193	0.605	0.662	0.059	11.21
Log T	0.511	0.202	0.110	0.456	0.119	3.82
C_2	3.80	2.56	-0.205	-0.00431	0.00433	-0.996
C_3	36.1	25.0	-0.503	-0.00456	0.00052	-8.83
Log (G)	4.43	0.193	-0.137	0.280	0.125	2.24
Dependent Log(Log $\frac{N_1}{N_2}$)	0.466	0.265				

Intercept	-1.37
Multiple Correlation	0.727
Std. Error of Estimate	0.183

Analysis of Variance for the Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	5	10.74	2.14	63.7
Deviation from Regression	284	9.57	0.0337	
Total	289	20.3		

TABLE 29. MULTIPLE REGRESSION ANALYSIS RESULTS FOR DISINFECTION BY ClO_2

Variable	Mean	Standard Deviation	Correlation X vs Y	Regression Coefficient	Std. Error of Reg. Coef.	Computed T Value
Log C_1	0.525	0.216	0.548	0.628	0.0797	7.88
Log T	0.500	0.210	0.031	0.0781	0.139	0.560
C_2	3.17	1.16	0.157	0.00314	0.0139	0.224
C_3	25.1	13.6	-0.00719	-0.00719	0.00156	-4.61
Log (g)	4.42	0.201	-0.0241	0.0502	0.146	0.343
Dependent Log(Log $\frac{N_1}{N_2}$)	0.399	0.204				

Intercept	-0.0212
Multiple Correlation	0.698
Std. Error of Estimate.	0.150

(continued)

TABLE 29. (continued)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Attributable to Regression	5	1.88	0.377	16.7
Deviation from Regression	88	1.98	0.0225	
Total	93	3.87		

Multiple regression analysis with the ClO_2 data also produced positive regression coefficients for the dosage, detention time, and velocity gradient and a negative regression coefficient for BOD_5. The magnitude of the standard error of the regression coefficient and the T value associated with the TKN indicate that the effect of this parameter is fairly insignificant.

The 'T' value designates the degrees of confidence with which the corresponding regression coefficients may be assumed to be statistically significant. In the case of Cl_2 disinfection, the 'T' values for the dosage, detention time, and BOD_5 correspond to a degree of confidence greater than 99.5 percent. The 'T' value associated with the velocity gradient, G, represents a degree of confidence greater than 95 percent, while that associated with the TKN indicates less than a 70 percent degree of confidence. The 'T' values associated with BOD_5 and the ClO_2 dosage indicate degrees of confidence greater than 95 percent each.

The 'T' values for ClO_2 disinfection associated with detention time, velocity gradient, and TKN represent degrees of confidence lower than 50 percent, 30 percent, 20 percent, respectively. These low values indicate that variations of these parameters did not account for variations in performance. The 'F' value in the multiple regression analysis gives an indication of the statistical significance of the entire regression expression. 'F' values associated with both the Cl_2 and ClO_2 regression analysis represent degrees of confidence greater than 99 percent.

The final regression equations obtained from the Rochester pilot plant data are as follows:

$$\log \text{kill} = .0422(C)^{.662}(G)^{.280}(DT)^{.456}(10)^{-.00431TKN-.00456BOD} \quad (6)$$

for Cl_2, and

$$\log \text{kill} = .952(C)^{.628}(G)^{.0502}(DT)^{.0781}(10)^{.00314TKN-.00719BOD} \quad (7)$$

for ClO_2.

Lists of the multiple regression analysis input data and the regression residuals for both Cl_2 and ClO_2 are presented in Appendix E.

Illustrative Trends of the Regression Model

Subsequent to their development, the regression models were used to investigate the separate effects of the independent variables on the disinfection unit performance. Variation in unit performance was first evaluated with respect to mixing intensity and detention time. Plots of performance versus GT were developed using detention times of 1, 4, and 30 minutes. These detention times were selected in an effort to compare the model results with the results Glover (49) obtained using a Cl_2 residual of 5 mg/l. A Cl_2 dosage of 8 mg/l in the Cl_2 regression model roughly corresponds to the Cl_2 residual of 5 mg/l used by Glover (49). The 4 mg/l ClO_2 dosage in the ClO_2 regression model is roughly comparable to an 8 mg/l Cl_2 dose. Values for TKN and BOD_5 used in this model analysis were the average values experienced in the Rochester studies.

Plots of Glover's (49) results along with the results obtained using the regression models are presented in Figure 45. A comparison of the curves for Cl_2 shows similar trends. The slope of these curves indicates that disinfection with Cl_2 is greatly enhanced with an increase in mixing intensity. The slope associated with the ClO_2 curve implies that additional mixing does not produce a very significant change in bacterial reductions when ClO_2 is used as the disinfectant. Figure 45 also suggests that at very low mixing intensities and short contact times, ClO_2 is more effective than Cl_2 in reducing bacterial populations.

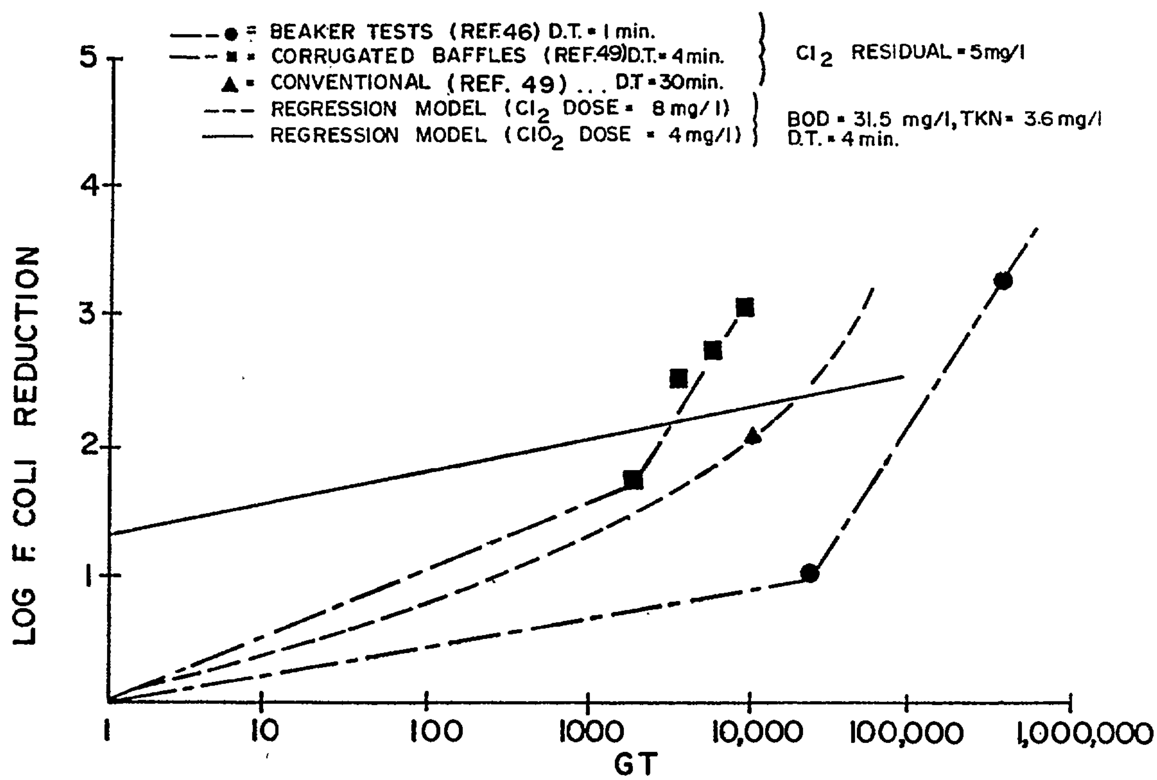


FIGURE 45. Comparison of Regression Model With Literature Results

Figure 46 is a plot of performance versus GT for different dosages of Cl_2 using the average TKN and BOD_5 values from the Rochester data. Apparent in Figure 46 is the influence of mixing intensity on Cl_2 disinfection effectiveness. This figure also suggests that there is a more pronounced effect on the performance when the Cl_2 dosage is varied at the higher mixing intensities.

A plot of performance versus GT for various ClO_2 dosages is presented in Figure 47 for average TKN and BOD_5 values. The slope of the curves indicates that mixing intensity has only a slight effect on the effectiveness of disinfection experienced with ClO_2. The distance between the curves suggests that increasing the ClO_2 dosage produces similar increases in bacterial kill, regardless of the mixing intensity. Comparison of Figures 46 and 47 shows ClO_2 to be a better disinfectant than Cl_2 at lower mixing intensities.

The effect of changing BOD_5 was the next area evaluated using the regression models. Figure 48 presents plots of performance versus dosage for both Cl_2 and ClO_2. BOD_5 values used in the analysis corresponded to half the average, the average, and twice the average of the BOD_5 values encountered in Rochester. Comparing the plots shows that lower dosages of ClO_2 are employed relative to those required when using Cl_2. The plots also indicate that variations in the BOD_5 level of the applied wastewater produce significant changes in the disinfection effectiveness of Cl_2 and $ClO2$, the greatest sensitivity observed for ClO_2.

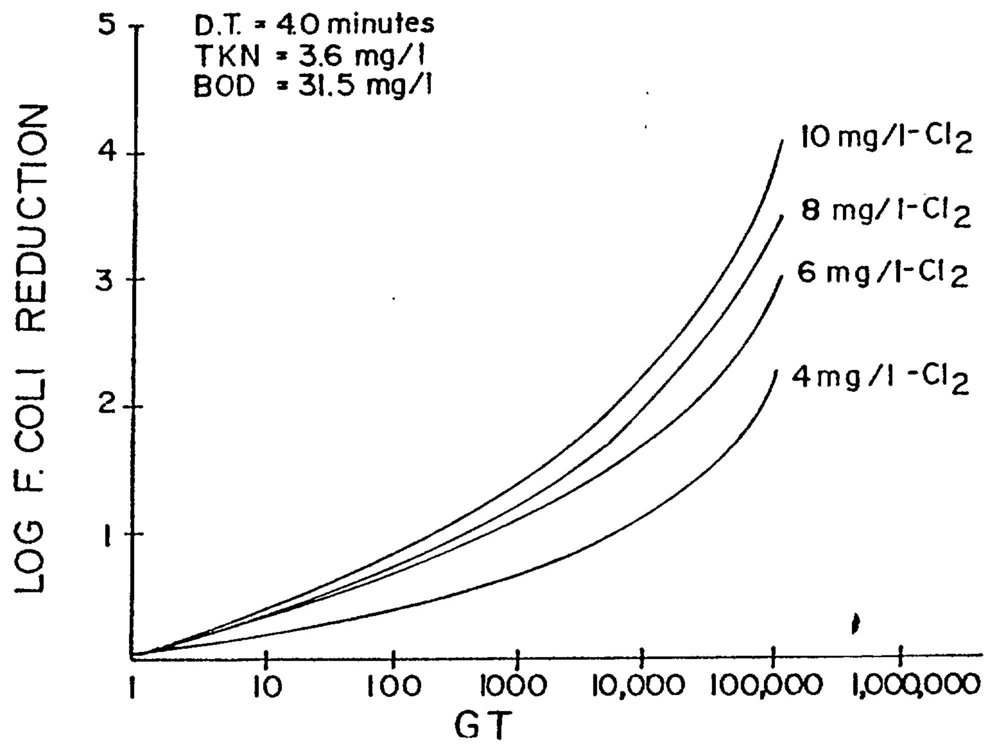


FIGURE 46. Effect of Cl_2 Dose in Regression Models

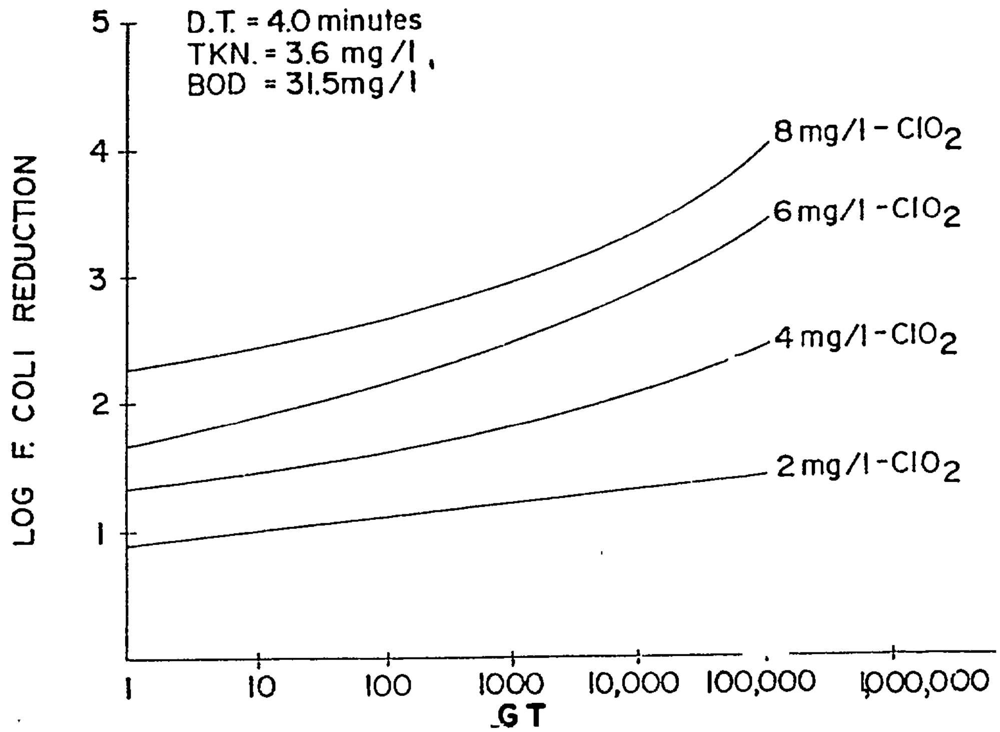


FIGURE 47. Effect of ClO_2 Dose in Regression Models

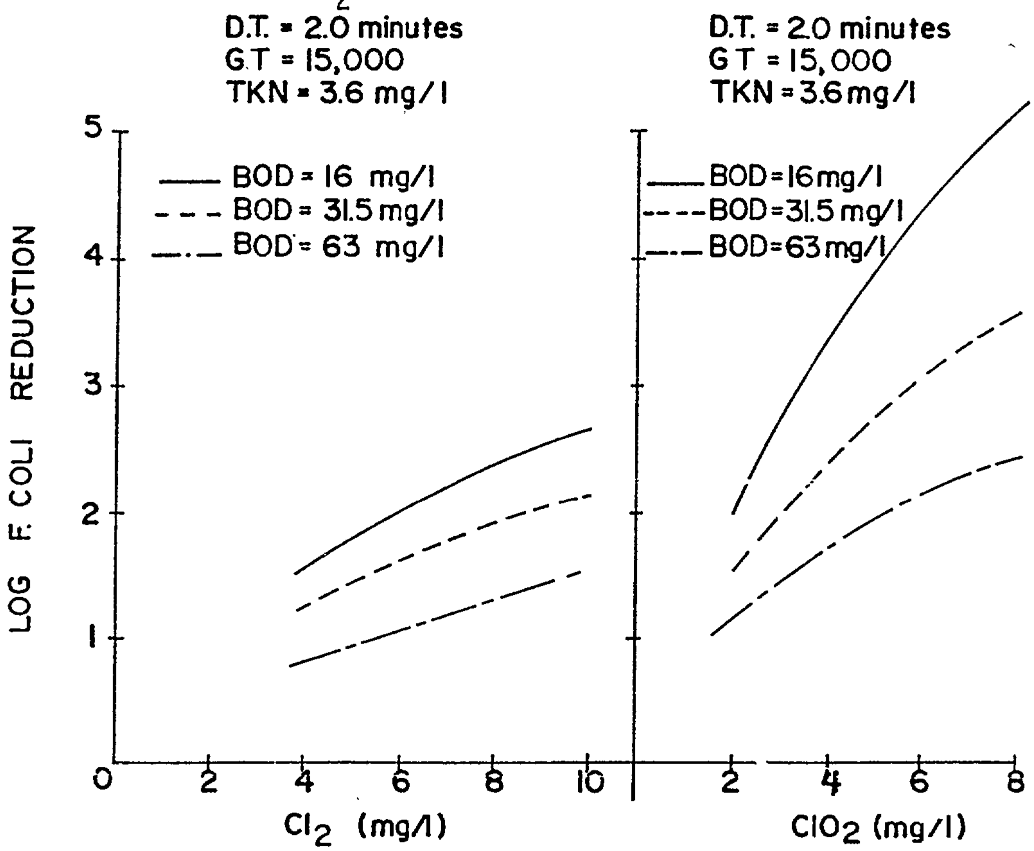


FIGURE 48. Effect of BOD_5 in Regression Models

A similar sensitivity analysis was conducted using the TKN information. Results of this analysis are presented in Figure 49. The set of curves for both Cl_2 and ClO_2 indicates that variation in the TKN levels produces a fairly insignificant effect on the bacterial reductions experienced with either of these two disinfectants.

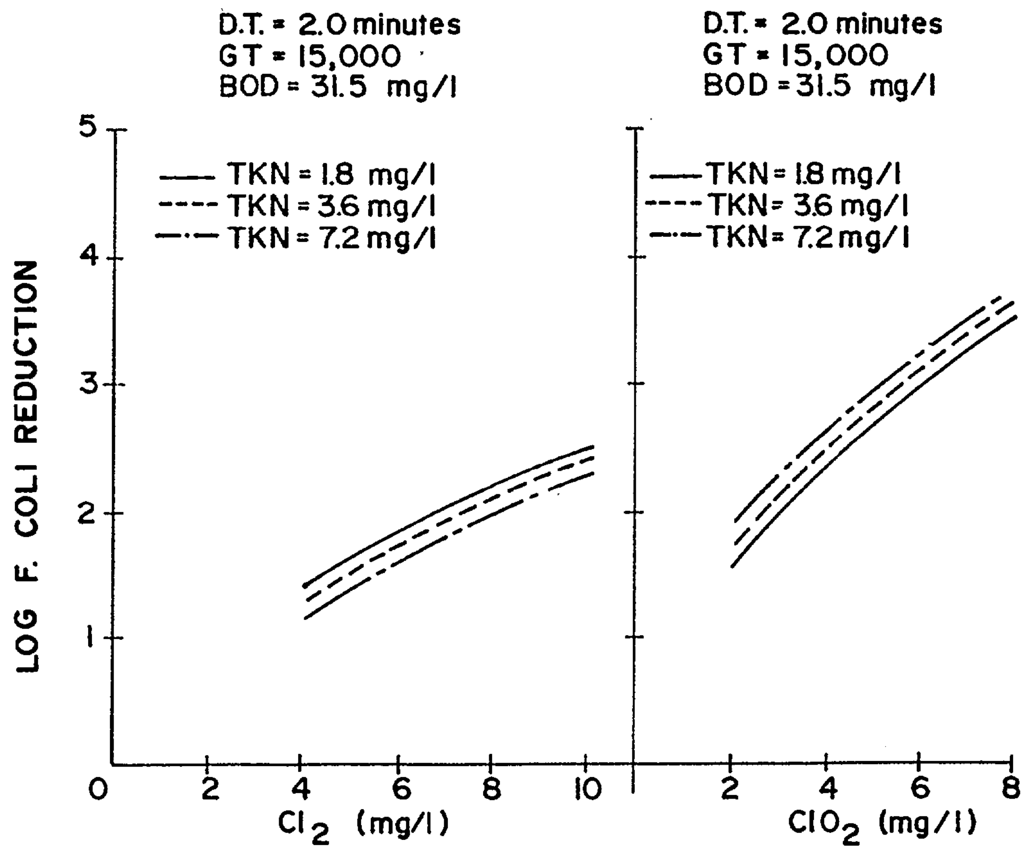


FIGURE 49. Effect of TKN in Regression Models

Figures 50 and 51 indicate the correlation between actual data and performance predicted by the regression equations.

Cost/Benefit Analysis

Design factors such as G, D.T., and dose affect both capital and operation/maintenance costs as well as the performance of the disinfection treatment facilities. It was the objective of the cost/benefit analysis to determine the combination of design factors necessary to develop the most cost-effective facility for the disinfection of combined sewer overflows.

Disinfection cost equations have been developed from the cost curves presented in reference (54). Capital costs for the disinfection facilities are presented as a function of the size of contact chamber and the amount of mixing provided. All costs have been adjusted to the ENR construction cost index of 2480.

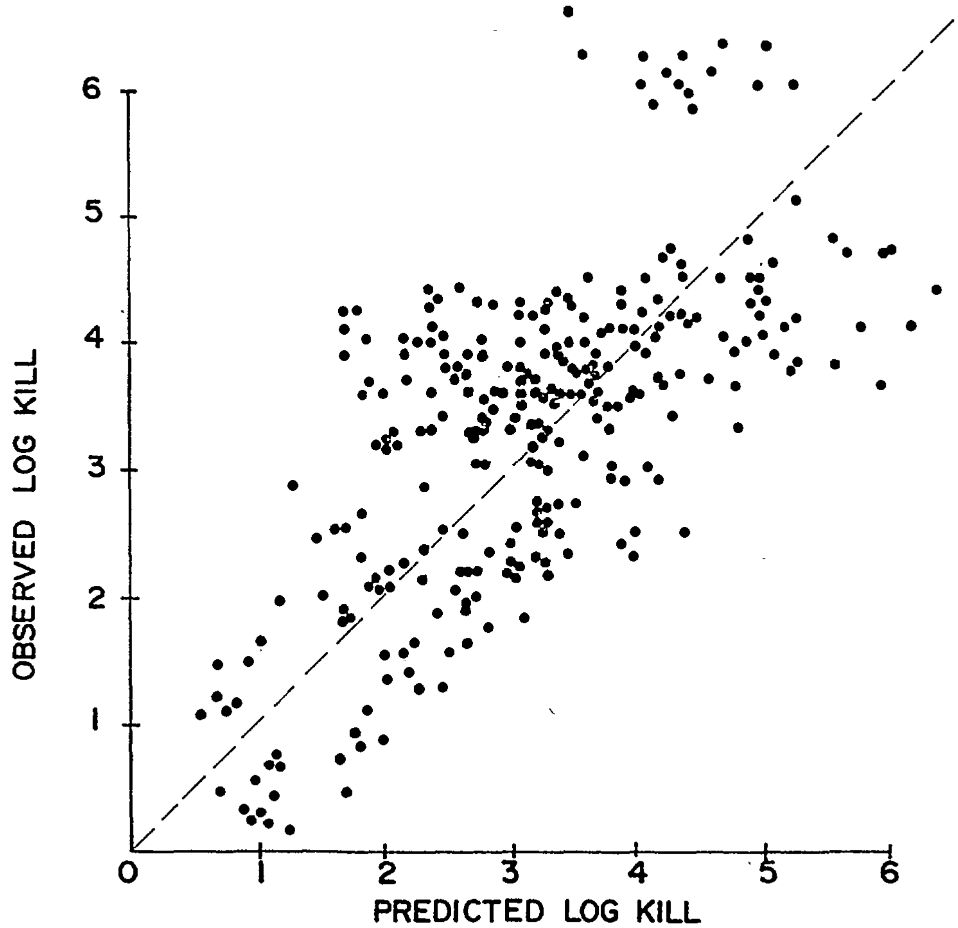


FIGURE 50. Predicted vs. Observed Bacterial Reductions for Chlorine

$$\text{CAPITAL COST (\$)} = 10.229\,(G)^{.5668}\,(V)^{.65} \quad (8)$$

where G = velocity gradient, sec^{-1}

V = volume of contact chamber, ft^3

When the capital costs are amortized over 20 years at an interest rate of 6 percent, the following yearly cost is attained:

$$\text{CAPITAL COST (\$/yr)} = 0.89176\,(G)^{.5668}\,(V)^{.65} \quad (9)$$

Using the cost curve relating manpower requirements to the size of a rapid mix basin, the following equation is developed:

$$\text{MAN-HOURS} = 0.04867\,(OF)^{.78031}(V)^{.633} \quad (10)$$

where OF = number of overflow events per year

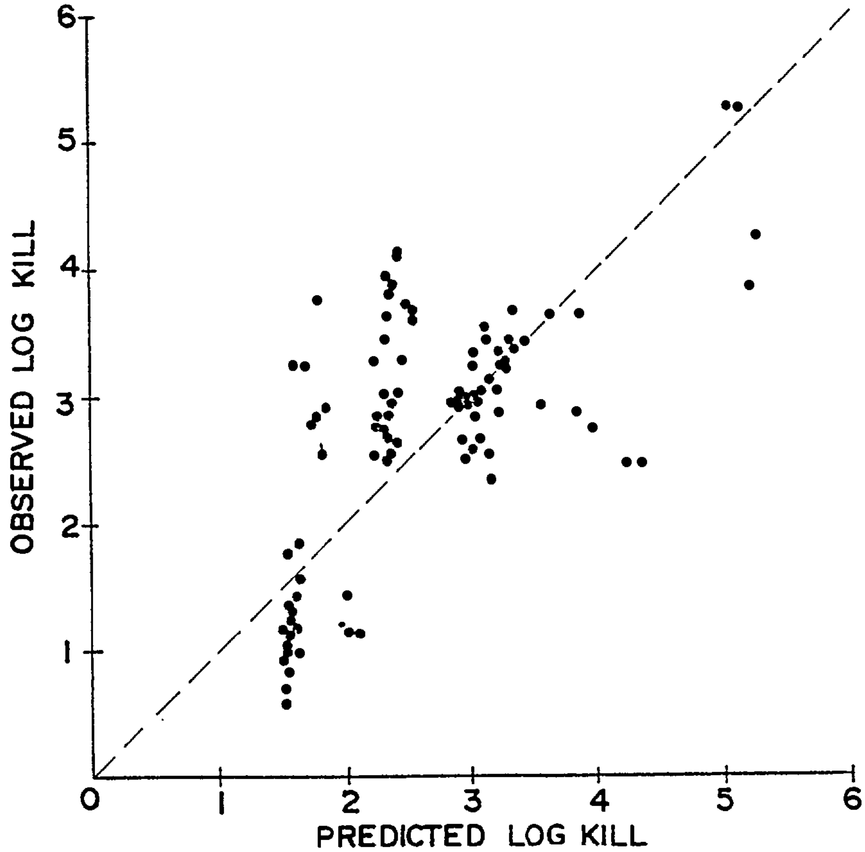


FIGURE 51. Predicted vs. Observed Bacterial Reductions for Chlorine Dioxide

For the purposes of the cost/benefit analysis, all overflows in the Rochester area under the application of the two-year design storm were considered eliminated and all wet-weather flow was assumed treated at central facilities. It was also assumed that a rainfall of 2.5 mm (0.10 in) would produce enough runoff to warrant the operation of these facilities. Averaging the number of days per year in which the rainfall in Rochester exceeded 2.5 mm (0.10 in) (1961-1975). Equation 10 yields:

$$\text{MAN-HRS/yr} = 1.4431\ (V)^{.633} \quad (11)$$

Assuming a manpower cost of \$15/hr, the final operation and maintenance cost equation becomes:

$$\text{O \& M COST (\$/yr)} = 21.646\ (V)^{.633} \quad (12)$$

Transformation of the material and supply cost curves produced the following:

$$\text{M \& S COST (\$/yr)} = 1.0768\ (V)^{.6404} \quad (13)$$

The expression relating costs to power requirements, assuming a charge of \$.025/KWH, was found to be:

$$\text{PWR COST(\$/yr)} = \frac{G^2V}{257{,}875} \quad (14)$$

Chemical costs were based on a total yearly treatment of 17,600 m^3 (4651 mil gal), which corresponds to the average yearly quantity of wet-weather flow experienced in Rochester over the past ten years (1965-1975). Using a cost for Cl_2 of $0.10/lb, the chemical cost expression for Cl_2 becomes:

$$Cl_2 \text{ COST } (\$/yr) = 3878.9 \text{ (DOSE)} \quad (15)$$

where DOSE = disinfectant dosage, mg/l

Assuming a cost of $0.50/lb for ClO_2 the cost equation becomes:

$$ClO_2 \text{ COST } (\$/yr) = 19394.5 \text{ (DOSE)} \quad (16)$$

The cost equations were used to optimize facilities costs for a selected set of operating conditions. These operating conditions included the treatment rate, values of TKN and BOD_5, and the desired bacterial kill. Facilities costs were calculated for different detention times and disinfectant dosages and the minimum cost was determined along with optimum GT, dose, G, and D.T. values. In all of the optimization analyses, the treatment rate was fixed at 1041 m^3/day (275 mgd), which is the design rate of proposed wet-weather facilities for Rochester. An evaluation of facilities costs for three different quality conditions was performed using the cost optimization program. This was done for both Cl_2 and ClO_2. Minimum-cost facilities were developed for 3, 4, 5, and 6 log reductions of F. Coliforms. Comparisons were conducted employing wastewater quality representative of settled CSO, filtered CSO, and carbon adsorption effluent. Comparisons of the minimum total costs for the optimum Cl_2 and ClO_2 systems under these conditions are presented in Tables 30, 31, and 32. In most instances, the ClO_2 optimum systems exhibited lower detention times and GT values than the Cl_2 systems. However, because of the higher chemical costs associated with ClO_2, all of the Cl_2 optimum systems exhibited much lower total system costs than the ClO_2 systems. This apparently indicates that even in a high-rate application, utilization of Cl_2 instead of ClO_2 as the disinfectant will produce a more cost-effective disinfection facility.

Examples of two cost optimizations are shown in Figure 52 illustrating the trends obtained during the iteration procedure for determining the optimum cost system.

It is noted that attainment of high-rate disinfection employs chlorine dosages slightly higher than those normally encountered in conventional disinfection. It is recognized that such effluents may require dechlorination to protect receiving water aquatic life. The cost of these facilities has not been included in this analysis.

CHLORINE/CHLORINE DIOXIDE COMBINATIONS

Several tests were conducted during the Rochester studies to investigate two-stage disinfection with both Cl_2 and ClO_2. It has been suggested (42) that Cl_2 added 15 to 30 seconds prior to the addition of ClO_2, enhances disinfection. It was hypothesized that after the ClO_2 has been oxidized to ClO_2^-, any free Cl_2 also present might oxidize ClO_2^- back to ClO_2. It was further suggested (42) that this process may prolong the existence of the more potent disinfectant, ClO_2, and thus enhance disinfection beyond that expected by the sum of the respective concentrations of Cl_2 and ClO_2.

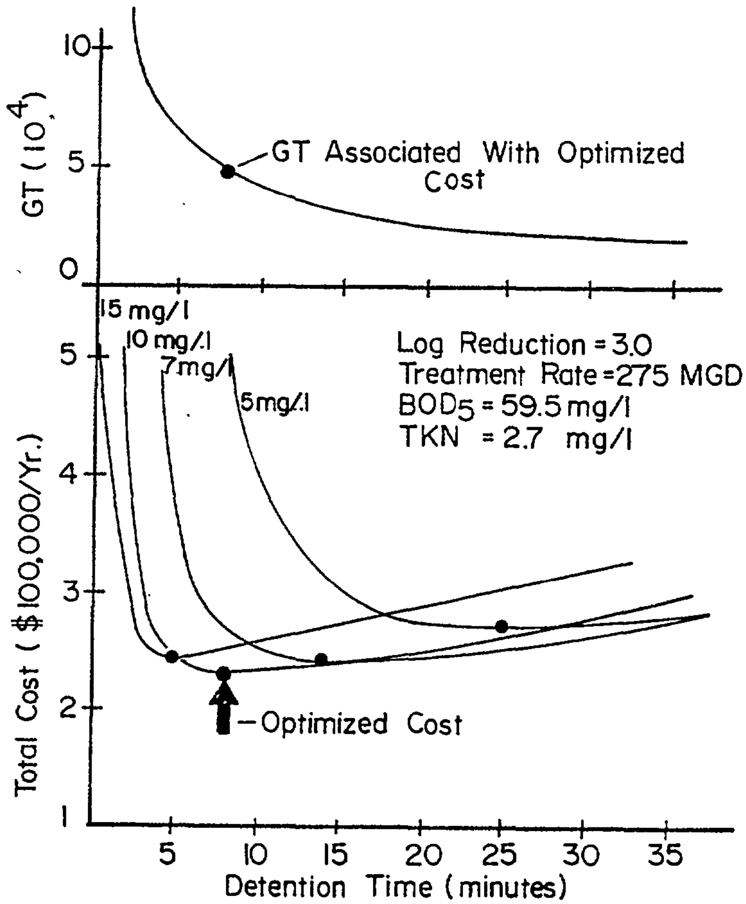


FIGURE 52. Optimization Trends

Storm No. 69 involved a series of tests on dry-weather flow comparing the disinfection performance of chlorine, chlorine dioxide, and various combinations of the two. These tests were conducted with Cl_2 added before ClO_2 and employed corrugated baffles. The results of the above tests are presented in Figures 53, 54, and 55. Figure 53 shows bacterial kill as a function of Cl_2 and ClO_2 doses for a 5.6 minute contact time. Iso-kill lines are interpolated between the observed data. This presentation indicates that ClO_2 causes the same bacterial kill as chlorine at roughly half the dosage. The fact that the iso-kill lines are nearly linear indicates that combination treatment does not exhibit a synergistic effect; combination treatment simply results in replacing a portion of one disinfectant with another.

Figures 54 and 55 represent the same test conditions but at contact times of 3.8 and 1.9 minutes. Again, the iso-kill lines are nearly linear. The slopes of the iso-kill lines presented in Figures 54 and 55 are greater, demonstrating that the contact time is less critical with ClO_2 than with Cl_2.

TABLE 30. COST OPTIMIZATION. CSO-PRIMARY EFFLUENT*

	Required Log Kill 3.0	4.0	5.0	6.0
Treatment With Chlorine Dioxide				
Minimum Cost ($/yr)	481,000	673,000	875,000	1,086,000
Optimum GT	26,400	48,800	63,400	86,400
Optimum Dose (mg/l)	12.0	17.8	24.1	31.0
Optimum D.T. (min)	4.0	7.0	11.0	15.0
Optimum G (sec^{-1})	110	102	96	96
Treatment With Chlorine				
Minimum Cost ($/yr)	232,000	279,000	322,000	362,000
Optimum GT	47,500	62,000	75,600	89,800
Optimum Dose (mg/l)	10.0	12.4	15.3	17.8
Optimum D.T. (min)	8.0	11.0	14.0	17.0
Optimum G (sec^{-1})	99	94	90	88

* At BOD_5 = 59.5 mg/l
TKN = 2.7 mg/l
Treatment Rate = 275 mgd

TABLE 31. COST OPTIMIZATION. CSO-FILTERED EFFLUENT*

	Required Log Kill 3.0	4.0	5.0	6.0
Treatment with Chlorine Dioxide				
Minimum Cost ($/yr)	201,000	278,000	357,000	440,000
Optimum GT	8,500	12,200	16,300	24,500
Optimum Dose (mg/l)	4.1	6.1	8.5	10.8
Optimum D.T. (min)	1.0	2.0	2.0	3.0
Optimum G (sec^{-1})	141	102	136	136
Treatment With Chlorine				
Minimum Cost ($/yr)	169,000	203,000	234,000	263,000
Optimum GT	30,900	39,900	48,500	57,000
Optimum Dose (mg/l)	6.4	8.1	10.1	11.7
Optimum D.T. (min)	5.0	7.0	8.0	10.0
Optimum G (sec^{-1})	103	95	101	95

* At BOD_5 = 12.6 mg/l
TKN = 2.0 mg/l
Treatment Rate = 275 mgd

TABLE 32. COST OPTIMIZATION. CSO-ACTIVATED CARBON EFFLUENT*

	Required Log Kill 3.0	4.0	5.0	6.0
Treatment With Chlorine Dioxide				
Minimum Cost ($/yr)	168,000	230,000	295,000	363,000
Optimum GT	6,800	10,000	13,900	16,400
Optimum Dose (mg/l)	3.2	4.9	6.6	8.7
Optimum D.T. (min)	1.0	1.0	2.0	2.0
Optimum G (sec^{-1})	113	167	116	137

(continued)

TABLE 32. (continued)

	Required Log Kill 3.0	4.0	5.0	6.0
Treatment With Chlorine				
Minimum Cost ($/yr)	159,000	190,000	219,000	245,000
Optimum GT	28,300	36,000	43,700	52,400
Optimum Dose (mg/l)	6.0	7.5	9.3	10.6
Optimum D.T. (min)	4.0	6.0	7.0	9.0
Optimum G (ec-1)	118	100	104	97

* At BOD_5 = 2.5 mg/l
TKN = 2.0 mg/l
Treatment Rate = 275 mgd

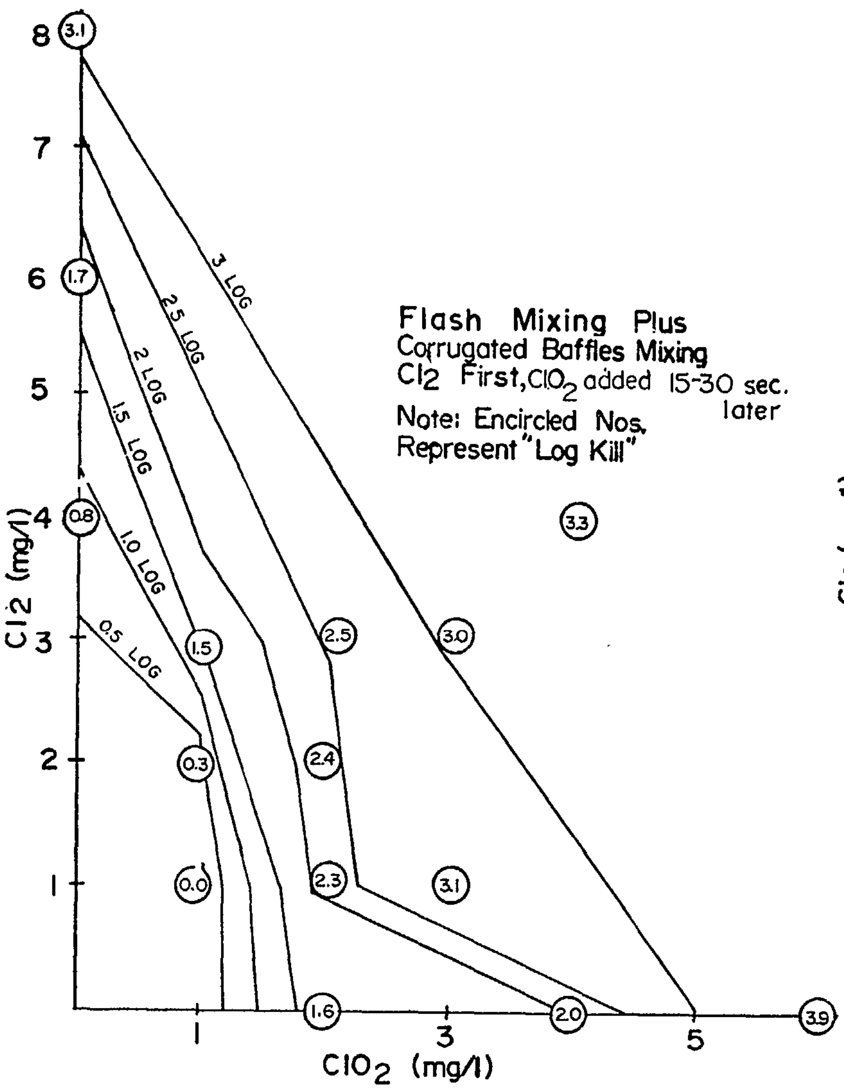


FIGURE 53. Two Stage Disinfection Iso-Kill Curves. Storm No. 69. Swirl Separator Effluent, D.T. In Disinfection Basin - 5.6 minutes

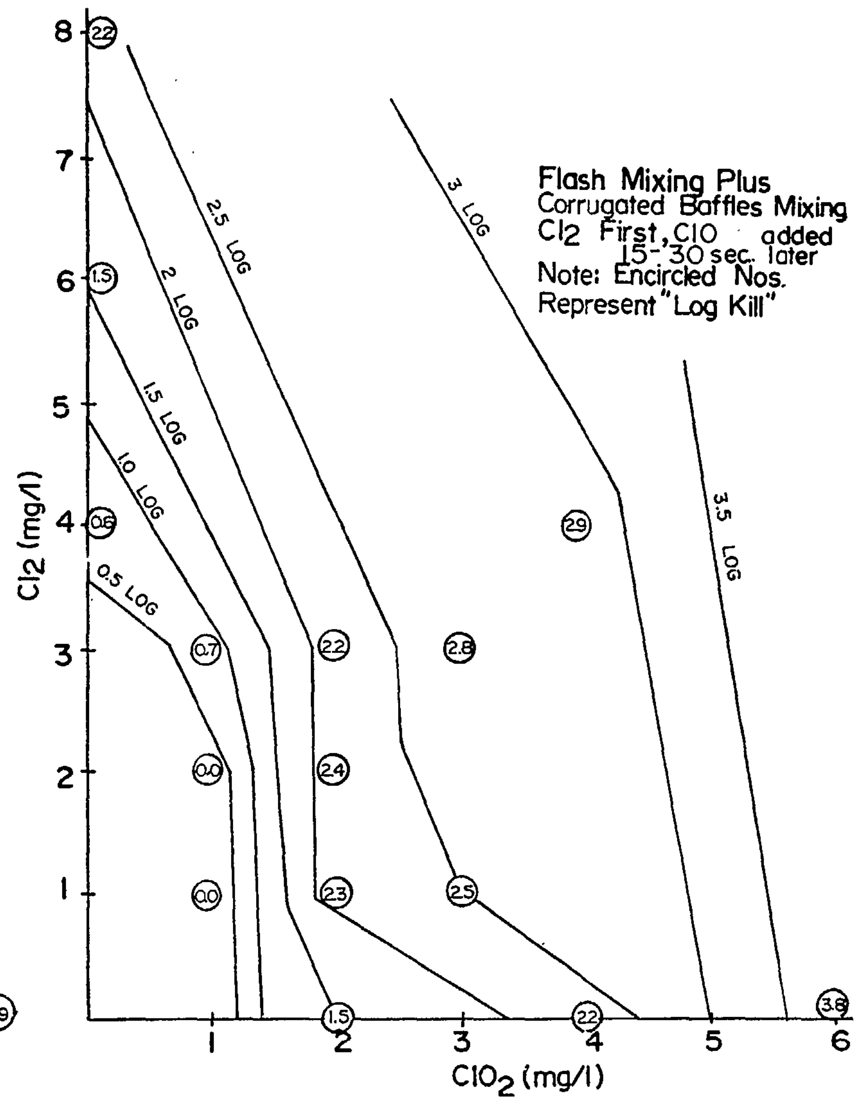


FIGURE 54. Two Stage Disinfection Iso-Kill Curves. Storm No. 69. Swirl Separator Effluent, D.T. In Disinfection Basin = 3.8 minutes

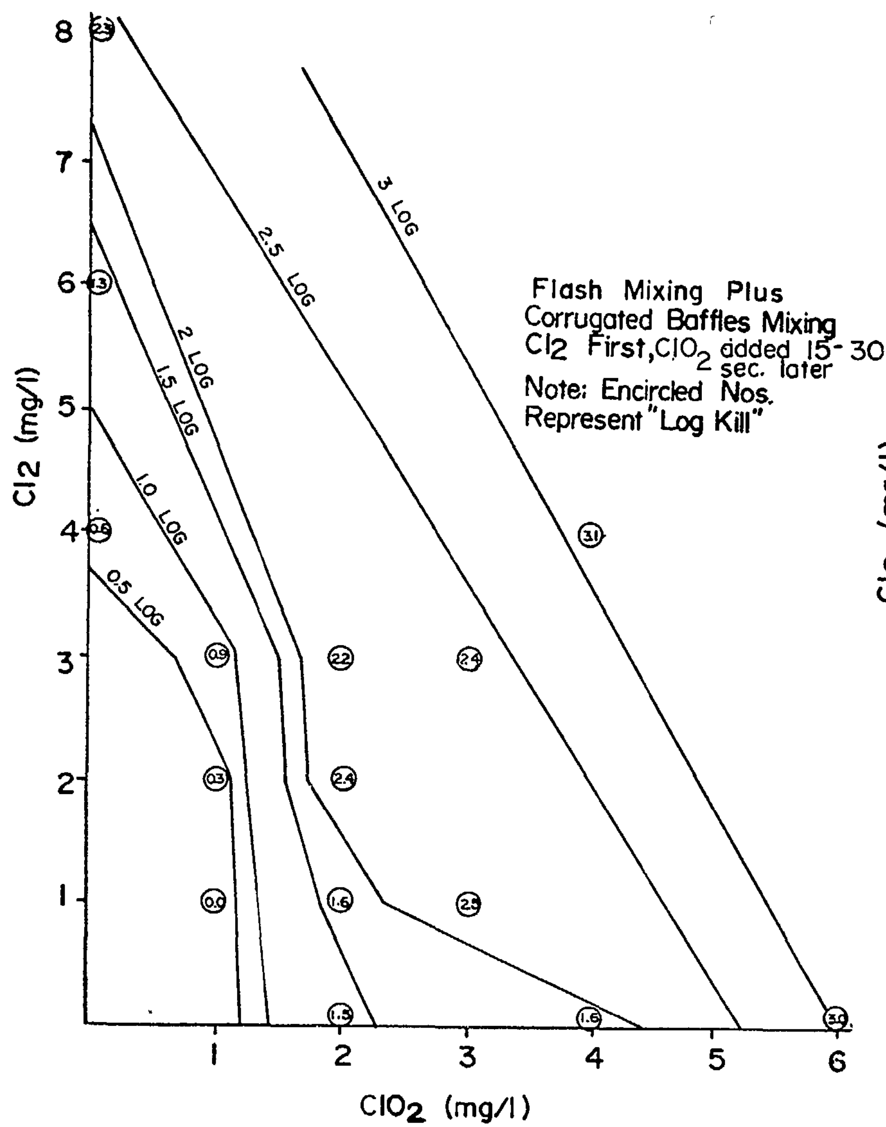


FIGURE 55. Two Stage Disinfection Iso-Kill Curves. Storm No. 69. Swirl Separator Effluent. D.T. in Disinfection Basin = 1.9 minutes.

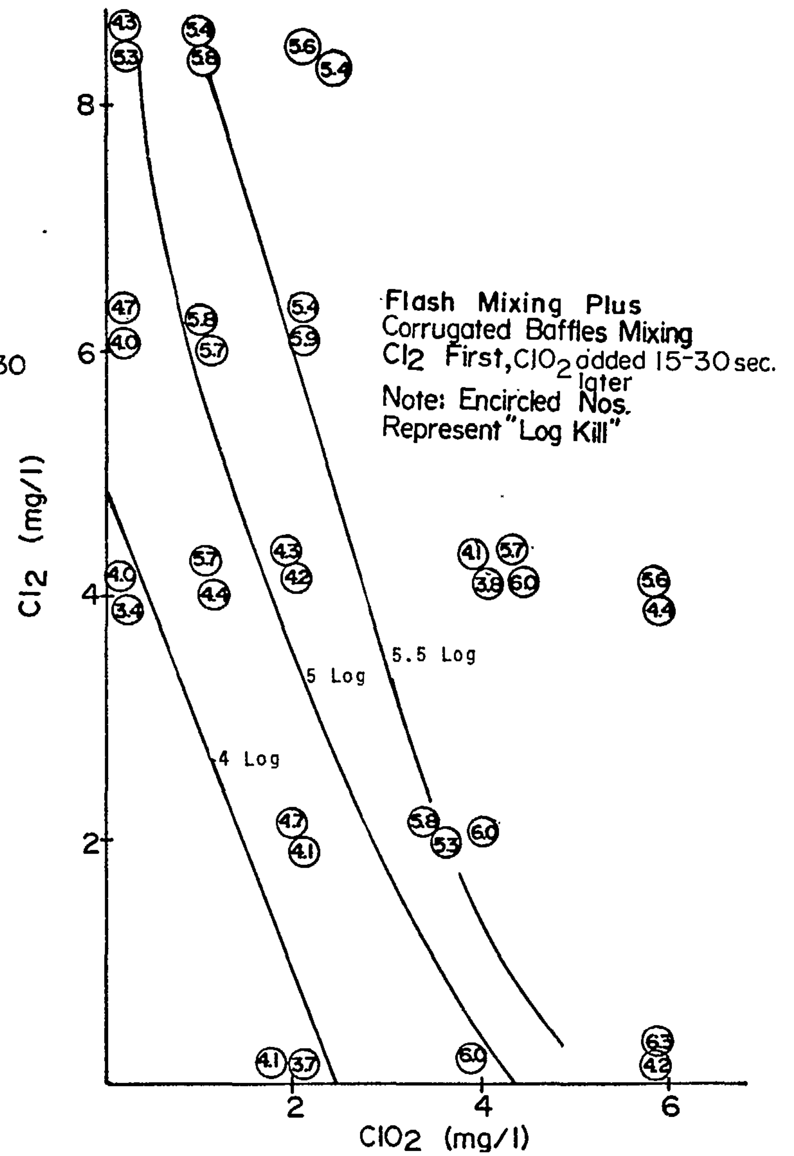


FIGURE 56. Two Stage Disinfection Iso-Kill Curves. Storm No. 17. DMHRF Effluent. D.T. in Disinfection Basin = 5.6 minutes.

Disinfection tests similar to those conducted during storm No. 69 were also performed for Storm No. 17. The results of these investigations are presented in Figures 56, 57 and 58. Again, a series of iso-kill lines were interpolated between the observed data. A comparison of these results with those obtained for Storm No. 69 reveals that similar trends were exhibited in both cases. The linear relations again illustrate no apparent synergistic effect on the combination treatment. Similar bacterial kills were again experienced with approximately half as much ClO_2 as Cl_2.

The effects of mixing and order of addition on two-stage disinfection were examined during Storms No. 19, 69 and 70. Figures 59 and 60 show the results obtained when these investigations were conducted on dry-weather flow (Storms No. 69 and 70). Wet-weather (Storm No. 17) results are presented in Figures 61, 62 and 63. Both series of tests implied that slightly higher bacterial kills are obtained when ClO_2 is introduced prior to the addition of Cl_2. Examination of the results also disclosed that in the majority of the tests, sequential flash mixing was more effective in reducing bacterial populations than were the other two mixing conditions (corrugated baffles and single flash).

A comparison of Figures 59, 60, 62 and 63 revealed that, at similar dosage combinations, greater bacterial reductions were achieved during the wet-weather investigations.

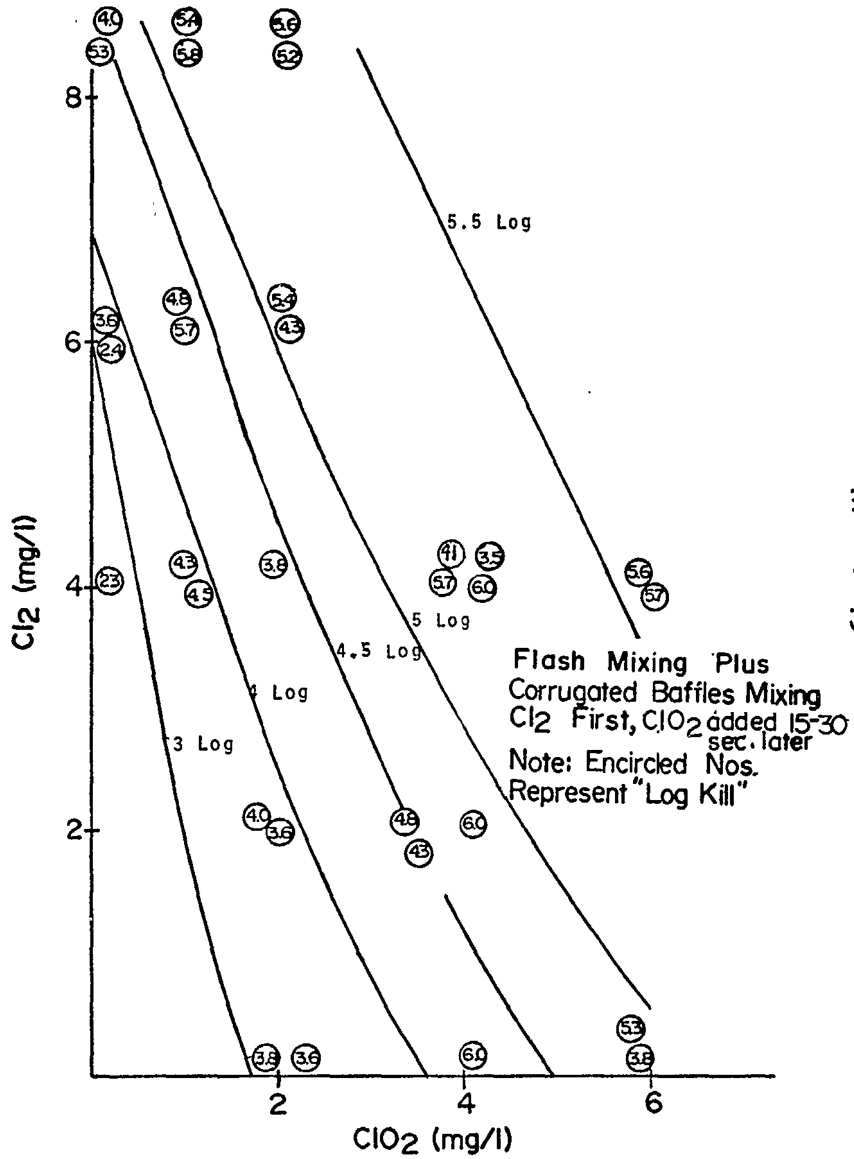


FIGURE 57. Two Stage Disinfection Iso-Kill Curves. Storm No. 17. DMHRF Effluent. D.T. In Disinfection Basin = 3.8 minutes

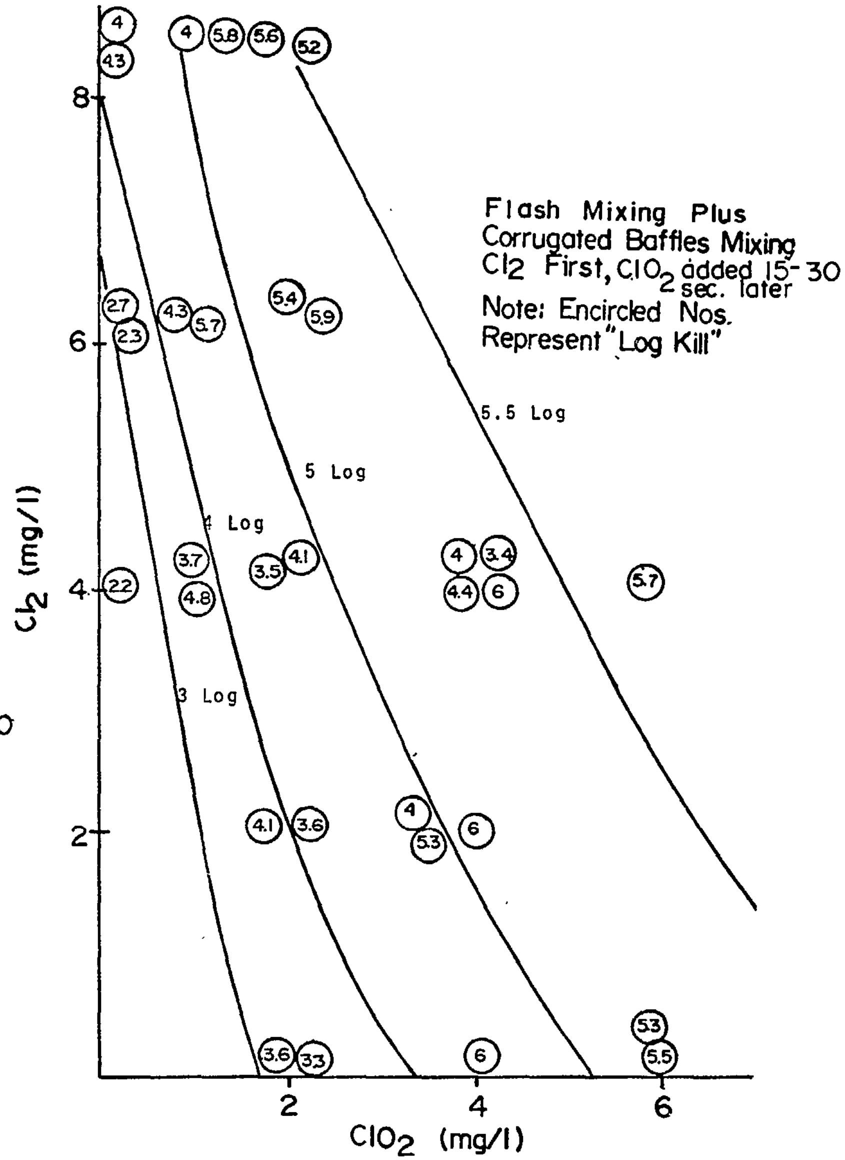


FIGURE 58. Two Stage Disinfection Iso-Kill Curves. Storm No. 17. DMHRF Effluent. D.T. In Disinfection Basin = 1.9 minutes

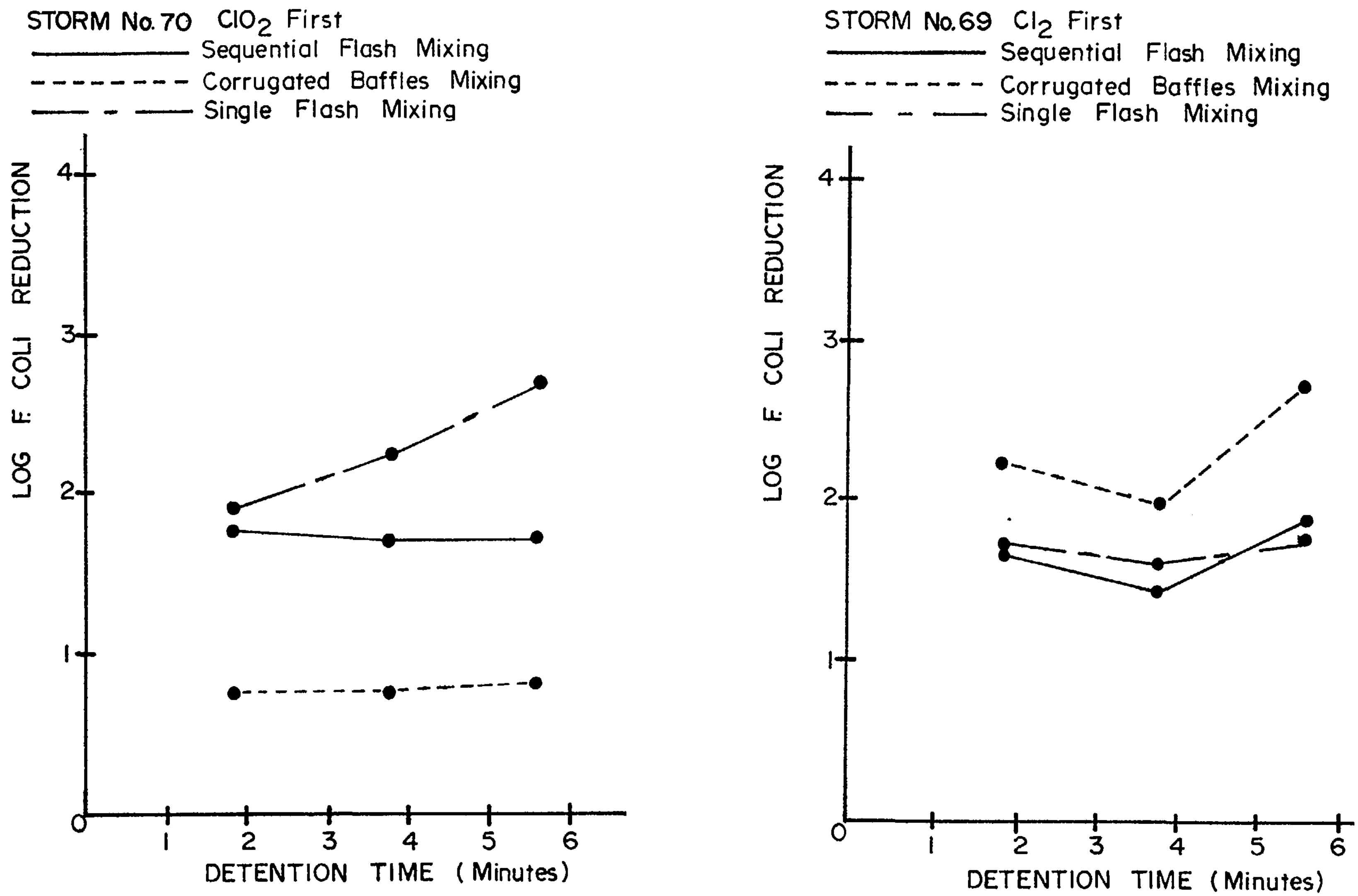


FIGURE 59. Comparisons of Order of Addition Cl_2 - ClO_2 Combinations. ClO_2 = 2 mg/l; Cl_2 = 2 mg/l

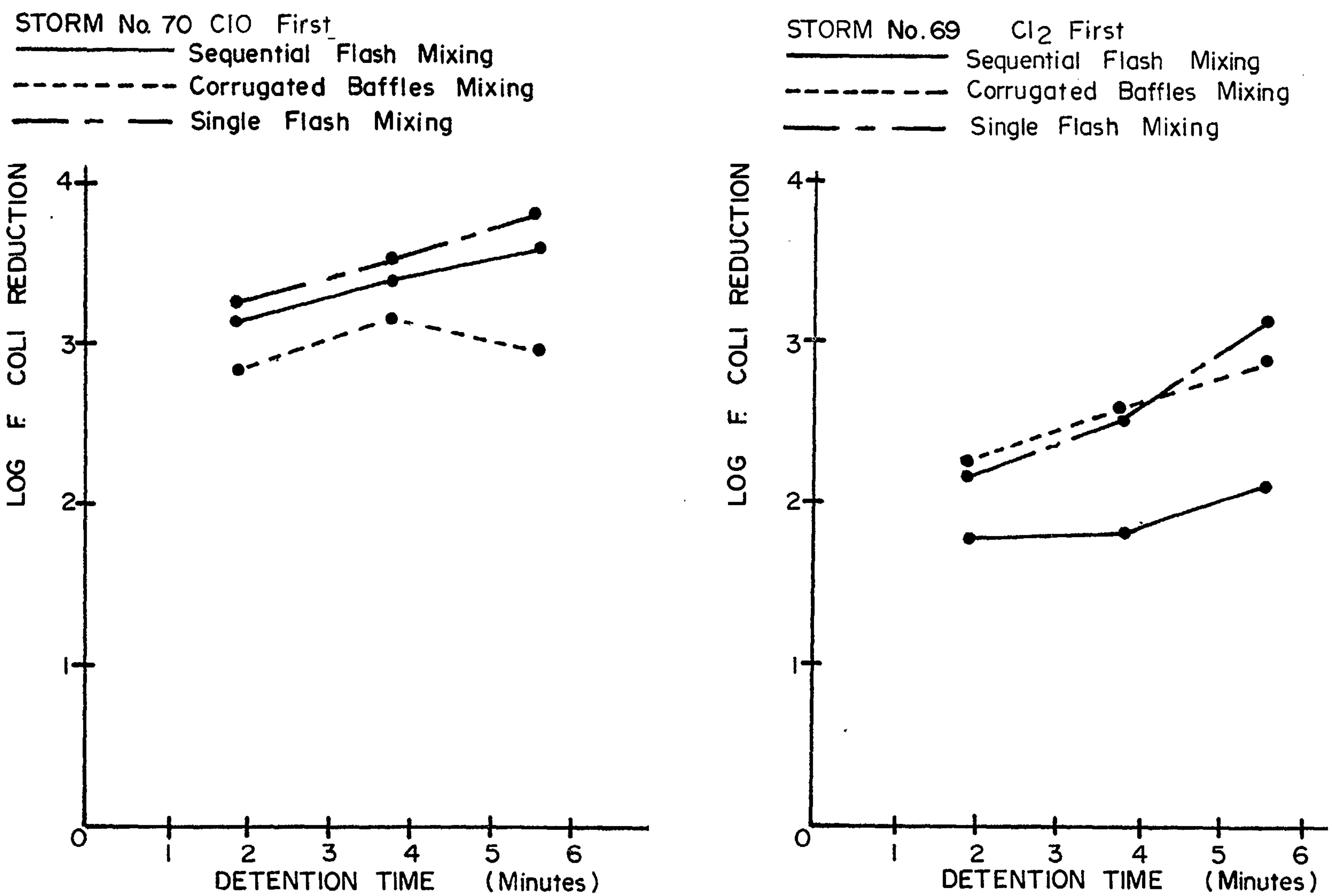


FIGURE 60. Comparison of Order of Addition Cl_2. - ClO_2 Combinations. ClO_2 = 3 mg/l; Cl_2 = 3 mg/l

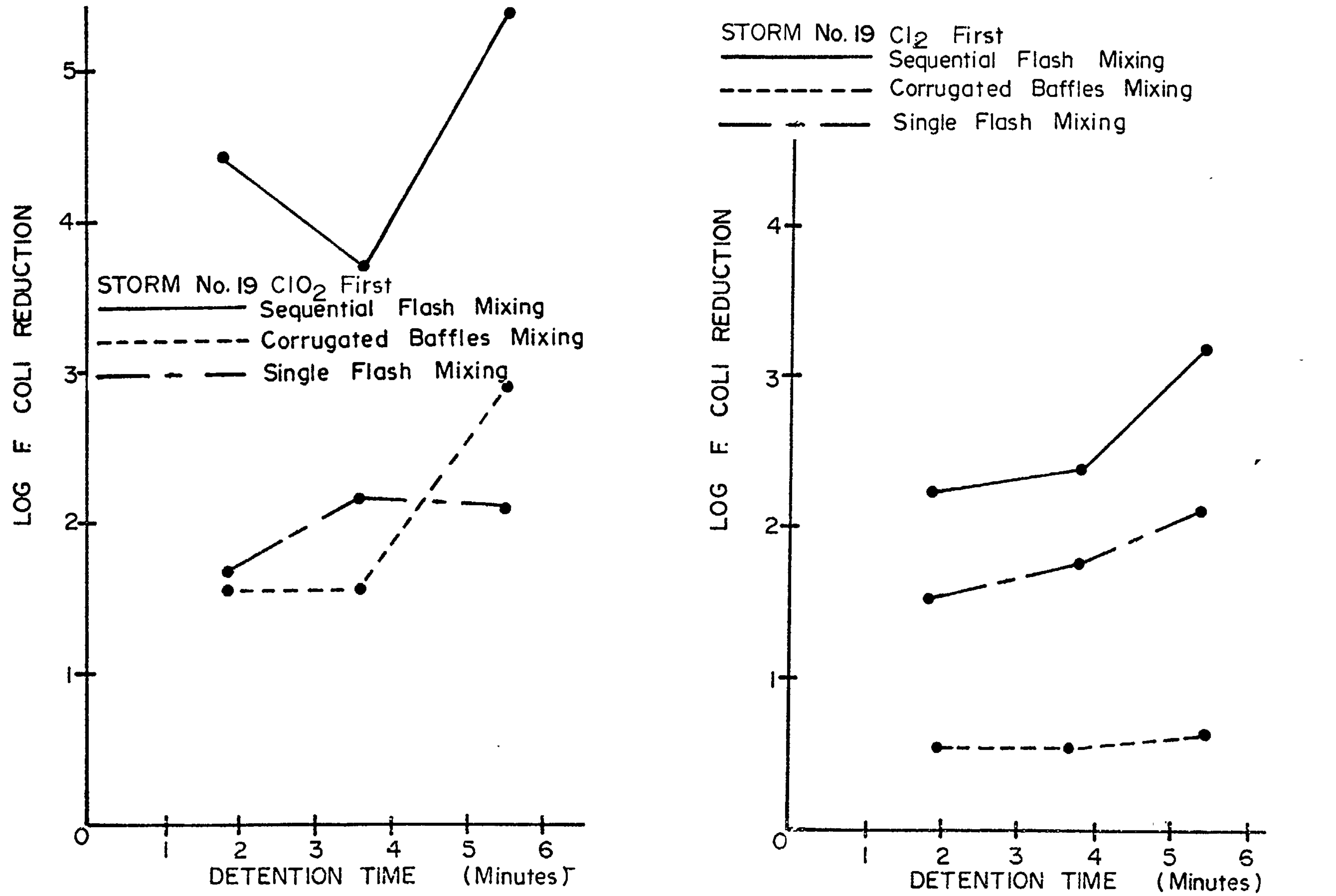


FIGURE 61. Comparison of Order of Addition Cl_2 - ClO_2 Combinations. ClO_2 = 1 mg/l; Cl_2 = 1 mg/l

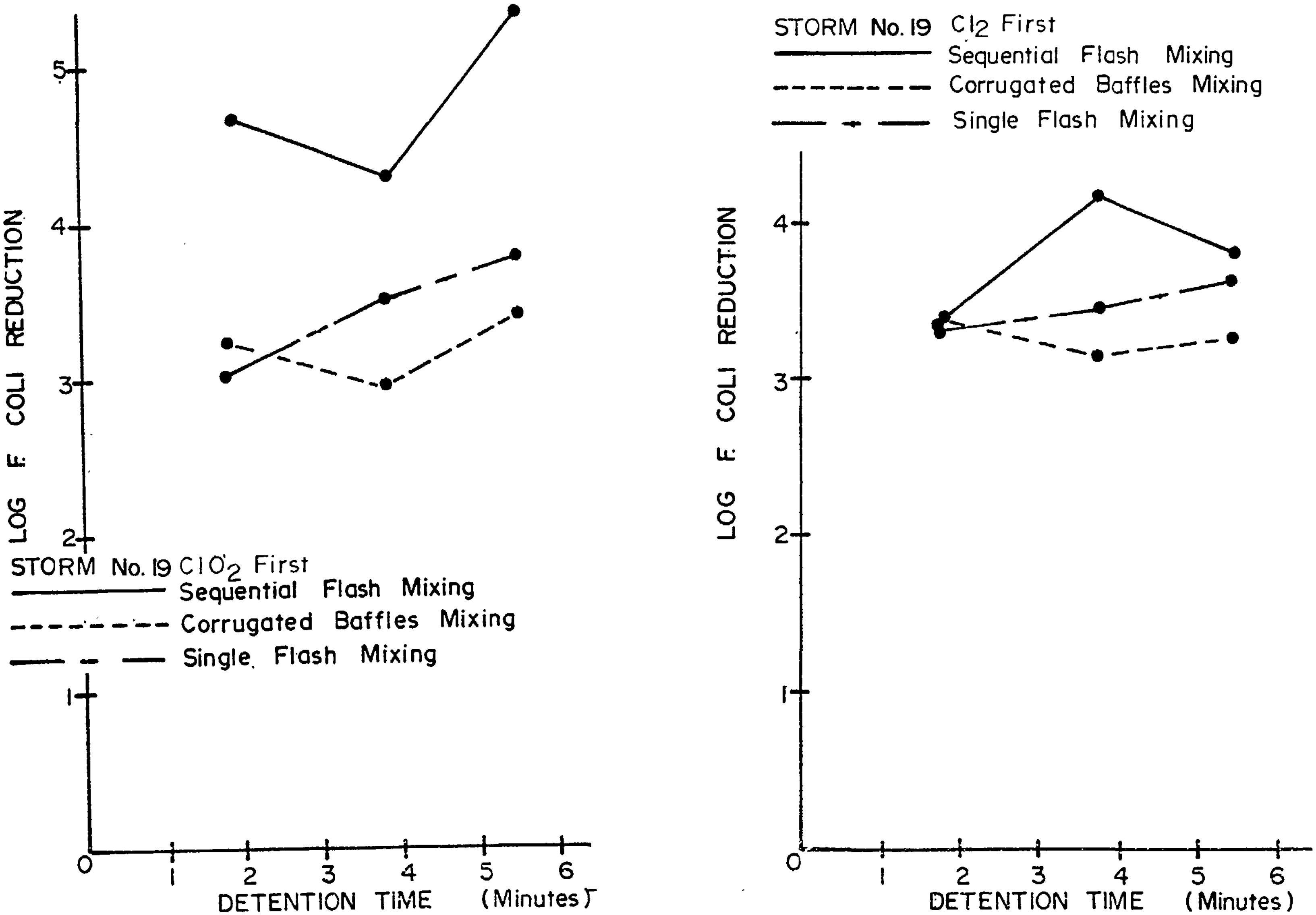


FIGURE 62. Comparison of Order of Addition Cl_2 - ClO_2 Combinations. ClO_2 = 2 mg/l; Cl_2 = 2 mg/l

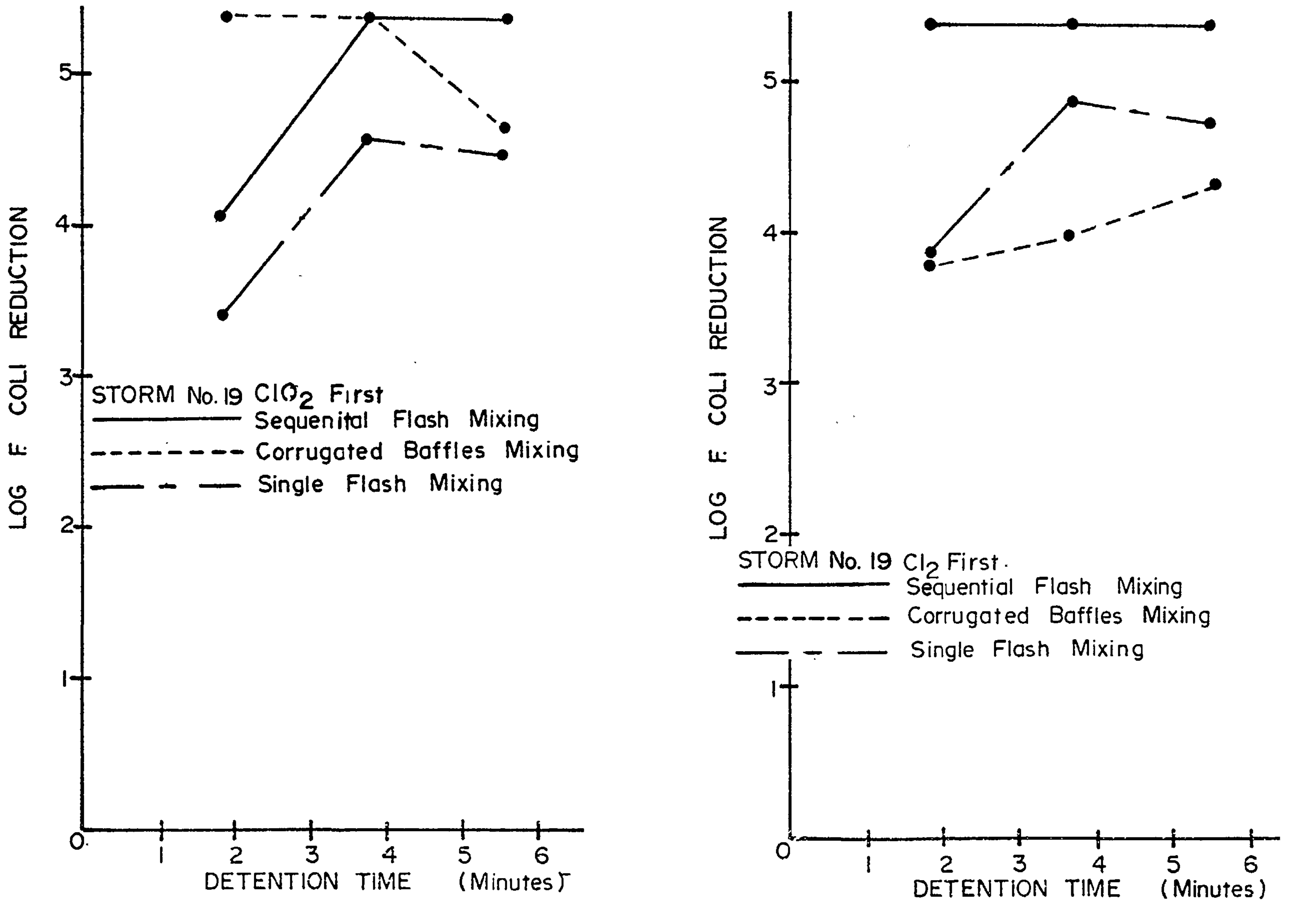


FIGURE 63. Comparison of Order of Addition Cl_2 - ClO_2 Combinations. ClO_2 = 3 mg/l; Cl_2 = 3 mg/l

SECTION 12

SOLIDS HANDLING CONSIDERATIONS

SLUDGE THICKENING

The scope of the pilot plant investigations did not permit extensive studies of optimization of sludge withdrawal rates from the primary systems. The philosophy of operation of the swirl devices was to withdraw sludges at a rate sufficiently high to prevent solids contamination of the effluent. Sludge withdrawal techniques associated with the swirl devices have been described earlier in Section 7. Rough approximations of the effect of reduced draw-off rates may be gained by analysis of sludge settleability curves, assuming that compaction would be attained in the hopper of the swirl separator. Figure 64 shows sludge settleability curves for the three primary treatment systems composite sludges acquired during Storm No. 13. These tests represent measurements of the compacting sludge layer in a 1000 ml graduated cylinder with quiescent settling.

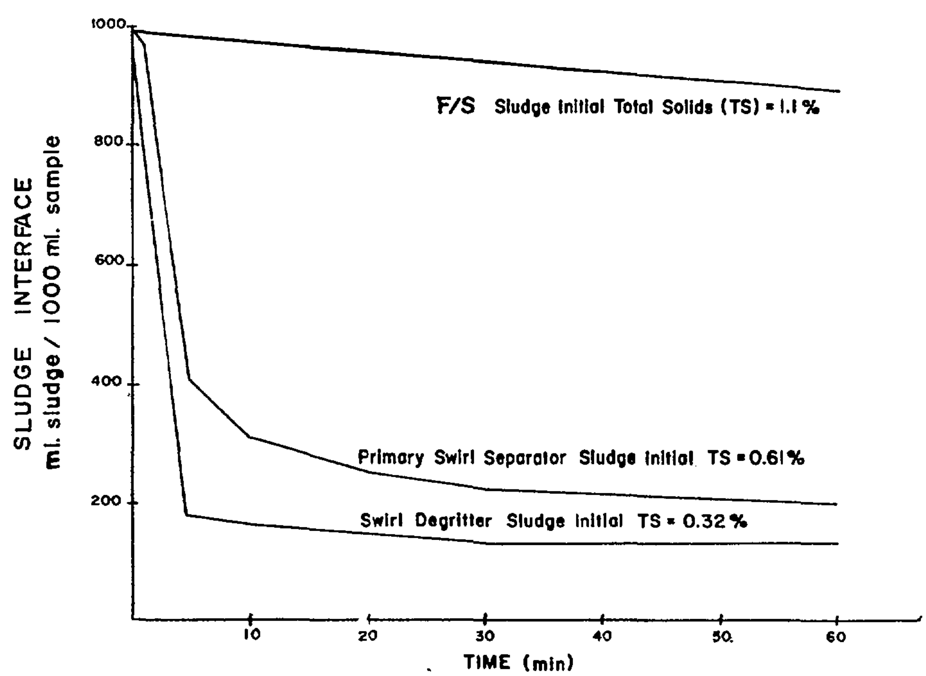


FIGURE 64. CSO Primary Treatment Sludge Settling Curves (Storm No. 13)

SLUDGE DEWATERABILITY

Dewaterability of CSO treatment residuals was also evaluated utilizing sludge derived from the pilot plant primary treatment systems. Figures 65 and 66 show results of Buchner filtration tests of flocculation/sedimentation (F/S) sludge for Storm Nos. 13 and 14, respectively. These sludges were gravity thickened to 3.28 percent total solids (TS) (Storm No. 13) and 9.32 percent TS (Storm No. 14) prior to testing. A cationic polymer (Hercules 812) was used for flocculation. These Figures also show specific resistance (a measure of dewaterability, sec^2/g) as a function of polymer dosage. Comparison of Figures 65 and 66 indicates that sludges derived from sedimentation basins employing polymer treatment exhibit a lower specific resistance than sludges originating from untreated sedimentation systems. These Figures also indicate that polymer treated sedimentation sludge is more conducive to dewatering than untreated sedimentation sludge.

Figures 67 and 68 illustrate Buchner filtration test results for combined swirl degritter and swirl primary separator sludge from Storms No. 13 and 14, respectively. Examination of the results indicates that polymer treated swirl sludge dewaters much more easily than untreated swirl sludge.

The chemical requirement for dewaterability of the sludge may be affected by its septicity. Figures 69, 70 and 71 show the changes in pH and alkalinity of pilot plant sludges upon storage at room temperature.

DISCUSSION

Sludge Volume and Characteristics

Table 33 gives a preliminary estimate of the quantity of sludge solids produced in Rochester, N.Y. during 1975 (assuming the average CSO discharge per storm).

This analysis assumes 100 percent treatment of the CSO and includes grit, sludge and scum loadings. It should be noted that utilization of biological treatment methods and/or the employment of chemical addition in the selected treatment process would also add solids to the final sludge volume.

TABLE 33. ESTIMATED LOADINGS FOR 100% CSO TREATMENT

No.	Description	Quantity
I	Average CSO per storm	3.2×10^5 m^3 (85 mil gal)
II	Average SS concentration of CSO	244 mg/l
III	Average O&G concentration of CSO	47 mg/l
IV	Estimated volume of screenings in CSO (wet basis)	>15ml/m^3 (>2 ft^3/mil gal)

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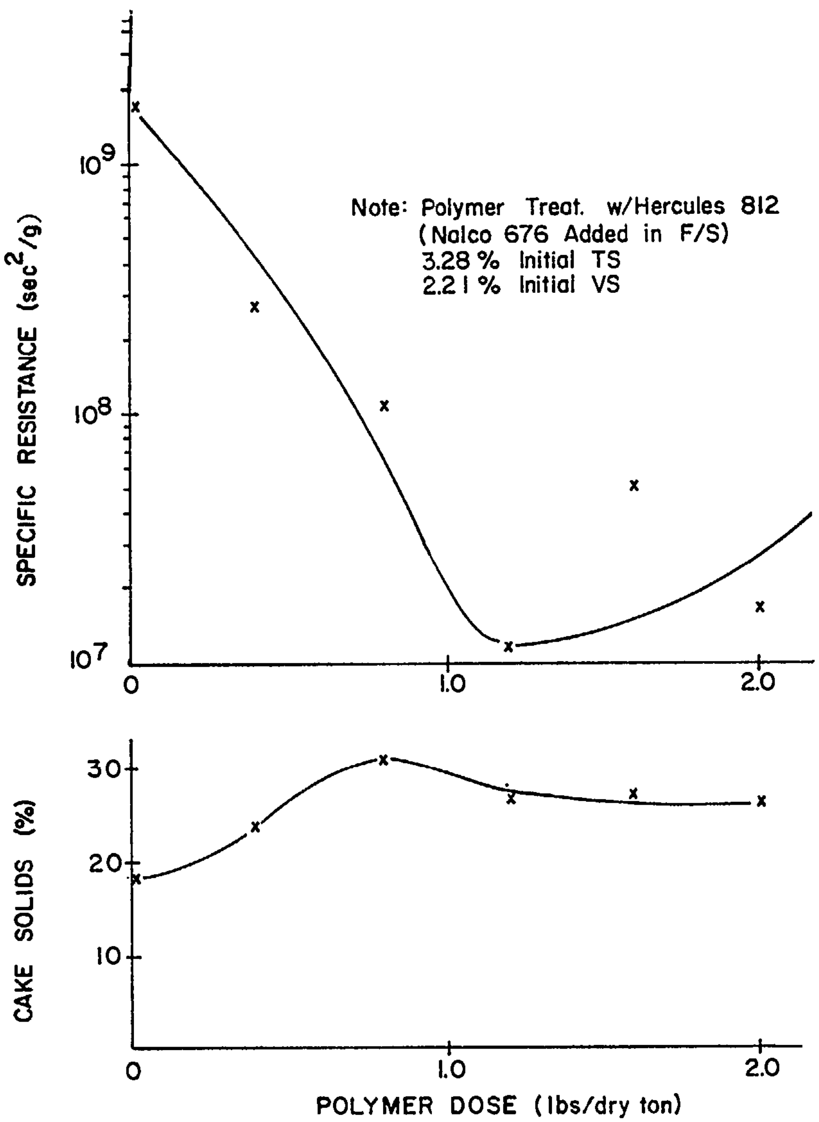

FIGURE 65. Sludge Dewaterability Tests: Storm No. 13 F/S Sludge

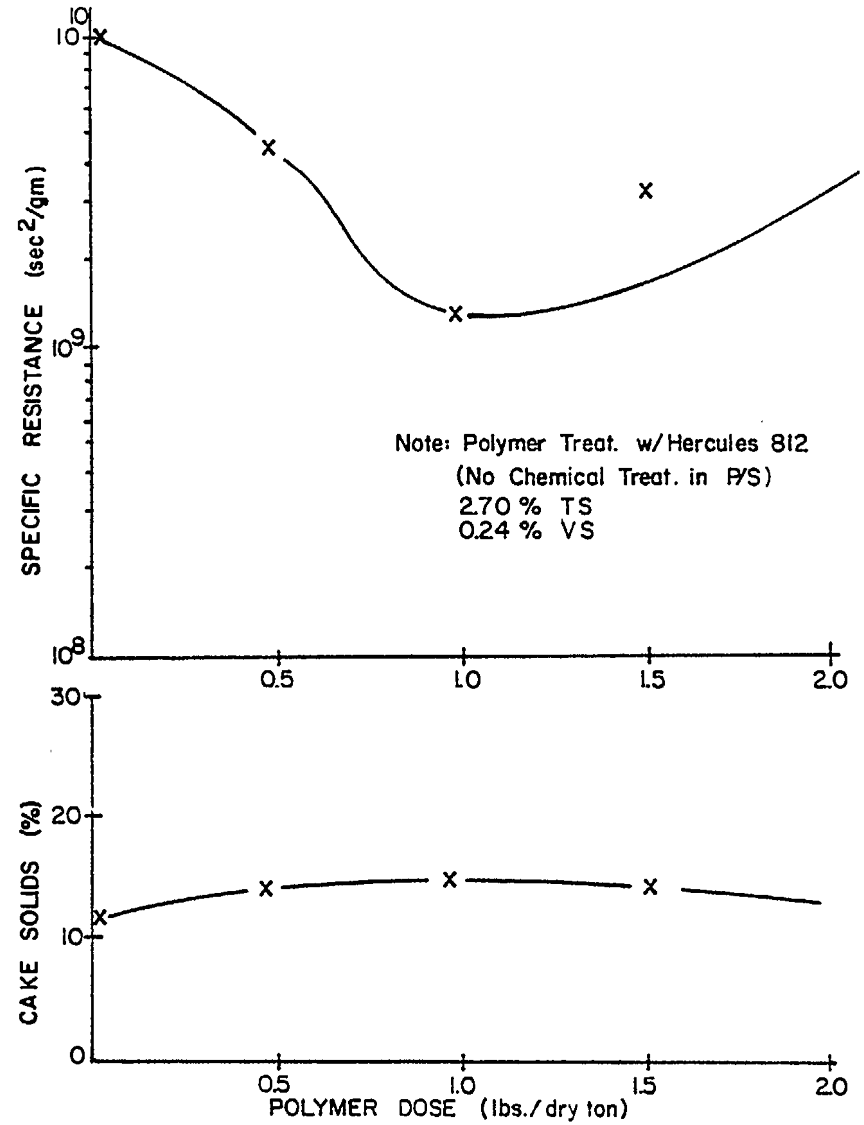

FIGURE 66. Sludge Dewaterability Tests: Storm No. 14 Swirl Degritter and Separator Sludges

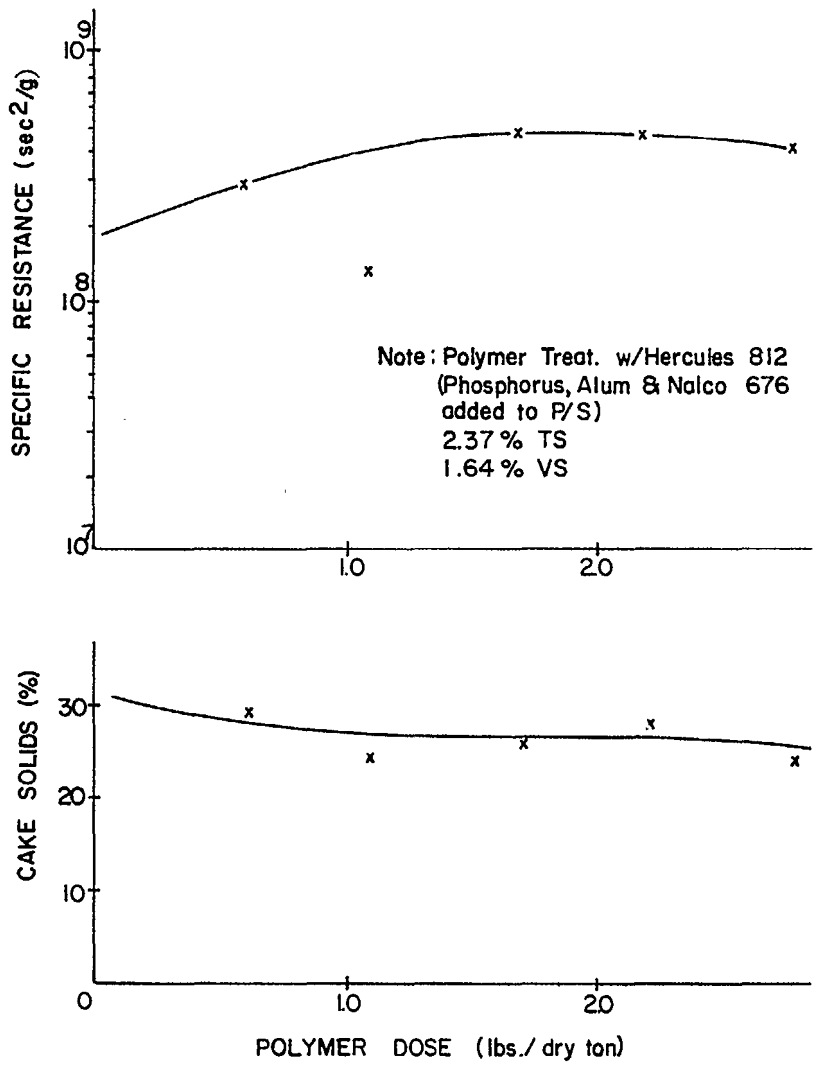

FIGURE 67. Sludge Dewaterability Tests: Storm No. 14 Swirl Degritter and Separator Sludges

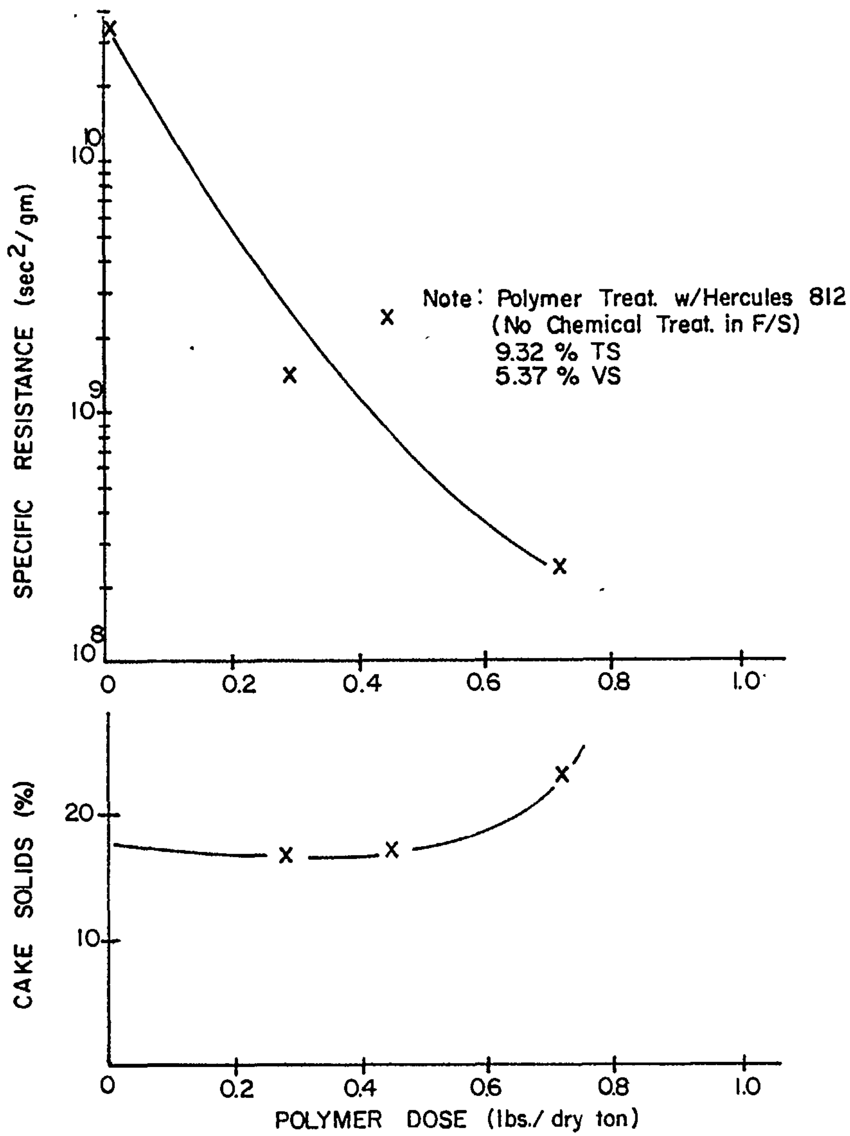

FIGURE 68. Sludge Dewaterability Tests: Storm No. 13 F/S Sludge

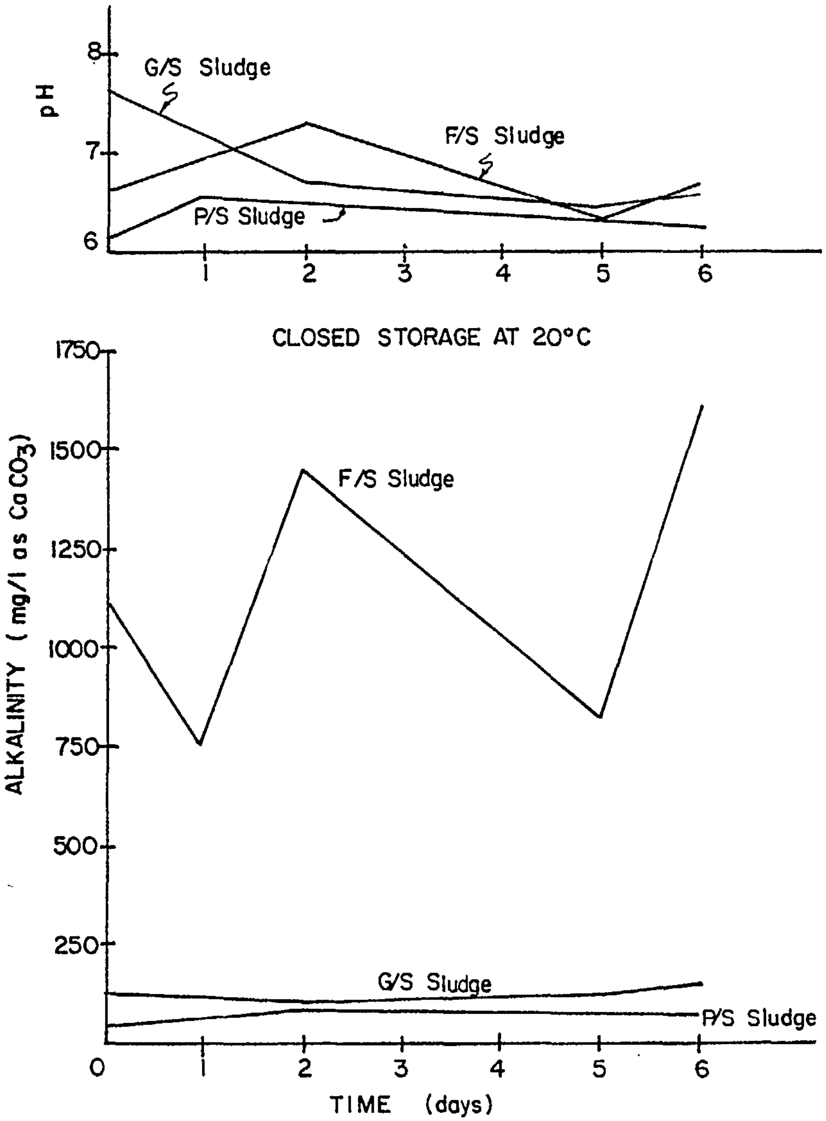

FIGURE 69. Sludge Aging Studies: Storm No. 14 F/S Sludge

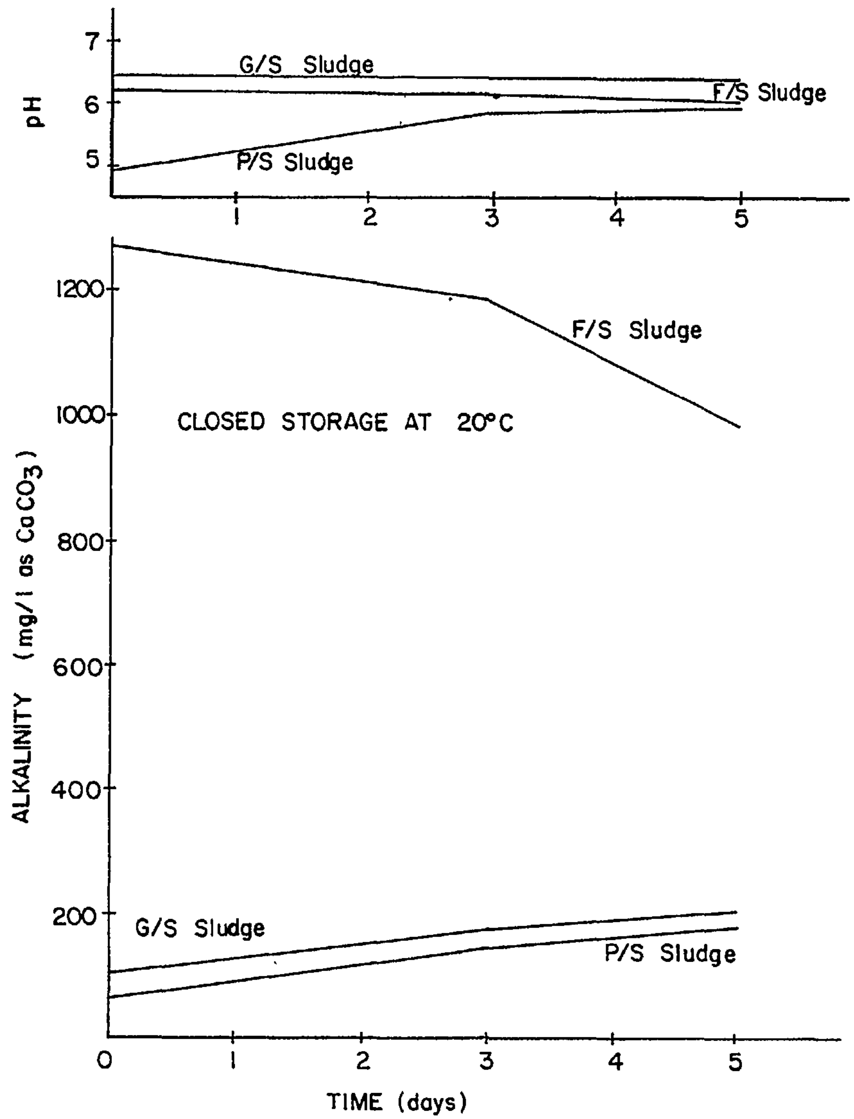

FIGURE 70. Sludge Aging Studies: Storm No. 13 Swirl Degritter and Separator Sludges

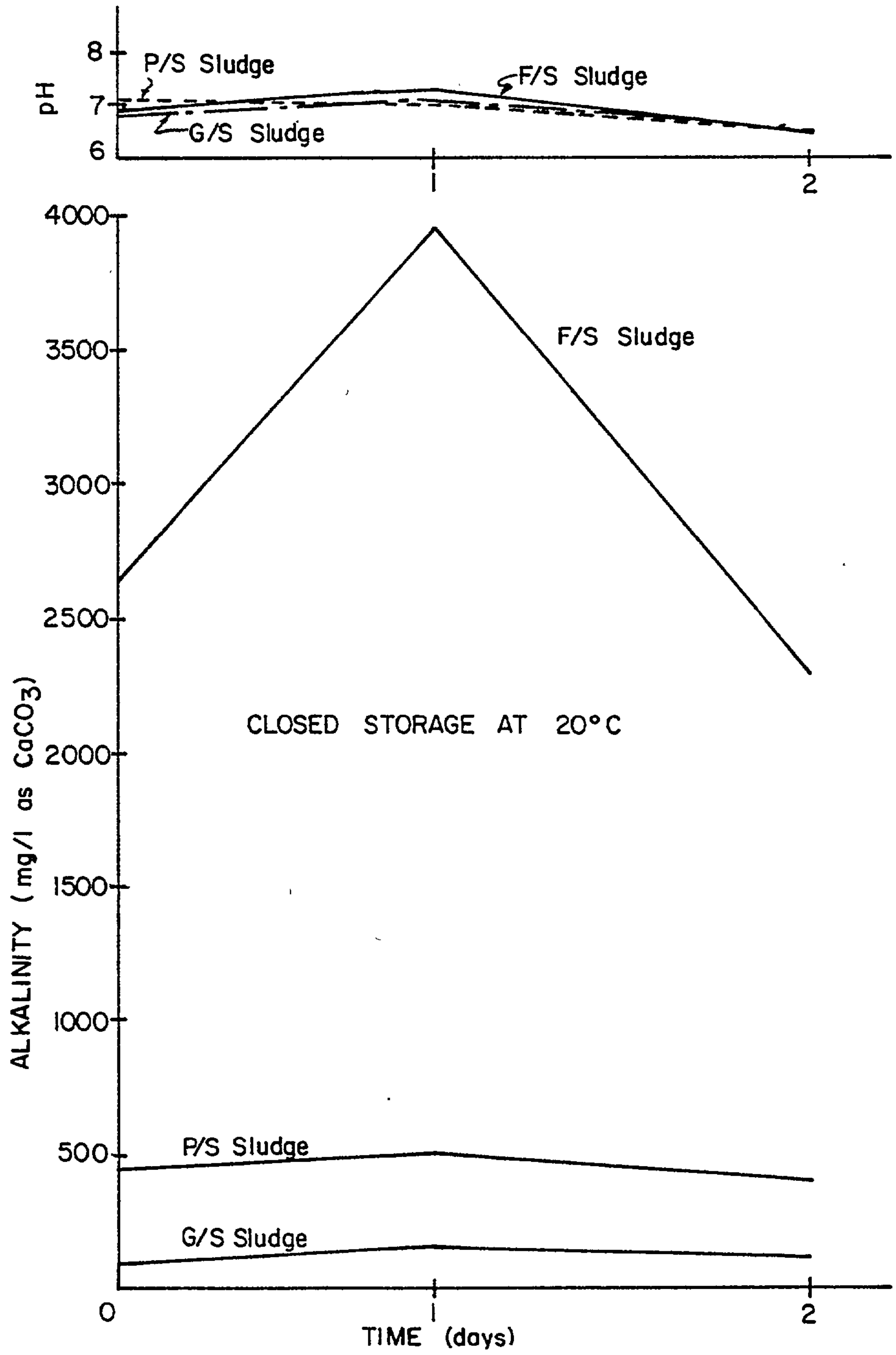

FIGURE 71. Sludge Aging Studies. Storm No. 15

TABLE 33. (continued)

No.	Description	Quantity
V	Estimated quantity of grit expressed as % of SS	9%-15.5%
VI	Average No. of overflows anticipated per year	43
VII	Estimated quantity of sludge anticipated from an average storm (dry solids basis)	42,600-48,000 kg (94,000 - 106,000 lb)
VIII	Estimated quantity of O&G anticipated from an average storm (dry solids basis)	3,800 kg (8,400 lb)
IX	Estimated quantity of screenings anticipated from an average storm	4.76 m^3 (>170 ft^3)
X	Estimated quantity of grit anticipated from an average storm (dry solids basis)	6,985 - 12,250 kg (15,400 - 27,000 lb)
XI	Estimated current VanLare operation	
	(A) Sludge processed per day (dry solids basis)	38,900 kg (85,700 lb)
	(B) Grit processed per day (dry solids basis)	7,500 kg (16,600 lb)
	(C) Screenings processed per day (wet solids basis)	4,600 kg (10,200 lb)

The volatile percentage of solids found in the flocculation/sedimentation system, swirl degritter and swirl primary separator sludges and the pilot plant influent are listed in Table 34. The pilot plant sludges averaged between 20 and 60 percent volatile solids. Envirex (55) reported sludges exhibiting volatile fractions ranging from 25 to 63 percent; biological treatment showed the highest volatile fraction (about 60 percent), while the physical and physical/chemical treatment processes exhibited sludges with a 25 to 48 percent volatile fraction. The volatile percentages of solids found in the pilot plant sludges were similar to the volatile percentage of SS in Rochester CSO (Table 8).

TABLE 34. ROCHESTER PILOT PLANT VOLATILE SOLIDS FRACTIONS

Storm No.	Influent % Vol.	F/S* Sludge % Vol.	Swirl Degritter Sludge % Vol.	P/S** Sludge % Vol.
1	18.9			
3	42.8	70.6	49.4	
4	55.9	31.8		
5	44.2	72.4	61.5	63.5
6	56.8		50.4	83.0
7A	60.3		48.0	13.0
7B	62.4	69.9	31.8	8.2
8	55.9		37.8	16.6
9	52.4	46.6	44.2	28.8
10	43.9	42.2	52.5	32.0
11	50.1	40.8	39.8	24.8
12	54.9	41.1	31.8	10.3
13	67.6	67.0	61.8	49.3
14	40.4	52.7	48.4	40.8
15	36.1		53.8	46.2
16	34.9	26.6	39.5	32.2
17	48.7	65.2	70.8	50.6
18	48.8		63.8	42.2
19	22.4		31.0	32.0

* F/S - Flocculation/Sedimentation
** P/S - Swirl Primary Separator

Possible toxic substances in CSO sludges include heavy metals (zinc, lead, copper, nickel, chromium, and mercury), PCB and pesticides (pp' DDD, pp' DDT, and dieldrin). A list of the heavy metals encountered in the pilot plant influent and the process effluents, which could contribute to the heavy metal content in the process sludges, is presented in Table 35. Another heavy metals analysis was performed on both the swirl degritter and swirl primary separator sludges for Storm No. 17. The results of this analysis are presented in Table 36. Also shown in Table 36 are the ranges of heavy metals reported in the Envirex (55) study for sludges associated with physical and physical/chemical treatment systems.

TABLE 35. PILOT PLANT CSO HEAVY METALS DATA*

	Cd mg/l	Cr mg/l	Cu mg/l	Hg ug/l	Ni mg/l	Pb mg/l	Zn mg/l
Storm No. 8							
Influent		0.03	0.05				0.07
Storm No. 9							
G/S Effluent	0.02	<.01	0.04		<.02	<.02	
P/S Effluent	<.01	<.01	0.06	0.59	0.03	0.00	0.17
P/S Effluent	<.01	<.01	0.04		<.02	<.02	
DMHRF Effluent	<.01	<.01	0.04	<.01	0.03	<.02	0.11

(continued)

TABLE 35. (continued)

	Cd mg/l	Cr mg/l	Cu mg/l	Hg° ug/l	Ni mg/l	Pb mg/l	Zn mg/l
Storm No. 10							
Influent	<.01	<.01	0.04		<.02	<.02	
F/S Effluent	<.01	<.01	0.04		<.02	<.02	
G/S Effluent	<.01	<.01	0.04		<.02	<.02	
P/S Effluent	<.01	<.01	0.02		<.02	<.02	
Storm No. 11							
Influent	<.01	<.01	<.01	1.48	<.02	<.02	
P/S Effluent	<.01	<.01	<.01	0.79	<.02	<.02	
DMF Effluent	<.01	<.01	<.01	0.39	<.02	<.02	
Storm No. 17							
First Half Influent	<.01	<.01	<.01	24.2	<.02	<.02	0.07
Second Half Influent	<.01	<.01	<.02	28.0	<.02	<.02	0.11
F/S Effluent	<.01	<.01	0.06	20.2	<.02	<.02	0.15
G/S Effluent	<.01	<.01	0.08	28.9	0.03	<.02	0.12
P/S Effluent	<.01	<.01	0.06	23.1	<.02	<.02	0.13
M/S Effluent	<.01	<.01	0.06	20.7	<.02	<.02	0.10

* G/S - Swirl Degritter
P/S - Swirl Primary Separator
F/S - Flocculation Sedimentation
M/S - Micro Screen
DMHRF - Dual-Media High-Rate Filter

TABLE 36. HEAVY METAL CHARACTERISTICS OF CSO SLUDGES*

Description	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Storm No. 17 Swirl Degritter Sludge	23.4	249.6	1235	0.78	147.4	1241	2345
Storm No. 17 Swirl Primary Separator Sludge	15.8	386.1	4554	0.28	85.6	1658	1980
Physical Treat-† ment Processes		50- 250	200-800	0.01-3.0	125-300	1200-2500	800-1200
Physical/Chemi-§ cal Processes		150-1700	250-500	2.0 -4.0	50-225	150-1600	700-1700

(continued)

* Results reported as mg/kg of Dry Solids

† Taken from Envirex Report (55); processes included storage-sedimentation and microscreening

§ Taken from Envirex Report (55); processes included screening/dissolved-air flotation and dissolved-air flotation.

Summary of Envirex Study

CSO sludge characteristics vary as the influent solids concentrations vary. It was thus necessary to assess alternatives which may prove useful in the handling of storm generated discharge residuals. These alternatives included (1) bleed-back of the residuals to the dry-weather treatment facilities, (2) separate on-site residuals treatment and (3) land disposal of treated or untreated CSO residuals.

The following presents a summary of conclusions developed in the Envirex study (55). These conclusions are general and are not universally applicable. Site factors specific to Rochester are discussed later.

I. Effect of Handling CSO Treatment Residuals by Bleed-Back to the Municipal Dry-Weather Plant --

Investigations have indicated that bleed-back of raw CSO treatment sludges to the municipal dry-weather plant is not practical.

The Envirex report generally indicated that bleed-back of CSO treatment sludges to the dry-weather treatment plant over a 24-hour period would grossly overload the plant hydraulically, solids-wise and/or organically, resulting in appreciably decreased treatment efficiency and deterioration of the plant effluent quality.

Extending the bleed-back period does not appear to be a viable alternative. Even under favorable conditions(minimum design dry-weather plant operating conditions, no diurnal dry-weather flow flucuations, etc), a bleed-back period of up to one to two weeks or more would be required. For less than favorable conditions (plant operating conditions between minimum and maximum design operating conditions, significant dry-weather flow fluctuations, etc), a bleed-back period greater than that indicated under favorable conditions would be required. If the dry-weather plant were operating at maximum design operating conditions, no bleed-back would be allowable. Disadvantages of prolonged bleed-back periods include: (1) the longer the bleed-back period is extended, the more unfavorable the alternative becomes, (2) the capability of handling succeeding CSO treatment residual events is materially reduced and (3) because of the anticipated extended bleed-back period, provision would have to be made during sludge storage to minimize organic solids decomposition and prevent nuisance conditions from occurring.

Bleed-back of CSO treatment sludges directly to the dry-weather sludge handling facilities over a 24 hour period would hydraulically overload the facilities, both solids-wise and organically. These overloads would be expected to detrimentally affect the dewatering and stabilization performance and treatment efficiency of the dry-weather sludge handling facilities. The downgrading in treatment efficiency would be manifested in poorly stabilized sludge for disposal and grossly deteriorated thickener effluents, filtrates, supernatants, etc. for recirculation back to the dry-weather treatment plant.

Since handling of CSO treatment sludges in the dry-weather sludge handling facilities does not appear to be feasible, it becomes apparent that CSO sludge must be separately treated. Two alternatives for separate treatment are (1) on-site facilities and/or (2) additional parallel facilities at the dry-weather plant.

Biological CSO treatment facilities should be located at sewage treatment facilities to provide a continuous active biomass. Therefore, CSO sludges originating from biological treatment should be separately handled in separate parallel facilities at the dry-weather treatment plant.

Physical and physical-chemical CSO treatment facilities lend themselves more easily to remote satellite locations. However, because of the problems involved in transporting the sludges from the remote CSO treatment site to the dry-weather plant, CSO sludges derived from these systems should be separately treated at on-site facilities.

II. Effect of Handling CSO Treatment Residuals by Separate On-Site Treatment--

A. Generally, the process elements comprising a CSO sludge handling system would include grit and low volatile solids removal, sludge dewatering, stabilization and ultimate disposal. The specific sludge treatment train utilized will be dependent upon the characteristics of the CSO conveyance system and the treatment method employed.

Grit and Low Volatile Solids Removal -- Physical and physical-chemical CSO treatment methods treat raw CSO with little or no preliminary treatment for inert solids removal. It is therefore expected that CSO sludges from physical and physical-chemical treatment will require provision for grit and low volatile solids removal.

Biological CSO treatment methods are usually preceded by treatment steps which remove the major portion of the grit and inert solids in the raw CSO. Therefore, it is anticipated that CSO sludges from biological treatment will not generally require provision for grit and low volatile solids removal.

Stabilization -- It is necessary to stabilize sludges before ultimate disposal in order to minimize health hazards and nuisance conditions and further reduce mass. Stabilization processes and equipment include anaerobic and aerobic digestion, heat treatment, composting and chemical treatment (chlorine oxidation and lime treatment). Preliminary examination of these alternatives indicates that anaerobic disgestion and lime stabilization are more applicable to handling CSO sludges. Evaluation and comparison of these two processes from an operating, cost, and land requirement standpoint indicate the advisibility of employing lime stabilization.

Dewatering and Volume Reduction -- Evaluation and comparison of gravity thickening, vacuum filtration, centrifugation and incineration for applicability in handling CSO sludge indicates that thickening and vacuum filtration are the dewatering methods preferred for handling CSO sludges.

Ultimate Sludge Disposal -- Evaluation and comparison of ocean dumping, drying and land disposal (by landfill, land spreading and/or land reclamation) indicates that land disposal is the most applicable to handling CSO sludges.

B. Estimation of costs for handling and disposal of CSO sludge using landspreading and landfill as the ultimate disposal alternatives indicates that although landspreading has a significantly lower initial investment, landfills have significantly lower operating costs and appreciably lower land requirements.

C. The logistics of operating and maintaining multiple CSO solids handling plants at different locations throughout a city are formidable but not insurmountable. Similar logistics would be required for multiple CSO treatment facilities from which the sludges to be handled are derived.

III. Considerations for Land Disposal Alternatives

The criteria that must be considered for any waste disposal operation are:

1) land application method to be used,
2) required preapplication treatment,
3) collection and transportation of the waste to the site,
4) suitability of the area in terms of present and future land uses in and around the site, proximity to surface waters, and sensitive environmental areas,
5) amount of land required
6) effects of climate on the disposal operation,
7) site topography, geology, and existing vegetation,
8) surface runoff control,
9) necessary storage facilities,
10) waste distribution techniques,
11) treatment efficiency and pollutional loading constraints, especially in regard to nitrogen and heavy metals,
12) possible growth of crops,
13) protection of public health, and
14) a site monitoring program.

Specific recommendations regarding some of the preceding criteria are outlined in the Envirex Report (55).

Facilities and Cost Estimates

Using the estimated sludge quantities given in Table 33 it is seen that treatment of an average storm in Rochester over a 24-hr period would produce a solids loading of 110-124 percent of the current solids loadings at the VanLare plant. Preliminary estimates were compiled to assess the order of magnitude of sludge handling facilities required for the Rochester area. These estimates are presented on Table 37. This analysis assumed that the CSO solids would be treated in a manner similar to that used for treatment of dry-weather solids at the existing VanLare plant, i.e., sludge thickening, storage, vacuum filtration, and incineration (Option A). The cost of facilities to handle these solids was found to be in the range of $4.5 million.

Implementation of the treatment train recommended by Envirex (55), which consists of gravity thickening, lime stabilization, vacuum filtration and landfill (Option B), would substantially reduce these costs by replacing the high costs associated with the incineration process with much lower landfill costs. Based on figures derived from the Envirex Report (55), it is estimated that capital costs for lime stabilization and landfilling are $96,000 and $533,000, respectively. Thus, sludge handling facilities costs would be reduced to the range of $3.3 million.

While it appears that landfilling of sludges is the least costly alternative, there are several factors which might reduce requirements for incineration. It is possible that existing incinerators at VanLare might be capable of handling wet-weather sludges if some modifications are incorporated. Detention of wet-weather sludges may permit attenuation of vacuum filter and incinerator loadings. Lime stabilization should be applied prior to detention. Inclusion of wet-weather sludges also results in a sludge mixture that contains a higher ratio of primary/secondary components. The improved dewaterability of this type of sludge may enhance operation of the existing incinerators.

The cost estimates presented here assume centralized treatment of CSO and CSO sludges. Volume I of this Report concluded that receiving water constraints preclude the use of satellite CSO treatment; therefore, costs of satellite sludge handling facilities have not been developed.

TABLE 37. SLUDGE PROCESSING FACILITIES

		Project Cost Estimate (Mid-1976)§,††	
No.	Treatment Operation	Incinerator (Option A)	Landfill (Option B)
I.	Lime Stabilization: 9,463 m^3/day (2.5 mgd) loading (1% sludge)		$ 96,000
II.	Thickeners* Design Loading: 962,200 kg (212,000 lb) dry solids/day	$1,570,000	96,000
III.	Sludge Storage Design Loading: 1,204 m^3 (318,000 gal) - 8% sludge	540,000	540,000

(continued)

TABLE 37. (continued)

No.	Treatment Operation	Project Cost Estimate (Mid-1976) Incinerator (Option A)	Landfill (Option B)
IV.	Vacuum Filters** Design Loading: 1-in-20 yr max. 7,260 kg (16,000 lb) dry solids/ day	590,000	590,000
V.	Landfill: (5 yr: land purchase, preparation)		533,000
VI.	Sludge Incinerator† Design Loading: 1-in-20 yr max. 7,260 kg (16,000 lb) dry solids/ day	1,880,000	
	TOTAL PROJECT COST ESTIMATE:§§	$4,580,000	$3,329,000

§ No special site conditions have been factored into estimate.

†† Equipment cost estimates are based upon references (54) and (56).

* Thickener costs include structure, mechanism, associated pumps and piping.

** Vacuum Filter costs include all mechanical equipment, pumps, piping, etc. These costs also include sludge conditioning tanks and an allowance for a structure to house filter and controls.

† Sludge incinerator costs include incinerator, controls, and necessary appurtenances including air pollution controls and ash handling equipment. An allowance has also been included for a suitable structure to house the facilities.

§§ Project costs include engineering, legal and miscellaneous fees plus contingency allowance and estimated interest during construction.

SECTION 13

CAPITAL AND OPERATING COST ESTIMATES

BASIS OF COST ESTIMATES

The cost equations presented in this section have been employed to estimate capital, operating and maintenance costs for full-scale flocculation/sedimentation and swirl concentrator unit processes. These equations were developed from cost curves presented by Benjes (57), and are based on the application of the unit process to CSO. Capital costs include structural, mechanical, piping, housing, labor, contingency, electrical and instrumentation expenses. The capital costs do not include the fees associated with land and site work, engineering, legal and administrative services, fiscal concerns, and interest during construction. Operating and maintenance costs include labor, power, chemicals, miscellaneous supplies, administration costs, laboratory and sampling, and yard maintenance. All cost equations are adjusted to November, 1976 according to the ENR Construction Cost Index of 2480.

CAPITAL COSTS

The following equation for estimating sedimentation basin capital cost has been developed from reference 57,

$$\text{SED CAP COST (\$)} = 238 \quad (SA)^{0.817} \qquad (1)$$

where SA = surface area, ft^2.

The equation for estimating flocculation basin capital costs was derived from the cost curve relating construction cost to basin volume and is presented below:

$$\text{FLOC CAP COST (\$)} = 1.27\ (10^6) \times (.438 + (2.29)(10^{-6})(FBV)) \qquad (2)$$

where FBV = flocculation basin volume, ft^3.

Employment of chemical treatment in the flocculation/sedimentation process would require additional capital cost due to the installation of chemical feed systems. Cost equations were therefore developed for both alum and polymer feed systems since these chemicals were employed during the Rochester studies. The respective capital cost equations for alum treatment and polymer treatment were as follows:

$$\text{ALUM CAP COST (\$)} = 1.127\ (10^3)\ (28.8 + 0.0655 \quad (ALPPH)^{1.09}) \qquad (3)$$

where ALPPH = alum feed rate, lb/hr

and,

$$\text{POLY CAP COST (\$)} = 1.12\ (10^6)\ (.0081 + .0183\ (\text{POLPPH})^{.898}) \quad (4)$$

where POLPPH = polymer feed rate, lb/hr

The cost equation for estimating swirl primary separator capital cost has also been developed from reference 57 and modified by cost data from LaSalle (12). The finalized form of the swirl primary separator capital cost equation was:

$$\text{SWIRL CAP COST (\$)} = 1620\ (\text{SA})^{0.779} \quad (5)$$

where SA = surface area, ft^2

OPERATION AND MAINTENANCE COSTS

A number of operation and maintenance costs are associated with the flocculation/sedimentation and swirl concentrator processes. The equations developed for estimating these costs are presented below.

Flocculation/Sedimentation

Operating and maintenance requirements were developed for a flocculation/sedimentation system consisting of a rapid mix basin, a flocculation basin and a sedimentation basin. Estimates of operation and maintenance labor costs associated with the rapid mix basin were derived from the following equation:

$$\text{R-M LABOR (\$/yr)} = .0156\ (\text{LC})\ (\text{NOF})\ (\text{V})^{.681} \quad (6)$$

where LC = labor cost, \$/hr
NOF = number of overflow events per year
V = basin volume, ft^3
R-M = rapid mix

Rapid mix materials costs were assessed using the equation:

$$\text{R-M MATERIALS (\$/yr)} = .844\ (\text{V})^{.688} \quad (7)$$

and power costs were estimated from:

$$\text{R-M POWER (\$/yr)} = .104\ (\text{PC})\ (\text{NOF})\ (\text{V}) \quad (8)$$

where PC = power cost, \$/kwh

The above equation was developed assuming two days of operation per overflow event.

Flocculation basin operating and maintenance labor costs were obtained from the following equation:

$$\text{FLOC LABOR (\$/yr)} = .000375\ (LC)\ (NOF)\ (V) \quad (9)$$

Material and supply costs for the flocculation basin were calculated using:

$$\text{FLOC MATERIALS (\$/yr)} = 1.99\ (V)^{.588} \quad (10)$$

Operating and maintenance costs associated with the sedimentation basin were derived from:

$$\text{SED LABOR (\$/yr)} = 0.0211\ (LC)\ (NOF)\ (SA)^{.875} \quad (11)$$

where SA = surface area of basin, ft^2

and materials costs were computed from:

$$\text{SED MATERIALS (\$/yr)} = 8114\ (SA/112500)^{0.7} \quad (12)$$

Sedimentation basin power requirements were estimated from:

$$\text{SED POWER (\$/yr)} = .0042\ (PC)\ (NOF)\ (SA)^{.926} \quad (13)$$

Employing chemical treatment in the flocculation/sedimentation process would also contribute to its operating and maintenance costs. Listed below are the equations which were developed for estimating these costs for both the alum and polymer feed systems.

1) Manpower Requirements

$$\text{ALUM FEED LABOR (\$/yr)} = .0452\ (LC)(NOF)(ALPPH)^{.715} \quad (14)$$

$$\text{POLY FEED LABOR (\$/yr)} = 2.94\ (LC)(NOF)(POLPPH)^{.167} \quad (15)$$

2) Materials and Supplies:

$$\text{ALUM FEED MATERIALS (\$/yr)} = 1.12\ (47.5 + .914\ (ALPPH)) \quad (16)$$

$$\text{POLY FEED MATERIALS (\$/yr)} = 1.12\ (69.6 + 69.5\ (POLPPH)) \quad (17)$$

3) Requirements (assumes two days of operation per overflow event):

$$\text{ALUM FEED POWER (\$/yr)} = (NOF)\ (PC)\ (12.2 + .00676(ALPPH)) \quad (18)$$

$$\text{POLY FEED POWER (\$/yr)} = (NOF)\ (PC)(7.52 + 4.05\ (POLPPH)) \quad (19)$$

4) Chemicals:

$$\text{ALUM FEED CHEMICALS (\$/yr)} = 8.34\ (MGTPY)(DOSE)(CC) \quad (20)$$

$$\text{POLY FEED CHEMICALS (\$/yr)} = 8.34\ (MGTPY)(DOSE)(CC) \quad (21)$$

where MGTPY = million gallons treated per year
DOSE = chemical dose, mg/l
CC = chemical cost, \$/lb

Swirl Concentrator

The cost equation developed for estimating swirl concentrator labor costs was:

$$\text{SWIRL LABOR (\$/yr)} = (LC)(NOF)(12.1 + .0082\ (SA)) \quad (22)$$

Estimates of materials and supply costs for the swirl concentrator were computed from the following equation:

$$\text{SWIRL MATERIALS (\$/yr)} = 2028\ (NUMUNITS)^{0.7} \quad (23)$$

where NUMUNITS = number of swirl units

Miscellaneous Costs

Presented below is a list of equations which were developed to estimate additional operating and maintenance costs which would generally accompany any type of combined sewer overflow treatment facility.

1) Administration and general manpower:

$$\text{A \& G LABOR (\$/yr)} = 20\ (LC)(Q)^{.460} \quad (24)$$

where Q = treated flow, mgd

2) Administration and general materials and supplies:

$$\text{A \& G MATERIALS (\$/yr)} = 84.5\ (Q)^{.470} \quad (25)$$

3) Laboratory manpower (assumes 2 days of lab. work per overflow event):

$$\text{LAB LABOR (\$/yr)} = 17.4\ (LC)\ (NOF) \quad (26)$$

4) Laboratory materials and supplies (assumes 2 days of lab. work per overflow event and 4 samples/day):

$$\text{LAB MATERIALS (\$/yr)} = 51.8\ (NOF) \quad (27)$$

5) Yardwork manpower (assumes yardwork area equal to 2.5 times the equipment surface area):

$$\text{YARD LABOR (\$/yr)} = 26.7\ (LC)\ (SA/400)^{.795} \quad (27)$$

6) Yardwork materials and supplies:

$$\text{YARD MATERIALS (\$/yr)} = 15.4\ (SA/400)^{.862} \quad (28)$$

Several other costs associated with CSO handling and treatment are discussed in Section 14. These include overflow storage and transmission facilities and sludge disposal costs.

SECTION 14

COMPARISON OF ALTERNATIVES

COST/BENEFIT COMPARISON OF SWIRL PRIMARY SEPARATOR VERSUS FLOCCULATION/SEDIMENTATION

Cost/benefit comparisons of four alternative primary systems for treating CSO are presented below. These include: 1) flocculation/sedimentation with no chemical treatment, 2) flocculation/sedimentation with polyelectrolyte treatment, 3) flocculation/sedimentation with alum and polyelectrolyte treatment, and 4) swirl primary separator with no chemical treatment. All costs were adjusted to November, 1976 based on the ENR Construction Cost Index of 2480. Comparisons of satellite versus centralized treatment, and storage versus treatment optimizations are presented in Volume I of this Report (3).

Performance equations defined percent SS removal at various hydraulic loadings and influent SS concentration. However, the designs associated with each hydraulic loading result in facilities with different capital costs. The operation and maintenance costs associated with each system are also different. For example, treatment with chemicals in the flocculation/sedimentation system results in improved performance but also results in higher operating and maintenance costs. It was the intent of the cost/benefit analysis to compare the cost and performance tradeoffs resulting from variations in-system design and operating conditions. Several design configurations were selected for each primary system and capital costs and predicted performance were developed for each design condition.

Operation and maintenance costs associated with each design were then calculated from the operation and maintenance equations outlined in Section 13. The following assumptions were made to develop the performance and cost data for an example facility: a) collection and attenuation of overflows with treatment at a central facility (VanLare STP in Rochester, N.Y.) and a treatment rate of 275 mgd, b) 77 overflow events per year and c) a total treated CSO volume of 4651 mil gal per year. The assumed treatment rate was based on the design rate of the proposed wet-weather facilities at VanLare. The number of overflow events and total CSO volume were based on the available Rochester data for recent years.

The costs outlined in this Section include comparison of the primary unit processes only. These costs do not include real estate nor facilities for collection, transmission and storage of CSO, pumping, flow measurement, preliminary screening, disinfection, sludge handling, treatment and disposal. It was assumed that these items and associated costs would be common to each of the primary alternatives. Disinfection and sludge handling costs have been discussed in Sections 11 and 12. Costs associated with the collection, transmission and storage of CSO and raw wastewater pumping are outlined in

Volume I of this Report (3). That Volume also presents additional treatment alternatives and cost optimizations of various CSO abatement alternatives.

Capital, operating and maintenance costs, and predicted performance results for various design conditions at two different influent SS levels were developed.

Amortization is for a period of 20 years at an interest rate of 6 percent per annum. Total yearly treatment facility costs for two influent SS conditions are plotted in Figures 72 and 73. These figures indicate the estimated cost to achieve stated performance levels using alternative systems. For example, Figure 73 indicates that for flows encountered during first-flush overflows ($c_o \sim 500$ mg/l), three of the four alternatives would be expected to provide 50 percent removal of SS at approximately the same annual cost. For influent SS concentrations more representative of average CSO conditions ($c_o \sim 300$ mg/l), Figure 72 indicates that swirl primary separators are cost-competitive with flocculation/sedimentation incorporating chemical treatment. For SS removals greater than 60 percent, the only system capable of providing this treatment appears to be a flocculation/sedimentation system employing alum and polyelectrolyte treatment.

Examination of Figures 72 and 73 also indicates that in all cases, the highest SS removals are attained utilizing a flocculation/sedimentation system employing alum and polyelectrolyte treatment. These Figures illustrate that large improvements in performance of the flocculation/sedimentation system are attained by chemical treatment for a relatively small increase in yearly cost.

SECONDARY LEVEL TREATMENT ALTERNATIVES

The addition of high-rate filters to the primary systems would result in overall SS removals of 72 to 84 percent when filters are operated without chemical treatment. Addition of high-rate filters that employ chemical treatment following the primary systems would result in overall SS removals of 86 to 92 percent. The capital cost associated with a high-rate filtration system employing polyelectrolyte treatment is estimated to be \$6,300,000. This cost is based on a design flow of 1×10^6 m^3/day (275 MDG) and a surface flux of 651 l/min m^2 (16 gpm/ft^2). The capital cost has been developed from reference 57 and includes structural, mechanical, piping, housing, labor, contingency, and electrical and instrumentation expenses.

The addition of a carbon adsorption system to the primary treatment processes would result in overall BOD_5 removals of 92 to 98 percent. Capital costs were developed for a carbon adsorption system consisting of a carbon contactor and complete regeneration facilities (41). Carbon contactor costs include carbon, miscellaneous tanks, piping, valves, building costs, and instrumentation. Regeneration costs include a feeding and conveying system, scrubber, afterburner, instrumentation storage, dewatering, defining tanks, and building costs. The capital cost associated with the carbon contactor was based on a design flow of 1 x 10^6 m^3/day (275 mgd) and a contact time of 30 minutes. Regeneration costs were developed for a furnace loading rate of 195 kg/m^2 yr (40 lb/ft^2 yr), a carbon exhaustion rate of 60 gm/m^3 (500 lb/mil gal), 77 overflow events per year and a total treated CSO volume of 17.6 x 10^6 m^3 (4651 mil gal) per year. Total capital cost of the carbon adsorption system was estimated to be $45,000,000.

MISCELLANEOUS COSTS

The capital costs associated with flow measurement and primary sludge pumping were derived from cost curves presented in reference 57. These costs include structural, mechanical, piping, housing, labor, contingency, and electrical and instrumentation costs. The flow measurement cost was based on a design flow of 1 x 10^6 m^3/day (275 mgd) and was estimated to be $64,000. Assuming a SS concentration of 209 mg/l (average SS value of Rochester pilot plant influent), a SS removal rate of 70 percent and a sludge solids concentration of 2.5 percent, the sludge pumping cost was estimated at $327,000.

Cost curves developed by Smith (59) were utilized to derive the preliminary screening capital cost. The capital cost was estimated to be $1,200,000. This cost includes a screen chamber, grit chamber (or swirl degritter), overflow, and bypass chamber.

DISCUSSION

The above anlaysis applies only to the stated case of central treatment at the the VanLare facility. Other areawide alternatives are discussed in Volume I of this Report (3). That Volume considers several alternatives including: (1) storage and treatment of the first-flush from all of the river overflow sites at wet-weather facilities located at the VanLare plant and treatment of all post first-flush flows with primary swirl devices; (2) storage and treatment of the total overflow at a treatment plant located on the Genesee River in the vicinity of the lower falls; (3) storage and treatment of the total overflow at a treatment plant located at the VanLare facility; (4) storage and treatment similar to that expressed in Alternative 1, with the exception that the post first-flush is not treated but directly discharged to the river; (5) treatment of the entire overflow volume at each of the river overflow locations using primary swirl concentrators; and (6) conveyance of the river overflows to the Cross-Irondequoit Tunnel for storage and treatment at the VanLare facility.

Optimization of storage versus treatment rates were also discussed in Volume I of this Report. That Volume concluded that since organic loadings to the Genesee River are critical, the only alternative that could be considered was collection and storage of the combined sewer overflow with treatment by facilities at the VanLare location. A storage volume of 0.2 x 10^6 m^3 (60 mil gal) was recommended with a treatment rate of 1 x 10^6 m^3/day (275 mgd) at the wet-weather facilities. In order to meet the requirement of the EPA for primary treatment with disinfection, it appears

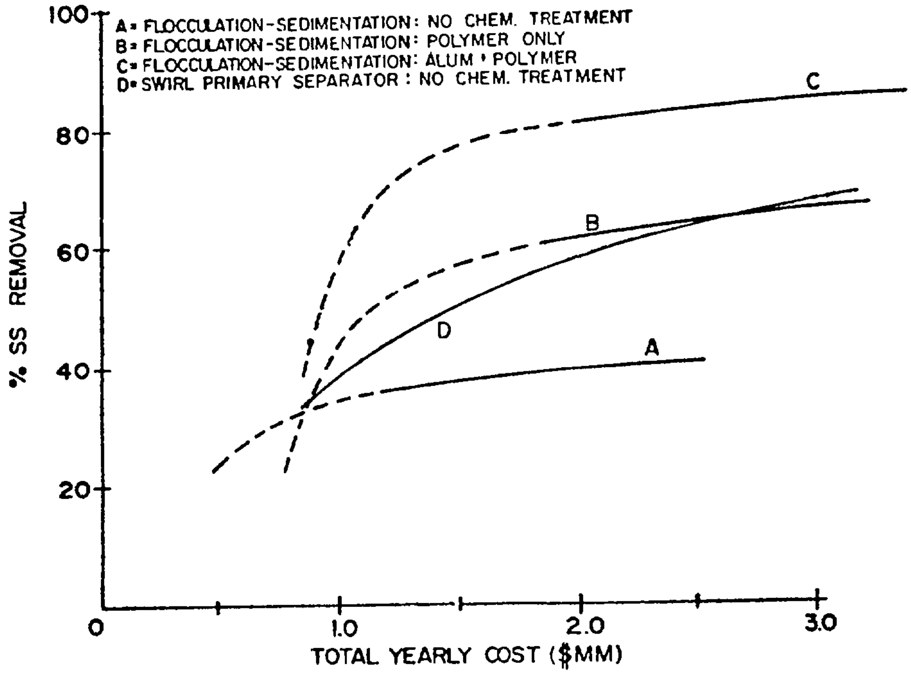

FIGURE 72. Cost-Performance Comparisons. Inf. SS=300 mg/l

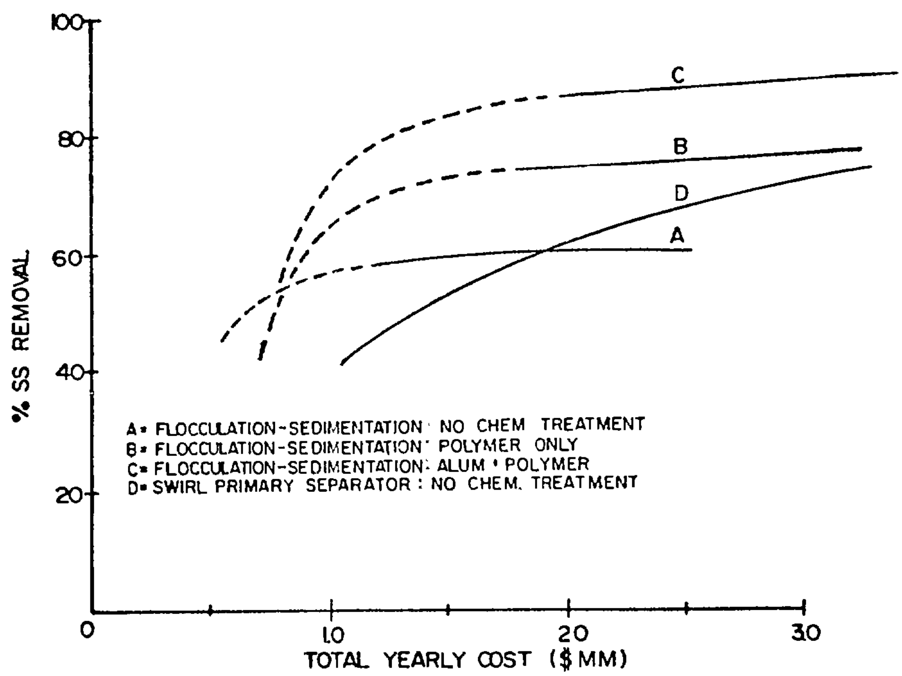

FIGURE 73. Cost-Performance Comparisons. Inf. SS=500 mg/l

that the most appropriate system would be flocculation/sedimentation operated at 82 m^3/day m^2 (2000 gpd/ft^2) with alum and polyelectrolyte treatment followed by a high-rate disinfection process employing a 5 minute detention time and a mixing intensity (GT) of 35,000. Recommended sludge handling would include thickening, lime stabilization, vacuum filtration, and landfill disposal.

The alternatives evaluated in this Section were specifically limited to swirl separators and flocculation/sedimentation with and without chemical treatment. Based on receiving water quality objectives, as discussed in Volume I of this report, the objective was to develop recommendations for primary treatment of CSO at Rochester using centralized facilities. Other alternatives, such as dissolved air flotation, microscreening, dual-media high-rate filtration, or carbon adsorption, may be viable processes for other locations, depending on effluent objectives.

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APPENDIX A
SS vs. Time Plots-Flocculation/Sedimentation and Swirl Concentrators

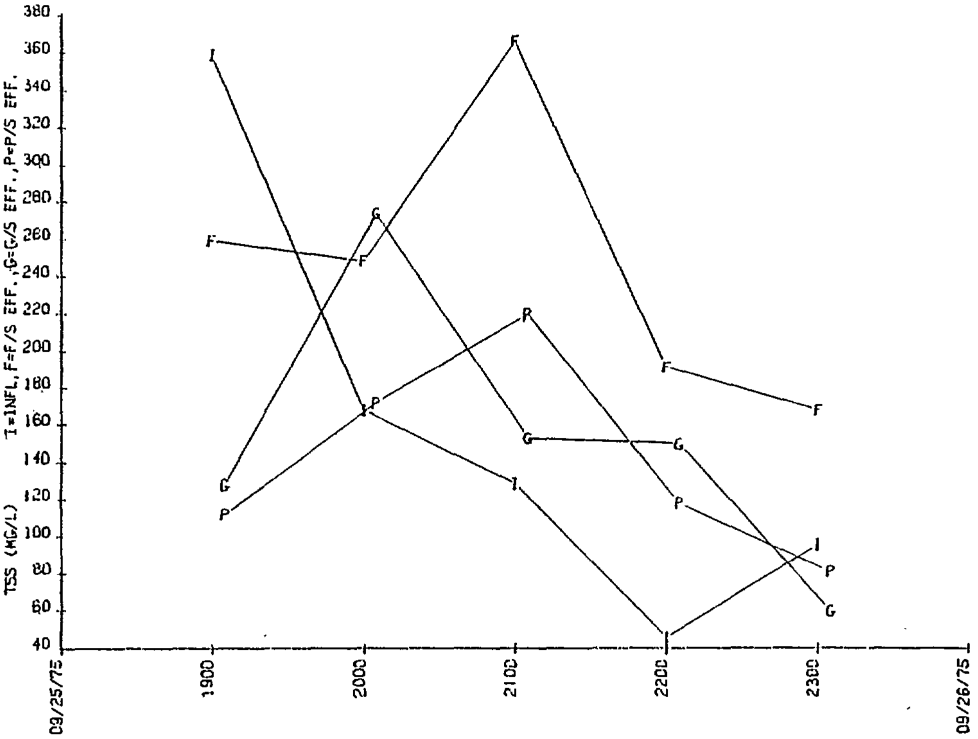
<u>Legend</u>

I = Influent

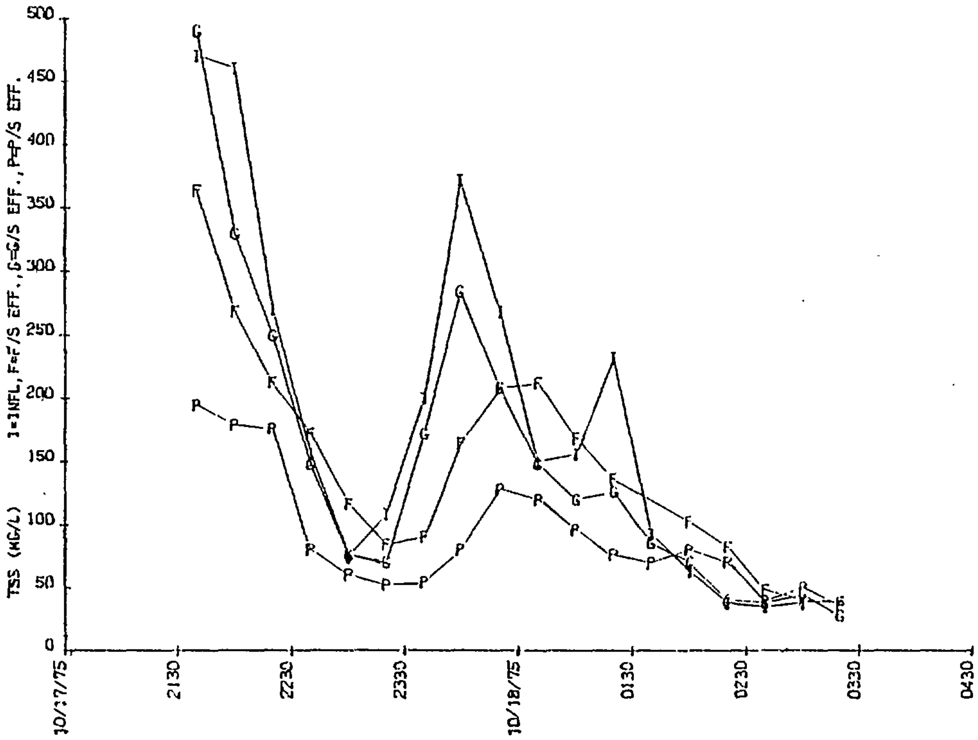
F = Flocculation/sedimentation system effluent

G = Swirl degritter effluent

P = Swirl primary separator effluent



STORM #01 - F/S, G/S, &P/S SYSTEMS



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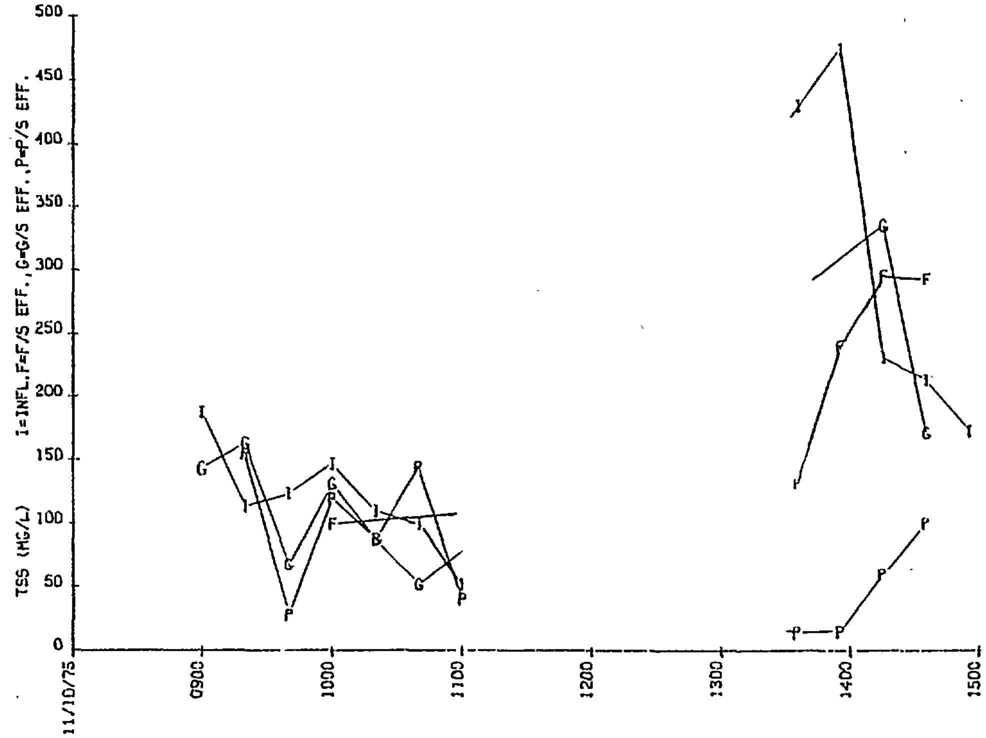

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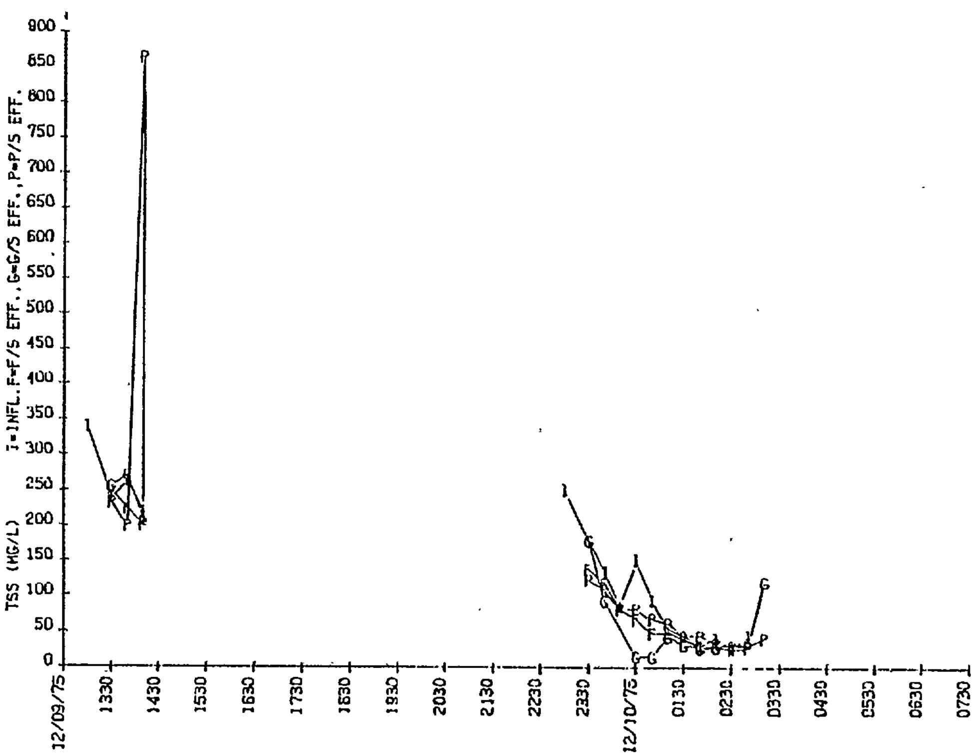
STORM #05 - F/S, G/S, &P/S SYSTEMS

STORM #06 - F/S, G/S, &P/S SYSTEMS



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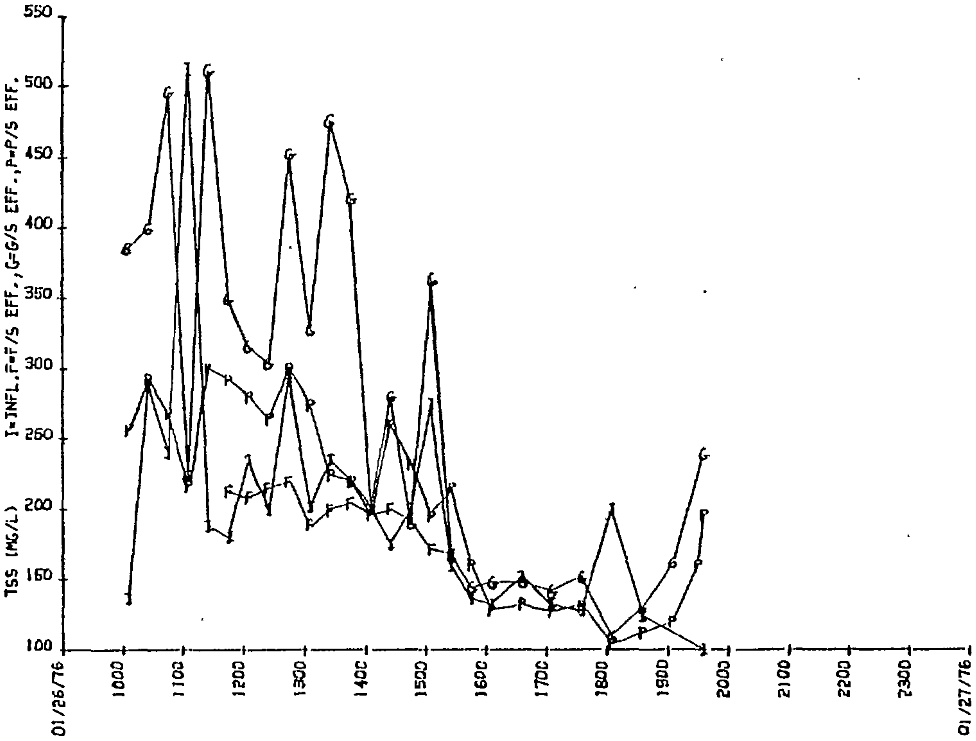

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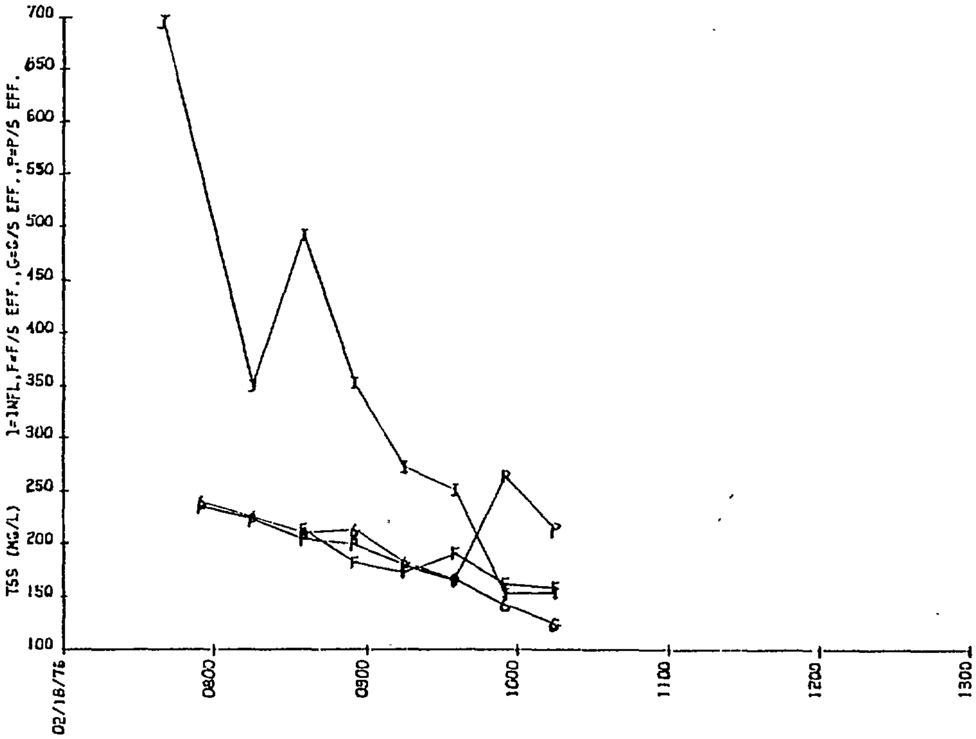

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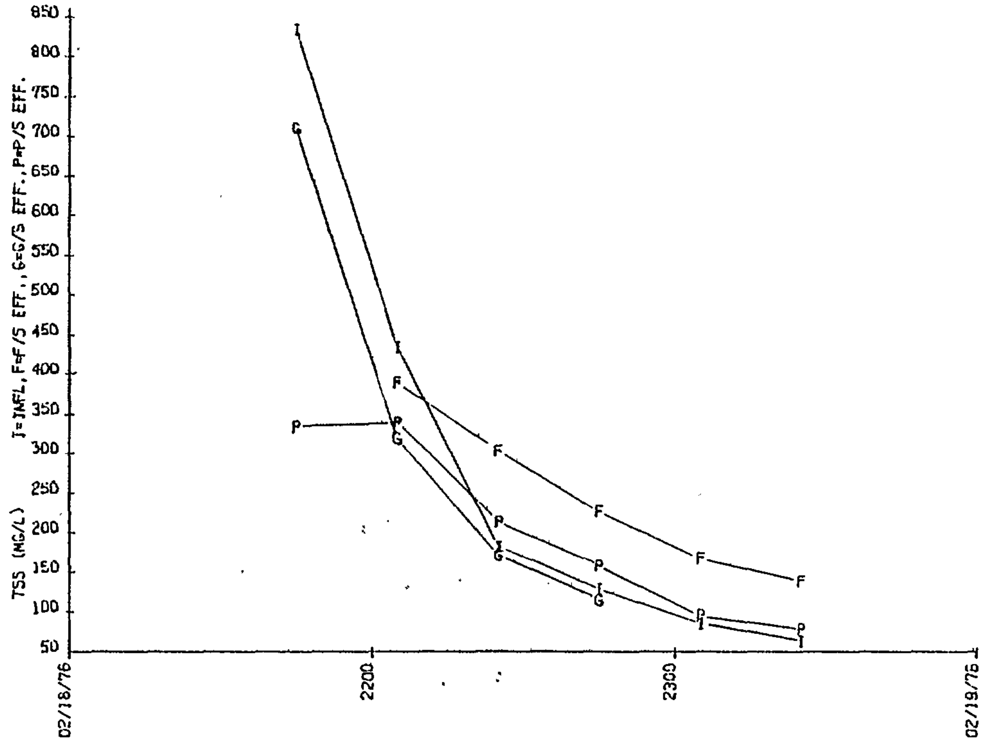
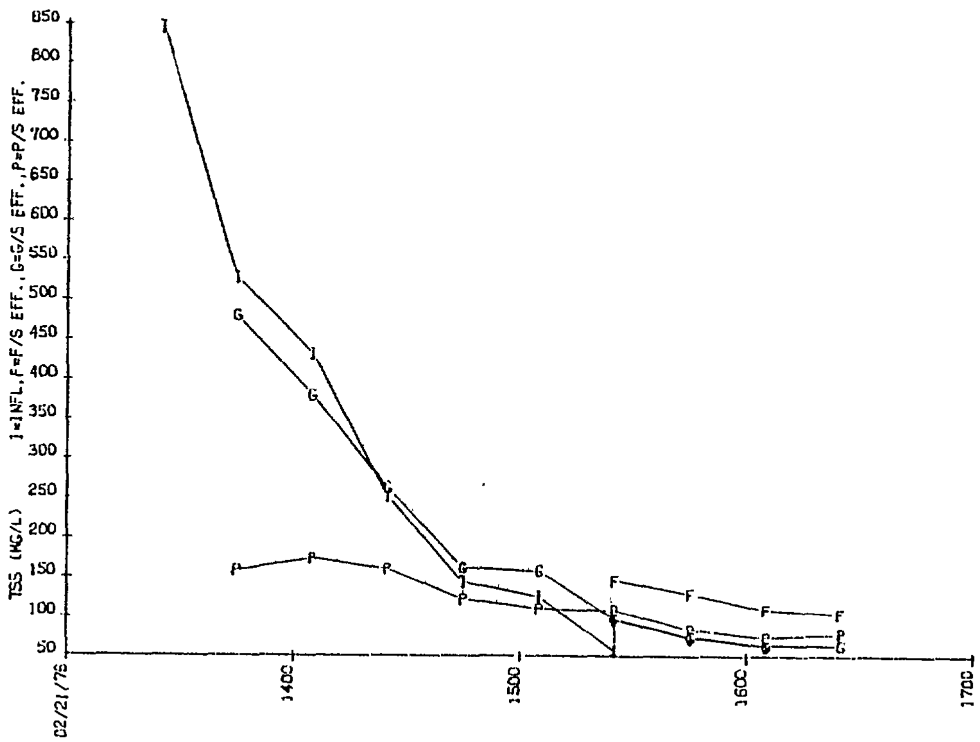
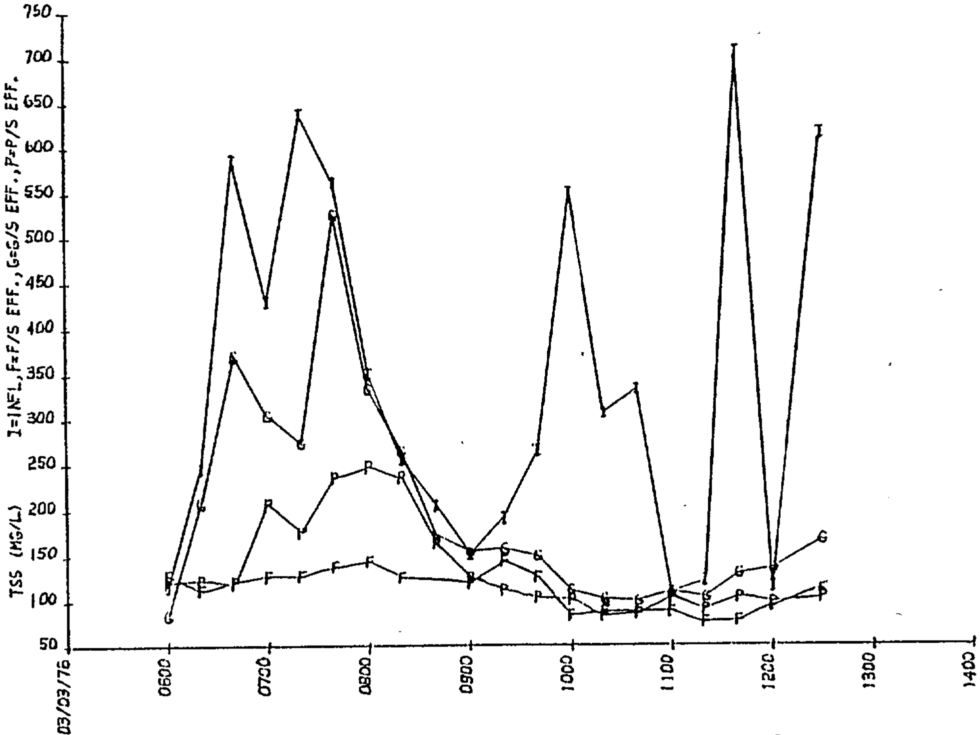


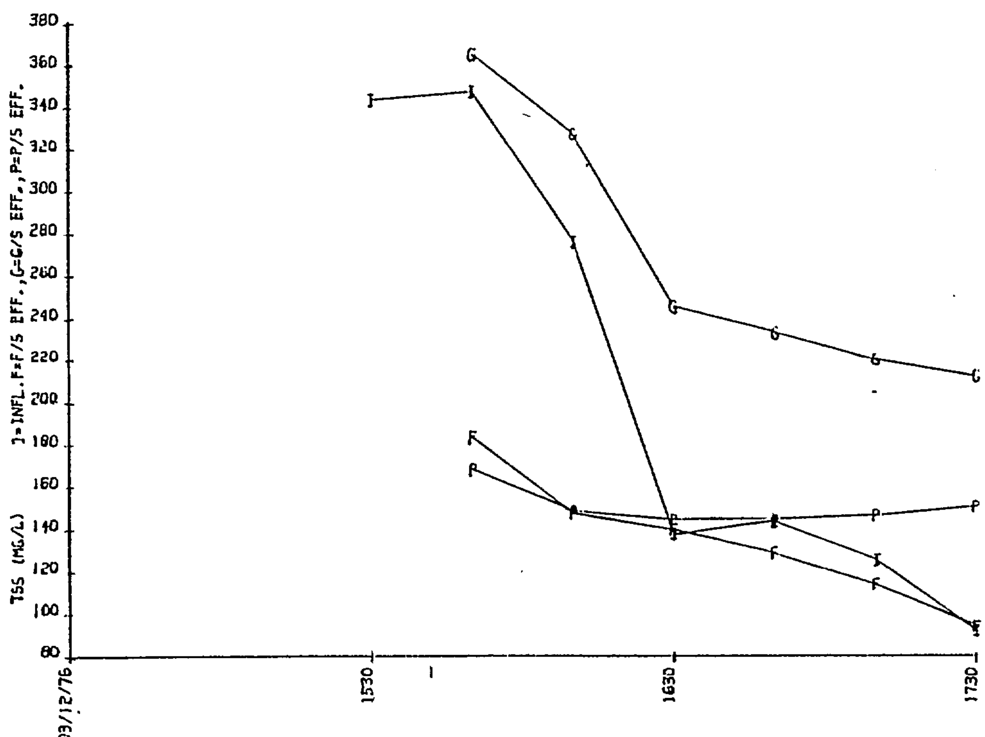
STORM #10 - F/S, G/S, &P/S SYSTEMS



STORM #11 - F/S, G/S, &P/S SYSTEMS

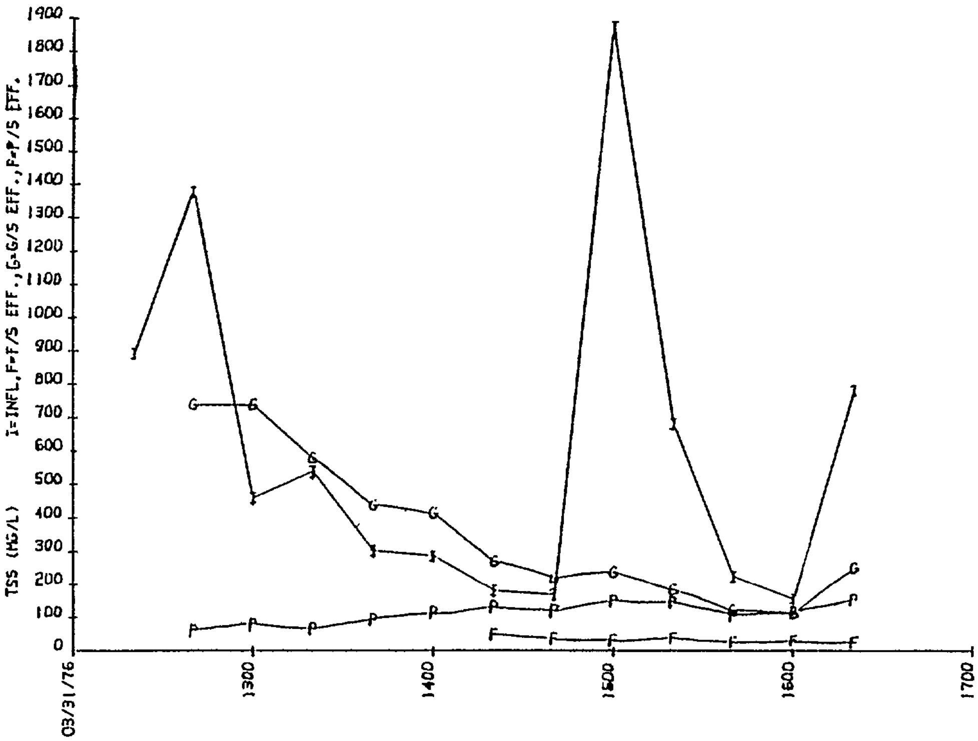


STORM #12 - F/S, G/S, &P/S SYSTEMS



STORM #13 - F/S, G/S, &P/S SYSTEMS

STORM #14 - F/S, G/S, &P/S SYSTEMS



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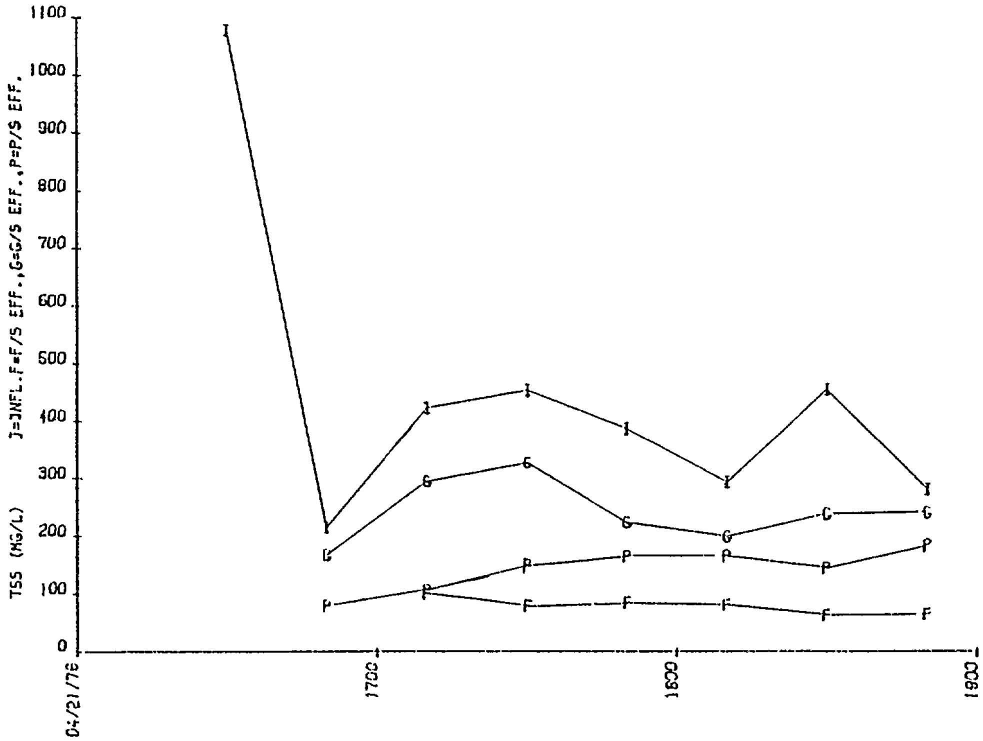
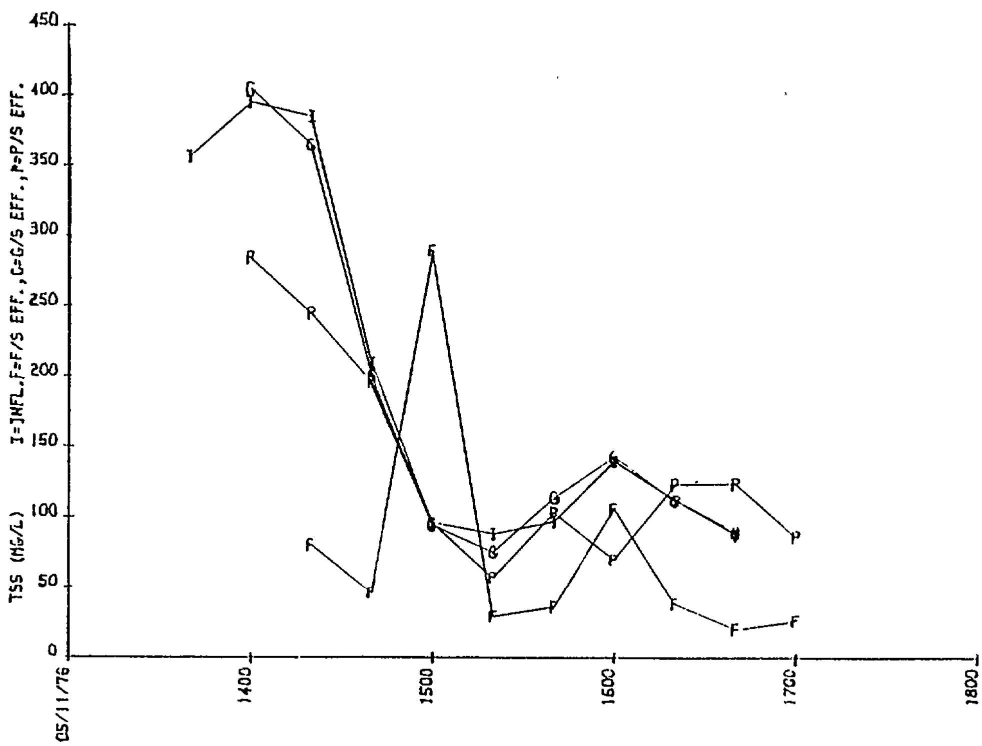


STORM #16 - F/S,G/S,&P/S SYSTEMS



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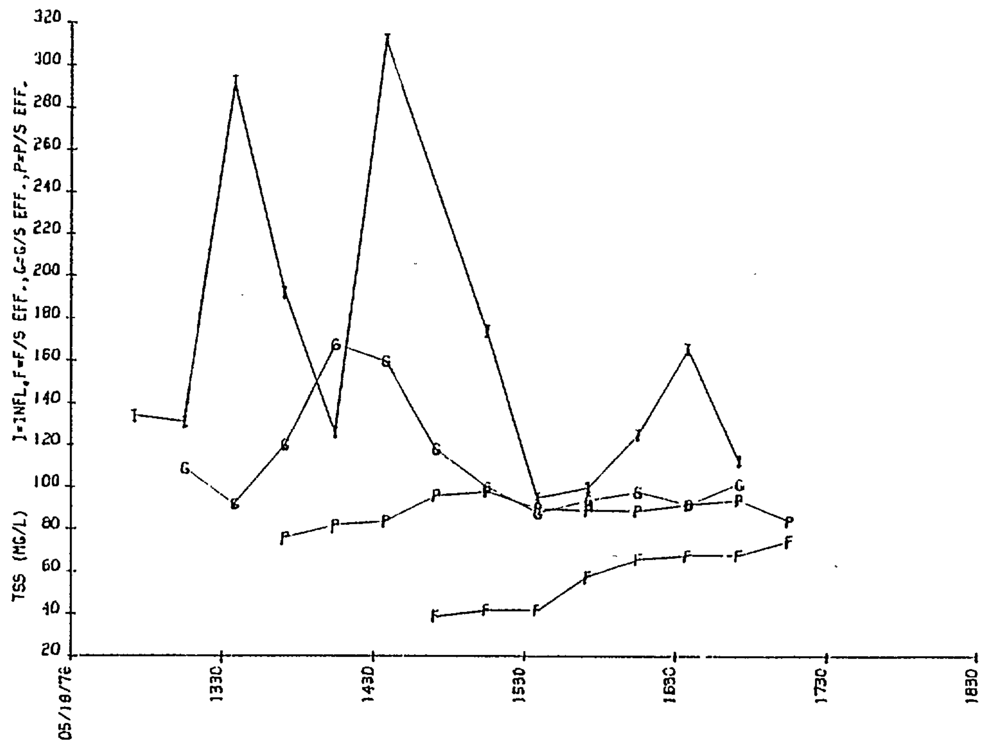
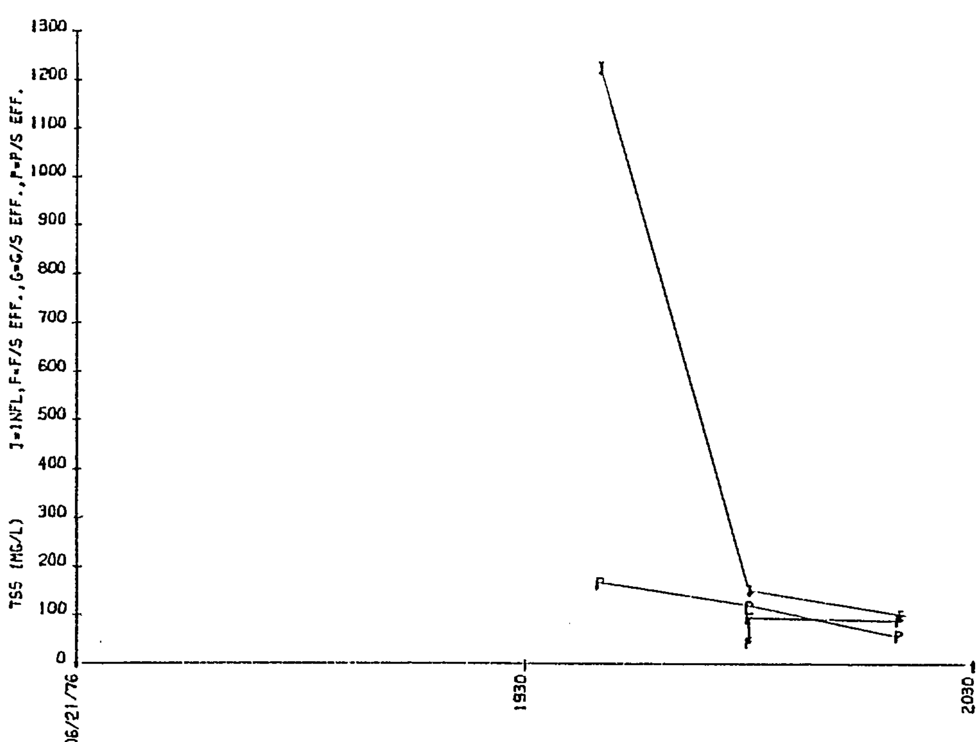


STORM #18 - F/S, G/S, &P/S SYSTEMS



STORM #19 - F/S, G/S, &P/S SYSTEMS

APPENDIX B
Statistical Analysis of Influent and Effluent Data
Flocculation/Sedimentation and Swirl Concentrators

Note: The tables in Appendices B, C and D were developed by a generalized computer routine. The number of significant digits displayed does not reflect the accuracy of the analyses.

Concentrations of all parameters except pH, SETTS and F.Coli are expressed as mg/l. SETTS concentrations are expressed as ml/l. F.Coli concentrations are expressed as colonies/100 ml.

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 01)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	46.0000	359.000	159.000	132.289	98.0884	1.10919	3.20409
VSS	6	8.70000	47.0000	28.1167	24.9788	11.8209	.700721E-01	2.33277
TS	0							
VS	0							
SETTS	0							
BOD5	6	2.60000	38.0000	11.9500	7.82084	12.2161	1.46837	3.55044
COD	15	.000000	16.0000	7.93333	.000000	4.26562	.334634	2.61159
TOC	15	4.00000	47.0000	22.0667	16.8739	14.8120	.390864	1.49190
O&G	6	4.00000	32.0000	13.3333	9.34405	11.2793	.745010	1.70109
PH	15	5.60000	6.50000	6.18666	6.18389	.193620	.438180	2.48993
TKN	15	.200000	.800000	.346666	.291188	.227645	1.14519	2.61261
TIP	15	.600000E-01	.200000	.110666	.103318	.421847E-01	.704785	2.23575
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 02)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	0							
VSS	0							
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	8	11.0000	39.0000	30.3750	28.2318	9.66873	.945758	2.47616
TOC	8	23.0000	99.0000	53.0000	48.2182	22.7596	.615867	2.63992
O&G	5	19.0000	36.0000	29.6000	28.9208	5.88557	.827791	2.44638
PH	5	5.60000	5.80000	5.71999	5.71915	.979795E-01	.408015	1.16654
TKN	8	1.20000	6.10000	2.90000	2.63450	1.36290	1.35330	4.12981
TIP	8	.100000	.650000	.277500	.237370	.165057	1.21356	3.49812
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 03)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	17	35.0000	470.000	187.176	137.722	136.919	.812030	2.55301
VSS	17	10.0000	270.000	91.4706	58.9758	77.7499	.984705	2.99768
TS	17	50.0000	618.000	235.647	185.661	157.450	.887958	2.88692
VS	17	6.00000	376.000	102.000	56.8140	103.289	1.35542	3.82696
SETTS	17	.300000	25.0000	4.82941	2.64043	5.84874	2.35884	8.45175
BOD5	16	5.00000	280.000	54.1875	29.6316	68.6125	2.23237	7.52120
COD	1	97.0000	97.0000	97.0000	96.9997	.000000	.000000	.000000
TOC	17	5.00000	61.0000	25.5294	20.4507	15.8962	.601954	2.54550
O&G	9	8.00000	41.0000	27.0000	24.1915	10.9949	.264326	1.72232
PH	9	5.60000	6.30000	5.89999	5.89700	.188562	.497272	3.12896
TKN	17	.300000	4.40000	1.41765	1.10330	1.02912	1.39811	4.68467
TIP	17	.000000	.730000	.264117	.000000	.231543	.607915	1.91025
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 04)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	52.0000	475.000	196.750	164.648	124.605	1.23235	3.32541
VSS	12	32.0000	224.000	106.250	92.0946	57.6962	1.01155	3.08488
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	0							
TOC	0							
O&G	0							
PH	0							
TKN	0							
TIP	0							
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 05)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	24.0000	148.000	84.5714	71.1363	44.4614	.707700E-01	1.43589
VSS	7	12.0000	88.0000	41.1429	31.4398	26.8510	.337900	1.87031
TS	9	296.000	969.000	447.555	414.678	203.450	1.78187	4.91215
VS	9	103.000	585.000	198.000	164.285	148.901	1.88093	5.16022
SETTS	0							
BOD5	9	30.0000	3300.00	815.555	340.967	1006.71	1.58021	4.30594
COD	0							
TOC	9	56.0000	530.000	143.889	109.667	140.510	2.22747	6.37756
O&G	5	3.60000	101.600	34.2400	20.3630	34.7430	1.27683	2.96791
PH	9	5.80000	6.80000	6.22222	6.21338	.332592	.258358	1.83651
TKN	9	3.70000	17.6000	6.94444	6.19702	3.99641	1.97960	5.70077
TIP	9	.610000	4.58000	1.99111	1.48931	1.47287	.620061	1.70696
AL	9	.000000	5.00000	1.66667	.000000	1.49071	.983871	3.21000
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 06)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO, MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	36,0000	244,000	107.333	87.7545	71,4765	.928541	2.21133
VSS	12	12,0000	128,000	60.6667	49.8393	36,5087	,697723	2.11760
TS	13	233,000	488,000	333,615	324,200	81,6545	,662221	2.48086
VS	13	88,0000	239,000	152,231	147,734	36,7657	.408623	3.47424
SETTS	4	1,00000	5,00000	2,25000	1,83142	1,60078	1,09702	2,29447
BODS	13	8,00000	60,0000	25,0000	20.5782	16,1436	.951652	2.56378
COD	13	22,0000	32,0000	25,6159	25,4100	3,34062	,831824	2.46950
TOC	13	23,0000	79,0000	32,3077	30.5459	13.8530	2,88069	9,96398
O&G	6	,000000	6,40000	1,26667	.000000	2,33714	1,65988	3.93642
PH	13	6,10000	7,00000	6.79999	6,79549	.241788	1,79576	5.59957
TKN	13	1,70000	4,10000	2,57692	2,49574	.684053	.945496	2.80907
TIP	13	,330000	,730000	.557692	,545705	.110951	.295612	2.37333
AL	13	1,00000	4,50000	2.42308	2,27726	.851382	.801542	3,66286
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 7A)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO, MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	220.000	340,000	266,000	262,378	45.4753	,771733	2.04139
VSS	4	128.000	208,000	161,000	158,189	30,7734	,505861	1.74577
TS	4	1133,00	2014,00	1559,75	1523,38	334,923	,900938E-01	1,54183
VS	4	133,000	150,000	143,000	142,862	6,20484	,678147	2.09445
SETTS	4	4,60000	6,00000	5,40000	5,36423	.616441	.153673	1.20221
BODS	4	72,0000	95,0000	83,0000	82,4734	9,35414	,824692E-01	1,27589
COD	4	45,0000	78,0000	55,5000	54,0414	13,5000	.921811	2,11203
TOC	4	50,0000	73,0000	62,5000	61,6589	10,1612	,857842E-01	1.12279
O&G	0							
PH	4	6,80000	7,30000	7,07499	7,07131	,227761	,713316E-01	1.09464
TKN	4	4,00000	5,70000	4,62500	4,57413	.701338	.550333	1,69627
TIP	4	,590000	,660000	.632500	.631805	,294746E-01	,362042	1,46767
AL	4	,000000	1,20000	.600000	,000000	,600000	,000000	1,00000
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 7B)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO, MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	28,0000	252,000	95,4166	74,4156	67,9351	,962357	2.85586
VSS	12	13,3000	172,000	62,1500	46,4397	46,9302	1,00401	3.03538
TS	12	760,000	1642,00	993,500	970,649	236,367	1,74695	5.11824
VS	12	4,00000	127,000	49,3333	35,7059	35,1267	,803563	2,67312
SETTS	12	,100000	5,40000	1,25000	,409988	1,66508	1,36090	3,65269
BODS	12	8,00000	66,0000	27,3667	21,7449	17,9026	,723395	2,45644
COD	12	22,0000	47,0000	26,1667	25,4232	7,17440	2,05785	6,09702
TOC	12	3,00000	49,0000	18,0833	14,1454	12,4195	1,08008	3,58235
O&G	0							
PH	12	6,60000	7,40000	7,02500	7,02031	,255359	,309610	1,70008
TKN	12	.800000	11,5000	1,90000	1,21780	2,90803	2,96614	9,90830
TIP	12	.130000	,250000	,184166	,181831	.295687E-01	,460941	3,25636
AL	12	,000000	1,20000	,500000	.000000	.288675	,914527	3,83520
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 08)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO, MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	25	100,000	512,000	201.800	189,121	81,9197	2.06970	8.61099
VSS	25	52,0000	228,000	111,160	105,668	36,8713	1,19319	5.01858
TS	25	1230,00	3017,00	1984,16	1908,36	553,469	.327156	1.73193
VS	25	98,0000	273,000	169,840	162,560	49,8892	,400930	2.40192
SETTS	25	,100000	9,00000	2,90400	2,13489	2,13269	1,21579	3.91044
BODS	25	38,0000	201.000	76,6400	71,4582	32,3788	2,14489	9,09765
COD	25	33,0000	205,000	101,200	86,4906	55,3114	.477886	1,70903
TOC	25	20,0000	94,0000	51,3200	48,3107	17,7915	,624669	2,75610
O&G	0							
PH	25	6,15000	6,85000	6,51399	6,51121	,188955	,839988E-01	2,29804
TKN	25	1,90000	6,10000	3,18000	3,04836	,974472	1,20696	4,59228
TIP	25	,170000	1,24000	,452400	,416847	,201401	2,14645	9,76421
AL	25	,000000	2,80000	1,08800	,000000	,571537	,993077	4,50997
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 09)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO, MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	154,000	696,000	341,125	302,583	170,064	,868842	2,82465
VSS	8	75,0000	392,000	186,875	158,590	109,416	.814082	2,23068
TS	8	413,000	602,000	526,750	523,117	59,7887	,738852	2,35141
VS	8	30,0000	150,000	86,7500	74,4700	44,0561	.769877E-01	1.31986
SETTS	8	,900000	3,40000	1,88750	1,71041	,856501	.702485	2,06076
BODS	8	21,0000	38,0000	30,8750	30,1819	6,31343	,349398	1,54627
COD	7	6,00000	17,0000	11,5714	11,0447	3,33197	,638388E-01	2,22625
TOC	7	23,0000	46,0000	32,2857	31,3869	7,81416	,512421	1.83970
O&G	0							
PH	8	6,80000	7,30000	7,17499	7,17325	,156125	1,55190	4.32127
TKN	7	,180000	2,28000	1,04428	,765762	,673325	,337986	2,32381
TIP	7	,140000	,550000	,241428	,216775	,132280	1,69075	4.31135
AL	8	3,46000	26,9200	7,38000	5,67237	7,40935	2,23821	6,06999
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 10)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	64.0000	834.000	288.833	190.479	272.788	1.15178	2.82304
VSS	6	26.0000	320.000	120.667	83.6491	103.741	.993208	2.49727
TS	6	486.000	1120.00	624.000	593.650	225.838	1.65745	3.93828
VS	6	70.0000	353.000	142.667	120.744	97.3288	1.55124	3.71516
SETTS	6	.100000	7.50000	2.48333	1.23799	2.55435	1.07222	2.68071
BOD5	6	31.0000	130.000	58.6667	51.3185	34.0816	1.34429	3.33777
COD	4	11.0000	27.0000	16.7500	15.6890	6.33936	.765049	1.95666
TOC	4	20.0000	123.000	57.2500	44.0098	41.1240	.715563	1.89644
O&G	0							
PH	6	6.90000	7.40000	7.16666	7.16463	.169967	.286543	1.81949
TKN	4	.640000	.960000	.822500	.810049	.141134	.148559	1.19557
TIP	4	.150000	.370000	.277500	.263453	.804285E-01	.599144	2.02290
AL	4	3.46000	7.69000	5.00000	4.75726	1.65304	.791010	2.00000
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 11)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	57.0000	845.000	261.500	171.353	248.468	1.24329	3.35005
VSS	10	32.0000	445.000	126.600	85.8427	124.332	1.59118	4.47503
TS	10	442.000	9502.00	1478.70	751.006	2679.76	2.64729	8.04884
VS	10	76.0000	9044.00	1025.60	181.401	2674.01	2.66221	8.09702
SETTS	10	.300000	10.5000	2.91000	1.55348	3.20170	1.27782	3.43033
BOD5	10	18.0000	125.000	45.7000	37.2685	32.3668	1.38735	3.84906
COD	0							
TOC	10	12.0000	96.0000	32.7000	26.2655	24.6983	1.60255	4.51915
O&G	0							
PH	10	7.60000	8.50000	8.08999	8.08570	.262488	.222860	2.22599
TKN	10	1.40000	6.50000	2.68000	2.45204	1.35410	2.10434	6.44632
TIP	10	.220000	.430000	.294000	.286002	.713021E-01	.690024	2.03030
AL	9	.000000	1.70000	.611111	.000000	.779521	.638661	1.47955
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 12)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	24	102.000	706.000	321.375	266.009	191.395	.563623	1.96301
VSS	23	42.0000	543.000	191.739	146.040	140.483	1.03328	3.09704
TS	22	829.000	2963.00	1433.41	1354.67	515.317	1.27040	4.44017
VS	22	147.000	469.000	226.045	215.634	77.4651	1.67666	5.36819
SETTS	24	1.00000	6.10000	2.77083	2.51733	1.24347	.946742	3.37225
BOD5	23	22.0000	264.000	95.6522	77.8176	62.9875	1.15338	3.49723
COD	0							
TOC	24	13.0000	76.0000	33.3333	30.5913	13.9602	.998330	4.40591
O&G	0							
PH	24	6.40000	7.00000	6.67916	6.67600	.204082	.406559E-01	1.80630
TKN	24	2.00000	6.10000	3.52083	3.38659	1.03802	1.17227	3.86635
TIP	24	.700000E-01	18.9000	3.42416	1.15871	5.62119	1.91610	5.14114
AL	24	.000000	2.40000	.749998	.000000	.533073	.757529	4.76217
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 13)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	15	92.0000	383.000	214.333	195.485	91.0520	.456369	1.84874
VSS	15	62.0000	308.000	147.600	132.116	69.5478	.650958	2.49318
TS	15	607.000	1096.00	749.667	738.393	136.521	1.06633	3.30338
VS	15	111.000	373.000	195.733	181.241	82.7440	1.08058	2.82334
SETTS	15	.300000	18.5000	5.74666	4.00154	4.56243	1.31219	4.43731
BOD5	15	55.0000	168.000	109.733	102.249	40.3062	.204062	1.41436
COD	0							
TOC	15	37.0000	108.000	62.8667	60.4591	18.0402	.796376	3.22641
O&G	8	39.2000	93.6000	66.8000	64.1704	17.8314	.229162	2.02469
PH	15	6.50000	7.40000	7.00666	7.00160	.264491	.482727	2.23125
TKN	15	4.31000	6.86000	5.46466	5.42210	.692751	.541144	2.48104
TIP	15	.420000	1.11000	.642666	.619936	.183065	1.13599	3.59723
AL	15	.000000	.800000	.533333E-01	.000000	.199555	3.47440	13.0714
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 14)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	158.000	492.000	349.417	330.723	106.551	.299219	1.86131
VSS	12	62.0000	244.000	146.167	133.588	57.5642	.840735E-02	1.72500
TS	12	898.000	1796.00	1361.33	1326.58	298.656	.197665	1.65238
VS	12	104.000	306.000	222.333	213.014	60.0449	.336680	2.18868
SETTS	4	6.00000	7.50000	6.75000	6.72675	.559017	.000000	1.64000
BOD5	12	75.0000	210.000	141.833	135.122	41.6870	.833302E-01	2.04484
COD	0							
TOC	6	63.0000	270.000	129.167	114.471	68.6037	1.18969	3.18380
O&G	6	31.6000	60.8000	48.1333	46.6670	11.3153	.438568	1.49630
PH	6	7.30000	7.90000	7.63333	7.63119	.179506	.505739	2.80016
TKN	6	3.40000	5.50000	4.16666	4.12140	.694536	1.17687	3.39015
TIP	6	.450000	1.21000	.869999	.819713	.281365	.185185	1.43481
AL	6	1.20000	5.60000	3.40000	3.05783	1.40000	.810948E-05	2.11953
FCOLI	1	20.0000	20.0000	20.0000	20.0000	.000000	.000000	.000000

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 15)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	13	158.000	1875.00	611.692	449.561	500.743	1.29702	3.74211
VSS	13	33.0000	1010.00	283.077	162.145	293.651	1.36444	3.72589
TS	13	359.000	2056.00	887.615	742.809	562.001	1.11083	3.00295
VS	12	110.000	1202.00	426.583	311.579	361.928	1.34619	3.41828
SETTS	5	2.30000	17.0000	9.94000	7.09802	6.41922	.220344	1.23561
BODS	13	42.0000	510.000	170.923	121.370	138.741	1.01024	3.14930
COD	0							
TOC	5	9.00000	270.000	92.8000	55.9361	91.2368	1.27913	3.00148
O&G	7	18.8000	168.000	55.3714	41.5514	48.4813	1.64020	4.26820
PH	5	6.80000	7.40000	7.19999	7.19686	.209762	1.17007	2.83044
TKN	5	1.80000	9.80000	5.24000	4.16883	3.26717	.274818	1.35343
TIP	5	.230000	2.00000	1.19800	.855157	.753748	.352322	1.22133
AL	5	.800000	2.00000	1.32000	1.26393	.391918	.567722	2.43620
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 16)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	216.000	1812.00	566.100	445.370	475.619	1.80389	4.91556
VSS	10	56.0000	620.000	208.200	155.245	176.158	1.40832	3.56503
TS	10	371.000	955.000	580.200	554.013	181.491	.696807	2.33606
VS	10	116.000	358.000	183.300	170.298	76.2011	1.14796	3.11469
SETTS	4	.800000	4.00000	1.75000	1.39985	1.30671	1.11431	2.30242
BODS	10	23.0000	114.000	56.2000	48.7082	29.8857	.581622	1.97280
COD	0							
TOC	10	28.0000	92.0000	50.9000	47.7090	18.8862	.837597	2.87192
O&G	5	13.2000	54.8000	31.7600	27.4060	16.6788	.327290	1.32482
PH	10	7.00000	7.30000	7.12000	7.11918	.107703	.769426E-01	1.51844
TKN	10	1.10000	5.80000	2.74000	2.24791	1.71883	.602549	1.70153
TIP	10	.140000	2.36000	.496999	.306025	.649492	2.29405	6.81235
AL	10	1.00000	8.00000	3.68000	2.94354	2.41901	.651115	1.86011
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 17)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	88.0000	395.000	196.700	162.519	124.271	.685099	1.67302
VSS	10	14.0000	260.000	113.800	79.2006	89.8095	.619377	1.64648
TS	10	448.000	960.000	646.700	621.531	188.410	.659118	1.80986
VS	10	112.000	406.000	231.700	204.922	116.237	.583956	1.64539
SETTS	4	3.50000	18.0000	10.2500	8.45192	5.79331	.148505	1.35854
BODS	10	73.0000	318.000	143.600	126.260	77.9784	1.06047	2.89462
COD	.0							
TOC	10	22.0000	135.000	79.1000	67.2914	39.5283	.659820E-01	1.48896
O&G	5	25.2000	60.0000	41.3600	38.4760	15.4663	.212182	1.23152
PH	10	6.60000	7.20000	6.85999	6.85778	.174356	.172161	2.52287
TKN	10	2.10000	7.60000	3.81000	3.46719	1.76490	.988857	2.60961
TIP	10	.170000	1.64000	.733000	.564611	.501398	.711437	2.10988
AL	10	.000000	2.50000	1.12000	.000000	.847112	.347988	1.55071
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 18)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	95.0000	312.000	163.333	151.819	68.0580	1.20878	3.15978
VSS	12	20.0000	228.000	93.4167	74.1239	62.1496	.954755	2.90866
TS	12	256.000	771.000	424.667	399.466	153.407	.781994	2.67699
VS	12	90.0000	342.000	167.917	155.260	70.1135	1.09299	3.60976
SETTS	4	2.50000	10.5000	6.62500	5.87874	2.83670	.130912	1.98843
BODS	12	34.0000	190.000	82.6667	71.4303	46.6946	.976131	2.84926
COD	0							
TOC	12	21.0000	114.000	51.2500	44.9047	26.5773	.669144	3.10860
O&G	6	20.4000	134.000	60.3333	50.8669	36.7575	1.08363	2.95548
PH	12	6.80000	7.10000	6.95666	6.96578	.110554	.424705	1.83462
TKN	12	1.30000	8.40000	3.35833	2.69540	2.31281	.921020	2.47929
TIP	12	.260000	1.14000	.555000	.495471	.273450	.834722	2.48316
AL	12	.000000	4.20000	1.76666	.000000	1.39363	.267832	1.72698
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- INFLUENT CSO (STORM # 19)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	74.0000	1228.00	324.667	183.592	411.060	1.66112	3.94734
VSS	6	28.0000	89.0000	44.8333	41.0494	21.0904	1.35082	3.33776
TS	6	275.000	417.000	346.833	340.948	63.4860	.219629E-01	1.07290
VS	6	52.0000	74.0000	60.6667	59.9305	9.62057	.429297	1.39434
SETTS	2	2.00000	2.50000	2.25000	2.23606	.250000	.000000	1.00000
BODS	6	25.0000	54.0000	36.8333	35.5806	9.95685	.633575	1.96526
COD	0							
TOC	6	8.00000	29.0000	20.6667	19.1623	6.82316	.676013	2.42653
O&G	2	53.2000	55.6000	54.4000	54.3867	1.20000	.000000	1.00000
PH	6	7.30000	8.00000	7.61666	7.61199	.267187	.240834	1.39149
TKN	6	.900000	2.30000	1.40000	1.33301	.461880	.943838	2.69678
TIP	6	.100000	.340000	.206666	.197465	.664997E-01	1.07430	2.95361
AL	6	4.10000	14.0000	7.60000	6.95857	3.28684	.862830	2.78005
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 01)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	168.000	366.000	243.667	236.165	63.1207	.830126	2.77738
VSS	6	.000000	86.0000	32.0000	.000000	33.2415	.517452	1.65406
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	15	4.00000	24.0000	11.6000	10.2278	5.88556	.808495	2.52321
TOC	15	9.00000	51.0000	22.8000	20.0663	11.7314	.925075	3.10345
O&G	6	.000000	44.0000	21.0000	.000000	15.9896	.557730E-01	1.55464
PH	15	5.75000	6.35000	6.03999	6.03737	.177200	.203357	1.82522
TKN	15	.300000	1.80000	.766666	.627727	.517257	1.11029	2.76855
TIP	15	.600000E-01	.260000	.132000	.119582	.600222E-01	.877626	2.61097
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 02)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	0							
VSS	0							
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	9	12.0000	54.0000	37.0000	32.7378	15.9164	.316951	1.48219
TOC	9	30.0000	60.0000	44.3333	42.9323	10.7600	.228625	1.60561
O&G	5	2.00000	24.0000	13.2000	9.89876	7.88416	.344759E-01	1.64668
PH	5	5.70000	6.20000	5.90000	5.89731	.178885	.628943	1.95316
TKN	9	1.40000	7.10000	3.76666	3.17924	2.09973	.386711	1.54352
TIP	9	.180000	.710000	.386666	.331016	.215716	.510504	1.46341
AL	0							
FCOLI	8	2000.00	2000.00	2000.00	1999.99	.000000	.000000	.000000

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 03)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	17	38.0000	364.000	147.294	122.487	85.0381	.800154	3.25031
VSS	17	12.0000	179.000	62.6470	48.4260	45.2482	1.14918	3.54918
TS	17	75.0000	533.000	221.294	195.091	116.358	1.30115	4.27736
VS	17	29.0000	199.000	82.9412	70.6142	49.5645	1.06808	2.99531
SETTS	17	.100000	3.50000	1.47059	.941665	1.13902	.491913	1.86884
BOD5	17	6.10000	160.000	50.1059	35.6803	41.3163	1.34174	4.01772
COD	0							
TOC	17	5.00000	64.0000	28.8235	19.9866	16.2054	.970088	3.03594
O&G	8	4.00000	41.0000	28.0000	24.0375	10.1735	1.34194	4.23706
PH	8	5.70000	6.30000	6.02500	6.02107	.216506	.249364	1.41171
TKN	17	.700000	6.30000	1.70000	1.43755	1.27510	2.70722	10.0810
TIP	16	.300000E-01	.940000	.358125	.243630	.271137	.605344	2.24037
AL	0							
FCOLI	17	200000.	.730000E 07	.161765E 07	988598.	.170172E 07	2.08658	7.50234

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 04)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	100.000	296.000	212.400	194.126	81.8623	.288413	1.31447
VSS	5	20.0000	135.000	89.6000	75.1095	40.3514	.618376	2.19647
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	0							
TOC	0							
O&G	0							
PH	0							
TKN	0							
TIP	0							
AL	0							
FCOLI	3	.102000E 07	.900000E 07	.377333E 07	.228517E 07	.369756E 07	.704067	1.50000

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 05)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	63.0000	164.000	101.400	93.9815	40.0779	.496351	1.58573
VSS	4	52.0000	132.000	89.0000	82.4110	33.8674	.107038	1.19338
TS	0							
VS	0							
SETTS	0							
BOD5	8	300.000	1530.00	630.000	500.075	480.469	1.13814	2.38175
COD	4	33.0000	47.0000	38.0000	37.6533	5.33854	.966162	2.22161
TOC	8	59.0000	161.000	100.500	94.5358	36.6742	.770414	2.02179
O&G	4	.800000	37.6000	15.6000	6.85570	14.7486	.451108	1.60362
PH	8	6.20000	7.00000	6.63750	6.63370	.223257	.340084	2.80055
TKN	8	3.90000	10.6000	6.25000	5.97637	1.96023	1.02083	3.43012
TIP	8	.650000	3.52000	1.50750	1.29371	.898411	1.22660	3.41789
AL	7	1.00000	3.00000	2.28571	2.15522	.699854	.459279	2.10417
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 06)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	13	62.0000	200.000	128.538	123.364	35.5649	.246000	2.84450
VSS	13	24.0000	92.0000	51.0769	47.1357	20.4053	.777238	2.52626
TS	0							
VS	0							
SETTS	4	1.00000	3.00000	1.75000	1.61185	.750000	.888889	2.18518
BOD5	13	5.00000	33.0000	16.0000	13.8558	8.33897	.666982	2.48376
COD	13	24.0000	37.0000	28.1538	27.9503	3.50486	1.05101	3.59252
TOC	13	16.0000	57.0000	30.6154	29.1151	10.1036	1.07106	4.10555
O&G	6	.000000	8.00000	1.33333	.000000	2.98142	1.78885	4.20000
PH	13	5.90000	6.70000	6.20000	6.19460	.260177	.576583	2.08165
TKN	13	1.50000	3.20000	2.36154	2.29490	.558209	.143808	1.63201
TIP	13	.330000	.760000	.561538	.547174	.124644	.369417E-01	2.04023
AL	13	.000000	3.00000	2.11538	.000000	.788227	1.20802	4.42478
FCOLI	12	270000.	.122000E 07	571250.	511547.	291877.	1.15713	2.95109

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 7A)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	3	200.000	248.000	224.000	223.139	19.5959	.000000	1.50000
VSS	3	80.0000	100.000	88.0000	87.5901	8.64098	.595170	1.50000
TS	0							
VS	0							
SETTS	3	2.50000	3.30000	2.83333	2.81366	.339934	.528004	1.50000
BOD5	3	76.0000	82.0000	78.6667	78.6271	2.49444	.381814	1.50001
COD	3	46.0000	73.0000	56.6667	55.5327	11.7284	.611949	1.50000
TOC	3	52.0000	82.0000	62.3333	60.9111	13.9124	.704368	1.50000
O&G	0							
PH	3	7.00000	7.40000	7.26666	7.26418	.188562	.707046	1.49994
TKN	3	5.00000	5.50000	5.16667	5.16140	.235702	.707115	1.50001
TIP	3	.590000	.920000	.723333	.710223	.141970	.580388	1.50001
AL	3	1.20000	1.60000	1.46667	1.45370	.188562	.707106	1.50000
FCOLI	1	.100000E 07	.100000E 07	.100000E 07	999987.	.000000	.000000	.000000

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 7B)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	11	25.0000	140.000	59.9091	50.3316	37.4225	1.03543	2.73446
VSS	11	4.00000	62.0000	21.7273	15.8934	17.2789	1.09426	3.12566
TS	1	932.000	932.000	932.000	931.997	.000000	.000000	.000000
VS	1	46.0000	46.0000	46.0000	45.9999	.000000	.000000	.000000
SETTS	11	.100000	1.70000	.500000	.240119	.589298	1.06880	2.49920
BOD5	11	10.9000	55.0000	23.1818	19.9637	13.7439	1.15747	3.09722
COD	11	20.0000	42.0000	25.3636	24.7749	6.10919	1.82034	5.21804
TOC	11	8.00000	32.0000	15.4545	14.2537	6.74689	1.27670	3.75720
O&G	0							
PH	11	6.80000	7.40000	7.13636	7.13336	.205704	.368661	1.90008
TKN	11	.800000	2.10000	1.43636	1.35769	.453617	.161140	1.58198
TIP	11	.160000	.400000	.238182	.228205	.724654E-01	.853149	2.84287
AL	12	.400000	1.20000	.500000	.464415	.238047	2.22398	6.46713
FCOLI	6	595000.	.142000E 07	928333.	869461.	340694.	.494090	1.46687

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 08)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	168.000	220.000	197.917	197.297	15.3539	.588367	2.45491
VSS	12	52.0000	71.0000	57.7500	57.5089	5.41795	1.02982	3.47486
TS	0							
VS	0							
SETTS	12	.600000	1.60000	1.10833	1.03826	.379601	.643420E-01	1.43031
BOD5	12	74.0000	105.000	89.0000	88.5752	8.61200	.119770	2.51953
COD	9	127.000	187.000	157.222	155.786	21.1806	.545654E-01	1.61973
TOC	13	35.0000	63.0000	49.2308	48.3620	9.10750	.940511E-01	1.55152
O&G	0							
PH	13	6.25000	6.70000	6.44615	6.44473	.135109	.268766	2.20581
TKN	12	3.10000	4.40000	3.87499	3.85468	.389711	.411260	2.12522
TIP	12	.640000	1.18000	.855833	.837109	.182001	.426001	1.88779
AL	12	.800000	2.00000	1.30000	1.27004	.288675	.914530	3.83521
FCOLI	12	780000.	.160500E 07	.115417E 07	.113412E 07	213706.	.226285	2.88600

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 09)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	160.000	214.000	181.000	180.095	18.3848	.585769	2.19185
VSS	6	71.0000	92.0000	80.8333	80.5339	6.96220	.100971	1.94383
TS	0							
VS	0							
SETTS	6	.100000	.300000	.166667	.151309	.745355E-01	.626100	2.04000
BOD5	6	15.0000	45.0000	26.0000	23.3791	12.5033	.673253	1.54043
COD	6	10.0000	16.0000	13.1667	12.9901	2.11476	.219299	1.65677
TOC	6	22.0000	50.0000	29.6667	28.5481	9.26762	1.63394	3.95246
O&G	0							
PH	6	6.80000	8.00000	7.41666	7.40132	.477552	.988060E-01	1.33795
TKN	6	.780000	1.64000	1.24000	1.20883	.266270	.273158	2.35887
TIP	6	.170000	.260000	.208333	.206196	.302306E-01	.412927	2.02646
AL	6	4.23000	4.23000	4.23000	4.22999	.286102E-05	1.00000	1.00000
FCOLI	6	290000.	405000.	357500.	355435.	37388.7	.591920	2.28333

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 10)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	140.000	390.000	246.000	229.436	91.3717	.395807	1.73499
VSS	5	54.0000	125.000	90.8000	86.4577	27.6217	.662994E-01	1.40347
TS	0							
VS	0							
SETTS	5	.200000	1.50000	.700000	.537827	.485798	.596608	1.82204
BOD5	5	27.0000	64.0000	44.6000	42.2499	14.0656	.420175E-01	1.47360
COD	5	22.0000	27.0000	24.4000	24.3461	1.62481	.179052	2.26860
TOC	5	17.0000	61.0000	43.4000	39.7454	15.4609	.627881	2.10590
O&G	0							
PH	5	6.80000	7.20000	7.04000	7.03839	.149666	.343553	1.84691
TKN	5	1.05000	1.32000	1.16000	1.15643	.923039E-01	.653096	2.24742
TIP	5	.310000	.360000	.332000	.331560	.172046E-01	.395895	1.99454
AL	5	3.46000	5.77000	4.54000	4.46544	.821389	.133721	1.72272
FCOLI	5	650000.	.102000E 07	834000.	821102.	145134.	.507779E-01	1.36365

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 11)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	104.000	146.000	122.000	120.879	16.7182	.328393	1.49678
VSS	4	48.0000	77.0000	59.0000	57.9912	11.2916	.692864	1.90256
TS	0							
VS	0							
SETTS	4	.700000	1.30000	.950000	.923704	.229126	.498785	1.76191
BOD5	4	22.0000	34.0000	26.2500	25.8612	4.71036	.847697	2.05436
COD	0							
TOC	4	11.0000	22.0000	17.2500	16.7207	4.02337	.505253	1.95043
O&G	0							
PH	4	7.70000	8.10000	7.84999	7.84857	.150000	.888987	2.18530
TKN	4	2.20000	3.20000	2.70000	2.66825	.412311	.119583E-06	1.22145
TIP	4	.300000	.330000	.310000	.309764	.122474E-01	.816497	2.00000
AL	4	.000000	.000000	.000000	.000000	.000000	.000000	.000000
FCOLI	4	255000.	615000.	438750.	414916.	140061.	.523966E-01	1.42840

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 12)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	22	76.0000	144.000	114.000	112.063	20.1269	.499881	2.15602
VSS	22	34.0000	86.0000	56.0909	54.3984	13.7969	.266983	1.99905
TS	0							
VS	0							
SETTS	22	.600000	1.20000	.818181	.806396	.143452	.880355	3.68614
BOD5	21	17.0000	138.000	36.1429	32.5220	23.8173	3.68023	15.9710
COD	0							
TOC	22	15.0000	39.0000	22.3636	21.4403	6.75913	.829682	2.65810
O&G	0							
PH	17	6.60000	7.00000	6.75882	6.75777	.119108	.626048	2.67699
TKN	22	2.20000	4.00000	3.09545	3.06357	.440534	.336470E-01	2.42016
TIP	22	.350000	23.3000	3.82272	1.03451	6.48505	1.70448	4.64205
AL	22	.000000	.800000	.327272	.000000	.333278	.350710	1.52721
FCOLI	22	330000.	.180000E 07	894545.	606086.	395247.	.477306	2.35440

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 13)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	14	89.0000	191.000	123.857	119.967	32.6449	.833817	2.42248
VSS	14	51.0000	108.000	71.8571	70.0760	16.5523	.696741	2.43072
TS	0							
VS	0							
SETTS	14	.700000	4.10000	1.52143	1.40541	.755152	2.71391	9.83308
BOD5	14	64.0000	119.000	81.2143	79.9711	15.3212	1.51055	4.15137
COD	0							
TOC	13	31.0000	76.0000	50.5385	48.6621	13.9814	.407937	1.81815
O&G	7	46.4000	112.000	66.3999	63.9633	19.9657	1.48897	4.08105
PH	13	6.60000	7.30000	7.00000	6.99655	.218386	.443076	2.40110
TKN	13	3.60000	7.05000	5.66922	5.58532	.937824	.389971	2.74460
TIP	13	.270000	1.10000	.690769	.643218	.239822	.102068	2.03498
AL	11	.000000	.000000	.000000	.000000	.000000	.000000	.000000
FCOLI	7	215000.	.125500E 07	615000.	541608.	311528.	.906678	2.98924

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 14)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	157.000	240.000	201.200	199.710	23.9825	.303235	2.22723
VSS	10	56.0000	80.0000	68.5000	67.8887	9.03609	.176879	1.49824
TS	0							
VS	0							
SETTS	4	1.30000	2.20000	1.80000	1.76066	.367424	.211682	1.34156
BOD5	10	63.0000	96.0000	84.4000	83.9227	8.51117	1.28877	4.44686
COD	0							
TOC	5	60.0000	87.0000	73.4000	72.7015	10.0916	.297062E-01	1.48294
O&G	5	27.6000	36.8000	33.5200	33.3302	3.46318	.746402	1.96616
PH	5	7.70000	7.90000	7.77999	7.77963	.748330E-01	.343813	1.84703
TKN	5	4.40000	4.70000	4.56000	4.55885	.101980	.271482	1.95560
TIP	5	.480000	1.58000	.874000	.790200	.405887	.755202	2.12177
AL	5	1.20000	2.40000	1.68000	1.61713	.466476	.363177	1.62803
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 15)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	26.0000	50.0000	35.4286	34.6687	7.53766	.638834	2.50716
VSS	7	4.00000	14.0000	7.42857	6.64722	3.49927	.600940	2.21360
TS	0							
VS	0							
SETTS	3	.100000	.200000	.133333	.125992	.471405E-01	.707108	1.50000
BODS	7	18.0000	45.0000	31.8571	30.4042	9.28021	.998443E-01	1.61225
COD	0							
TOC	3	25.0000	38.0000	31.3333	30.8812	5.31246	.938740E-01	1.50000
O&G	4	5.60000	12.4000	9.00000	8.63324	2.50599	.363590E-05	1.70688
PH	3	7.50000	7.50000	7.50000	7.49998	.000000	.000000	.000000
TKN	3	2.80000	4.80000	4.10000	3.98258	.920145	.700848	1.50000
TIP	3	.130000	.250000	.200000	.192650	.509902E-01	.528003	1.50000
AL	3	1.20000	1.40000	1.33333	1.32988	.942808E-01	.707107	1.50000
FCOLI	4	215000.	.164000E 07	716000.	517659.	569197.	.785860	1.97302

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 16)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	62.0000	102.000	75.6250	74.5042	13.3972	.665539	2.26695
VSS	8	17.0000	44.0000	27.8750	26.6355	6.50643	.543459	2.20571
TS	0							
VS	0							
SETTS	3	.200000	.300000	.266667	.262074	.471404E-01	.707104	1.50000
BODS	8	16.0000	46.0000	30.0000	27.7351	11.6512	.265072	1.45812
COD	0							
TOC	8	15.0000	38.0000	28.0000	26.8744	7.56637	.197380	1.66915
O&G	4	11.6000	17.6000	14.3000	14.0707	2.56710	.133002	1.19780
PH	8	6.90000	7.20000	6.98750	6.98688	.927025E-01	1.19157	3.74921
TKN	8	1.80000	4.90000	3.21250	2.98805	1.20461	.283446	1.48282
TIP	8	.230000	.580000	.368750	.346152	.131476	.402367	1.61315
AL	8	1.70000	3.30000	2.62500	2.56629	.528559	.511067	1.86224
FCOLI	4	36000.0	285000.	131750.	101519.	93298.9	.809479	2.11049

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 17)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	20.0000	289.000	74.4444	50.9790	80.3134	2.01856	5.72383
VSS	9	2.00000	189.000	40.0000	17.5952	55.9821	1.99144	5.64637
TS	0							
VS	0							
SETTS	3	.100000	.700000	.300000	.191293	.282843	.707107	1.50000
BODS	9	50.0000	99.0000	66.5555	64.7578	16.1390	.752098	2.26019
COD	0							
TOC	9	10.0000	69.0000	33.2222	28.7465	17.5105	.727472	2.55744
O&G	6	68.4000	89.6000	76.7333	76.3908	7.33727	.491934	2.11355
PH	9	6.90000	7.30000	7.08888	7.08771	.128620	.105609	1.98918
TKN	9	3.50000	6.70000	5.01111	4.87184	1.15513	.108797	1.53549
TIP	9	.100000	.400000	.230000	.211161	.886942E-01	.181544	2.44391
AL	9	2.10000	3.70000	2.98888	2.93244	.558658	.399769	2.02923
FCOLI	3	123000.	.111000E 07	536000.	371316.	418715.	.519916	1.50000

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 18)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	39.0000	75.0000	57.2500	55.6001	13.3299	.233488	1.38939
VSS	8	9.00000	20.0000	13.8750	13.4089	3.62069	.322195	1.84191
TS	0							
VS	0							
SETTS	3	.100000	.100000	.100000	.100000	.000000	.000000	.000000
BODS	8	12.0000	31.0000	20.8750	19.7369	7.00781	.390944	1.56705
COD	0							
TOC	8	23.0000	32.0000	26.7500	26.5590	3.23071	.358646	1.60339
O&G	3	22.0000	158.800	73.3333	51.5449	60.8406	.664958	1.50000
PH	8	4.70000	6.60000	5.46250	5.40777	.788887	-.490261	1.34437
TKN	8	2.50000	6.40000	3.98750	3.71912	1.53821	.558274	1.61139
TIP	8	.930000	1.25000	.876250	.810325	.315196	.313567	1.48515
AL	8	8.00000	22.4000	15.1750	14.0964	5.47671	.947120E-01	1.40107
FCOLI	5	.000000	25500.0	14200.0	.000000	8812.48	.386708	1.94306

ROCHESTER CSO PP --- PERFORMANCE DATA --- FLOC-SED EFFLUENT (STORM # 19)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	36.0000	96.0000	63.8000	59.2114	24.4491	.295571	1.28056
VSS	5	12.0000	30.0000	18.6000	17.5964	6.62118	.750582	2.03299
TS	0							
VS	0							
SETTS	2	.100000	.100000	.100000	.100000	.000000	.000000	.000000
BODS	5	9.80000	13.0000	11.3200	11.2448	1.29368	.152695	1.36165
COD	0							
TOC	5	5.00000	18.0000	12.8000	11.6951	4.66476	.523480	2.00018
O&G	4	50.0000	56.4000	52.0000	51.9381	2.57682	1.06044	2.25550
PH	5	6.50000	7.00000	6.81999	6.81750	.183303	.685745	2.22452
TKN	5	1.10000	1.40000	1.20000	1.19524	.109545	.912888	2.50002
TIP	5	.180000	.620000	.332000	.294292	.169399	.738774	1.92301
AL	5	6.80000	14.0000	10.3400	9.85484	3.14559	.127963	1.31153
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 01)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	60.0000	274.000	148.000	134.575	64.1275	.818700	3.08007
VSS	6	15.0000	42.0000	25.8333	24.3931	8.93339	.657480	2.24858
TS	0							
VS	0							
SETTS	0							
BODS	3	6.60000	14.0000	10.8667	10.3502	3.12552	.496229	1.50000
COD	15	4.00000	12.0000	5.86667	5.48945	2.36267	1.37250	3.85925
TOC	15	6.00000	58.0000	22.4000	18.6221	13.6470	1.05809	3.64538
O&G	6	.000000	23.0000	12.5000	.000000	9.84462	.163503	1.20365
PH	15	5.85000	6.20000	6.03333	6.03242	.104350	.257339	2.36301
TKN	15	.000000	.800000	.266666	.000000	.249444	.819921	2.58138
TIP	15	.300000E-01	.190000	.873332E-01	.755252E-01	.444921E-01	.576661	2.72746
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 02)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	0							
VSS	0							
TS	0							
VS	0							
SETTS	0							
BODS	0							
COD	9	7.00000	38.0000	25.3333	22.1315	11.2250	.292504	1.60236
TOC	9	23.0000	84.0000	48.8889	44.9788	20.0745	.607129	2.13100
O&G	5	20.0000	34.0000	29.6000	29.0575	5.27636	.959381	2.39536
PH	5	5.70000	6.00000	5.78000	5.77884	.116619	1.15008	2.66614
TKN	9	1.20000	5.30000	2.44444	2.18863	1.23658	1.18381	3.84538
TIP	9	.170000	.620000	.274444	.250655	.136309	1.72150	4.72250
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 03)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	18	28.0000	490.000	151.444	112.269	118.864	1.32748	4.28530
VSS	18	8.00000	350.000	79.5000	50.1430	81.3355	2.02920	7.10701
TS	18	89.0000	691.000	227.389	192.217	148.597	1.72028	5.73436
VS	18	4.00000	334.000	73.5555	36.2480	81.4111	1.83902	6.24496
SETTS	18	.200000	23.5000	4.00000	1.93674	5.46482	2.57086	9.24541
BODS	18	12.0000	210.000	46.5889	32.7540	48.2211	2.27084	7.71696
COD	0							
TOC	18	6.00000	123.000	24.3333	17.8997	25.7638	3.05052	12.0116
O&G	9	7.00000	51.0000	29.8889	24.8242	14.8507	.150807	1.99212
PH	9	5.60000	6.20000	5.92222	5.91923	.187248	.222292	1.93695
TKN	18	.200000	4.40000	1.38889	.870578	1.23328	.949068	2.81405
TIP	18	.700000E-01	.810000	.257222	.201748	.194302	1.37659	4.16010
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 04)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	52.0000	336.000	144.500	124.045	83.3412	1.21562	3.79130
VSS	8	32.0000	112.000	68.8750	64.0787	25.1865	.232924	1.91311
TS	0							
VS	0							
SETTS	0							
BODS	0							
COD	0							
TOC	0							
O&G	0							
PH	0							
TKN	0							
TIP	0							
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 05)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	72.0000	359.000	141.875	124.843	86.0558	1.87544	5.16204
VSS	8	68.0000	304.000	126.500	112.955	71.0194	1.80506	4.98845
TS	0							
VS	0							
SETTS	0							
BODS	8	60.0000	49800.0	7278.75	1302.14	16092.4	2.25618	6.11318
COD	8	31.0000	57.0000	41.8750	40.9991	8.69536	.392013	1.77625
TOC	8	43.0000	182.000	88.6250	82.2163	38.0524	1.59898	4.80663
O&G	0							
PH	0							
TKN	8	3.20000	8.00000	5.15000	4.95625	1.45945	.676385	2.45080
TIP	8	.680000	3.78000	1.40500	1.14881	1.00856	1.46932	3.97686
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 06)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	13	66.0000	328.000	151.846	139.231	66.8337	1.23118	4.19160
VSS	13	48.0000	136.000	77.1538	74.1958	23.1777	1.24652	3.78781
TS	0							
VS	0							
SETTS	4	1.00000	2.50000	1.62500	1.54003	.544862	.652024	2.09695
BODS	13	5.00000	40.0000	15.6154	13.1639	9.84915	1.35830	3.86067
COD	13	22.0000	32.0000	26.3846	26.1800	3.34062	.517624	1.95921
TOC	13	11.0000	77.0000	38.1538	34.0358	17.3863	.561252	2.73449
O&G	0							
PH	0							
TKN	13	1.70000	4.00000	2.43846	2.33418	.767151	.968693	2.39978
TIP	13	.360000	.770000	.536153	.519589	.135450	.383896	1.65768
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 7A)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	3	212.000	272.000	246.667	245.309	25.3684	.502066	1.50000
VSS	3	108.000	144.000	121.333	120.319	16.1107	.674556	1.50000
TS	0							
VS	0							
SETTS	3	4.40000	7.10000	5.76666	5.65865	1.10252	.453133E-01	1.50000
BODS	3	67.0000	80.0000	75.3333	75.0924	5.90668	.691934	1.50000
COD	3	45.0000	59.0000	51.3333	51.0125	5.79272	.333069	1.50000
TOC	3	47.0000	59.0000	52.6667	52.4385	4.92161	.200706	1.50000
O&G	0							
PH	0							
TKN	3	4.20000	5.40000	4.86667	4.84028	.498868	.381799	1.50000
TIP	3	.530000	.700000	.600000	.595776	.725718E-01	.549444	1.50001
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 7B)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	11	15.0000	180.000	56.8182	41.3824	50.1068	1.41154	3.71107
VSS	11	3.00000	76.0000	20.6364	14.3753	20.1597	1.85538	5.37998
TS	0							
VS	0							
SETTS	12	.100000	3.00000	.833333	.359296	1.06466	1.23351	2.81002
BODS	12	9.10000	43.0000	18.5250	15.7923	11.1390	.967767	2.56969
COD	12	15.0000	35.0000	22.0000	21.1430	5.61249	.868245	3.10053
TOC	9	4.00000	39.0000	16.1111	13.3760	9.79165	1.10797	3.68916
O&G	0							
PH	0							
TKN	12	.100000	1.80000	.991666	.805015	.469855	.370601	2.40710
TIP	12	.140000	.250000	.179166	.175137	.388283E-01	.455889	1.68657
AL	0							
FCOLI	2	40.0000	63.0000	51.5000	50.1995	11.5000	.000000	1.00000

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 08)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	26	110.000	512.000	278.538	249.745	126.350	.363911	1.76807
VSS	26	22.0000	220.000	88.5385	75.1375	49.2257	.705957	2.81687
TS	0							
VS	0							
SETTS	25	.800000	9.00000	3.46800	2.71807	2.29830	.762967	2.66932
BODS	26	28.0000	221.000	85.9615	72.0187	51.5904	.870702	2.82088
COD	0							
TOC	26	33.0000	95.0000	53.7692	51.7418	15.5051	.909337	3.23451
O&G	0							
PH	26	7.10000	8.20000	7.81538	7.81198	.226499	.985178	4.67957
TKN	26	.000000	1.76000	.180384	.000000	.380257	2.88582	11.7347
TIP	24	.370000	4.26000	1.10750	.943747	.798317	2.71639	10.6599
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 09)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	125.000	240.000	188.750	184.555	38.3528	.333589	1.76551
VSS	8	60.0000	103.000	85.7500	84.7414	12.5971	.598657	2.85947
TS	0							
VS	0							
SETTS	8	.700000	2.10000	1.31250	1.22526	.485894	.460004	1.85867
BODS	8	8.00000	33.0000	22.3750	20.7410	7.49896	.497846	2.44982
COD	8	14.0000	24.0000	18.3750	18.1525	2.86956	.319886	2.77369
TOC	8	20.0000	52.0000	33.8750	31.8886	11.6987	.385646	1.83050
O&G	0							
PH	8	6.90000	7.60000	7.33750	7.33350	.239465	.825600	2.14650
TKN	8	.680000	2.88000	1.47875	1.34304	.669111	.889743	2.82862
TIP	8	.220000	.990000	.356250	.309403	.243359	2.13304	9.78704
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFL. (STORM # 10)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	116.000	710.000	329.750	259.852	231.811	.830120	2.04302
VSS	4	37.0000	275.000	132.250	102.338	90.2258	.638715	1.91214
TS	0							
VS	0							
SETTS	6	.100000	7.50000	2.26667	.882538	2.62086	1.11644	2.83470
BOD5	6	16.0000	120.000	42.8333	32.9763	35.9231	1.50616	3.64576
COD	6	11.0000	27.0000	16.1667	15.4844	5.17741	1.30967	3.38911
TOC	6	14.0000	88.0000	38.8333	30.3294	27.8293	.796456	1.96825
O&G	0							
PH	2	7.60000	7.70000	7.65000	7.64983	.500002E-01	.000000	1.00000
TKN	6	1.10000	1.60000	1.22667	1.21422	.184270	1.22796	2.93889
TIP	6	.110000	.260000	.180000	.173106	.493288E-01	.183288	1.43263
AL	2	1.92000	1.92000	1.92000	1.92000	.000000	.000000	.000000
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 11)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	64.0000	480.000	193.778	149.347	141.676	.907803	2.42418
VSS	9	40.0000	176.000	89.0000	76.9890	48.9875	.731376	2.00917
TS	0							
VS	0							
SETTS	9	.400000	4.10000	1.81111	1.37446	1.25117	.557159	1.91541
BOD5	9	28.0000	62.0000	37.4444	36.0514	10.9454	1.05135	3.07069
COD	0							
TOC	8	10.0000	55.0000	30.3750	26.2803	15.8109	.493827	1.80986
O&G	0							
PH	0							
TKN	9	1.30000	6.00000	2.47777	2.23674	1.32479	1.93290	5.67849
TIP	9	.190000	.310000	.265555	.262321	.397523E-01	.657220	2.08167
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 12)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	24	85.0000	526.000	186.000	164.061	105.794	1.63644	5.23543
VSS	24	40.0000	197.000	85.5000	76.9050	42.5598	1.14776	3.18292
TS	0							
VS	0							
SETTS	24	.800000	6.00000	2.46666	2.08714	1.48286	.959507	2.65623
BOD5	24	30.0000	137.000	50.7500	45.7211	26.8410	1.70974	5.27086
COD	0							
TOC	24	3.00000	74.0000	36.8750	31.3430	17.0717	.200416	2.62713
O&G	0							
PH	0							
TKN	24	1.50000	3.60000	2.40000	2.34244	.533854	.504458	2.53371
TIP	24	.000000	.280000	.866665E-01	.000000	.832998E-01	.937003	2.49489
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 13)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	14	204.000	366.000	253.286	249.691	45.1306	1.21793	3.58200
VSS	14	80.0000	209.000	120.714	116.436	35.0131	1.31092	3.75836
TS	0							
VS	0							
SETTS	14	1.00000	17.0000	5.04286	3.69350	4.52086	1.64046	4.48296
BOD5	14	28.0000	142.000	58.7143	54.5923	26.2690	2.16503	7.41822
COD	0							
TOC	14	48.0000	111.000	65.7857	63.5167	19.2990	1.52326	3.91530
O&G	0							
PH	0							
TKN	14	4.78000	8.47000	6.73428	6.62326	1.20744	.339309E-01	1.73880
TIP	14	.610000	3.42000	1.83071	1.55251	1.00121	.472830	1.84398
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 14)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	194.000	494.000	349.000	336.953	87.6594	.172962	2.22742
VSS	12	83.0000	214.000	148.917	143.412	38.8318	.145438	2.04869
TS	0							
VS	0							
SETTS	4	4.50000	7.50000	6.35000	6.21649	1.25200	.430696	1.55191
BOD5	12	54.0000	140.000	101.250	97.0849	27.1757	.417152	1.88956
COD	0							
TOC	12	60.0000	153.000	103.250	99.4411	27.8661	.230667	1.95879
O&G	0							
PH	0							
TKN	12	3.90000	5.50000	4.61666	4.59202	.479293	.265018	2.16539
TIP	12	.300000	4.61000	1.00583	.706832	1.15201	2.50972	8.03151
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 15)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	116.000	740.000	361.000	302.160	212.886	.695338	2.11132
VSS	12	20.0000	467.000	153.083	97.0734	145.662	1.22543	3.09610
TS	0							
VS	0							
SETTS	4	4.30000	28.0000	13.7000	10.9976	8.87384	.711891	2.02038
BOD5	12	20.0000	322.000	94.1667	60.9474	100.045	1.57323	3.82488
COD	0							
TOC	12	35.0000	380.000	128.250	87.4479	122.066	1.25194	2.94685
O&G	0							
PH	0							
TKN	12	1.40000	9.30000	3.04166	2.48806	2.34963	1.80089	4.81045
TIP	12	.600000	3.37000	1.65333	1.36880	.990263	.562520	1.82277
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 16)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	168.000	328.000	245.333	239.652	51.9679	.233660	1.76652
VSS	9	42.0000	124.000	67.0000	62.5973	26.5246	1.06901	2.84762
TS	0							
VS	0							
SETTS	3	6.00000	8.00000	6.66667	6.60384	.942808	.707108	1.50000
BOD5	9	12.0000	62.0000	30.4444	25.6750	17.9574	.710401	1.97794
COD	0							
TOC	4	27.0000	84.0000	45.0000	40.3605	22.9456	1.03254	2.22792
O&G	0							
PH	0							
TKN	4	1.30000	4.00000	2.30000	2.04753	1.11580	.529096	1.67098
TIP	4	.770000	1.84000	1.45000	1.36967	.440624	.575099	1.72561
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 17)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	75.0000	405.000	177.556	148.087	116.460	1.08684	2.51586
VSS	9	57.0000	275.000	122.333	101.544	82.4351	1.10985	2.45922
TS	0							
VS	0							
SETTS	3	4.50000	20.0000	9.66667	7.39862	7.30677	.707107	1.50000
BOD5	9	69.0000	260.000	131.000	113.282	76.6101	1.02809	2.39510
COD	0							
TOC	9	15.0000	154.000	83.4444	67.0688	46.3635	.673568E-01	1.69003
O&G	0							
PH	0							
TKN	9	3.40000	7.60000	4.56666	4.42385	1.25786	1.44504	3.98062
TIP	9	.230000	1.68000	.725555	.613199	.456242	1.55541	4.79688
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 18)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	88.0000	168.000	111.750	109.288	25.3118	1.29261	3.29349
VSS	12	26.0000	92.0000	50.4167	46.7595	20.0560	.696451	2.24862
TS	0							
VS	0							
SETTS	4	1.40000	6.00000	3.22500	2.66445	1.91099	.380565	1.49232
BOD5	12	33.0000	96.0000	60.5000	56.4594	23.0308	.571570	1.60662
COD	0							
TOC	12	14.0000	71.0000	38.1667	33.4915	18.5330	.285118	1.67375
O&G	0							
PH	0							
TKN	12	1.50000	7.70000	3.01666	2.51365	2.01983	1.21332	3.02854
TIP	12	.280000	.610000	.427500	.412900	.114900	.520427	1.72002
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- GRIT-SWIRL EFFLUENT (STORM # 19)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS

NO DATA EXISTS FOR THIS REQUEST

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 01)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	81.0000	220.000	131.333	122.883	49.5771	.721829	2.08956
VSS	6	19.0000	164.000	71.1667	53.8560	49.4045	.732235	2.48347
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	15	5.00000	23.0000	12.0000	10.6486	5.87651	.589350	1.94955
TOC	15	8.00000	42.0000	20.8000	18.0809	10.4830	.376512	1.94123
O&G	6	4.00000	17.0000	11.5000	10.3836	4.46261	.388146	1.94928
PH	15	5.55000	6.30000	5.90333	5.89977	.203688	.326108	2.59257
TKN	15	.100000	1.20000	.433333	.391695	.351504	.486775	2.42651
TIP	15	.500000E-01	.220000	.986665E-01	.873175E-01	.526982E-01	1.15837	3.06571
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 02)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	0							
VSS	0							
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	9	12.0000	35.0000	23.6667	22.2453	7.61577	.265919	1.95730
TOC	9	30.0000	53.0000	43.5555	42.9209	7.16645	.454309	2.09127
O&G	5	23.0000	47.0000	34.4000	33.4534	8.01498	.186546	2.06637
PH	5	5.70000	6.10000	5.85999	5.85844	.135646	.750156	2.36401
TKN	9	1.40000	6.00000	3.34444	2.89886	1.77145	.478752	1.54599
TIP	9	.190000	.790000	.382222	.332319	.211753	.825277	2.10551
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 03)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	18	36.0000	195.000	91.2222	80.6733	47.5202	1.00174	2.77097
VSS	18	12.0000	115.000	35.7222	27.9335	30.6028	1.77648	4.55023
TS	18	80.0000	388.000	198.278	181.158	81.1217	.569728	3.09203
VS	17	13.0000	140.000	56.7059	48.0757	31.4486	1.03760	4.06641
SETTS	18	.100000	2.10000	.905555	.756645	.470781	.552936	3.21835
BOD5	18	9.70000	107.000	32.0833	24.6306	26.5005	1.60434	4.57544
COD	0							
TOC	18	5.00000	33.0000	18.2222	16.6320	7.45769	.538769	2.59468
O&G	9	3.00000	50.0000	14.6667	11.2150	12.9672	2.11627	6.18011
PH	9	5.60000	6.20000	5.88888	5.88616	.179161	.167052	2.14280
TKN	18	.300000	6.00000	1.95000	1.26479	1.68069	1.14103	3.54813
TIP	18	.900000E-01	.970000	.379444	.313601	.238920	1.09656	3.30615
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 04)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	14.0000	155.000	76.5000	56.5579	50.0764	.205468	1.60361
VSS	9	2.00000	56.0000	19.4444	12.1862	16.3986	.944367	3.10013
TS	0							
VS	0							
SETTS	0							
BOD5	0							
COD	0							
TOC	0							
O&G	0							
PH	0							
TKN	0							
TIP	0							
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 05)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	104.000	184.000	137.714	135.252	26.2608	.335482	2.04999
VSS	7	96.0000	172.000	123.429	120.857	25.9607	.633018	2.17608
TS	0							
VS	0							
SETTS	0							
BOD5	7	180.000	33600.0	5991.43	1739.15	11295.9	2.02258	5.12580
COD	7	33.0000	46.0000	40.0000	39.7235	4.65986	.144007	1.48944
TOC	7	55.0000	104.000	74.5714	73.1918	14.7929	.734004	2.74758
O&G	0							
PH	0							
TKN	7	3.50000	5.30000	4.34285	4.29303	.665168	.323415	1.48807
TIP	7	.730000	2.95000	1.23714	1.09892	.721936	1.78511	4.60619
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 06)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	13	8.00000	124.000	48.7692	35.5482	35.7042	.891042	2.85673
VSS	12	4.00000	84.0000	30.3333	20.3117	24.7365	.944869	2.82592
TS	0							
VS	0							
SETTS	4	1.00000	2.00000	1.50000	1.41421	.500000	.000000	1.00000
BODS	13	8.00000	24.0000	15.3846	14.6650	4.79644	.519462	2.04473
COD	13	24.0000	35.0000	29.2308	29.0301	3.40031	.336810E-01	2.05701
TOC	13	17.0000	57.0000	35.2308	33.5688	10.9906	.596673	2.51765
O&G	0							
PH	0							
TKN	13	1.40000	3.60000	2.39230	2.30305	.646245	.168825	1.94167
TIP	13	.390000	.670000	.518461	.509516	.966233E-01	.209805	1.70187
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 7A)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	200.000	864.000	375.000	300.721	282.593	1.14817	2.32812
VSS	4	88.0000	524.000	204.000	147.869	184.889	1.14958	2.32935
TS	0							
VS	0							
SETTS	4	1.80000	48.0000	13.6250	4.66894	19.8480	1.15416	2.33292
BODS	4	35.0000	360.000	134.500	89.5771	131.047	1.10872	2.30179
COD	4	40.0000	86.0000	63.7500	61.2373	17.3548	.983050E-01	1.58240
TOC	4	54.0000	470.000	160.250	96.4517	178.861	1.15368	2.33253
O&G	0							
PH	0							
TKN	4	5.30000	7.10000	5.95000	5.91317	.683740	.950274	2.21377
TIP	4	.420000	.760000	.619999	.605856	.124700	.661383	2.05789
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 7B)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	30.0000	124.000	62.4167	55.6867	30.2805	.717779	2.30404
VSS	12	13.0000	64.0000	26.6667	23.2431	15.0236	1.27976	3.46330
TS	0							
VS	0							
SETTS	12	.100000	2.70000	.725000	.326201	.869026	1.20158	2.96675
BODS	12	9.00000	52.0000	21.9167	18.3053	14.1330	1.12607	2.88713
COD	12	17.0000	37.0000	22.5833	22.0236	5.45371	1.42925	4.45071
TOC	12	6.00000	52.0000	18.5000	14.9460	13.4505	1.39680	3.74587
O&G	0							
PH	0							
TKN	12	.300000	2.10000	1.10000	.937628	.580229	.470965	2.14715
TIP	12	.160000	.390000	.211666	.204491	.584285E-01	.902875	2.51953
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 08)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	27	104.000	300.000	209.481	198.703	63.9868	.175928	1.66075
VSS	27	28.0000	116.000	68.1852	63.1943	25.4370	.171259	1.75710
TS	0							
VS	0							
SETTS	27	.100000	2.70000	1.76296	1.55258	.647587	.556208	2.71347
BODS	27	30.0000	98.0000	67.2592	64.0239	19.8673	.116567	1.85884
COD	27	35.0000	209.000	99.2963	83.9084	57.8226	.669363	1.92766
TOC	27	18.0000	94.0000	55.3333	50.0791	22.2976	.658096E-01	1.91792
O&G	0							
PH	27	6.80000	8.00000	7.66296	7.65828	.261262	1.56103	5.55325
TKN	27	1.50000	4.60000	2.95925	2.86138	.731947	.330705E-02	2.82608
TIP	27	.140000	1.02000	.450740	.410757	.194896	.935845	3.84756
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 09)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	166.000	265.000	211.375	209.350	29.2999	.224423	2.35968
VSS	8	60.0000	105.000	88.3750	87.0900	14.2998	.732869	2.37041
TS	0							
VS	0							
SETTS	8	.800000	1.50000	1.10000	1.07262	.244949	.153098	-1.62500
BODS	8	17.0000	30.0000	23.3750	22.8677	4.84607	.738298E-01	1.41462
COD	8	8.00000	18.0000	11.7500	11.3054	3.30719	.531310	2.18687
TOC	8	14.0000	37.0000	22.5000	21.2237	7.84219	.622803	2.13449
O&G	0							
PH	8	7.40000	7.60000	7.47499	7.47453	.829155E-01	.493559	1.62821
TKN	8	.730000	-2.33000	-1.42125	1.31312	.544665	.243880	-1.85605
TIP	8	.000000	.210000	.103750	.000000	.830567E-01	.522999E-01	1.17454
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFL. (STORM # 10)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	79.0000	340.000	204.000	175.809	104.157	.215481	1.44571
VSS	6	36.0000	115.000	75.5000	68.5381	30.8045	.660944E-01	1.38782
TS	0							
VS	0							
SETTS	6	.500000	2.00000	1.28333	1.13163	.592780	.355643E-01	1.38835
BOD5	6	17.0000	42.0000	26.8333	24.8570	10.8645	.620449	1.48722
COD	6	13.0000	26.0000	17.1667	16.5661	4.81029	.849857	2.18198
TOC	6	13.0000	37.0000	22.5000	20.9623	8.46069	.459015	1.91687
O&G	0							
PH	2	7.80000	7.90000	7.85000	7.84983	.500002E-01	.000000	1.00000
TKN	6	1.10000	2.10000	1.53667	1.48662	.407049	.569955	1.51529
TIP	6	.150000	.350000	.206666	.197488	.687184E-01	1.34953	3.27443
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 11)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	74.0000	174.000	118.778	113.475	35.5083	.242119	1.59476
VSS	9	30.0000	89.0000	50.2222	47.1056	19.1298	.995666	2.62216
TS	0							
VS	0							
SETTS	9	1.50000	3.60000	2.70000	2.60810	.666666	.364492	1.88955
BOD5	9	16.0000	44.0000	25.5555	24.3489	8.42102	1.01401	2.94326
COD	0							
TOC	8	19.0000	46.0000	27.1250	25.7352	9.51890	1.08248	2.50074
O&G	0							
PH	0							
TKN	9	1.00000	2.60000	1.65555	1.57565	.527280	.541488	2.05629
TIP	9	.000000	.600000E-01	.155555E-01	.000000	.183249E-01	1.42802	4.06386
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 12)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	24	82.0000	248.000	129.792	121.788	51.0016	1.27270	3.18533
VSS	24	32.0000	152.000	66.6667	58.3895	36.6824	1.05199	2.86784
TS	0							
VS	0							
SETTS	24	.400000	2.60000	1.68750	1.56171	.588297	.829524E-01	2.39390
BOD5	24	13.0000	64.0000	31.9583	29.6075	12.5116	.715974	3.00268
COD	0							
TOC	24	7.00000	61.0000	28.9167	26.0604	12.7930	.703584	2.98527
O&G	0							
PH	0							
TKN	24	.900000	3.60000	2.30000	2.17848	.708872	.371783E-01	2.22717
TIP	24	.000000	.260000	.103750	.000000	.100905	.648766	1.61716
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 13)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	14	137.000	171.000	154.071	153.712	10.5591	.323778	1.76226
VSS	14	48.0000	72.0000	60.1429	59.8424	5.95047	.107970	2.86147
TS	0							
VS	0							
SETTS	14	.100000	1.10000	.285714	.218635	.250306	2.32122	8.11650
BOD5	14	22.0000	83.0000	41.9286	39.6305	15.0260	1.28520	4.47298
COD	0							
TOC	14	33.0000	59.0000	43.0000	42.3374	7.74597	.608611	2.12238
O&G	0							
PH	0							
TKN	14	5.68000	9.42000	7.49928	7.40364	1.19745	.138691	1.68899
TIP	14	1.14000	3.00000	2.15643	2.03610	.683756	.257894	1.35789
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 14)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	163.000	350.000	265.833	260.124	52.6859	.382008	2.26191
VSS	12	65.0000	140.000	107.167	104.005	25.1225	.191092	1.85125
TS	0							
VS	0							
SETTS	4	1.70000	5.10000	2.90000	2.61579	1.36931	.739060	1.91740
BOD5	12	63.0000	92.0000	79.5000	79.0739	8.07775	.364276	2.65752
COD	0							
TOC	12	31.0000	98.0000	71.8333	68.2004	20.7960	.516576	2.12643
O&G	0							
PH	0							
TKN	12	3.70000	6.80000	5.19166	5.11417	.882664	.517542E-01	2.30559
TIP	12	.290000	2.68000	.821666	.652898	.650484	1.85911	5.73251
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 15)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	12	63.0000	157.000	114.417	109.849	30.6678	.251999	1.93400
VSS	12	17.0000	70.0000	34.4167	32.1034	13.4936	1.20998	4.44803
TS	0							
VS	0							
SETTS	4	.600000	3.20000	2.07500	1.75492	.967923	.453744	1.82631
BOD5	12	16.0000	90.0000	37.1667	31.7640	22.7809	1.18596	3.07412
COD	0							
TOC	12	15.0000	50.0000	34.5000	33.0156	9.54376	.468780E-01	2.67366
O&G	0							
PH	0							
TKN	12	.700000	8.70000	3.25000	2.30223	2.80134	1.04818	2.46045
TIP	12	.620000	2.26000	1.61583	1.50366	.544478	.457802	1.82043
AL	2	95.0000	189.000	142.000	133.996	47.0000	.000000	1.00000
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 16)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	9	80.0000	185.000	140.111	135.902	32.2609	.502842	2.08323
VSS	8	30.0000	58.0000	43.1250	41.8082	10.6235	.128695	1.40479
TS	0							
VS	0							
SETTS	3	2.70000	4.60000	3.86667	3.76585	.833999	.639104	1.50000
BOD5	9	11.7000	36.0000	20.1889	18.1938	9.46777	.612285	1.61922
COD	0							
TOC	4	24.0000	42.0000	32.7500	31.7961	7.85414	.299921E-01	1.10270
O&G	0							
PH	0							
TKN	4	1.60000	4.50000	2.65000	2.40415	1.19269	.594131	1.74801
TIP	4	.450000	.900000	.707500	.680021	.190181	.219873	1.29735
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 17)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	10	57.0000	284.000	138.400	121.580	73.0933	.860055	2.33950
VSS	10	40.0000	204.000	94.5000	79.6525	58.0969	.877634	2.12394
TS	0							
VS	0							
SETTS	4	2.50000	12.0000	5.55000	4.48604	3.85130	.948142	2.14017
BOD5	10	67.0000	223.000	121.400	110.441	54.7196	.731184	2.01601
COD	0							
TOC	10	14.0000	108.000	41.8000	33.9123	28.0741	1.13818	3.43593
O&G	0							
PH	0							
TKN	10	2.80000	8.40000	4.96999	4.73995	1.69437	1.02753	2.83830
TIP	10	.170000	.970000	.524999	.461844	.249289	.313829	1.94497
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 18)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	11	76.0000	98.0000	88.5454	88.3187	6.25755	.362332	2.30620
VSS	11	24.0000	52.0000	35.5454	37.1522	10.2102	.138187E-01	1.30017
TS	0							
VS	0							
SETTS	4	.300000	.400000	.325000	.322372	.433013E-01	1.15471	2.33335
BOD5	11	34.0000	81.0000	53.8182	51.2135	17.0977	.411316	1.56036
COD	0							
TOC	11	20.0000	105.000	37.0000	32.9154	22.6756	2.35985	7.41668
O&G	0							
PH	0							
TKN	11	1.50000	7.00000	3.32727	2.84014	1.91220	.717233	1.95664
TIP	11	.260000	.690000	.488181	.467922	.135433	.114149	1.69524
AL	0							
FCOLI	0							

ROCHESTER CSO PP --- PERFORMANCE DATA --- PRIM-SWIRL EFFLUENT (STORM # 19)

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	6	58.0000	168.000	99.0000	91.7661	38.9487	.562916	2.05024
VSS	6	12.0000	48.0000	27.6667	24.9856	12.3513	.509091	1.85466
TS	0							
VS	0							
SETTS	2	1.00000	1.40000	1.20000	1.18322	.200000	.000000	1.00000
BOD5	6	13.0000	38.0000	26.3333	24.6256	9.06764	.683038E-01	1.53560
COD	0							
TOC	6	13.0000	29.0000	18.6667	18.0073	5.24934	.942009	2.83543
O&G	0							
PH	0							
TKN	6	.900000	2.50000	1.66667	1.57163	.561743	.294818	1.69349
TIP	6	.160000	.260000	.205000	.201789	.359398E-01	.142016E-04	1.77253
AL	0							
FCOLI	0							

APPENDIX C
Statistical Analysis of Influent and Effluent Data
Microscreen System

Note: Concentrations of all parameters except pH and SETTS are expressed as mg/l. SETTS concentrations are expressed as ml/l.

STORM #12 - 03/03/76

INFLUENT -- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
AL	20	.000000	2.40000	.780000	.000000	.572363	.599790	4.14353
BOD5	19	22.0000	264.000	102.368	82.5904	66.4483	.950541	2.91556
CL-M	20	300.000	1404.00	599.500	543.568	289.865	1.38269	4.30510
PH	20	6.40000	7.00000	6.64499	6.64180	.206095	.311332	1.98125
SETTS	20	1.00000	5.00000	2.67500	2.48365	1.03096	.724954	3.00761
TC	20	32.0000	104.000	53.1000	51.1577	15.4722	1.51340	6.37626
TDS	20	369.000	2400.00	1064.85	972.249	463.507	1.06084	4.20748
TIC	20	15.0000	28.0000	20.6000	20.2507	3.83927	.412654	2.24096
TIP	20	.700000E-01	18.9000	3.31450	1.14402	5.59021	2.08677	5.84208
TKN	20	2.20000	6.10000	3.67999	3.55761	1.02742	1.25404	3.53427
TOC	20	13.0000	76.0000	32.5000	29.6438	14.4482	1.21554	4.78067
TS	20	829.000	2963.00	1381.50	1306.05	512.281	1.62301	5.49087
TSS	20	102.000	706.000	316.650	261.195	193.387	.675189	2.07204
VDS	14	4.00000	229.000	102.000	72.2852	56.9962	.101331	3.08818
VS	20	147.000	469.000	232.250	221.637	78.5658	1.58162	5.00203
VSS	19	42.0000	543.000	194.789	145.834	146.474	1.02810	2.99167

EFFLUENT -- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
BOD5	20	26.0000	66.0000	44.1500	42.6341	11.5986	.292574	1.92597
SETTS	20	.500000	2.10000	.959999	.872660	.466261	1.30471	3.33796
TC	20	34.0000	89.0000	64.6000	63.3941	11.8085	.356076	3.80773
TIC	20	13.0000	25.0000	19.1500	18.7840	3.69154	.235666E-01	1.79271
TIP	20	.290000	.600000	.421500	.413622	.810723E-01	.166041	2.32153
TKN	20	2.60000	4.60000	3.45499	3.41688	.524857	.690495	3.17363
TOC	20	12.0000	71.0000	45.4500	43.2406	12.1593	.423056	4.51938
TSS	20	98.0000	317.000	157.650	147.630	63.6569	1.41295	3.76480
VSS	20	40.0000	123.000	65.9000	62.3036	23.7800	1.15870	3.23386

STORM # 13 - 03/12/76

INFLUENT --- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
AL	3	.000000	.000000	.000000	.000000	.000000	.000000	.000000
BOD5	3	70.0000	168.000	115.000	107.960	40.4063	.289223	1.50000
CL-M	3	151.000	196.000	167.333	166.158	20.3361	.686644	1.50000
O&G	1	86.0000	86.0000	86.0000	85.9999	.000000	.000000	.000000
PH	3	6.50000	7.00000	6.80000	6.79651	.216025	.595134	1.49997
SETTS	3	4.50000	18.5000	11.0000	9.40720	5.75905	.255224	1.50000
TC	3	75.0000	146.000	98.6667	93.6463	33.4697	.707107	1.50000
TDS	3	454.000	748.000	559.000	544.355	133.918	.694088	1.50000
TIC	3	25.0000	38.0000	30.6667	30.2023	5.43650	.431047	1.50000
TIP	3	.560000	.680000	.630000	.627871	.509902E-01	.527995	1.49999
TKN	3	4.31000	5.44000	4.90666	4.88439	.463489	.202413	1.50000
TOC	3	46.0000	108.000	68.0000	62.8612	28.3314	.696550	1.50000
TS	3	613.000	1096.00	813.333	788.971	205.599	.536465	1.50000
TSS	3	138.000	348.000	254.333	236.944	87.2175	.372277	1.50000
VDS	3	7.00000	139.000	63.3333	34.9827	55.5957	.479569	1.50000
VS	3	134.000	363.000	229.000	209.855	97.4713	.536120	1.50000
VSS	3	90.0000	224.000	165.667	154.518	56.0615	.434219	1.50000

EFFLUENT -- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
BOD5	3	107.000	110.000	109.000	108.990	1.41421	.707107	1.50000
O&G	2	75.2000	76.8000	76.0000	75.9956	.799995	.286387E-04	1.00000
SETTS	3	2.10000	4.90000	3.86667	3.61735	1.25521	.676933	1.50000
TC	3	114.000	133.000	121.667	121.398	8.17856	.582382	1.50000
TIC	3	32.0000	42.0000	35.6667	35.3973	4.49691	.680979	1.50001
TIP	3	.880000	1.15000	.996666	.990415	.113235	.451767	1.50000
TKN	3	5.92000	7.57000	6.53333	6.49360	.737126	.672046	1.50001
TOC	3	72.0000	101.000	86.0000	85.1838	11.8603	.125873	1.50000
TSS	3	200.000	220.000	212.333	212.147	8.80656	.646061	1.50000
VSS	3	103.000	123.000	114.333	114.018	8.37987	.445107	1.50000

STORM # 17 - 05/11/76

INFLUENT -- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
AL	9	.000000	2.50000	1.01111	.000000	.823872	.632110	1.93242
BOD5	9	73.0000	318.000	134.222	118.235	76.6605	1.46067	3.90465
CL-M	9	58.0000	104.000	76.1111	74.9831	13.4614	.702531	2.73584
O&G	4	25.2000	59.2000	36.7000	34.4311	13.7996	.808846	1.99208
PH	9	6.60000	7.20000	6.84444	6.84215	.177082	.391899	2.68246
SETTS	3	3.50000	13.5000	7.66667	6.56926	4.24918	.528006	1.50000
TC	9	48.0000	164.000	100.889	92.4494	40.4102	.152109	1.53688
TDS	9	334.000	574.000	432.889	425.752	80.1865	.519388	2.10695
TIC	9	24.0000	36.0000	28.0000	27.6763	4.47214	1.07331	2.42333
TIP	9	.170000	1.53000	.632222	.501528	.421631	.954016	2.87506
TKN	9	2.10000	5.80000	3.38889	3.17766	1.29910	1.00261	2.48698
TOC	9	22.0000	128.000	72.8889	62.2822	36.7467	.295042E-01	1.46784
TS	9	448.000	946.000	611.889	592.223	165.301	.969053	2.50844
TSS	9	88.0000	395.000	179.000	148.959	118.433	1.06074	2.38938
VDS	9	58.0000	213.000	113.333	102.983	50.4777	.663657	2.17751
VS	9	112.000	406.000	213.111	190.298	107.502	.925324	2.30678
VSS	9	14.0000	250.000	99.7778	70.0217	83.6404	.977973	2.34238

EFFLUENT -- ROCHESTER CSO PILOT PLANT -- FMC DATA

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
BOD5	6	187.000	246.000	202.333	201.449	19.8634	1.65323	3.96982
O&G	3	45.6000	56.8000	52.2000	51.9720	4.78609	.553840	1.49999
SETTS	2	6.00000	8.50000	7.25000	7.14142	1.25000	.000000	1.00000
TC	6	106.000	162.000	135.333	134.192	17.2691	.231051	2.37340
TIC	6	29.0000	49.0000	36.3333	35.8569	6.18241	1.12598	3.28150
TIP	6	1.04000	1.44000	1.24167	1.23342	.142410	.329673E-01	1.61012
TKN	6	6.00000	7.70000	6.66666	6.63794	.626276	.459746	1.70033
TOC	6	73.0000	127.000	99.0000	97.6800	16.0831	.173070	2.67654
TSS	6	240.000	400.000	318.000	314.476	47.0213	.121561	2.80541
VSS	6	136.000	250.000	191.333	188.406	33.1344	.147959	2.93444

APPENDIX D

Statistic Analysis of Effluent Data Dual Media Filters

Note: Concentrations of all parameters except pH are expressed as mg/l.

Dual Media Filter Influent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 16140

ROCHESTER CSO P.P. --- SWINC DMFINC 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	59	16.0000	4012.00	131.508	58.7595	510.788	7.42768	56.4596
VSS	59	4.00000	68.0000	30.3220	26.6247	13.8618	.456080	3.15677
BOD5	53	3.00000	39.0000	17.1170	15.2999	8.08291	.687740	2.27673
TOC	43	5.00000	42.0000	20.6512	18.8004	8.66664	.624011	2.91969
COD	43	13.0000	73.0000	19.8139	18.7324	9.18354	4.54015	26.2746
O&G	0							
TKN	43	.200000	5.00000	1.28837	.949696	1.14185	1.57696	4.39731
TIP	41	.500000E-01	.660000	.188048	.136866	.182050	1.65388	4.01780
PH	42	6.30000	7.50000	7.01664	7.01069	.285287	.598704	2.69248
AL	22	.400000	2.40000	.636363	.698192	.524443	1.16308	4.10944

ROCHESTER CSO P.P. --- SWINC DMFINC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	49	16.0000	138.000	68.5306	56.0753	41.8898	.371236	1.32935
VSS	49	4.00000	82.0000	30.7755	26.6440	15.9492	1.17174	4.95418
BOD5	47	3.00000	65.0000	19.2468	16.0397	12.4835	1.68225	6.44666
TOC	31	8.00000	42.0000	19.1935	17.8110	7.81816	1.25742	4.42991
COD	27	13.0000	73.0000	18.7037	17.3354	11.0816	4.38672	21.4098
O&G	1	58.0000	58.0000	58.0000	58.0000	.000000	.000000	.000000
TKN	31	.400000	5.10000	1.20322	.907934	1.19609	2.21057	6.39270
TIP	31	.800000E-01	.320000	.133871	.123330	.654353E-01	1.99761	5.92297
PH	30	6.90000	7.50000	7.15999	7.15806	.164519	.701827E-01	2.12147
AL	10	.000000	1.30000	.450000	.000000	.355668	1.05352	3.86860

ROCHESTER CSO P.P. --- SWINC DMFINC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	44	16.0000	4012.00	164.250	70.5418	587.880	6.36718	41.7089
VSS	44	8.00000	68.0000	33.9318	30.8983	13.6004	.378345	2.91289
BOD5	38	9.20000	39.0000	19.5737	17.7223	8.45708	.267193	1.64713
TOC	28	5.00000	41.0000	22.7857	20.7383	8.93371	.897049E-01	2.25924
COD	28	14.0000	73.0000	22.1071	20.7102	10.7049	3.78626	18.3163
O&G	0							
TKN	28	.200000	5.00000	1.65000	1.19146	1.29766	.884052	2.55979
TIP	26	.500000E-01	.660000	.242692	.164028	.215487	.849492	1.97727
PH	28	6.30000	7.50000	6.89999	6.89385	.297609	.732219E-01	2.44564
AL	17	.400000	2.40000	1.01176	.856710	.550809	.614579	3.07056

ROCHESTER CSO P.P. --- SWINC DMFINC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	33	16.0000	4012.00	171.606	53.6221	679.252	5.47083	30.9657
VSS	33	4.00000	68.0000	30.1515	25.0873	16.4060	.552475	2.68992
BOD5	27	3.00000	30.0000	13.9222	12.4908	5.05241	1.32822	5.97403
TOC	33	5.00000	42.0000	21.6360	19.5043	9.18106	.364635	2.49535
COD	33	13.0000	27.0000	18.8485	18.4567	3.97050	.690156	2.28022
O&G	0							
TKN	33	.200000	5.00000	1.47879	1.03232	1.27011	1.07600	2.96543
TIP	31	.500000E-01	.660000	.221613	.153485	.203408	1.11088	2.51926
PH	32	6.30000	7.40000	6.94999	6.94356	.295804	.405621	2.08080
AL	23	.400000	2.40000	.869564	.723685	.536035	.981533	3.51449

ROCHESTER CSO P.P. --- SWINC DMFIPO 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	13	126.000	188.000	143.538	142.702	16.2462	1.51236	4.73137
VSS	13	28.0000	129.000	86.2308	82.4028	21.1779	1.10957	5.28167
BOD5	5	70.0000	90.0000	76.8000	76.4969	7.02567	1.07797	2.71212
TOC	13	19.0000	72.0000	39.2308	35.6943	17.0526	.540421	1.94446
COD	0							
O&G	3	50.0000	60.8000	56.6667	56.4587	4.75908	.647633	1.50000
TKN	13	3.00000	4.90000	4.15380	4.10882	.579940	.939106	2.57918
TIP	13	.200000	.450000	.304615	.295437	.735490E-01	.120081	2.36692
PH	13	6.60000	7.40000	6.92307	6.91986	.211783	.619353	2.86688
AL	13	.000000	1.30000	.599999	.000000	.427874	.530290E-01	2.02377

ROCHESTER CSO P.P. --- SWIPO DMFINC 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	46	52.0000	384.000	216.022	203.379	64.0082	.425020	3.63688
VSS	45	4.00000	100.000	72.0222	61.9109	29.6674	.281536	2.76618
BOD5	47	6.00000	101.000	33.7447	26.7014	24.8668	1.81761	7.91833
TOC	47	2.00000	150.000	37.7021	32.4917	22.0935	3.04727	16.8328
COD	17	13.0000	56.0000	24.2941	20.4382	16.3122	1.22250	2.55917
O&G	0							
TKN	44	.000000	6.70000	2.79386	.000000	2.03333	.590615	2.06550
TIP	48	.100000	21.2000	3.03416	.561745	5.63516	1.85632	5.08982
PH	45	6.60000	7.90000	7.17330	7.16319	.380292	.873612E-01	1.75629
AL	35	.000000	26.5000	2.53142	.000000	4.24914	5.08937	28.9488

Dual Media Filter Influent Data

O'BRIEN & GERE ENGINEERS, INC.   LABORATORY DATA SYSTEM   OCT 26, 1976   16140

ROCHESTER CSO P.P. --- SWIPO DMFINC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	35	52,0000	364,000	200,743	187,418	65,2354	,422253E-01	3,76289
VSS	34	4,00000	122,000	65,1176	54,6165	28,8706	,245304	2,38252
BOD5	36	7,00000	65,0000	29,9444	24,6909	18,2146	,640654	1,73486
TOC	36	2,00000	154,000	35,3055	29,8351	23,3021	3,54814	18,9622
COD	13	11,0000	21,0000	15,3077	15,1993	1,93687	1,78492	6,00508
O&G	0							
TKN	33	,000000	6,60000	2,79545	,000000	2,20413	,463939	1,68523
TIP	37	,120000	21,2000	3,13053	,610032	5,68860	1,85092	5,14083
PH	34	6,60000	7,90000	7,21470	7,20511	,370319	,220250E-01	1,87065
AL	25	,000000	26,5000	3,14000	,000000	4,85946	4,40474	21,3781

ROCHESTER CSO P.P. --- SWIPO DMFINC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	19	192,000	286,000	242,158	240,277	29,4122	,476889	2,04010
VSS	19	44,0000	122,000	82,7695	80,4762	19,1959	,124485	2,45404
BOD5	20	6,00000	141,000	33,0000	24,0064	31,0122	2,12821	7,57445
TOC	20	26,0000	154,000	47,0500	42,3916	27,5617	2,86520	11,4386
COD	4	51,0000	56,0000	53,5000	53,4694	1,80278	,000000	1,85207
O&G	0							
TKN	20	1,55000	5,80000	2,38900	2,19900	1,11441	1,69160	5,19791
TIP	20	,100000	17,0000	3,24599	,671634	5,18613	1,43119	3,55962
PH	19	6,60000	7,80000	7,16841	7,15603	,405297	,288859E-02	1,49613
AL	18	,000000	3,20000	1,62778	,000000	1,01094	,295109	1,79472

ROCHESTER CSO P.P. --- SWIPO DMFINC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	36	52,0000	384,000	211,083	196,503	67,9457	,384377	3,30068
VSS	35	4,00000	112,000	69,0000	57,8872	29,5142	,533629	2,27777
BOD5	36	6,00000	141,000	36,1111	28,8694	25,8078	1,86290	8,00754
TOC	36	2,00000	70,0000	35,1111	30,4478	15,7405	,297954	2,54619
COD	17	13,0000	56,0000	24,2941	20,4342	16,3122	1,22250	2,55917
O&G	0							
TKN	33	,000000	6,60000	2,80090	,000000	2,09527	,443831	1,90943
TIP	37	,100000	21,2000	2,98080	,510528	5,91586	1,93960	5,22046
PH	35	6,60000	7,90000	7,10571	7,09678	,356926	,352908	2,06975
AL	27	,000000	26,5000	2,57037	,000000	4,83472	4,45466	22,2459

ROCHESTER CSO P.P. --- SWIPO DMFIPO 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	204,000	276,000	230,375	229,231	23,3235	,598957	2,32984
VSS	8	63,0000	80,0000	71,6250	71,3507	6,26373	,562205E-01	1,57079
BOD5	8	11,0000	14,0000	12,6250	12,5952	,856957	,391042	2,53372
TOC	8	21,0000	49,0000	38,5000	37,2580	9,08295	,568998	2,30107
COD	0							
O&G	0							
TKN	8	1,64000	3,75000	2,11375	2,02747	,684615	1,60122	4,20073
TIP	8	,210000	22,0000	6,74120	1,30833	8,56303	,687786	1,71211
PH	8	6,80000	8,00000	7,36250	7,35235	,387096	,155801	1,87509
AL	8	2,00000	3,20000	2,55000	2,52736	,302783	,391064	2,53374

ROCHESTER CSO P.P. --- SWIAP DMFIPO 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	17	110,000	260,000	165,765	161,099	40,2558	,594331	2,63777
VSS	17	26,0000	103,000	59,7059	54,0226	25,0711	,584921E-01	1,56405
BOD5	9	17,0000	44,0000	31,1111	29,4683	9,58522	,273106	1,52978
TOC	16	19,0000	230,000	49,2500	39,6721	48,0215	3,21675	12,5732
COD	0							
O&G	5	16,0000	86,0000	37,4400	30,9220	25,3584	1,19790	2,85374
TKN	16	1,30000	8,33000	3,14874	2,75948	1,97448	1,96953	5,42000
TIP	16	,280000	14,7000	1,46500	,850985	3,39115	3,53511	13,6520
PH	14	3,10000	6,80000	6,31874	6,18032	1,11255	2,27096	6,31965
AL	16	7,70000	105,000	20,8875	12,8838	24,5460	2,26944	6,18858

ROCHESTER CSO P.P. --- SWIAP DMFIAP 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	25	98,0000	326,000	160,320	152,580	54,5723	1,33940	4,42584
VSS	25	30,0000	134,000	59,1600	54,3698	22,9568	1,48343	5,67676
BOD5	3	20,0000	28,0000	23,3333	23,0959	3,39933	,528009	1,50000
TOC	25	34,0000	62,0000	46,6800	46,1738	6,85693	,109542	2,28650
COD	0							
O&G	2	36,8000	38,0000	37,4000	37,3951	,600006	,000000	1,00000
TKN	25	3,40000	8,10000	5,09599	4,81763	1,73401	,432672	1,37632
TIP	25	,450000	2,14000	1,06959	,885581	,660206	,589402	1,41772
PH	25	4,00000	6,90000	5,68799	5,51019	1,36362	,402697	1,17246
AL	25	,000000	47,0000	33,6319	,000000	40,8595	,441929	1,24256

Dual Media Filter Influent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 16131

ROCHESTER CSO P.P. --- SW;AP DMF;AP 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	172.000	212.000	193.250	192.627	15.4171	.167701	1.30147
VSS	4	73.0000	89.0000	80.0000	79.8154	5.52268	.801464	2.00000
BOD5	2	20.0000	23.0000	21.5000	21.4476	1.50000	.000000	1.00000
TOC	4	42.0000	66.0000	53.7500	53.0161	8.84237	.710621E-01	1.71304
COD	0							
O&G	1	40.8000	40.8000	40.8000	40.7999	.000000	.000000	.000000
TKN	3	8.20000	9.70000	8.93333	8.91233	.612826	.814503E-01	1.50000
TIP	4	2.19000	2.40000	2.26750	2.26610	.804288E-01	.842413	2.08743
PH	4	4.00000	4.10000	4.07500	4.07476	.433010E-01	1.15452	2.33305
AL	4	93.0000	97.0000	96.0000	95.9837	1.73205	1.15470	2.33333

ROCHESTER CSO P.P. --- SW;AP DMF;AP 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	3	162.000	260.000	208.667	205.725	36.3073	.705498	1.50000
VSS	3	78.0000	103.000	86.3333	85.5738	11.7851	.707107	1.50000
BOD5	3	28.0000	44.0000	35.3333	34.7292	6.59966	.294802	1.50000
TOC	2	42.0000	44.0000	43.0000	42.9882	1.00000	.000000	1.00000
COD	0							
O&G	1	86.0000	86.0000	86.0000	85.9999	.000000	.000000	.000000
TKN	2	8.05000	8.33000	8.18999	8.18879	.139999	.817124E-04	1.00000
TIP	2	1.25000	2.04000	1.64500	1.59687	.394999	.000000	1.00000
PH	2	3.10000	3.70000	3.40000	3.38674	.300000	.000000	1.00000
AL	2	95.0000	103.000	99.0000	98.9188	4.00000	.000000	1.00000

ROCHESTER CSO P.P. --- SW;PO DMF;PO 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	204.000	248.000	218.000	217.425	16.1988	1.00956	2.57678
VSS	5	63.0000	80.0000	70.4000	70.0895	6.65131	.265243	1.44669
BOD5	5	11.0000	13.0000	12.2000	12.1766	.748331	.343620	1.84694
TOC	5	30.0000	45.0000	37.8000	37.4449	5.11468	.135240	1.91576
COD	0							
O&G	0							
TKN	5	1.64000	2.58000	1.85600	1.82521	.366038	1.42254	3.13423
TIP	5	.210000	22.0000	7.48399	1.34078	9.16749	.595484	1.56796
PH	5	6.80000	7.80000	7.29999	7.29119	.357771	.785629E-01	1.64550
AL	5	2.40000	3.20000	2.72000	2.70382	.299332	.343625	1.84694

ROCHESTER CSO P.P. --- SW;PO DMF;PO 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	5	204.000	248.000	218.000	217.425	16.1988	1.00956	2.57678
VSS	5	63.0000	80.0000	70.4000	70.0895	6.65131	.265243	1.44669
BOD5	5	11.0000	13.0000	12.2000	12.1766	.748331	.343620	1.84694
TOC	5	30.0000	45.0000	37.8000	37.4449	5.11468	.135240	1.91576
COD	0							
O&G	0							
TKN	5	1.64000	2.58000	1.85600	1.82521	.366038	1.42254	3.13423
TIP	5	.210000	22.0000	7.48399	1.34078	9.16749	.595484	1.56796
PH	5	6.80000	7.80000	7.29999	7.29119	.357771	.785629E-01	1.64550
AL	5	2.40000	3.20000	2.72000	2.70382	.299332	.343625	1.84694

ROCHESTER CSO P.P. --- SW;PO DMF;AP 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	140.000	228.000	188.714	185.591	34.1873	.527380E-01	1.33837
VSS	7	20.0000	76.0000	39.4286	35.8753	17.9432	.948614	2.79787
BOD5	7	11.0000	13.0000	11.5714	11.5492	.728431	.859895	2.36391
TOC	7	21.0000	56.0000	35.0000	33.1271	11.6005	.436507	2.06605
COD	0							
O&G	0							
TKN	6	1.60000	2.98000	2.27500	2.23268	.435612	.133124	2.17590
TIP	6	.250000	21.2000	5.57499	1.49393	7.76066	1.20835	2.87027
PH	6	6.70000	7.70000	7.19999	7.19026	.374166	.439972E-04	1.50000
AL	7	.000000	2.80000	1.82857	.000000	.877845	1.06909	2.99303

ROCHESTER CSO P.P. --- SW;PO DMF;AP 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	140.000	228.000	188.714	185.591	34.1873	.527380E-01	1.33837
VSS	7	20.0000	76.0000	39.4286	35.8753	17.9432	.948614	2.79787
BOD5	7	11.0000	13.0000	11.5714	11.5492	.728431	.859895	2.36391
TOC	7	21.0000	56.0000	35.0000	33.1271	11.6005	.436507	2.06605
COD	0							
O&G	0							
TKN	6	1.60000	2.98000	2.27500	2.23268	.435612	.133124	2.17590
TIP	6	.250000	21.2000	5.57499	1.49393	7.76066	1.20835	2.87027
PH	6	6.70000	7.70000	7.19999	7.19026	.374166	.439972E-04	1.50000
AL	7	.000000	2.80000	1.82857	.000000	.877845	1.06909	2.99303

Dual Media Filter Influent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 16145

ROCHESTER CSO P.P. --- SW;PO DMF;AP 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	140,000	228,000	188,714	185,591	34,1873	,527380E-01	1,33837
VSS	7	20,0000	76,0000	39,4286	35,8753	17,9432	,948614	2,79787
BOD5	7	11,0000	13,0000	11,5714	11,5492	,728431	,859895	2,36391
TOC	7	21,0000	56,0000	35,0000	33,1271	11,6005	,436807	2,06605
COD	0							
O&G	0							
TKN	6	1,60000	2,98000	2,27500	2,23268	,435612	,133124	2,17590
TIP	6	,250000	21,2000	5,57499	1,49393	7,76066	1,20835	2,87027
PH	6	6,70000	7,70000	7,19999	7,19026	,374166	,439972E-04	1,50000
AL	7	,000000	2,80000	1,82857	,000000	,877845	1,06909	2,99303

ROCHESTER CSO P.P. --- SW;AP DMF;NC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	58	31,0000	326,000	126,293	104,649	69,5141	,358897	2,54192
VSS	58	10,0000	134,000	49,4138	40,1840	28,8868	,433440	2,42910
BOD5	28	20,0000	34,0000	27,7857	27,6009	3,05143	,995683	4,32166
TOC	54	9,00000	86,0000	36,1296	34,1444	15,5849	,601086E-02	3,15867
COD	0							
O&G	5	18,4000	38,0000	28,6400	27,6138	7,58356	,785698E-01	1,42807
TKN	57	2,50000	8,30000	4,16842	3,94224	1,53041	1,29698	3,26797
TIP	58	,600000E-01	20,7000	1,41792	,449773	3,46041	4,31220	21,5409
PH	58	4,00000	9,10000	6,37926	6,25849	1,12277	1,29251	3,99278
AL	58	,000000	97,0000	16,5517	,000000	30,7801	1,73275	4,12120

ROCHESTER CSO P.P. --- SW;AP DMF;NC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	172,000	212,000	193,250	192,627	15,4171	,167701	1,50147
VSS	4	75,0000	89,0000	80,0000	79,8154	5,52268	,801464	2,00000
BOD5	2	20,0000	23,0000	21,5000	21,4476	1,50000	,000000	1,00000
TOC	4	42,0000	66,0000	53,7500	53,0161	8,84237	,714621E-01	1,71304
COD	0							
O&G	1	40,8000	40,8000	40,8000	40,7999	,000000	,000000	,000000
TKN	3	8,20000	9,70000	8,93333	8,91233	,612826	,814503E-01	1,50000
TIP	4	2,14000	2,40000	2,26750	2,26610	,804288E-01	,842413	2,08743
PH	4	4,00000	4,10000	4,07500	4,07476	,433010E-01	1,15452	2,33305
AL	4	93,0000	97,0000	96,0000	95,9817	1,73205	1,15470	2,33333

ROCHESTER CSO P.P. --- SW;AP DMF;NC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	41	31,0000	260,000	109,317	87,8670	68,0656	,475584	1,92807
VSS	41	10,0000	103,000	39,0732	31,2504	26,4892	,869578	2,40822
BOD5	31	19,0000	44,0000	28,6129	27,9308	6,13649	,283303	3,57719
TOC	37	9,00000	230,000	33,6216	26,8342	35,0569	4,71192	26,6539
COD	0							
O&G	6	21,6000	86,0000	36,4000	31,6291	22,7883	1,58751	3,82352
TKN	41	1,60000	8,33000	3,09463	2,86188	1,45631	2,31538	8,40576
TIP	42	,600000E-01	14,7000	,605908	,201984	2,23034	5,95033	37,5402
PH	42	3,10000	9,10000	6,59760	6,52902	,821578	2,19843	13,5611
AL	42	,000000	103,000	10,8190	,000000	20,6878	3,65765	15,9416

ROCHESTER CSO P.P. --- SW;AP DMF;PO 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	43	31,0000	326,000	128,349	98,3565	80,1650	,315089	1,93645
VSS	43	10,0000	134,000	50,3721	38,4425	33,0213	,313945	1,87045
BOD5	28	20,0000	34,0000	27,7857	27,6009	3,05143	,995683	4,32166
TOC	39	9,00000	86,0000	36,3590	31,4050	17,7554	,261697	2,62012
COD	0							
O&G	5	18,4000	38,0000	28,6400	27,6138	7,58356	,785698E-01	1,42807
TKN	42	2,50000	8,30000	4,33333	4,03418	1,74529	,915939	2,20888
TIP	43	,600000E-01	20,7000	1,71534	,416388	3,97592	3,61331	15,5561
PH	43	4,00000	9,10000	6,23255	6,08012	1,27073	,868722	2,79580
AL	43	,000000	97,0000	22,1678	,000000	33,9988	1,27133	2,71231

ROCHESTER CSO P.P. --- SW;AP DMF;PO 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	172,000	212,000	193,250	192,627	15,4171	,167701	1,50147
VSS	4	75,0000	89,0000	80,0000	79,8154	5,52268	,801464	2,00000
BOD5	2	20,0000	23,0000	21,5000	21,4476	1,50000	,000000	1,00000
TOC	4	42,0000	66,0000	53,7500	53,0161	8,84237	,714621E-01	1,71304
COD	0							
O&G	1	40,8000	40,8000	40,8000	40,7999	,000000	,000000	,000000
TKN	3	8,20000	9,70000	8,93333	8,91233	,612826	,814503E-01	1,50000
TIP	4	2,14000	2,40000	2,26750	2,26610	,804288E-01	,842413	2,08743
PH	4	4,00000	4,10000	4,07500	4,07476	,433010E-01	1,15452	2,33305
AL	4	93,0000	97,0000	96,0000	95,9817	1,73205	1,15470	2,33333

Dual Media Filter Effluent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 09159

ROCHESTER CSO P.P. --- SWING DMFINC 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	39	7.00000	89.0000	33.6410	25.3469	25.3078	.948168	2.60769
VSS	40	2.00000	52.0000	15.6750	10.5112	13.7671	1.09597	3.25456
BOD5	3	.000000	20.0000	6.66667	.000000	9.42809	.707107	1.50000
TOC	33	5.00000	33.0000	14.8485	13.3690	6.78286	.780850	3.00218
COD	33	8.00000	28.0000	18.0606	17.4411	4.60525	.575460	3.04751
O&G	0							
TKN	33	.500000	5.00000	1.38788	1.10322	.923351	.611327	1.72064
TP	32	.300000E-01	.500000	.175937	.131889	.142233	1.15593	2.45440
PH	32	6.40000	7.70000	7.04687	7.03791	.351767	.393936	1.95393
AL	19	.000000	1.60000	.526316	.000000	.390467	1.03256	4.05308

ROCHESTER CSO P.P. --- SWING DMFINC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	29	4.00000	93.0000	32.9655	24.5472	27.1324	1.25458	2.94653
VSS	29	.000000	37.0000	13.1724	.000000	8.57851	1.23352	4.08437
BOD5	6	7.60000	14.2000	11.0667	10.8699	2.02950	.169551	2.41110
TOC	17	5.00000	17.0000	13.1176	12.6735	2.90805	1.30782	4.51506
COD	5	11.0000	16.0000	13.6000	13.4447	2.05912	.131950	1.32093
O&G	3	51.2000	64.4000	56.1333	55.8579	5.88180	.668071	1.50000
TKN	17	.600000	24.7000	3.54705	2.12686	5.41295	3.46179	13.7426
TP	16	.700000E-01	.290000	.193750	.174240	.790470E-01	.268452	1.55201
PH	16	6.70000	7.30000	7.16874	7.16698	.156998	1.51060	5.27522
AL	13	.000000	.400000	.307698E-01	.000000	.106587	3.17544	11.0834

ROCHESTER CSO P.P. --- SWING DMFINC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	36	9.00000	103.000	53.4639	38.9292	34.7669	.739644E-01	1.24000
VSS	36	3.00000	48.0000	22.4055	16.9221	14.2552	.165399	1.64892
BOD5	1	10.0000	10.0000	10.0000	10.0000	.000000	.000000	.000000
TOC	18	6.00000	31.0000	11.8333	10.3410	7.41806	1.80308	4.74383
COD	18	14.0000	27.0000	18.5000	18.2094	3.51584	1.26171	3.42725
O&G	0							
TKN	18	.400000	3.10000	1.20555	1.03149	.773500	1.56390	3.49775
TP	18	.400000E-01	.450000	.147222	.107930	.136943	1.56871	3.72921
PH	18	6.50000	7.50000	7.08331	7.07788	.275378	.592320	2.42460
AL	7	.000000	1.20000	.514285	.000000	.412063	.192013	1.85651

ROCHESTER CSO P.P. --- SWING DMFINC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	20	16.0000	76.0000	34.1000	31.3197	15.1687	1.24672	3.81551
VSS	20	5.00000	52.0000	20.4000	17.5326	12.2041	1.33115	5.60927
BOD5	4	.000000	20.0000	7.50000	.000000	8.29150	.493382	1.62810
TOC	20	5.00000	35.0000	18.0500	15.7085	8.72624	.210865	1.94818
COD	20	10.0000	32.0000	19.5000	18.8124	5.05470	.245069	3.26426
O&G	0							
TKN	20	.400000	4.00000	1.81500	1.38586	1.17016	.277321	1.71398
TP	18	.400000E-01	.510000	.228889	.151706	.172816	.147471	1.26262
PH	19	6.40000	7.50000	6.81052	6.80379	.305897	.738913	2.58054
AL	19	.000000	1.20000	.652631	.000000	.414688	.213539	1.67125

ROCHESTER CSO P.P. --- SWING DMFIPD 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	25	17.0000	63.0000	29.5600	28.2219	10.0601	1.79058	6.05620
VSS	25	10.0000	40.0000	19.2800	18.4014	6.37193	1.52971	5.61723
BOD5	17	2.20000	11.8000	6.64705	6.04284	2.75769	.313203	2.04586
TOC	25	11.0000	27.0000	18.4400	18.0843	3.57860	.220185	3.21950
COD	0							
O&G	6	42.8000	60.4000	53.6666	53.3691	5.43282	.982645	3.07735
TKN	25	2.40000	5.30000	3.51200	3.44789	.666525	.246298	3.59158
TP	25	.140000	.320000	.238800	.233038	.490974E-01	.592782	2.61337
PH	25	6.70000	7.50000	7.02399	7.02186	.172696	.419244	3.50027
AL	25	.000000	.400000	.480000E-01	.000000	.129984	2.33874	6.46972

ROCHESTER CSO P.P. --- SWIPD DMFINC 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	47	16.0000	169.000	52.1489	45.7753	29.3301	1.96025	8.16375
VSS	47	1.00000	57.0000	17.7021	14.2568	11.2664	1.60088	6.59078
BOD5	24	3.70000	19.0000	8.48749	7.74796	4.03074	1.40978	3.83747
TOC	46	5.00000	77.0000	14.0217	11.3257	12.8730	3.46512	15.8081
COD	16	10.0000	51.0000	19.2500	17.0480	11.5731	1.90122	5.15622
O&G	0							
TKN	45	.000000	5.20000	1.84755	.000000	1.53464	.956024	2.84687
TP	46	.500000E-01	18.1000	1.55912	.327748	3.98459	3.06499	11.0190
PH	43	6.60000	8.00000	7.26277	7.25273	.379732	.287096E-02	2.01318
AL	43	.000000	11.6000	.709301	.000000	1.80784	5.14074	30.7367

Dual Media Filter Effluent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 09139

ROCHESTER CSO P.P. --- SWIPO DMF INC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	20	16.0000	84.0000	35.4800	31.8815	18.1366	1.35193	3.83121
VSS	20	4.00000	31.0000	12.6300	11.0604	6.63754	1.07283	3.77392
BOD5	12	3.70000	8.00000	5.97499	5.78572	1.46066	.117824	1.68503
TOC	19	2.00000	17.0000	10.3158	9.38915	3.79823	.221182	2.37777
COD	11	12.0000	16.0000	13.7273	13.6759	1.21288	.838804	2.67499
O&G	0							
TKN	16	.600000	4.30000	1.64000	1.41699	1.05076	1.73357	4.58284
TIP	20	.400000E-01	1.81000	.380000	.217384	.475520	2.09861	6.26190
PH	17	5.40000	8.00000	7.17647	7.14511	.643089	1.16237	4.30580
AL	16	.000000	22.7000	1.90000	.000000	5.40843	3.53116	13.6802

ROCHESTER CSO P.P. --- SWIPO DMF INC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	17	46.0000	172.000	92.2941	85.5240	37.2965	.766872	2.26058
VSS	17	16.0000	60.0000	32.7059	30.1492	13.1765	.602042	2.36076
BOD5	6	13.0000	36.0000	20.3333	19.1069	8.13770	1.54960	3.82789
TOC	17	8.00000	29.0000	18.3529	17.2400	5.99941	.671790E-01	2.27216
COD	2	29.0000	33.0000	31.0000	30.9354	2.00000	.000000	1.00000
O&G	0							
TKN	17	.940000	4.00000	1.90823	1.79125	.778182	1.82553	5.30093
TIP	17	.500000E-01	1.73000	.429990	.302612	.421830	2.06029	6.28223
PH	17	6.80000	7.60000	7.28238	7.27782	.254917	.526983	1.68550
AL	17	.000000	2.00000	.423529	.000000	.692420	.181523	1.56030

ROCHESTER CSO P.P. --- SWIPO DMF INC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	15	23.0000	110.000	64.4667	57.7537	27.9496	.153044	1.88329
VSS	15	7.00000	40.0000	20.8667	17.6191	11.4185	.338551	1.64558
BOD5	9	3.70000	8.60000	6.99999	6.83789	1.32413	1.42713	4.59679
TOC	14	1.00000	30.0000	15.0714	11.8619	8.44701	.353039	2.08864
COD	11	13.0000	54.0000	26.9091	22.4226	14.0331	.736173	1.75000
O&G	0							
TKN	15	1.00000	3.40000	1.87533	1.68042	.909687	.666625	1.66463
TIP	15	.700000E-01	1.80000	.309333	.196658	.421164	2.92227	10.5111
PH	15	6.10000	7.70000	6.96666	6.95364	.423740	.135870	2.70065
AL	15	.000000	.400000	.160000	.000000	.185959	.408248	1.16667

ROCHESTER CSO P.P. --- SWIPO DMFIPO 10 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	8	36.0000	114.000	84.0000	78.6791	26.9815	.550744	1.80451
VSS	8	.000000	34.0000	21.7500	.000000	11.0199	.784551	2.28917
BOD5	0							
TOC	8	11.0000	24.0000	17.5000	17.0912	3.70810	.588393E-01	2.49554
COD	0							
O&G	0							
TKN	8	1.17000	2.58000	1.76250	1.72016	.376521	.753119	3.57132
TIP	8	.600000E-01	12.0000	1.82250	.369770	3.87023	2.21585	6.00198
PH	8	6.70000	8.00000	7.41250	7.40382	.355097	.504835	3.04877
AL	8	.000000	1.20000	.450000	.000000	.466369	.717206	1.79429

ROCHESTER CSO P.P. --- SWIAP DMFIPO 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	25	1.80000	118.000	23.2600	8.08912	34.0370	1.70889	4.80577
VSS	25	.400000	52.0000	9.50400	2.27571	14.6233	1.62968	4.92768
BOD5	3	18.8000	42.0000	28.3333	24.3122	11.0807	.705554	1.50000
TOC	23	9.00000	41.0000	15.2609	13.9987	7.45546	2.00443	6.85545
COD	0							
O&G	8	9.20000	65.2000	19.7500	15.5850	17.6442	2.05538	5.54556
TKN	24	1.50000	8.33000	2.69666	2.39859	1.73801	2.66679	8.79269
TIP	24	.000000	1.98000	.232083	.000000	.420786	2.09293	5.98228
PH	23	3.50000	8.90000	6.89999	6.81548	.890039	2.83672	9.31113
AL	24	.000000	91.0000	7.56250	.000000	25.9852	3.02492	10.1868

ROCHESTER CSO P.P. --- SWIAP DMFIAP 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	16	10.0000	108.000	50.7318	42.8685	25.4154	.176096	2.31078
VSS	16	1.30000	42.0000	21.0500	15.9176	12.3299	.709018E-01	1.91781
BOD5	2	13.5000	21.9000	17.7000	17.1944	4.20000	.000000	1.00000
TOC	15	3.00000	34.0000	21.3333	19.0230	7.69992	.697869	3.07986
COD	0							
O&G	0							
TKN	15	2.20000	4.40000	2.85999	2.79289	.731027	2.69441	9.80064
TIP	15	.600000E-01	.580000	.133333	.909828E-01	.141453	2.28753	6.52169
PH	15	4.20000	7.10000	6.67999	6.61337	.676461	3.23544	12.0695
AL	15	.000000	52.0000	3.97333	.000000	12.8403	3.47003	13.0526

Dual Media Filter Effluent Data

O'BRIEN & GERE ENGINEERS, INC. LABORATORY DATA SYSTEM OCT 26, 1976 16131

ROCHESTER CSO P.P. --- SWIAP DMFIAP 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	3	23.5000	105.000	75.8333	62.5180	37.0862	.693281	1.50000
VSS	3	9.30000	40.0000	24.1000	21.5253	13.4494	.634515	1.50000
BOD5	0							
TOC	3	20.0000	39.0000	32.6667	31.2166	8.95668	.707103	1.50000
COD	0							
O&G	1	24.0000	24.0000	24.0000	24.0080	.000000	.000000	.000000
TKN	2	7.90000	8.70000	8.30000	8.29035	.400000	.321306E-08	1.00000
TIP	3	.420000	1.58000	1.15000	.987245	.518909	.673964	1.50000
PH	3	4.00000	4.20000	4.10000	4.09918	.816495E-01	.176798E-08	1.50000
AL	3	56.0000	93.0000	78.0000	76.2128	15.8955	.575162	1.50000

ROCHESTER CSO P.P. --- SWIAP DMFIAP 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	2	72.0000	94.0000	83.0000	82.2678	11.0000	.000000	1.00000
VSS	2	32.0000	40.0000	36.0000	35.7770	4.00000	.000000	1.00000
BOD5	0							
TOC	1	33.0000	33.0000	33.0000	33.0000	.000000	.000000	.000000
COD	0							
O&G	1	40.8000	40.8000	40.8000	40.7999	.000000	.000000	.000000
TKN	1	8.05000	8.05000	8.05000	8.04999	.000000	.000000	.000000
TIP	1	1.28000	1.28000	1.28000	1.28000	.000000	.000000	.000000
PH	1	3.60000	3.60000	3.60000	3.60000	.000000	.000000	.000000
AL	1	87.0000	87.0000	87.0000	86.9999	.000000	.000000	.000000

ROCHESTER CSO P.P. --- SWIPO DMFIPO 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	4	96.0000	146.000	119.000	117.066	21.4709	.101830	1.16721
VSS	4	32.0000	46.0000	40.2500	39.8894	5.21916	.618342	1.95588
BOD5	0							
TOC	4	16.0000	27.0000	22.7500	22.2956	4.32290	.609262	1.79977
COD	0							
O&G	0							
TKN	4	1.17000	2.62000	1.76750	1.69451	.528269	.681886	2.10633
TIP	4	.110000	.560000	.270000	.220722	.172771	.945270	2.18740
PH	4	7.30000	7.50000	7.42500	7.42492	.829156E-01	.493365	1.62809
AL	4	1.20000	2.00000	1.60000	1.54919	.400000	.372529E-08	.999999

ROCHESTER CSO P.P. --- SWIPO DMFIPO 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	5	78.0000	174.000	123.600	119.485	31.5886	.212152	2.17631
VSS	5	24.0000	51.0000	35.4000	34.0371	10.0519	.449719	1.62254
BOD5	0							
TOC	5	18.0000	37.0000	25.0000	24.1412	6.84105	.734630	2.23263
COD	0							
O&G	0							
TKN	5	1.26000	2.58000	1.87200	1.82127	.435584	.280265	2.19340
TIP	5	.190000	26.1000	5.55199	.753329	10.2789	1.49644	3.24514
PH	5	7.00000	7.50000	7.27999	7.27738	.193907	.378186	1.40806
AL	5	1.20000	2.00000	1.60008	1.55922	.357771	.418900E-08	1.25000

ROCHESTER CSO P.P. --- SWIPO DMFIAP 18 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	7	20.0000	92.0000	46.8571	39.8189	26.9572	.620984	1.72953
VSS	7	4.00000	20.0000	8.00000	6.82608	5.23723	1.57526	4.04668
BOD5	0							
TOC	7	9.00000	32.0000	16.5714	15.0849	7.59430	.970870	2.71808
COD	0							
O&G	0							
TKN	7	1.37000	2.24000	1.82428	1.80509	.259387	.208918	2.41306
TIP	7	.150000	15.0000	2.70571	.582245	5.09780	1.92197	4.87269
PH	7	6.70000	7.60000	7.11428	7.10797	.899699	.852286E-01	1.76131
AL	7	.400000	1.40000	.857142	.767788	.398897	.595109	2.39938

ROCHESTER CSO P.P. --- SWIPO DMFIAP 26 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD.DEVIATION	SKEWNESS	KURTOSIS
TSS	7	32.0000	100.000	70.0000	66.1007	21.5672	.282985	2.20002
VSS	7	6.00000	26.0000	10.7143	9.06946	7.06529	1.35032	3.27359
BOD5	0							
TOC	7	11.0000	33.0000	21.7143	20.3401	7.62916	.214068	1.64851
COD	0							
O&G	0							
TKN	7	1.56000	2.24000	1.79286	1.77991	.221599	.836943	2.71313
TIP	6	.700000E-01	.340000	.211666	.186919	.945897E-01	.339945E-01	1.74505
PH	7	6.80000	8.00000	7.37142	7.36397	.341067	.299746	2.81215
AL	7	.800000	3.20000	2.11429	1.97681	.666399	.457750	3.17799

Dual Media Filter Effluent Data

ROCHESTER CSO P.P. --- SWIPO DMFIAP 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	7	20.0000	144.000	93.7143	80.1050	41.3926	.484808	2.00611
VSS	7	9.00000	40.0000	21.5714	18.9524	10.8346	.526125	1.84508
BOD5	0							
TOC	7	7.00000	34.0000	21.4286	19.4057	8.24373	.256311	2.23067
COD	0							
O&G	0							
TKN	7	1.37000	2.24000	1.76428	1.74597	.255726	.338362	2.57397
TIP	7	.300000E-01	1.23000	.418571	.227689	.435707	.975455	2.18853
PH	7	7.00000	7.80000	7.41428	7.40854	.289968	.352960	1.77458
AL	7	.800000	3.20000	2.40000	2.23371	.709124	1.38454	3.96280

ROCHESTER CSO P.P. --- SWIAP DMFINC 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	72	7.00000	178.000	56.8569	40.1028	48.3147	.975569	2.38749
VSS	72	2.00000	74.0000	23.0444	15.5505	20.9159	1.06630	2.59013
BOD5	25	6.90000	26.0000	18.0280	17.3779	4.40558	.492568	3.16441
TOC	68	.000000	51.0000	24.8255	.000000	11.5935	.417973	2.43861
COD	0							
O&G	4	18.4000	31.6000	25.2000	24.3769	6.40624	.583702E-02	1.00778
TKN	71	2.40000	7.10000	3.69436	3.50989	1.36174	1.77366	4.65779
TIP	71	.900000E-01	1.91000	.497037	.317044	.506249	1.70428	4.70307
PH	71	4.00000	7.30000	6.48305	6.38129	1.01384	1.95987	5.03940
AL	72	.000000	89.0000	12.1888	.000000	27.1697	2.09205	5.48384

ROCHESTER CSO P.P. --- SWIAP DMFINC 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	75.0000	136.000	117.250	114.099	24.8130	1.04038	2.23628
VSS	4	28.0000	54.0000	44.2500	42.8800	10.2561	.672180	1.86128
BOD5	0							
TOC	4	27.0000	48.0000	40.5000	39.5608	8.07775	.922073	2.16052
COD	0							
O&G	1	26.8000	26.8000	26.8000	26.7999	.000000	.000000	.000000
TKN	4	7.50000	8.30000	7.82500	7.81953	.294745	.692004	2.06395
TIP	4	.950000	1.77000	1.54250	1.49586	.343465	1.12744	2.31072
PH	4	4.10000	4.30000	4.15000	4.14910	.866024E-01	1.15476	2.33342
AL	4	60.0000	89.0000	81.7500	80.6483	12.5574	1.15470	2.33333

ROCHESTER CSO P.P. --- SWIAP DMFINC 25 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	51	7.00000	200.000	69.5843	52.4375	42.1558	.423038	3.18901
VSS	51	1.00000	95.0000	24.0000	14.2740	19.9685	1.21344	4.58005
BOD5	27	13.0000	31.0000	20.2000	19.4526	5.62763	.511377	2.05782
TOC	46	5.00000	45.0000	22.4565	20.2275	9.31269	.378738	3.20697
COD	0							
O&G	8	.000000	25.2000	18.0000	.000000	7.38846	1.64605	4.66229
TKN	49	1.10000	8.52000	2.25959	2.06487	1.19581	3.13073	16.0388
TIP	49	.000000	1.67000	.265918	.000000	.264697	2.96644	16.4969
PH	49	3.70000	7.00000	6.52854	8.50737	.454007	4.85968	30.8540
AL	49	.000000	83.0000	6.97345	.000000	11.5935	5.71349	37.7771

ROCHESTER CSO P.P. --- SWIAP DMFIPO 15 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	35	2.00000	110.000	13.0771	7.73295	22.8819	3.70930	15.1586
VSS	35	.700000	43.0000	4.42857	2.26657	9.30374	3.74974	15.2689
BOD5	25	4.00000	26.1000	18.9720	17.1083	6.35115	1.42126	3.68649
TOC	30	1.00000	42.0000	14.7667	12.2674	8.55835	1.61065	6.43324
COD	0							
O&G	4	9.60000	15.2000	12.3000	12.0995	2.21585	.810726E-01	1.36667
TKN	34	2.00000	7.50000	3.48235	3.35525	1.11526	2.49679	9.20751
TIP	35	.300000E-01	1.52000	.190285	.872753E-01	.338783	2.92849	10.7242
PH	34	3.80000	7.40000	6.64411	6.57220	.852397	2.56351	8.37568
AL	35	.000000	81.0000	4.63428	.000080	14.3146	3.81988	15.6042

ROCHESTER CSO P.P. --- SWIAP DMFIPO 20 GPM/SQFT

PARAMETER	POINTS	MINIMUM	MAXIMUM	AVERAGE	GEO. MEAN	STD DEVIATION	SKEWNESS	KURTOSIS
TSS	4	22.5000	104.000	61.0000	47.6816	38.1658	.253783E-01	1.03444
VSS	4	8.10000	38.0000	21.6500	17.0102	13.5182	.726321E-01	1.09709
BOD5	0							
TOC	4	20.0000	40.0000	30.2500	29.1295	8.07388	.496969E-01	1.29005
COD	0							
O&G	1	20.0000	20.0000	20.0000	20.0000	.000000	.000000	.000000
TKN	5	7.40000	8.20000	7.83333	7.82631	.329983	.294756	1.49998
TIP	4	.210000	1.42000	.834999	.668019	.501223	.110926	1.23999
PH	4	4.10000	4.30000	4.15000	4.14910	.866024E-01	1.15476	2.33342
AL	4	40.3000	85.0000	69.8250	67.0861	17.5853	.956927	2.16622

APPENDIX E
Chlorine and Chlorine Dioxide Analytical Data

Note: Concentrations of F.Coli are expressed as colonies/100 ml.

CL_2 DATA

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
43727	2.47986	3.88649	-1.40663	3.1	5.6	89604.	7.0	8.0	1.4	15.0	183.0	74.0	385000.	50.
43727	2.31641	3.30670	-.99029	3.1	3.8	89527.	7.0	8.0	1.4	15.0	183.0	74.0	385000.	190.
43727	2.90854	4.28443	-1.37589	3.9	5.6	89604.	7.0	8.0	1.4	15.0	183.0	74.0	385000.	20.
43731	3.50014	6.57403	-3.07389	9.1	3.8	89527.	7.0	6.8	1.4	45.0	160.0	71.0	375000.	0.
43731	3.74711	3.61979	.12732	9.1	5.6	89604.	7.0	6.8	1.4	45.0	160.0	71.0	375000.	90.
49246	3.50631	3.96496	-.45865	8.9	1.5	67211.	8.0	7.3	2.1	19.0	65.0	22.0	184500.	20.
49246	3.96058	3.56702	.39356	8.9	3.0	67302.	8.0	7.3	2.1	19.0	65.0	22.0	184500.	50.
49246	4.25382	3.66393	.58989	8.9	4.5	67394.	8.0	7.3	2.1	19.0	65.0	22.0	184500.	40.
43928	2.77811	3.92942	-1.15131	6.2	1.1	53795.	5.0	7.2	1.1	6.0	45.0	12.0	170000.	20.
43928	3.13845	3.45230	-.31384	6.2	2.2	53893.	5.0	7.2	1.1	6.0	45.0	12.0	170000.	60.
43951	3.13469	4.34242	-1.20773	5.2	1.9	89451.	5.0	7.0	1.1	6.0	25.0	8.0	220000.	10.
43951	3.54031	4.34242	-.80211	5.2	3.8	89527.	5.0	7.0	1.1	8.0	25.0	8.0	220000.	10.
43733	2.03749	3.20242	-1.16493	5.5	1.9	89451.	9.0	6.8	1.2	53.0	304.0	120.0	1020000.	640.
43733	2.30113	3.30103	-.99990	5.5	3.8	89527.	9.0	6.8	1.2	53.0	304.0	120.0	1020000.	510.
43733	2.46350	3.39581	-.93232	5.5	5.6	89604.	9.0	6.8	1.2	53.0	304.0	120.0	1020000.	410.
43733	1.69340	3.92942	-2.23602	4.2	1.9	89451.	9.0	6.8	1.2	53.0	304.0	120.0	1020000.	120.
43733	1.91252	3.72984	-1.81733	4.2	3.8	89527.	9.0	6.8	1.2	53.0	304.0	120.0	1020000.	190.
43735	1.85839	3.55764	-1.69925	3.3	1.9	89451.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	180.
43735	2.09886	3.17944	-1.08058	3.3	3.8	89527.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	430.
43735	2.24696	3.90982	-1.66287	3.3	5.6	89604.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	80.
43735	2.15788	3.73373	-1.57585	4.2	1.9	89451.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	120.
43735	2.43710	3.55764	-1.12054	4.2	3.8	89527.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	180.
43735	2.60907	3.77152	-1.16245	4.2	5.6	89604.	9.0	7.2	1.1	30.0	168.0	71.0	650000.	110.
49288	2.00670	3.57403	-1.56733	3.6	1.9	89451.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	140.
49288	2.26656	4.02119	-1.75463	3.6	3.8	89527.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	50.
49288	2.42628	4.41913	-1.99285	3.6	5.6	89604.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	20.
49288	3.33771	3.94201	-.60429	7.8	1.9	89451.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	60.
49288	3.76960	3.81707	-.04747	7.8	3.8	89527.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	80.
49288	4.03559	3.94201	.09358	7.8	5.6	89604.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	60.
49288	5.03172	4.41913	.61259	14.4	1.9	89451.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	20.
49288	5.68281	4.72016	.96265	14.4	3.8	89527.	8.0	7.8	3.0	26.0	129.0	60.0	525000.	10.
49290	2.10527	3.32585	-1.22058	3.6	1.9	89451.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	170.
49290	2.37769	4.25527	-1.87758	3.6	3.8	89527.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	20.
49290	2.54546	3.77815	-1.23269	3.6	5.6	89604.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	60.
49290	3.50167	3.65321	-.15154	7.8	1.9	89451.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	80.
49290	3.95477	3.55630	.39847	7.8	3.8	89527.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	100.
49290	4.23383	4.07918	.15465	7.8	5.6	89604.	8.0	8.1	2.4	22.0	104.0	48.0	360000.	30.
49561	2.58981	3.68425	-1.09444	7.8	1.9	89451.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	180.
49561	3.13130	3.79339	-.66209	7.8	5.6	89604.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	140.
49561	2.70984	3.59710	-.88725	8.3	1.9	89451.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	220.
49561	3.06048	3.98528	-.92479	8.3	3.8	89527.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	90.
49561	3.27643	3.61730	-.34087	8.3	5.6	89604.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	210.
49561	3.64757	4.24055	-.59298	13.0	1.9	89451.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	50.
49561	4.11955	2.97573	1.14382	13.0	3.8	89527.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	920.
49561	4.41022	4.46240	-.05217	13.0	5.6	89604.	7.0	6.8	2.2	51.0	112.0	68.0	870000.	30.
49563	3.31882	3.60638	-.28756	7.8	1.9	89451.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	250.
49563	3.74826	3.41326	.33501	7.8	3.8	89527.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	390.
49563	4.01274	4.00432	.00842	7.8	5.6	89604.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	100.
49563	3.78361	3.30535	.47826	9.5	1.9	89451.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	500.
49563	4.27320	3.42453	.84867	9.5	3.8	89527.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	380.
49563	4.57472	3.74905	.82567	9.5	5.6	89604.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	180.

CL_2 AND CLO_2 ANALYTICAL DATA UTILIZED IN MULTIPLE REGRESSION ANALYSIS

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
49563	4.95754	4.52720	.43034	14.2	1.9	89451.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	30.
49563	5.59904	3.77387	1.82516	14.2	3.8	89527.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	170.
49563	5.99411	4.70329	1.29081	14.2	5.6	89604.	7.0	6.7	2.6	27.0	128.0	64.0	1010000.	20.
49565	3.37582	3.19149	.18433	7.8	1.9	89451.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	785.
49565	3.81264	3.51816	.29448	7.8	3.8	89527.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	370.
49565	4.08156	4.48430	-.40263	7.8	5.6	89604.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	40.
49565	3.98468	2.53006	1.45463	10.0	1.9	89451.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	3600.
49565	4.50029	4.24126	.25903	10.0	3.8	89527.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	70.
49565	4.81783	3.65499	1.16284	10.0	5.6	89604.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	270.
49565	5.27917	3.83109	1.44808	15.3	1.9	89451.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	180.
49565	5.96227	3.68842	2.27385	15.3	3.8	89527.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	250.
49565	6.38298	4.38739	1.99559	15.3	5.6	89604.	7.0	6.7	3.0	25.0	138.0	64.0	1220000.	50.
49567	3.23469	3.69548	-.46079	7.1	1.9	89451.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	250.
49567	3.65324	4.49135	-.83811	7.1	3.8	89527.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	40.
49567	3.91102	4.31527	-.40425	7.1	5.6	89604.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	60.
49567	3.61010	3.64625	-.03615	8.4	1.9	89451.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	280.
49567	4.07723	3.88930	.18793	8.4	3.8	89527.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	160.
49567	4.36492	4.24832	.11660	8.4	5.6	89604.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	70.
49567	5.12931	3.88930	1.24001	14.2	1.9	89451.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	160.
49567	5.79302	4.09342	1.69960	14.2	3.8	89527.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	100.
49567	6.20178	4.13918	2.06260	14.2	5.6	89604.	7.0	6.8	3.4	23.0	126.0	70.0	1240000.	90.
49569	3.12518	3.47712	-.35194	6.7	1.9	89451.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	460.
49569	3.52956	3.77815	-.24859	6.7	3.8	89527.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	230.
49569	3.77861	2.98759	.79102	6.7	5.6	89604.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	1420.
49569	3.31416	3.59581	-.28165	7.3	1.9	89451.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	350.
49569	3.74300	3.88460	-.14160	7.3	3.8	89527.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	180.
49569	4.00711	4.13988	-.13277	7.3	5.6	89604.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	100.
49569	4.97577	4.23679	.73899	13.5	1.9	89451.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	80.
49569	5.61962	4.83885	.78077	13.5	3.8	89527.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	20.
49569	6.01614	4.66275	1.35339	13.5	5.6	89604.	7.0	7.0	2.9	23.0	120.0	60.0	1380000.	30.
49571	2.82650	3.54040	-.71390	6.5	1.9	89451.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	340.
49571	3.19224	3.62472	-.43248	6.5	3.8	89527.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	280.
49571	3.41749	3.92575	-.50826	6.5	5.6	89604.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	140.
49571	2.78332	3.41867	-.63534	6.4	1.9	89451.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	450.
49571	3.14348	4.16879	-1.02531	6.4	3.8	89527.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	80.
49571	3.36526	4.37291	-1.00765	6.4	5.6	89604.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	50.
49571	4.40536	4.59476	-.18940	12.8	1.9	89451.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	30.
49571	4.97539	4.46982	.50557	12.8	3.8	89527.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	40.
49571	5.32646	5.07188	.25458	12.8	5.6	89604.	7.0	6.9	4.0	30.0	126.0	66.0	1180000.	10.
50256	2.92659	3.56543	-.63885	7.1	1.9	89451.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	170.
50256	3.30527	3.30452	.00076	7.1	3.8	89527.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	310.
50256	3.53850	3.79588	-.25738	7.1	5.6	89604.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	100.
50256	2.72392	3.89279	-1.16887	6.4	1.9	89451.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	80.
50256	3.07638	3.61979	-.54341	6.4	3.8	89527.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	150.
50256	3.29345	4.09691	-.80345	6.4	5.6	89604.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	50.
50256	4.31133	4.19382	.11751	12.8	1.9	89451.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	40.
50256	4.86920	4.79588	.07332	12.8	3.8	89527.	7.0	6.6	3.0	33.0	88.0	46.0	625000.	10.
50257	3.03262	3.25123	-.21861	7.5	1.9	89451.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	300.
50257	3.42503	3.95020	-.52517	7.5	3.8	89527.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	60.
50257	3.66670	3.55226	.11444	7.5	5.6	89604.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	150.
50257	2.72933	3.31338	-.58405	6.4	1.9	89451.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	260.

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
50257	3.08249	3.52423	-.44174	6.4	3.8	89527.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	160.
50257	3.30000	4.25123	-.95123	6.4	5.6	89604.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	30.
50257	4.31989	4.72835	-.40846	12.8	1.9	89451.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	10.
50257	4.87888	4.02938	.84949	12.8	3.8	89527.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	50.
50257	5.22313	4.12629	1.09684	12.8	5.6	89604.	7.0	6.7	2.8	33.0	88.0	42.0	535000.	40.
50259	2.68764	3.34242	-.65478	7.4	1.9	89451.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	150.
50259	3.03541	3.81954	-.78413	7.4	3.8	89527.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	50.
50259	3.24958	4.21748	-.96790	7.4	5.6	89604.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	20.
50259	2.44523	3.31439	-.86915	6.4	1.9	89451.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	160.
50259	2.76164	3.43933	-.67769	6.4	3.8	89527.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	120.
50259	2.95650	3.56427	-.60777	6.4	5.6	89604.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	90.
50259	3.86623	3.51851	.34772	12.8	1.9	89451.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	100.
50259	4.36650	2.54538	1.82112	12.8	3.8	89527.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	940.
50259	4.67460	4.51851	.15609	12.8	5.6	89604.	7.0	6.7	3.4	43.0	78.0	40.0	330000.	10.
50374	2.77600	3.55520	-.77921	6.7	1.9	89451.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	220.
50374	3.13520	3.72154	-.58634	6.7	3.8	89527.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	150.
50374	3.35642	3.48265	-.12623	6.7	5.6	89604.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	260.
50374	2.74025	3.32942	-.58917	6.6	1.9	89451.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	370.
50374	3.09483	3.66718	-.57235	6.6	3.8	89527.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	170.
50374	3.31320	4.29557	-.98237	6.6	5.6	89604.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	40.
50374	4.24940	3.72154	.52786	12.8	1.9	89451.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	150.
50374	4.79925	3.94338	.85587	12.8	3.8	89527.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	90.
50374	5.13789	4.59660	.54130	12.8	5.6	89604.	7.0	6.7	3.4	34.0	112.0	42.0	790000.	20.
50376	2.80273	3.31079	-.50806	6.4	1.9	89451.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	220.
50376	3.16539	3.75012	-.58473	6.4	3.8	89527.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	80.
50376	3.38874	3.61182	-.22308	6.4	5.6	89604.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	110.
50376	2.88075	3.44909	-.56834	6.6	1.9	89451.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	160.
50376	3.25351	3.22185	.03166	6.6	3.8	89527.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	270.
50376	3.48308	4.35218	-.86910	6.6	5.6	89604.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	20.
50376	4.43607	4.17609	.25998	12.8	1.9	89451.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	30.
50376	5.01098	4.05115	.95893	12.8	3.8	89527.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	40.
50376	5.36359	4.17609	1.18750	12.8	5.6	89604.	7.0	6.7	3.3	30.0	114.0	44.0	450000.	30.
50378	2.75972	3.03557	-.27384	6.4	1.9	89451.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	560.
50378	3.11692	3.55131	-.43449	6.4	3.8	89527.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	170.
50378	3.33675	3.63563	-.29888	6.4	5.6	89604.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	140.
50378	2.83655	3.02588	-.18933	6.6	1.9	89451.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	570.
50378	3.20359	3.35039	-.14680	6.6	3.8	89527.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	270.
50378	3.42964	3.87866	-.44903	6.6	5.6	89604.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	80.
50378	4.36801	3.74036	.62764	12.8	1.9	89451.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	110.
50378	4.93321	4.30463	.62859	12.8	3.8	89527.	7.0	6.7	3.8	31.0	114.0	44.0	605000.	30.
50378	5.28130	3.78175	1.49955	12.8	5.6	89604.	7.0	6.7	3.6	31.0	114.0	44.0	605000.	100.
50526	3.00068	2.19957	.80111	7.5	2.2	53893.	4.0	6.8	3.1	22.7	11.0	1.0	19000.	120.
50526	3.24017	2.57978	.66039	7.5	3.4	53992.	4.0	6.8	3.1	22.7	11.0	1.0	19000.	50.
50586	2.98799	2.31654	.67135	5.8	1.9	89451.	4.0	6.8	3.1	18.3	40.0	13.0	114000.	550.
50586	3.37451	2.73468	.63983	5.8	3.8	89527.	4.0	6.8	3.1	18.3	40.0	13.0	114000.	210.
50586	3.61262	3.75587	-.14325	5.8	5.6	89604.	4.0	6.8	3.1	18.3	40.0	13.0	114000.	20.
50587	2.64505	3.70757	-1.06252	5.0	1.9	89451.	4.0	6.7	3.1	20.2	10.4	2.4	51000.	10.
50070	1.16947	.69381	.47566	7.2	1.9	89386.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	254000.
50070	1.47979	2.45519	-.97539	7.2	3.8	134084.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	4400.
50070	1.71714	4.25354	-2.53640	7.2	5.6	178783.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	70.
50070	.87657	.33521	.54336	4.7	1.9	89451.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	580000.

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
50070	.99225	.51886	.47339	4.7	3.8	69527.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	380000.
50070	1.06227	.68367	.37860	4.7	5.6	89604.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	260000.
50070	1.05530	1.65148	-.59618	6.2	1.9	89386.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	28000.
50070	1.19161	1.95251	-.76090	6.2	3.8	89397.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	14000.
50070	1.27543	2.87853	-1.60310	6.2	5.6	89409.	10.0	6.9	5.6	119.0	148.0	96.0	1255000.	1660.
50072	1.78515	.90580	.87935	7.2	1.9	89386.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	100000.
50072	2.62114	4.42867	-1.80753	7.2	5.6	178783.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	30.
50072	.93349	1.49082	-.55733	2.7	1.9	69451.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	26000.
50072	1.05428	.21560	.83868	2.7	3.8	69527.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	490000.
50072	1.12867	.42867	.70000	2.7	5.6	89604.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	300000.
50072	1.61087	2.54786	-.93699	6.2	1.9	89386.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	2280.
50072	1.81894	2.32601	-.50707	6.2	3.8	89397.	10.0	6.6	6.4	78.0	129.0	77.0	805000.	3800.
50074	2.44031	4.04139	-1.60108	7.2	3.8	134084.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	40.
50074	2.83171	4.34242	-1.51071	7.2	5.6	178783.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	20.
50074	.92824	.25251	.67572	2.4	1.9	69451.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	246000.
50074	1.04835	.00998	1.03837	2.4	3.8	89527.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	430000.
50074	1.74028	1.82390	-.08363	6.2	1.9	89386.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	6600.
50074	1.96506	2.06367	-.09860	6.2	3.8	89397.	10.0	7.2	6.0	71.0	94.0	60.0	440000.	3800.
50076	1.88882	4.02119	-2.13237	7.2	1.9	89386.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	40.
50076	2.77336	4.32222	-1.54886	7.2	5.6	178783.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	20.
50076	1.00685	.29691	.70994	2.8	1.9	89451.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	212000.
50076	1.13713	.73116	.40598	2.8	3.8	69527.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	78000.
50076	1.21737	.14613	1.07124	2.8	5.6	89604.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	300000.
50076	1.70442	1.84510	-.14068	6.2	1.9	89386.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	6000.
50076	1.92457	2.11810	-.19352	6.2	3.8	89397.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	3200.
50076	2.05995	3.22531	-1.16535	6.2	5.6	89409.	10.0	7.3	7.1	72.0	97.0	54.0	420000.	250.
50078	1.66640	4.13434	-2.46793	7.2	1.9	89386.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	40.
50078	2.44679	4.13434	-1.68755	7.2	5.6	178783.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	40.
50078	.57966	1.09294	-.51328	1.5	1.9	69451.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	44000.
50078	.65467	1.20492	-.55025	1.5	3.8	69527.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	34000.
50078	.70086	.43537	.26549	1.5	5.6	89604.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	200000.
50078	1.50372	1.98821	-.48449	6.2	1.9	89386.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	5600.
50078	1.69795	2.54887	-.85093	6.2	3.8	89397.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	1540.
50078	1.81738	4.25927	-2.44189	6.2	5.6	89409.	10.0	7.2	5.9	85.0	103.0	51.0	545000.	30.
50080	2.43355	4.33244	-1.89878	6.8	3.8	134084.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	10.
50080	2.82399	4.03141	-1.20742	6.8	5.6	178783.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	20.
50080	.68106	1.48734	-.80628	1.4	1.9	69451.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	7000.
50080	.76919	1.10199	-.33280	1.4	3.8	69527.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	17000.
50080	.82347	1.15635	-.33288	1.4	5.6	89604.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	15000.
50080	1.81622	2.65120	-.83497	6.2	1.9	89386.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	480.
50080	2.05082	3.18631	-1.13549	6.2	3.8	89397.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	140.
50080	2.19508	4.03141	-1.83633	6.2	5.6	89409.	10.0	7.1	4.9	68.0	97.0	60.0	215000.	20.
52105	1.92610	2.14111	-.21501	3.6	1.3	41114.	16.0	7.0	3.5	3.0	6.0	1.4	155000.	1120.
52105	2.17499	2.27652	-.10152	3.6	2.6	41126.	16.0	7.0	3.5	3.0	6.0	1.4	155000.	820.
52105	2.33532	2.86811	-.53279	3.6	3.9	41138.	16.0	7.0	3.5	3.0	6.0	1.4	155000.	210.
52131	2.05111	2.07058	-.01947	4.0	1.3	41114.	16.0	7.0	3.7	3.4	7.5	1.4	80000.	680.
52131	2.31616	2.14721	.16895	4.0	2.6	41126.	16.0	7.0	3.7	3.4	7.5	1.4	80000.	570.
52131	2.48689	2.52268	-.03598	4.0	3.9	41138.	16.0	7.0	3.7	3.4	7.5	1.4	80000.	240.
52107	2.72118	1.97517	.74601	6.3	1.3	49450.	16.0	7.0	4.7	8.0	19.0	9.0	340000.	3600.
52107	3.07278	2.21972	.85306	6.3	2.6	49462.	16.0	7.0	4.7	6.0	19.0	9.0	340000.	2050.
52107	3.29924	2.71856	.58068	6.3	3.9	49474.	16.0	7.0	4.7	8.0	19.0	9.0	340000.	650.

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (0)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
52109	2.74693	2.19629	.55064	6.2	1.3	49450.	16.0	7.0	6.7	4.4	7.0	4.0	220000.	1400.
52109	3.10185	1.83727	1.26458	6.2	2.6	49462.	16.0	7.0	6.7	4.4	7.0	4.0	220000.	3200.
52109	3.33046	2.98069	.34977	6.2	3.9	49474.	16.0	7.0	6.7	4.4	7.0	4.0	220000.	230.
52111	4.39738	6.04139	-1.64401	11.9	1.3	49450.	16.0	7.0	3.5	4.0	7.5	3.5	110000.	0.
52111	4.96554	6.04139	-1.07584	11.9	2.6	49462.	16.0	7.0	3.5	4.0	7.5	3.5	110000.	0.
52111	5.33150	6.04139	-.70968	11.9	3.9	49474.	16.0	7.0	3.5	4.0	7.5	3.5	110000.	0.
52113	3.63459	6.25527	-2.62068	8.4	1.2	59776.	16.0	7.0	4.7	3.2	39.0	7.0	180000.	0.
52113	4.10421	6.25527	-2.15106	8.4	2.4	59791.	16.0	7.0	4.7	3.2	39.0	7.0	180000.	0.
52113	4.42789	6.25527	-1.82738	8.4	3.7	59805.	16.0	7.0	4.7	3.2	39.0	7.0	180000.	0.
52115	3.62353	4.00432	-.38079	8.4	1.2	59776.	16.0	7.0	6.7	1.6	6.3	1.0	101000.	10.
52115	4.09172	6.00432	-1.91260	8.4	2.4	59791.	16.0	7.0	6.7	1.6	6.3	1.0	101000.	0.
52115	4.41441	6.00432	-1.58991	8.4	3.7	59805.	16.0	7.0	6.7	1.6	6.3	1.0	101000.	0.
52117	3.81435	4.11394	-.29959	8.6	1.2	59776.	16.0	7.0	3.5	.7	3.0	.9	130000.	10.
52117	4.30719	6.11394	-1.80675	8.6	2.4	59791.	16.0	7.0	3.5	.7	3.0	.9	130000.	0.
52117	4.64688	6.11394	-1.46706	8.6	3.7	59805.	16.0	7.0	3.5	.7	3.0	.9	130000.	0.
52133	3.69262	3.84510	-.15248	8.6	1.2	59776.	16.0	7.0	3.7	3.6	1.3	.2	70000.	10.
52133	4.16973	5.84509	-1.67536	8.6	2.4	59791.	16.0	7.0	3.7	3.6	1.3	.2	70000.	0.
52133	4.49858	5.84509	-1.34652	8.6	3.7	59805.	16.0	7.0	3.7	3.6	1.3	.2	70000.	0.
52396	4.17520	4.03141	.14379	8.4	1.9	89386.	13.0	7.2	2.4	10.6	18.0	10.0	215000.	20.
52396	4.71450	4.03141	.68309	9.4	3.8	89397.	13.0	7.2	2.4	10.6	18.0	10.0	215000.	20.
52396	5.04613	4.33244	.71369	8.4	5.6	89409.	13.0	7.2	2.4	10.6	18.0	10.0	215000.	10.
52400	4.19543	4.32222	-.12679	8.4	1.9	89386.	13.0	7.1	3.5	9.1	25.0	15.0	210000.	10.
52400	4.73734	6.32222	-1.58467	8.4	3.8	89397.	13.0	7.1	3.5	9.1	25.0	15.0	210000.	0.
52400	5.07058	6.32222	-1.25164	8.4	5.6	89409.	13.0	7.1	3.5	9.1	25.0	15.0	210000.	0.
52404	3.52645	2.70602	.81844	6.2	1.9	89386.	13.0	6.8	3.3	6.4	29.0	19.0	970000.	1900.
52404	3.98196	3.57180	.41016	6.2	3.8	89397.	13.0	6.8	3.3	6.4	29.0	19.0	970000.	260.
52404	4.26205	4.68574	-.42369	6.2	5.6	89409.	13.0	6.8	3.3	6.4	29.0	19.0	970000.	20.
52408	3.45357	2.33288	1.12069	6.2	1.9	89386.	13.0	7.1	3.5	8.2	21.0	13.0	495000.	2300.
52408	3.89965	2.43933	1.46032	6.2	3.8	89397.	13.0	7.1	3.5	8.2	21.0	13.0	495000.	1800.
52408	4.17397	3.99563	.17833	6.2	5.6	89409.	13.0	7.1	3.5	8.2	21.0	13.0	495000.	50.
52442	2.05552	2.20926	-.15374	4.0	1.9	89386.	14.0	7.1	24.7	10.3	20.0	12.0	680000.	4200.
52442	2.32102	2.38535	-.06433	4.0	3.8	89397.	14.0	7.1	24.7	10.3	20.0	12.0	680000.	2800.
52442	2.48428	4.05436	-1.57007	4.0	5.6	89409.	14.0	7.1	24.7	10.3	20.0	12.0	680000.	60.
52446	2.84702	2.32736	.51966	4.0	3.8	89397.	14.0	7.1	3.8	10.6	18.0	16.0	425000.	2000.
52446	3.04728	3.39794	-.35066	4.0	5.6	89409.	14.0	7.1	3.8	10.6	18.0	16.0	425000.	170.
52684	1.71580	1.87335	-.15755	4.2	1.9	89386.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	3400.
52684	2.17109	1.55974	.61136	4.2	3.8	134064.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	7000.
52684	2.51931	1.55974	.95958	4.2	5.6	178783.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	7000.
52684	1.66982	.46283	1.20699	4.0	1.9	89451.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	87500.
52684	1.88588	.83663	1.04925	4.0	3.8	89527.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	37000.
52684	2.01895	1.50174	.51721	4.0	5.6	89604.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	8000.
52684	1.66947	.73274	.93674	4.0	1.9	89386.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	47000.
52684	1.88511	1.10380	.78131	4.0	3.8	89397.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	20000.
52684	2.01772	1.32565	.69207	4.0	5.6	89409.	16.0	7.0	2.6	51.0	82.0	30.0	254000.	12000.
52694	2.23596	1.60974	.62622	4.9	1.9	89386.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	7000.
52694	2.82928	1.74303	1.08625	4.9	3.8	134064.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	5150.
52694	3.28307	2.47712	.80595	4.9	5.6	178783.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	950.
52694	2.20296	1.37566	.82730	4.8	1.9	89451.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	12000.
52694	2.48802	1.25072	1.23730	4.8	3.8	89527.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	16000.
52694	2.66358	2.50545	.15812	4.8	5.6	89604.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	890.
52694	2.03119	.85278	1.17841	4.2	1.9	89386.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	40000.

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
52694	2.29355	1.25072	1.04283	4.2	3.8	89397.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	16000.
52694	2.45489	1.87506	.57983	4.2	5.6	89409.	16.0	7.2	3.0	35.0	80.0	32.0	285000.	3800.
52704	2.71358	2.24917	.46441	6.5	1.9	89386.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	1155.
52704	3.43363	2.54833	.88531	6.5	3.8	134084.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	580.
52704	3.98436	2.93150	1.05281	6.5	5.6	178783.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	240.
52704	2.65052	2.19781	.45271	6.3	1.9	89451.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	1300.
52704	2.99349	2.37726	.61623	6.3	3.8	89527.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	860.
52704	3.20471	3.23257	-.02787	6.3	5.6	89604.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	120.
52704	2.71358	1.96933	.74425	6.5	1.9	89386.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	2200.
52704	3.06408	2.23257	.83151	6.5	3.8	89397.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	1200.
52704	3.27962	3.03300	.24661	6.5	5.6	89409.	16.0	7.0	2.9	35.0	152.0	95.0	205000.	190.
52714	2.59470	2.03892	.55578	6.2	1.9	89386.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	1600.
52714	3.28320	2.25181	1.03139	6.2	3.8	134084.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	980.
52714	3.80980	2.94201	.86779	6.2	5.6	178783.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	200.
52714	2.68578	1.61979	1.06600	6.5	1.9	89451.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	4200.
52714	3.03331	2.55284	.48047	6.5	3.8	89527.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	490.
52714	3.24735	2.66325	.58409	6.5	5.6	89604.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	380.
52714	2.66889	1.88131	.78758	6.5	1.9	89386.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	2300.
52714	3.01362	2.18996	.82366	6.5	3.8	89397.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	1130.
52714	3.22561	3.12909	.09651	6.5	5.6	89409.	16.0	7.0	2.9	36.0	80.0	30.0	175000.	130.
52724	3.23469	3.36172	-.12704	8.3	1.9	89386.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	150.
52724	4.09302	4.23679	-.14376	8.3	3.8	134084.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	20.
52724	3.25335	2.52288	.73048	8.4	1.9	89451.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	1035.
52724	3.67432	3.75966	-.08534	8.4	3.8	89527.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	60.
52724	3.93359	4.06069	-.12711	8.4	5.6	89604.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	30.
52724	3.23469	2.59333	.64136	8.3	1.9	89386.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	880.
52724	3.65250	3.69272	-.04022	8.3	3.8	89397.	16.0	7.0	5.5	31.0	82.0	32.0	345000.	70.
52734	3.31847	2.15112	1.16735	8.4	1.9	89386.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	1730.
52734	4.19904	2.89780	1.30124	8.4	3.8	134084.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	310.
52734	4.87253	3.30998	1.56254	8.4	5.6	178783.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	120.
52734	3.25114	2.73595	.51519	8.2	1.9	89451.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	450.
52734	3.67183	4.08814	-.41631	8.2	3.8	89527.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	20.
52734	3.93091	4.38916	-.45825	8.2	5.6	89604.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	10.
52734	3.23205	2.30638	.92567	8.1	1.9	89386.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	1210.
52734	3.64952	3.06695	.58257	8.1	3.8	89397.	16.0	7.0	2.9	32.0	84.0	36.0	245000.	210.

ClO_2 DATA

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
51677	2.03878	1.45484	.58394	1.8	1.3	41189.	17.0	6.7	4.0	11.4	36.0	11.0	142500.	5000.
51677	2.07881	1.11242	.96640	1.8	2.6	41277.	17.0	6.7	4.0	11.4	36.0	11.0	142500.	11000.
51677	2.10268	1.11242	.99027	1.8	3.9	41364.	17.0	6.7	4.0	11.4	36.0	11.0	142500.	11000.
51683	1.64226	3.25527	-1.61301	1.5	1.3	41189.	17.0	6.7	2.5	16.0	17.0	6.0	18000.	10.
51683	1.69373	3.25527	-1.56154	1.5	3.9	41364.	17.0	6.7	2.5	16.0	17.0	6.0	18000.	10.
51689	1.75457	2.78837	-1.03370	1.3	1.3	41189.	17.0	6.7	2.0	6.6	13.0	6.0	43000.	70.
51689	1.78913	2.85532	-1.06619	1.3	2.6	41277.	17.0	6.7	2.0	6.6	13.0	6.0	43000.	60.
51692	1.79772	3.77452	-1.97680	1.3	1.3	41189.	17.0	6.7	1.8	6.2	8.0	4.7	59500.	10.
51692	1.83302	2.57040	-.73738	1.3	2.6	41277.	17.0	6.7	1.8	6.2	8.0	4.7	59500.	160.
51692	1.85407	2.92942	-1.07535	1.3	3.9	41364.	17.0	6.7	1.8	6.2	8.0	4.7	59500.	70.
51678	3.56161	2.89854	.66307	3.7	1.3	49522.	17.0	6.7	4.0	4.7	23.3	5.3	142500.	180.
51678	3.67309	3.67669	-.00360	3.7	3.9	49691.	17.0	6.7	4.0	4.7	23.3	5.3	142500.	30.
51684	3.07186	2.65321	.41865	3.0	1.3	49522.	17.0	6.7	2.5	5.7	5.2	2.0	18000.	40.
51684	3.13211	2.55630	.57581	3.0	2.6	49607.	17.0	6.7	2.5	5.7	5.2	2.0	18000.	50.
51684	3.16801	2.35218	.81583	3.0	3.9	49691.	17.0	6.7	2.5	5.7	5.2	2.0	18000.	80.
51690	2.92481	3.03543	-.10652	2.6	2.6	49607.	17.0	6.7	2.0	3.7	8.0	3.0	43500.	40.
51753	3.03020	2.59843	.43177	2.7	3.9	49691.	17.0	6.7	1.8	3.7	7.0	4.5	59500.	150.
51685	4.23296	2.47712	1.75583	4.5	1.2	59855.	17.0	6.7	2.5	1.8	10.0	2.5	18000.	60.
51685	4.36873	2.47712	1.89161	4.5	3.7	60042.	17.0	6.7	2.5	1.8	10.0	2.5	18000.	60.
51691	3.86919	3.63849	.23070	4.1	1.2	59855.	17.0	6.7	2.0	3.1	5.5	2.4	43500.	10.
51691	3.993[illegible]	2.73540	1.25790	4.1	3.7	60042.	17.0	6.7	2.0	3.1	5.5	2.4	43500.	80.
51754	3.85845	2.87143	.98702	4.0	3.7	60042.	17.0	6.7	1.8	4.9	5.5	3.1	59500.	80.
52299	2.34342	3.61055	-1.26713	2.1	1.9	89386.	14.0	7.0	4.4	11.2	22.0	16.0	775000.	190.
52299	2.38919	3.81012	-1.42093	2.1	3.8	89397.	14.0	7.0	4.4	11.2	22.0	16.0	775000.	120.
52299	2.41520	4.11115	-1.69595	2.1	5.6	89409.	14.0	7.0	4.4	11.2	22.0	16.0	775000.	60.
52303	2.47449	3.29275	-.81826	2.1	1.9	89386.	14.0	6.9	4.6	8.0	48.0	24.0	1040000.	530.
52303	2.52282	3.60206	-1.07923	2.1	3.8	89397.	14.0	6.9	4.6	8.0	48.0	24.0	1040000.	260.
52303	2.55028	3.69481	-1.14453	2.1	5.6	89409.	14.0	6.9	4.6	8.0	48.0	24.0	1040000.	210.
52384	5.04078	5.28780	-.24702	5.8	1.9	89386.	13.0	6.9	3.6	3.1	31.0	20.0	1940000.	10.
52384	5.13923	5.28780	-.14857	5.8	3.8	89397.	13.0	6.9	3.6	3.1	31.0	20.0	1940000.	10.
52388	5.22015	3.83885	1.38131	5.8	3.8	89397.	13.0	7.0	3.7	2.2	28.0	21.0	345000.	50.
52388	5.27697	4.23679	1.04019	5.8	5.6	89409.	13.0	7.0	3.7	2.2	28.0	21.0	345000.	20.
52468	2.88992	2.97772	-.08780	4.8	1.9	89386.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52468	3.00696	2.97772	.02924	4.8	3.8	134084.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52468	3.08391	2.97772	.10619	4.8	5.6	178783.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52468	2.89002	2.97772	-.08770	4.8	1.9	89451.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52468	2.94656	2.67669	.26989	4.8	3.8	89527.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	20.
52468	2.97876	2.50060	.47816	4.8	5.6	89604.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	30.
52468	2.94637	2.97772	-.03136	4.8	3.8	89397.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52468	2.97844	2.97772	.00071	4.8	5.6	89409.	11.0	6.6	6.4	31.0	39.0	12.0	9500.	10.
52624	1.51819	.91576	.60243	1.9	1.9	89386.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	19000.
52624	1.57958	.83279	.74659	1.9	3.8	134084.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	23000.
52624	1.62010	.99039	.62971	1.9	5.6	178783.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	16000.
52624	1.51824	.56104	.95720	1.9	1.9	89451.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	43000.
52624	1.54796	.70315	.84480	1.9	3.8	89527.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	31000.
52624	1.56486	.99039	.57447	1.9	5.6	89604.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	16000.
52624	1.51819	1.15312	.36507	1.9	1.9	89386.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	11000.
52624	1.54784	1.19451	.35333	1.9	3.8	89397.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	10000.
52624	1.56469	1.34941	.21528	1.9	5.6	89409.	16.0	7.0	2.6	34.0	100.0	35.0	156500.	7000.
52634	1.56415	1.77207	-.20792	2.0	1.9	89386.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	3600.
52634	1.62750	1.83702	-.20951	2.0	3.8	134084.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	3100.

SAMP NO.	PREDICTED LOG KILL	OBSERVED LOG KILL	RESIDUAL	DOSE (MG/L)	D.T. (MIN)	GT	TEMP (C)	PH	TKN (MG/L)	BOD (MG/L)	TSS (MG/L)	VSS (MG/L)	INFLUENT F. COLI	EFFLUENT F. COLI
52634	1.66915	1.55023	.11892	2.0	5.6	178783.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	6000.
52634	1.56052	1.04962	.51100	2.0	1.9	85451.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	19000.
52634	1.59482	1.21443	.38039	2.0	3.8	89527.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	13000.
52634	1.61224	1.43628	.17596	2.0	5.6	89604.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	7800.
52634	1.56415	1.12426	.43990	2.0	1.9	89386.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	16000.
52634	1.59470	1.28698	.30772	2.0	3.8	89397.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	11000.
52634	1.61206	1.15229	.45978	2.0	5.6	89409.	16.0	7.0	2.8	34.0	100.0	42.0	213000.	15000.
52644	2.34804	3.91645	-1.56841	4.0	1.9	89386.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	20.
52644	2.44313	4.21748	-1.77434	4.0	3.8	134084.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	10.
52644	2.50565	3.74036	-1.23471	4.0	5.6	178783.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	30.
52644	2.34812	2.68600	-.33788	4.0	1.9	89451.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	340.
52644	2.39407	2.96221	-.56813	4.0	3.8	89527.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	180.
52644	2.42022	3.01336	-.59314	4.0	5.6	89604.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	160.
52644	2.34804	2.50991	-.16187	4.0	1.9	89386.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	510.
52644	2.39390	2.53624	-.14234	4.0	3.8	89397.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	480.
52644	2.41996	2.61542	-.19546	4.0	5.6	89409.	16.0	7.0	2.7	35.0	90.0	38.0	165000.	400.
52654	2.25410	3.27684	-1.02275	4.2	1.9	89386.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	120.
52654	2.34539	3.45293	-1.10755	4.2	3.8	134084.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	80.
52654	2.40541	3.87890	-1.47350	4.2	5.6	178783.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	30.
52654	2.27796	2.77624	-.49828	4.2	1.9	89451.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	380.
52654	2.32254	2.69327	-.37073	4.2	3.8	89527.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	460.
52654	2.34791	2.86466	-.51676	4.2	5.6	89604.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	310.
52654	2.25410	2.51093	-.25683	4.2	1.9	89386.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	700.
52654	2.29812	2.86466	-.56654	4.2	3.8	89397.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	310.
52654	2.32314	3.03380	-.71067	4.2	5.6	89409.	16.0	7.0	2.8	39.0	95.0	30.0	227000.	210.
52664	3.02496	2.83286	.19210	6.0	1.9	89386.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	360.
52664	3.14748	3.15872	-.01124	6.0	3.8	134084.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	170.
52664	3.22802	3.34777	-.11976	6.0	5.6	178783.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	110.
52664	3.02507	2.99123	.03385	6.0	1.9	89451.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	250.
52664	3.08427	3.04674	.03753	6.0	3.8	89527.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	220.
52664	3.11795	3.48608	-.36812	6.0	5.6	89604.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	80.
52664	3.02495	3.30998	-.28502	6.0	1.9	89386.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	120.
52664	3.08405	3.24304	-.15899	6.0	3.8	89397.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	140.
52664	3.11761	3.54407	-.42645	6.0	5.6	89409.	16.0	7.0	2.9	35.0	85.0	30.0	245000.	70.
52674	3.22012	3.21307	.00705	6.4	1.9	89386.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	180.
52674	3.35054	3.38916	-.03863	6.4	3.8	134084.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	120.
52674	3.43627	3.42695	.00932	6.4	5.6	178783.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	110.
52674	3.22024	3.05337	.16686	6.4	1.9	89451.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	260.
52674	3.28326	3.21307	.07018	6.4	3.8	89527.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	180.
52674	3.31911	3.46835	-.14923	6.4	5.6	89604.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	100.
52674	3.22012	2.87728	.34284	6.4	1.9	89386.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	390.
52674	3.26302	3.21307	.06994	6.4	3.8	89397.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	180.
52674	3.31875	3.69019	-.37144	6.4	5.6	89409.	16.0	7.0	2.8	34.0	93.0	38.0	294000.	60.

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16. ABSTRACT - The pilot plant treatability studies were designed to interact with combined sewer overflow (CSO) monitoring and system modeling efforts for the Rochester Pure Water District with the ultimate objective of evaluating CSO abatement alternatives (see Volume I of this Report).

The studies covered treatment by the following unit processes: flocculation/sedimentation, swirl degritting and swirl primary separation, microscreening with sonic cleaning, dual-media filtration, activated carbon adsorption, sludge dewatering and high-rate disinfection. Applied flowrates to the system ranged between 5 and 177 gpm.

Pilot operations covered 19 overflow events during the period of September 1975 through June 1976. The studies evaluated the effects of design loadings and influent quality on system performance. Data were evaluated through application models. These models were used to develop optimum cost/benefit comparisons of systems. Results were also compared to published literature for similar installations at other locations.

Cost estimates related to facility sizing of all treatment processes were compiled and documented from literature sources. Cost equations were developed and applied for comparison of a number of alternatives in conjunction with the performance models. Cost/benefit relationships of the individual primary and chemical/physical systems are also presented in this report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Combined sewers, *Overflows--sewers, Water pollution, *Waste treatment, Sewage, Contaminants, Sewage treatment, *Pilot Plants, Cost analysis, *Cost effectiveness, *Flocculating, *Sedimentation, *Swirling, Gravity concentrators, Grit removal, Strainers, *Filtration, *Activated carbon treatment, *Disinfection, Bactericides, *Mathematical models, Sludge, Mixing, Polyelectrolytes.	Physical-chemical treatment, *Combined sewer overflows, Pollution abatement, Water pollution control, Rochester, N.Y., Suspended solids removal, *Flocculation/sedimentation, *Swirl degritter, *Swirl primary separator, *Microscreening, *Wastewater treatment, *High-rate dual-media filtration, *Carbon adsorption, *High-rate disinfection, Chlorine dioxide, Alum, Mixing intensity, Storm runoff.	13B

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