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Research and Development

Nitrogen and Phosphorus Control by Two Facilities in Florida

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NITROGEN AND PHOSPHORUS CONTROL BY TWO FACILITIES IN FLORIDA

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. 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 efforts of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report describes the operational and analytical considerations necessary for municipal wastewater treatment facilities that are required to produce high quality effluents.

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ABSTRACT

Municipal wastewater treatment plants employing multi-stage processes can be operated to consistently produce high quality final effluents.

Data for both the 11,400 m^3/d Hillsborough County, Florida and the 6,813 m^3/d Florida Cities Water Company facilities are presented in tabular and graphic form.

These data show that both utilities can achieve the stringent State of Florida effluent limitations. These limitations, for selected sites in the State, require that the effluent shall not contain more than 5 mg/l five day Biochemical Oxygen Demand, 5 mg/l suspended solids, 3 mg/l total nitrogen and 1 mg/l total phosphorus.

This report was submitted in fulfillment of Grant No. 805005 by Hillsborough County under partial sponsorship by the United States Environmental Protection Agency. This report covers a period from February 1976 to December 1978 and work was completed January 1979.

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FIGURES (continued)

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SECTION 1

INTRODUCTION

Designated areas of the State of Florida are subject to wastewater effluent discharge standards of five milligrams per liter BOD_5, five milligrams per liter suspended solids, three milligrams per liter of total nitrogen and one milligram per liter total phosphorus, depending on the population density and receiving water quality.

These water quality standards are established under the State of Florida Pollution of Waters Act referred to as the Wilson-Grizzle Act. It was enacted in 1970 under Chapter 403.086 of the Florida Statutes and amended by Chapter 72-58 of the Laws of Florida in 1972 and Chapter 17-3.04, Florida Administrative Code.

The Federal Environmental Protection Agency permit requirements as set forth by Region IV limit effluent residuals to 8 mg/l BOD, 8 mg/l suspended solids, 5 mg/l total nitrogen and 2 mg/l total phosphorus.

Florida's second largest industry, tourism, and other water related industries are dependent upon the availability of safe, clean waters. Through the enactment of the Wilson-Grizzle Bill, the State's greatest natural resource, its costal waters, will be protected from degradation.

The River Oaks treatment facility, operated by the Hillsborough County Utilities Department, and the two treatment facilities known as Gulf Gate and South Gate (Sarasota County) operated by the Florida Cities Water Company are subject to the Wilson-Grizzle effluent standards.

Florida rules define secondary treatment as having a minimum efficiency of 90 percent. Sarasota County also has an Ordinance which demands 98 percent removal of BOD_5 and suspended solids.

Chapter 17-3.04 does provide: (3) Alternate effluent disposal is a minimum of secondary treatment (90 percent) followed by an effluent disposal system approved by the Department which will prevent any effluent from being discharged to the surface waters of the State. Such disposal may include land disposal, deep injection wells, or combinations thereof, or other methods approved by the Department.

These facilities have been in operation for several years and have demonstrated the feasibility of controlling both nitrogen and phosphorus in municipal effluents. This report will concern the operational and analytical considerations involved with the daily routine for the River Oaks and Gulf

Gate facilities. Since the River Oaks and Gulf Gate facilities are required to meet the same effluent limitations, but employ different processes, comparative data should be of interest to designers, operators and regulatory personnel.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. This study has shown that multi-stage wastewater treatment systems can be very efficient for the control of BOD_5, SS, TN and TP.

2. Combined chemical-biological processes can be managed by plant operators.

3. Combined chemical-biological processes depend upon adequate laboratory control.

4. Sludges generated by these processes can be applied to agricultural land.

RECOMMENDATIONS

1. Efficiency data should be routinely displayed as frequency distribution plots so that variability of effluent composition can be documented.

2. Effluent limitations should be based on probability of occurrence rather than "never to exceed values", in the case of general pollutants such as nutrients. Toxic residuals however may have to be restricted to absolute values.

SECTION 3

RIVER OAKS FACILITY, HILLSBOROUGH COUNTY

The plant is located in the Northwest area of Hillsborough County on the outskirts of the City of Tampa as shown in Figure 1. The receiving water is a man-made canal which is subject to tidal action, and empties into Old Tampa Bay.

The plant was designed to treat 11,400 m^3/d (~3 mgd) with provisions for future expansion to 34,000 m^3/d (9 mgd). Initial design was for a complete mix two sludge nitrification system, followed by deep bed, dual media, down flow filters for denitrification and filtration.

Figure 2 is a schematic layout of the River Oaks facility showing the major unit processes and initial points of chemical additions for control of nitrogen and phosphorus.

Table 1 gives the design valves of the major unit processes at plant hydraulic capacity of 34,000 m^3/d and a process design of 11,400 m^3/d.

Operation of the River Oaks Plant

Due to an unexpected economic recession, the projected growth rate in the area did not occur and the hydraulic loading on the facility was less than 3,785 m^3/d for several years. During this time the nitrification stage was bypassed and the carbonaceous reactor was operated as an extended aeration process to provide nitrified effluent for the dentrification units. Figure 3 is a view of the carbonaceous reactor. Considerable equipment and operational changes were made during this time to optimize phosphorus and nitrogen removal.

The best dosing point for sodium aluminate addition proved to be after the grit chamber and just before the inlet to the carbonaceous reactor. A 1.2:1 mole ratio of Al:P at this point provided the most efficient and economical dose to achieve the 1 mg/l effluent total phosphorus limitation. Figure 4 shows the sodium aluminate storage tank and dual metering pumps for addition of the chemical.

Continual problems with the denitrification filters plagued operation due to the fact that the filters would not accept the design application rate without rapid headloss and consequent frequent backwashing. Excessive slime growth, inorganic aluminum percipitates and media destratification were all evaluated as probable causes. Eventually the filters could be kept on line

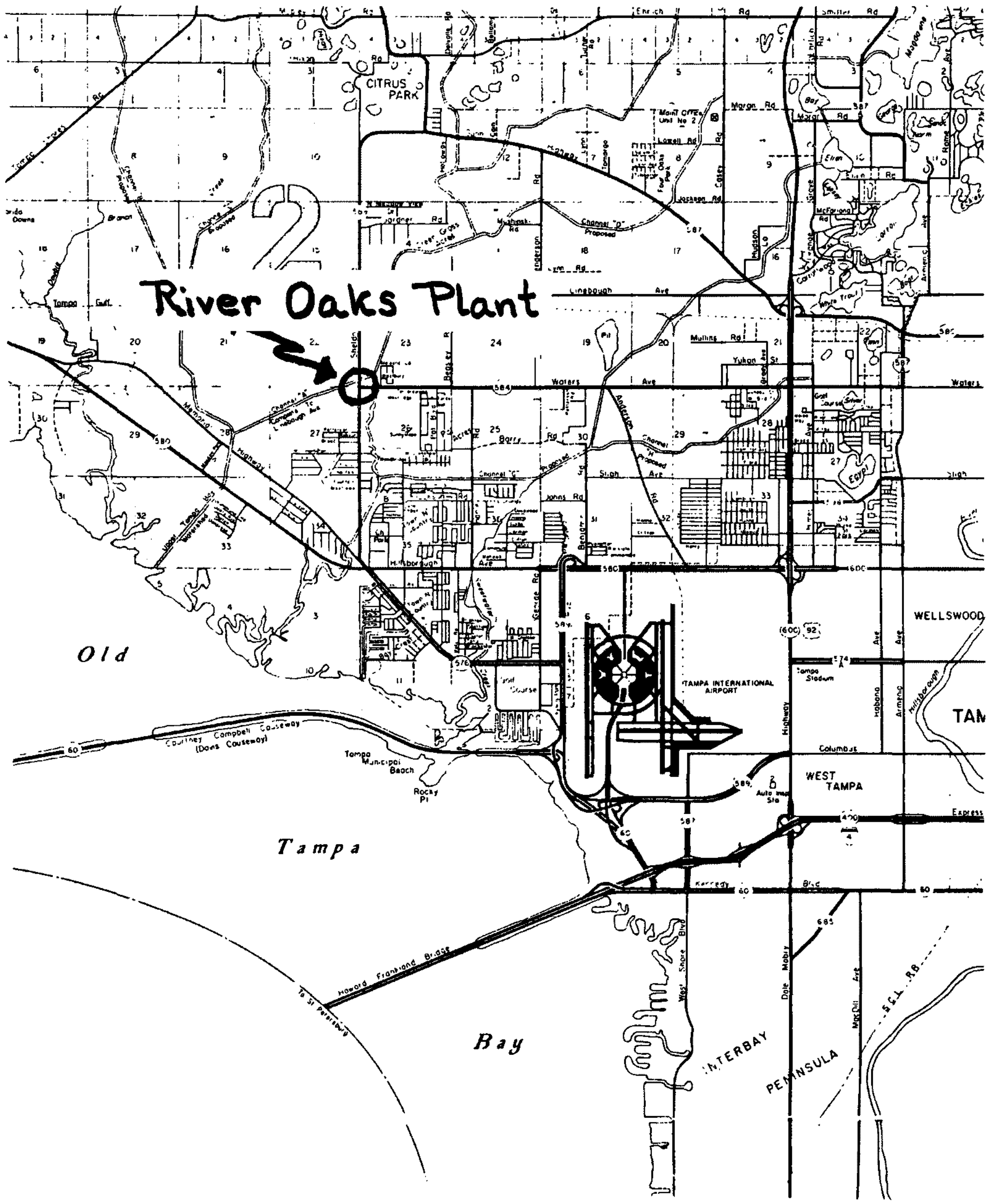

Figure 1. Location of River Oaks Facility

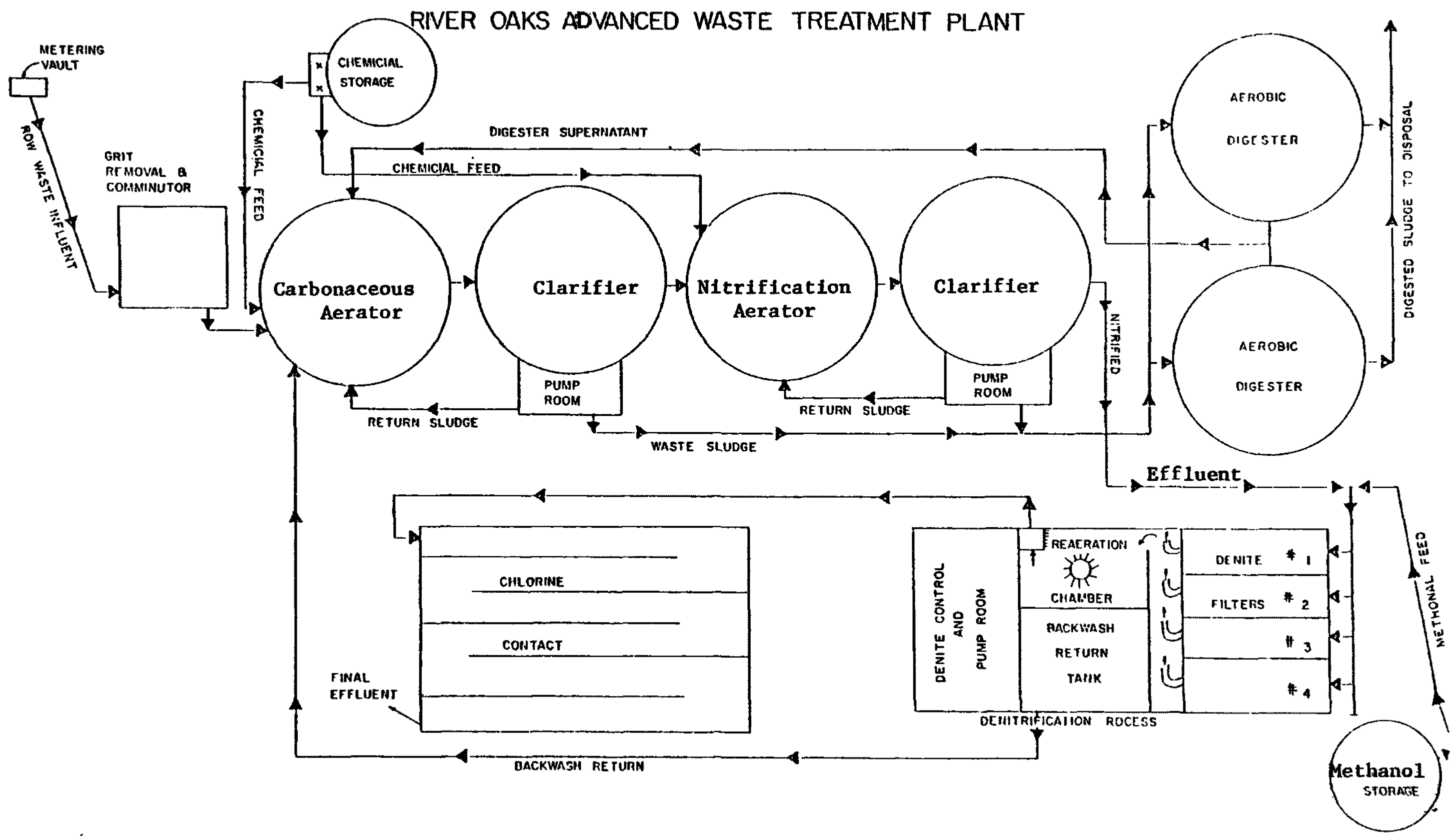

Figure 2. Flow Diagram of River Oaks

TABLE 1. Design Values For Major Components of The River Oaks Plant

COMPONENTS	DESIGN (at 11,400 m^3/d)	
Flow Meters Magnetic		
Influent	1	
Return Sludge (Carbon Cycle)	1	
Return Sludge (Nitrogen Cycle)	1	
Nitrogen Cycle Spikeline (Carbon Source)	1	
Denitrification Influent	1	
Grit Removal		
Cyclone Degritter	0.3 m	(12 in.)
Bar Rack (Hand cleaned)	34,000 m^3/d	(9 mgd)
Comminutor	34,000 m^3/d	(9 mgd)
Phosphorus Removal		
56 m^3 (15,000 gal) tank (storage)	1	
Chemical Feed Pump (1)	0.02 l/s	(17 gal/hr)
Chemical Feed Pumps (2)	0.2 l/s	(175 gal/hr) each
Denitrification Carbon Source		
38 m^3 (10,000 gal) tank (storage)	1	
500 gallon tank (day)	1	
Chemical Feed Pump	0.005 l/s	(5 gal/hr)
Chemical Feed Pump	0.03 l/s	(27 gal/hr)
Aeration Tank (Carbonaceous)		
Diameter	32 m x 3.6 m	(105 ft x 12 ft SWD)
Capacity	2,950 m^3	(778,912 gal)
Mechanical Aerators	3	
Aerator Horsepower	45 kW	(60 hp)
Detention Time	6.2 hrs	
Return Sludge Rate	6800-8700 m^3/d	(1.8 - 2.3 mgd)

TABLE 1. (continued) - Design Values for Major Components of the River Oaks Plant

COMPONENTS	DESIGN (at 11,400 m^3/d)	
Aeration Tank (Nitrification)		
Diameter	18 m x 3.6 m	(60 ft x 12 ft SWD)
Capacity	960 m^3	(253,791 gal)
Mechanical Aerators	1	
Horsepower	17 kW	(25 hp)
Diffused Air Blowers	3	
Capacity	0.5 m^3/s at 34 kn/m^2	(1042 cu ft/min at 5 psi)
Detention Time	2 hr	
Return Sludge Rate	6800-8700 m^3/d	(1.8 - 2.3 mgd)
Clarifiers (Nitrification & Carbonaceous)		
Diameter	27 m x 3.6 m	(90 ft x 12 ft SWD)
Capacity	2160 m^3	(571,030 gal)
Surface Settling Rate	19,190 1/m^2	(471 gal/sq ft)
Detention Time	4.56 hr	
Wier Overflow Rate	134 m^3/m/d	(10,600 gal/lin ft/day)
Aerobic Digesters		
Number of Units	2	
Diameter	23 m x 3.6 m	(75 ft x 12 ft SWD)
Capacity	1,500 m^3	(53,105 ft^3 (3.5 ft^3/ capita))
Aerators (Mechanical)	2	
Horsepower	30 kW	(40 hp)
Sludge Handling		
Sludge Thickening Tank	1	
Diameter	10 m x 3 m	(34 ft x 10.5 SWD)
Capacity	270 m^3	(71,272 gal)
Sludge Holding Tank	1	
Diameter	9 m x 7 m	(30 ft x 24 ft SWD)
Capacity	480 m^3	(126,831 gal)
Sludge Disposal (Contract Hauling)		
Chlorine Contact Tank		
Number of Rectangular Units	1	
Length	17 m	(55.6 ft)
Width	14.5 m	(48 ft)
Depth	1.5 m	(5 ft)
Total Volume	374 m^3	(99,813 gal)

TABLE 1. (continued) - Design Values for Major Components of the River Oaks Plant

COMPONENTS	DESIGN (at 11,400 m^3/d)	
Denitrification Filters (Dual Media)		
Number of Units	4	
Rectangular Units	7.6 m x 3 m x 4 m	(25 ft L x 10 ft W x 13 ft)
Denitrification (Anthracite)	0.9 m	(36 in.)
Polishing (Sand)	0.5 m	(18 in.)
Support (gravel)	0.3 m	(12 in.)
Surface Loading	1.4 - 4.1 $l/m^2/S$	(2.0 - 6.0 $gal/min/ft^2$)
Contact Wet Time	5 - 10 min	
Reaeration (Mechanical Aerator)	3.7 kW	1 - (5 hp)

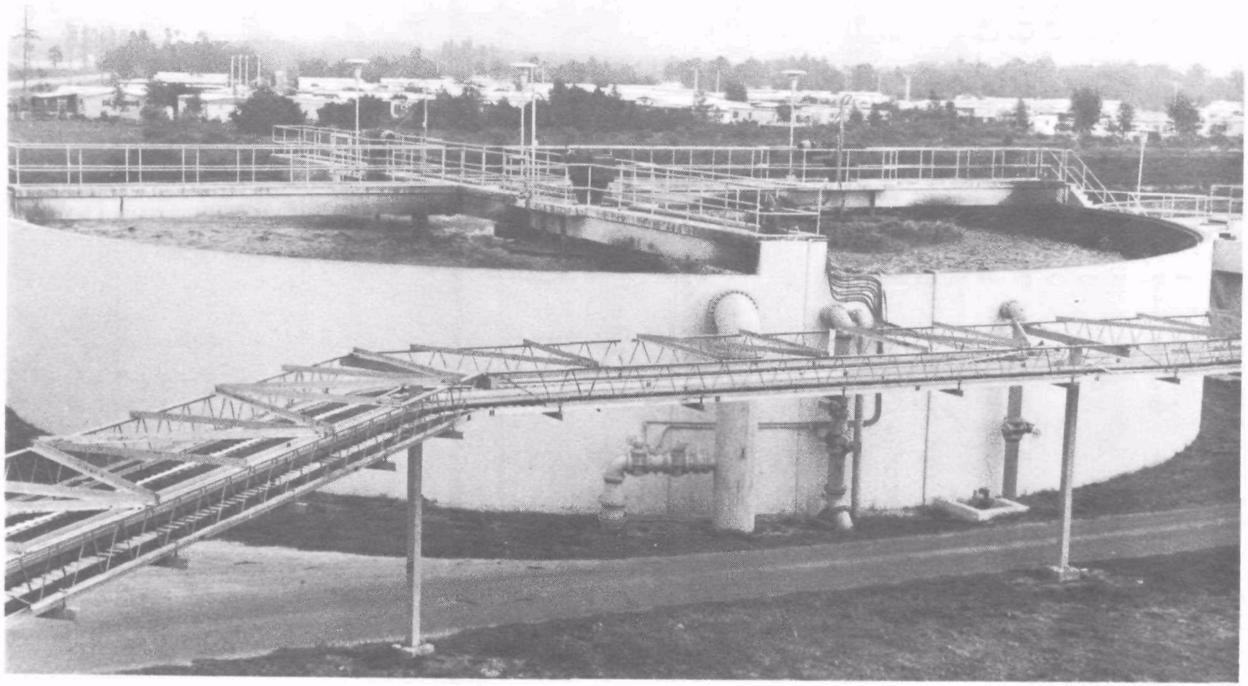

Figure 3. First Stage Carbonaceous Reactor

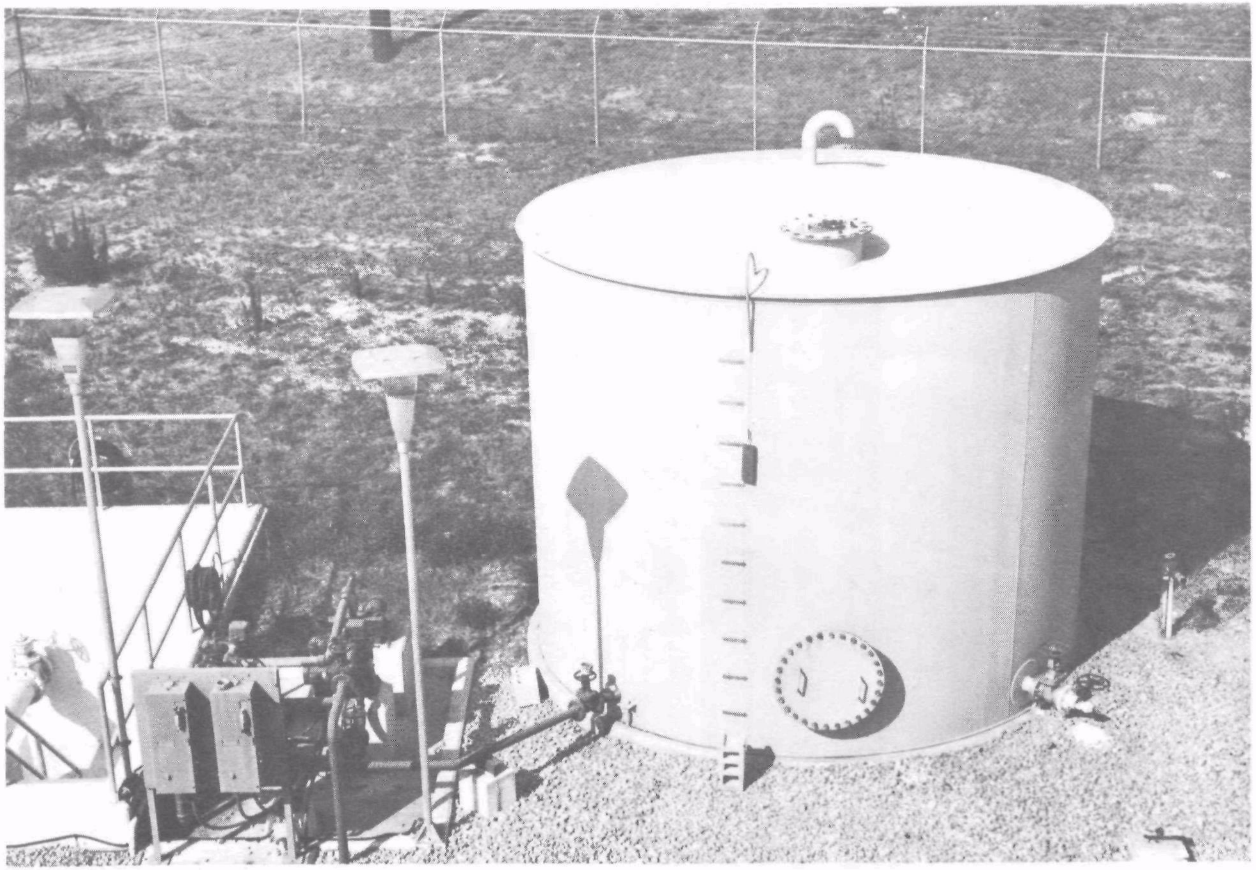

Figure 4. Sodium Aluminate Storage Tank

a reasonable length of time by maintaining a 1.5 mg/l chlorine residual in the backwash chamber and releasing nitrogen gas with periodic short pulses of air and backwash through the underdrain system. Figure 5 shows the influent end of the down flow dual media denitrification filters.

Careful monitoring of the methanol fed for denitrification showed that there was an 11 percent loss of methanol during storage due to evaporation. The original storage tank was not insulated. Foamed, in-place insulation was applied to the storage tank and the day-tank used for daily dosage control. Figures 6 and 7 show these tanks before and after foam insulation. The insulation was effective in greatly reducing evaporation losses.

Gradually population increased and the County purchased several small private utility package plants which were abandoned and the flows diverted to the River Oaks Plant. When flow increased over the 3,785 m^3/d mark, the nitrification system was placed into operation.

Staff Required for River Oaks Operation

1 - Chief Operator	-	40 hours per week
3 - Lead Operators	-	120 hours per week
3 - Shift Operators	-	120 hours per week
2 - Relief Operators	-	80 hours per week
2 - Laboratory Technicians	-	80 hours per week
		440 Total Manhours per week

Chemicals Required for River Oaks Operation

Sodium aluminate - 1.2:1 Al:P weight ratio
Methanol - 3:1 methanol to nitrate nitrogen weight ratio
Polymer - for sludge thickening
Chlorine for disinfection - 9 mg/l

Analytical Program and Sampling Schedule

The laboratory for the analysis of the River Oaks Advanced Wastewater Treatment Plant is located approximately one block away. Samples composited for 24 hours are collected by four automatic samplers and analyzed the following day. To meet minimum State requirements, analysis for total nitrogen, total phosphorus, suspended solids, BOD_5 and fecal coliform are required on the chlorinated effluent only. Analysis on the effluent alone would not provide the data necessary for process control. Therefore, four sample points were chosen throughout the treatment process for control. The sample locations are: the influent before any chemical addition or treatment, the carbon cycle clarifier effluent, the nitrogen cycle clarifier effluent and the chlorinated effluent. Table 2 shows the sampling and analysis schedule.

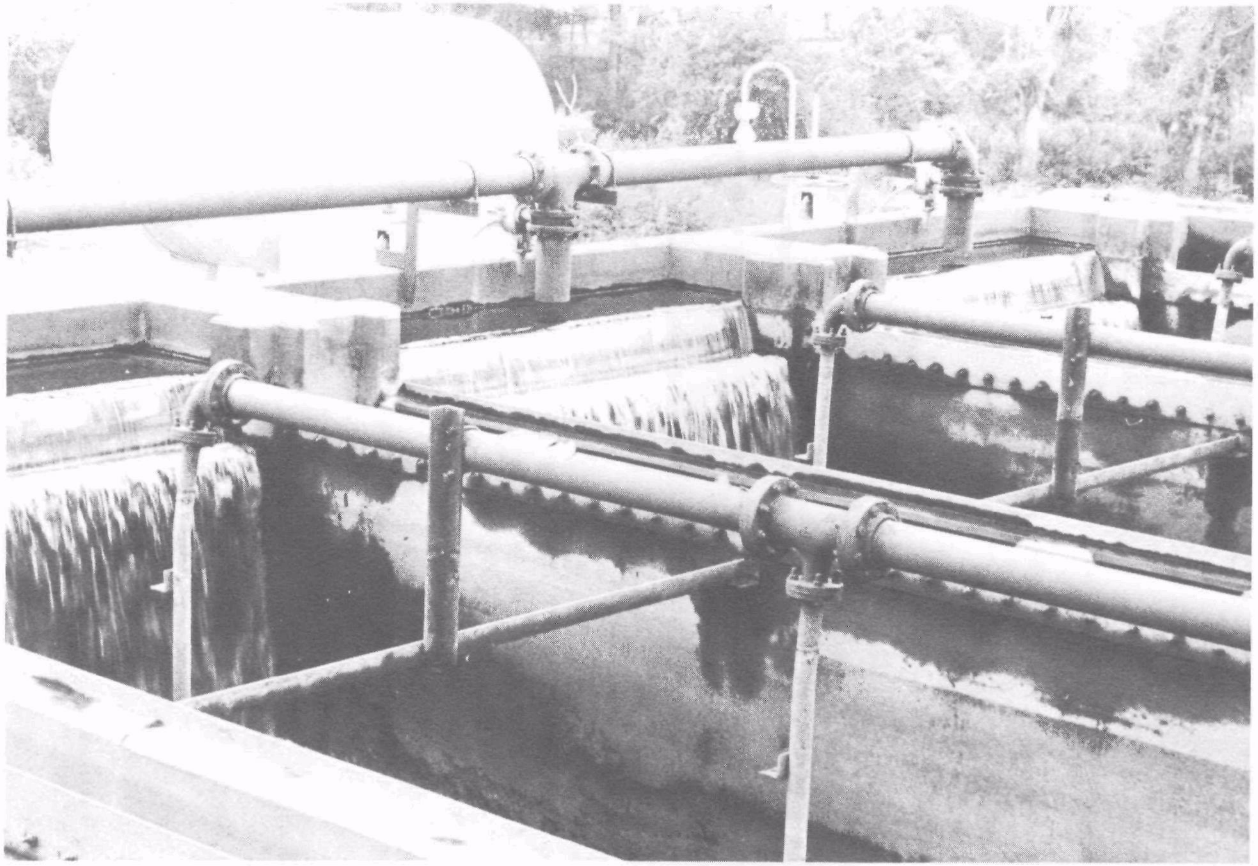

Figure 5. Influent to Denitrification Reactor

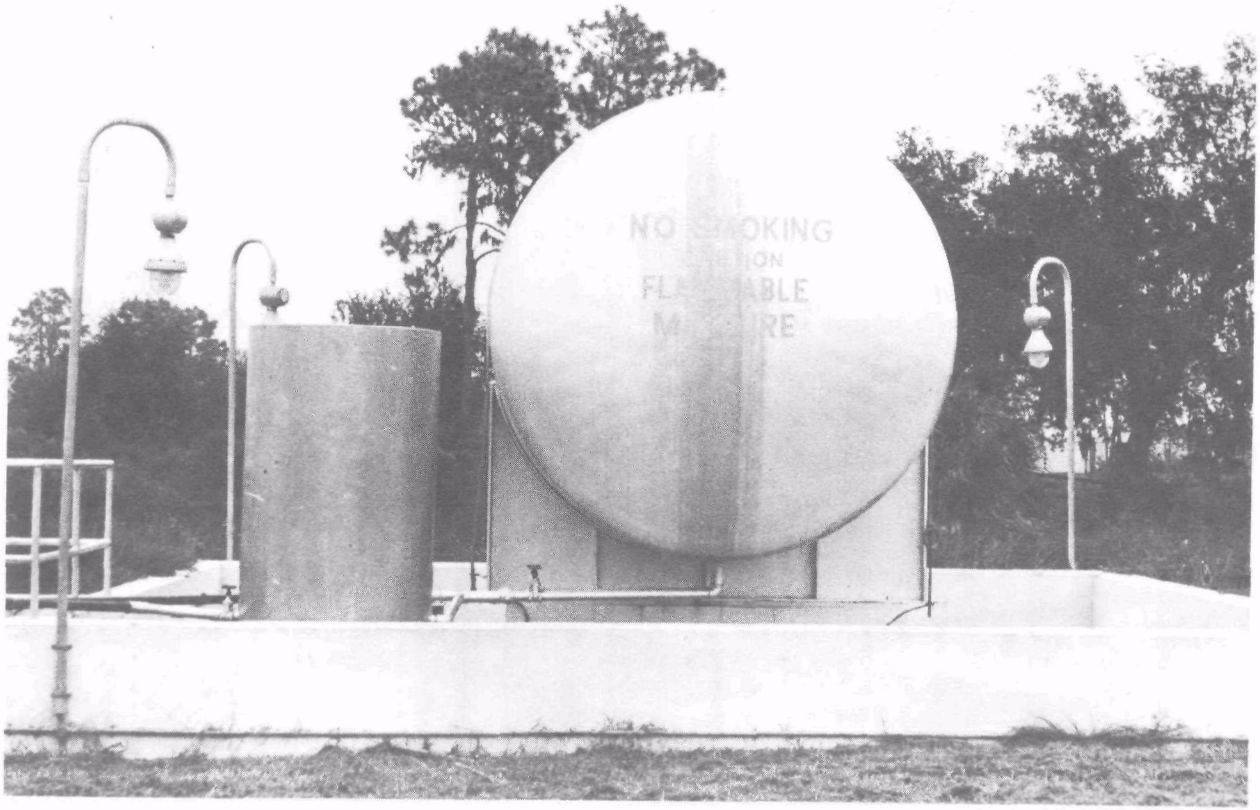

Figure 6. Methanol Tank Before Insulation

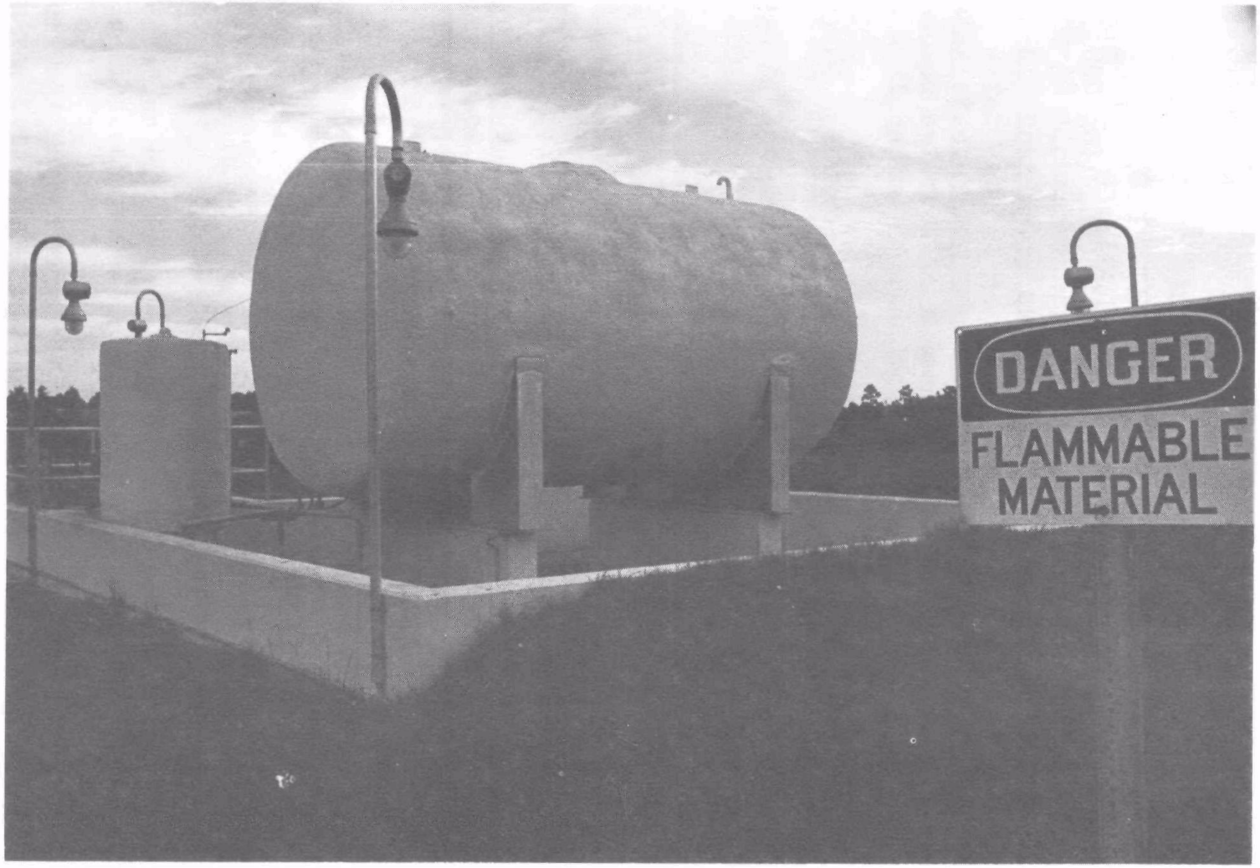

Figure 7. Insulated Methanol Tank

TABLE 2. Hillsborough County Utilities Sampling Schedules

ANALYSIS	RAW WASTEWATER	CARBONACEOUS CLARIFIER EFFLUENT	NITROGENOUS CLARIFIER EFFLUENT	CHLORINATED EFFLUENT EFFLUENT
BOD_5	5C	5C	5C	5C
SS	7C	7C	7C	7C
TKN	5C	5C	5C	7C
NO_3-N+NO_2-N	x	5C	5C	7C
NH_3-N	5C	5C	5C	x
P Total	5C	5C	5C	5C
D.O.	7G	7G	7G	7G
pH	7G	7G	7G	7G
Alkalinity	7C+G	7C+G	7C+G	7C+G
COD	5C	5C	5C	5C
Fecal Coliform	x	x	x	2G

1 = once per week
2 = twice per week
5 = five times per week
7 = seven times per week
8 = once per month

x = no sample
C = composite samples
G = grab samples

In order to better compare the data from the Gulf Gate treatment plant with the River Oaks Plant, four portable automatic samplers were purchased and set at comparable points of the treatment process at Gulf Gate for sampling. Once per week the four samples were split between the two laboratories for comparative analytical results. Figure 8 is a view of the Hillsborough County laboratory.

Sludge Production at River Oaks

About 25 m^3 of waste sludge is produced for each 3,785 m^3 of wastewater treated (6,800 gal/million gallons). This sludge is aerobically digested in two-1500 m^3 digesters utilizing floating mechanical aerators of 30 kW (40 hp) each. Loading rates dictated an average of 30 days detention per digester. After aerobic digestion, Nalco #7120 polymer is added to thicken the digested sludge from two percent solids to 3.2 percent solids. The sludge is then hauled by truck to a local orange grove for land spreading. Figure 9 shows the application of the digested sludge in the grove.

Efficiency of the River Oaks Multi-Stage Treatment

Tables 3, 4, and 5 show the overall efficiency of the facility in removing BOD_5, SS, TN (total nitrogen) and TP (total phosphorus). The tables cover the period 1976 to 1978. As the daily flow increased from less than 3,785 m^3/d (1 mgd) in 1976 to near 11,400 m^3/d (3 mgd) in 1978 there was no reduction in efficiency for removal of pollutants.

Figure 10 is a plot of 145 daily analyses for total nitrogen during the first six months of 1978 reported in Table 2. The data were arrayed in 0.1 mg/l increments and the frequency of occurrence plotted on logarithmic probability paper. Results show that 50 percent of the samples contained 1.5 mg/l TN, or less; and the effluent limitation of 3 mg/l TN was achieved on 90 percent of the samples.

This same technique was used to plot the total phosphorus values for the first six months of 1978 analyses. Figure 11 shows that 50 percent of the 155 data points were 0.7 mg/l TP, or less; and the effluent standard of 1 mg/l TP was achieved on 66 percent of the samples. Efficiency improved during the latter six months of operation.

Calculation of the spread factor, by comparing the mean value with one standard deviation, for each of the above data sets shows that the process control for TP is more variable than control of TN. Tables 3, 4, and 5 show that River Oaks more consistently meets the total nitrogen effluent limitation than the total phosphorus limitation on a monthly average basis.

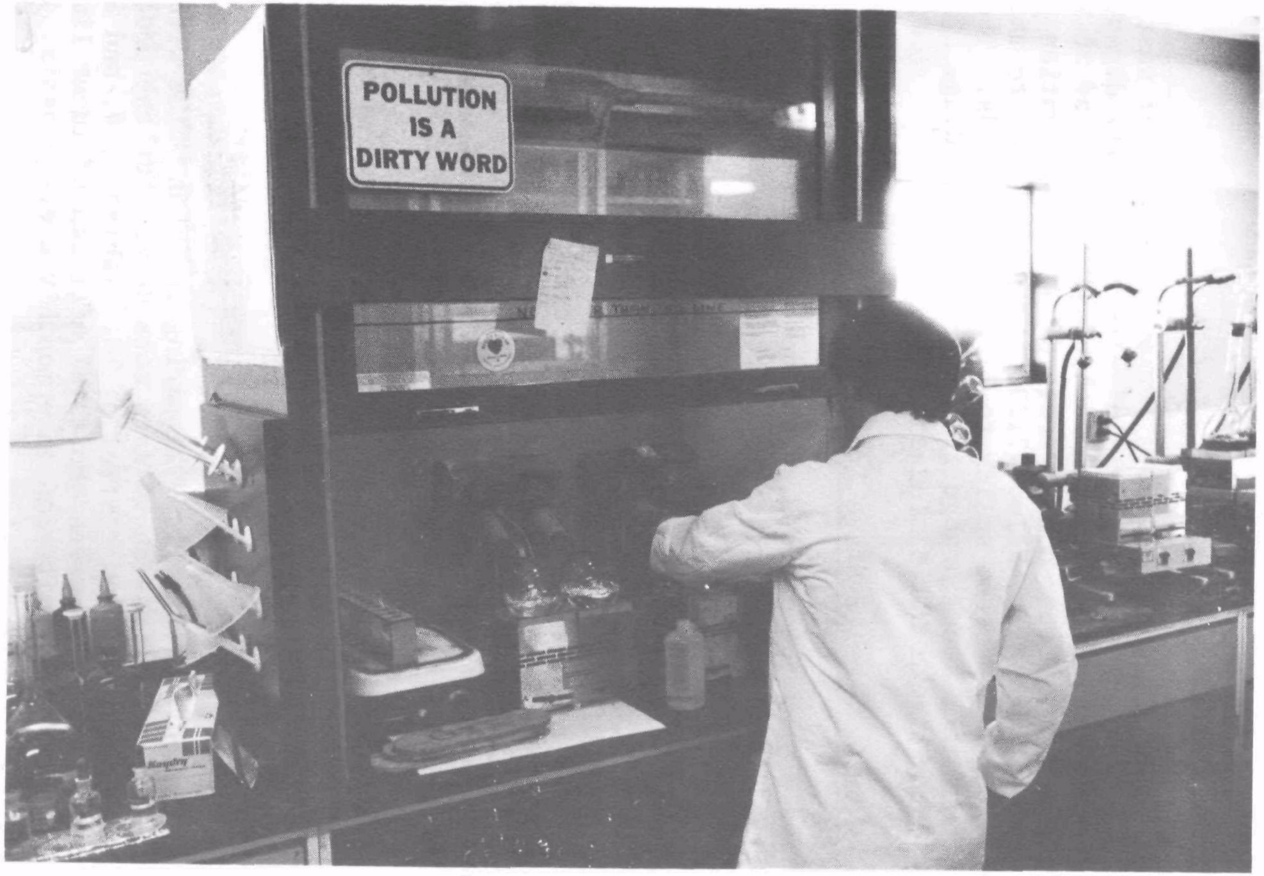

Figure 8. Hillsborough County Laboratory

Figure 9. Sludge Truck Transport to Orange Grove

TABLE 3. River Oaks Plant Efficiency, Monthly Average Values

YEAR 1976	ANALYSIS, mg/1				FINAL EFFLUENT				DAILY FLOW mgd**
	BOD_5		SS		TOTAL N				
	Inf.	Eff.	Inf.	Eff.	TKN	NO_x-N*	SOL. P	TP	
January	238	33	166	3	0.6	5.5	-	0.9	1.1
February	212	45	155	4	0.6	0.8	-	0.9	1.1
March	208	27	163	4	0.6	0.7	-	0.9	1.1
April	204	17	155	3	0.6	1.2	-	0.7	1.0
May	193	5	149	2	0.6	1.5	-	0.9	1.1
June	207	6	219	5	0.6	1.2	-	1.9	1.1
July	234	3	277	4	0.6	0.6	-	2.0	1.0
August	188	5	210	4	0.6	1.2	-	1.0	0.9
September	170	2	157	2	0.6	0.8	-	0.8	1.0
October	198	2	205	2	0.6	1.5	-	1.2	0.9
November	193	6	233	1.6	0.6	0.5	1.0	0.8	0.8
December	238	4	191	2	0.6	1.2	-	0.6	0.8

**mgd x 3,785 = m^3/d

*NO_x-N = NO_2-N+NO_3-N

TABLE 4. River Oaks Plant Efficiency, Monthly Average Values

YEAR 1977	ANALYSIS, mg/l BOD$_5$ Inf.	BOD$_5$ Eff.	SS Inf.	SS Eff.	FINAL EFFLUENT TOTAL N TKN	FINAL EFFLUENT TOTAL N NO_x-N*	SOL. P	TP	DAILY FLOW mgd**
January	237	4.0	168	1.0	0.6	1.5	0.5	0.8	1.0
February	238	5.0	235	2.6	0.6	1.8	0.7	0.9	1.3
March	245	4.0	220	1.9	0.6	0.8	0.3	0.4	1.3
April	258	1.6	193	1.4	0.6	1.2	0.7	0.9	1.2
May	249	2.3	172	1.6	0.7	1.2	0.7	0.9	1.2
June	263	2.6	197	1.2	0.6	0.3	0.8	0.9	1.3
July	207	2.0	153	1.0	0.6	0.1	0.8	0.9	1.5
August	197	0.6	196	1.1	1.6	1.3	0.5	0.6	2.0
September	200	1.6	134	1.2	1.1	1.2	1.1	1.3	2.3
October	242	0.9	175	1.4	1.3	2.1	0.7	1.2	2.1
November	261	1.4	234	0.9	1.2	0.8	0.8	1.4	2.1
December	240	2.0	210	1.0	0.9	0.6	0.5	0.6	2.1

**mgd x 3,785 = m^3/d

*NO_x-N = NO_2-N+NO_3-N

TABLE 5. River Oaks Plant Efficiency, Monthly Average Values

YEAR 1978	ANALYSIS, mg/l BOD$_5$ Inf.	Eff.	SS Inf.	Eff.	FINAL EFFLUENT TOTAL N TKN	NO_x-N*	SOL. P	TP	DAILY FLOW mgd**
January	239	3	212	1	1.2	0.1	1.3	1.2	2.2
February	205	2	190	1	1.1	0.7	0.9	1.1	2.5
March	207	2	212	1	1.2	1.5	0.4	0.5	2.3
April	250	3	239	1	1.1	0.7	0.9	1.0	2.0
May	206	1	214	2	1.1	0.6	1.0	1.6	2.3
June	218	1	229	1	1.0	0.1	0.8	0.9	2.1
July	238	1	293	3	2.1	0.1	0.5	0.6	2.3
August	229	1	246	2	1.2	0.1	0.3	0.4	2.4
September	207	1	162	1	2.7	0.2	0.4	0.5	2.6
October	216	2	177	2	2.6	0.7	0.6	0.7	2.9
November	216	1	181	4	1.6	0.5	0.5	0.8	2.8
December	183	1	166	3	2.1	0.5	0.7	0.8	2.9

**mgd x 3,785 = m^3/d

*NO_x-N = NO_2-N+NO_3-N

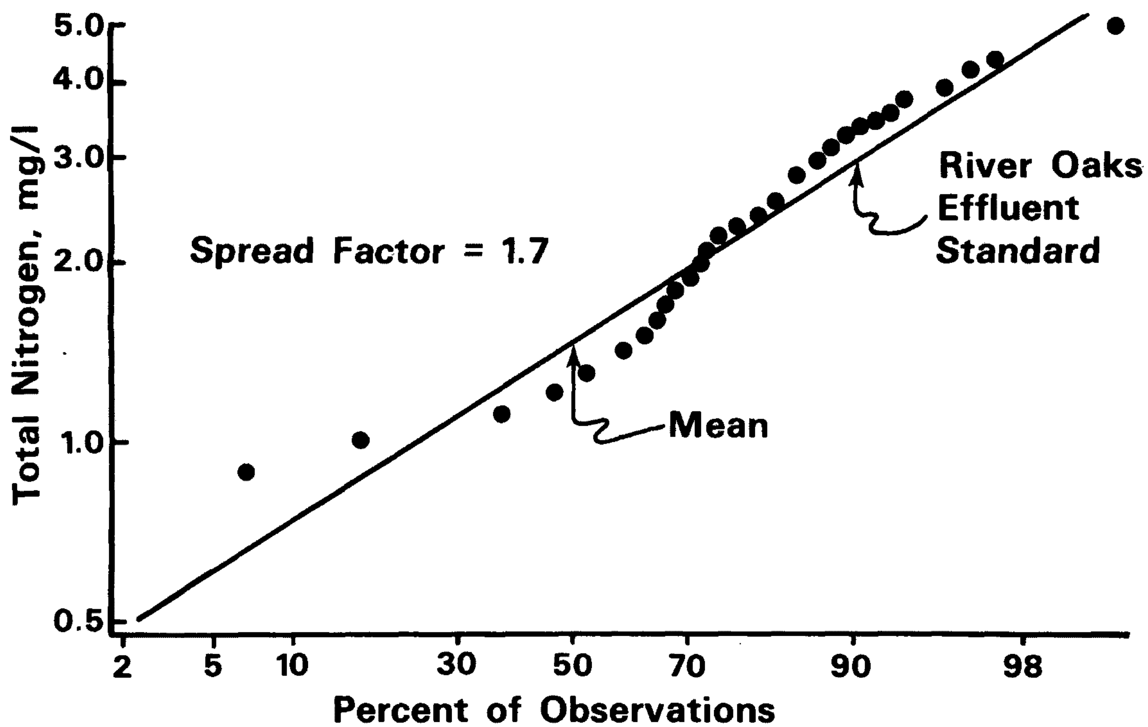

Figure 10. Total Nitrogen Content of River Oaks Final Effluent

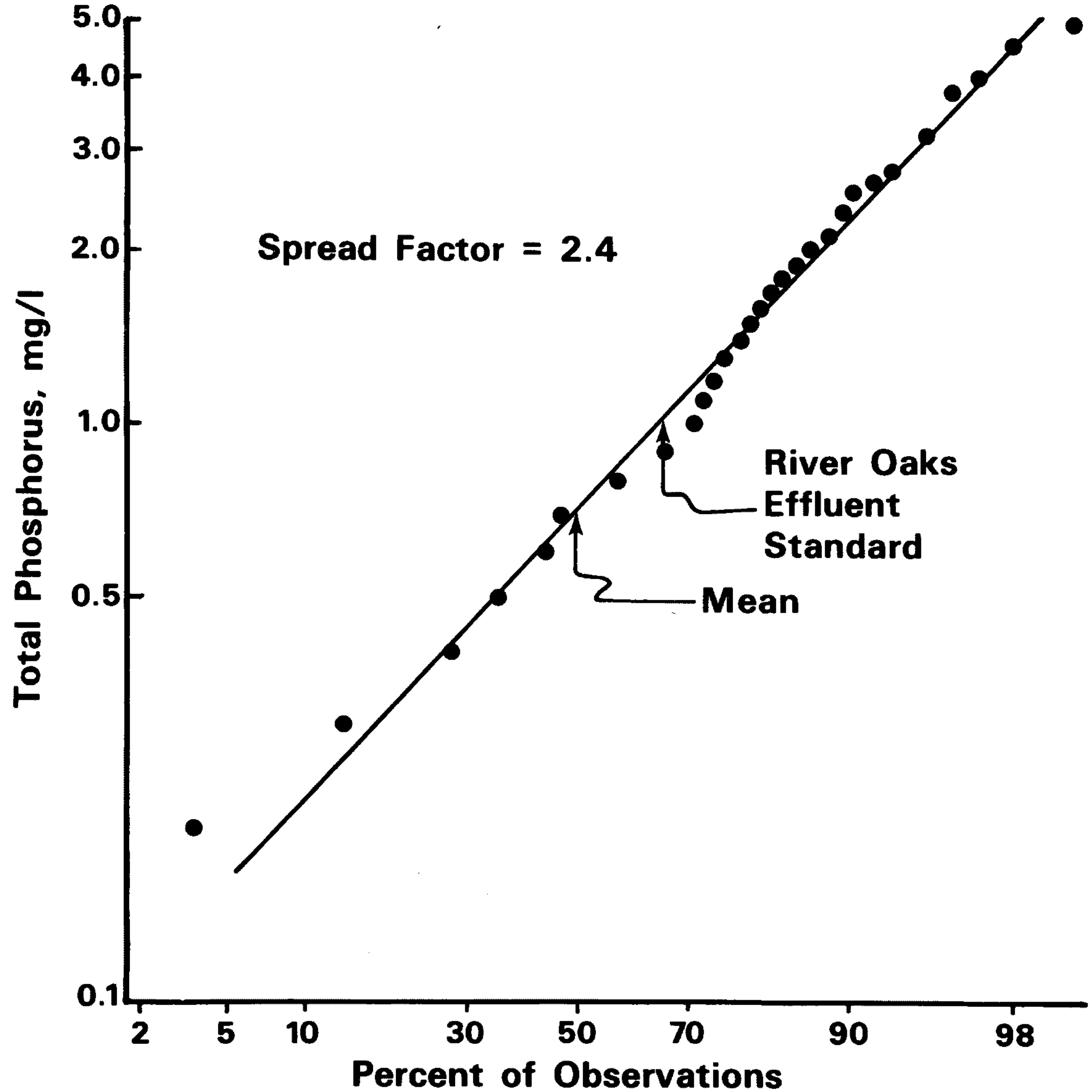

Figure 11. Total Phosphorus Content of River Oaks Final Effluent

SECTION 4
GULF GATE FACILITY, SARASOTA COUNTY

The Gulf Gate area utility was purchased by Florida Cities Water Company in 1965 and provides water and wastewater utility services. Figure 12 shows the location of the two plants owned by the Company in Sarasota County. The present facilities, designed to meet the AWT standards, were completed in early 1975 after being judged by Company management as being the most practical and economical process available to achieve the desired results. The billing and records office of the Company is shown on Figure 13.

Facilities Design

NOMINAL CAPACITY 6,813 m^3 (1.8 mgd)

1. Grit removal is sized to remove + 150 mesh grit.

2. Equalization tank is a 24m (80 ft) diameter tank having a capacity of 2,700 m^3 (715,000 gal.) with a turbine aerator and peripheral diffusers.

3. Aeration Tanks - There are 4 tanks having a total volume necessary to permit a BOD_5 loading of 961 g/m^3 (60 lb/1000 ft^3) at design flow. Each tank is provided with turbine aerators.

4. Intermediate Clarifiers - There are 3 designed for 2.2 hr detention and 35 $m^3/m^2/d$ (850 $gal/ft^2/d$).

5. Rotating Disc Nitrification - There are 8 shafts rated at 9290 m^2 (100,000 ft^2) each, for a hydraulic loading of 0.1 $m^3/m^2/d$ (2.2 gpd/ft^2).

6. Suspended Growth Denitrification - There are 3 mixing basins of equal volume with a total detention time of 2.5 hr. Each basin is equipped with a submerged mixer to keep the denitrification mixed liquor in suspension. Methanol is added for controlling the denitrification reaction.

7. Purge tank to blow out nitrogen operates at one minute rapid mix and 5 minutes high rate air purge.

8. Final Clarifiers - There are 2 with 2.5 hr detention time and a surface loading of 30 $m^3/m^2/d$ (750 gpd/ft^2).

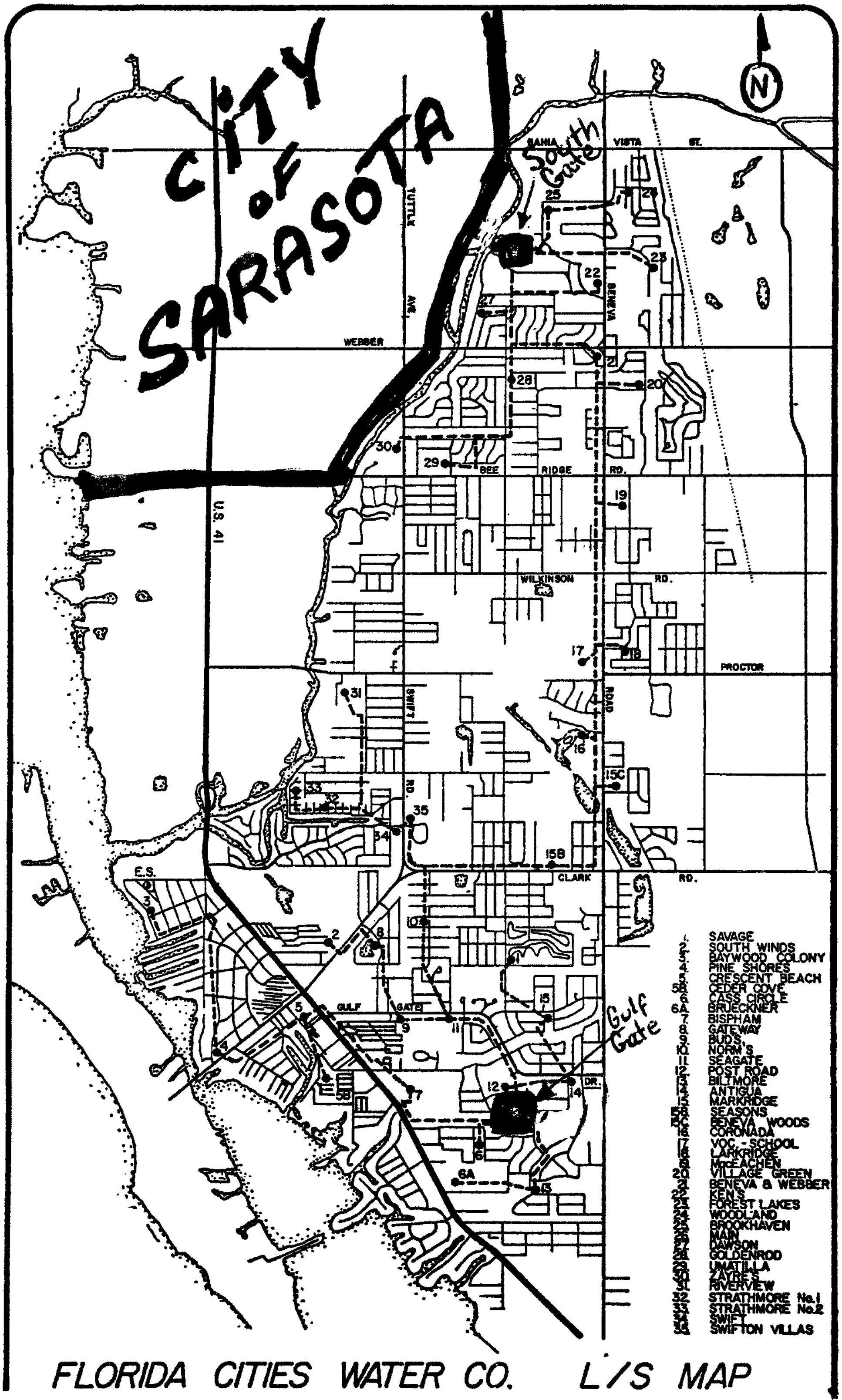

Figure 12. Location of Company Treatment Plants

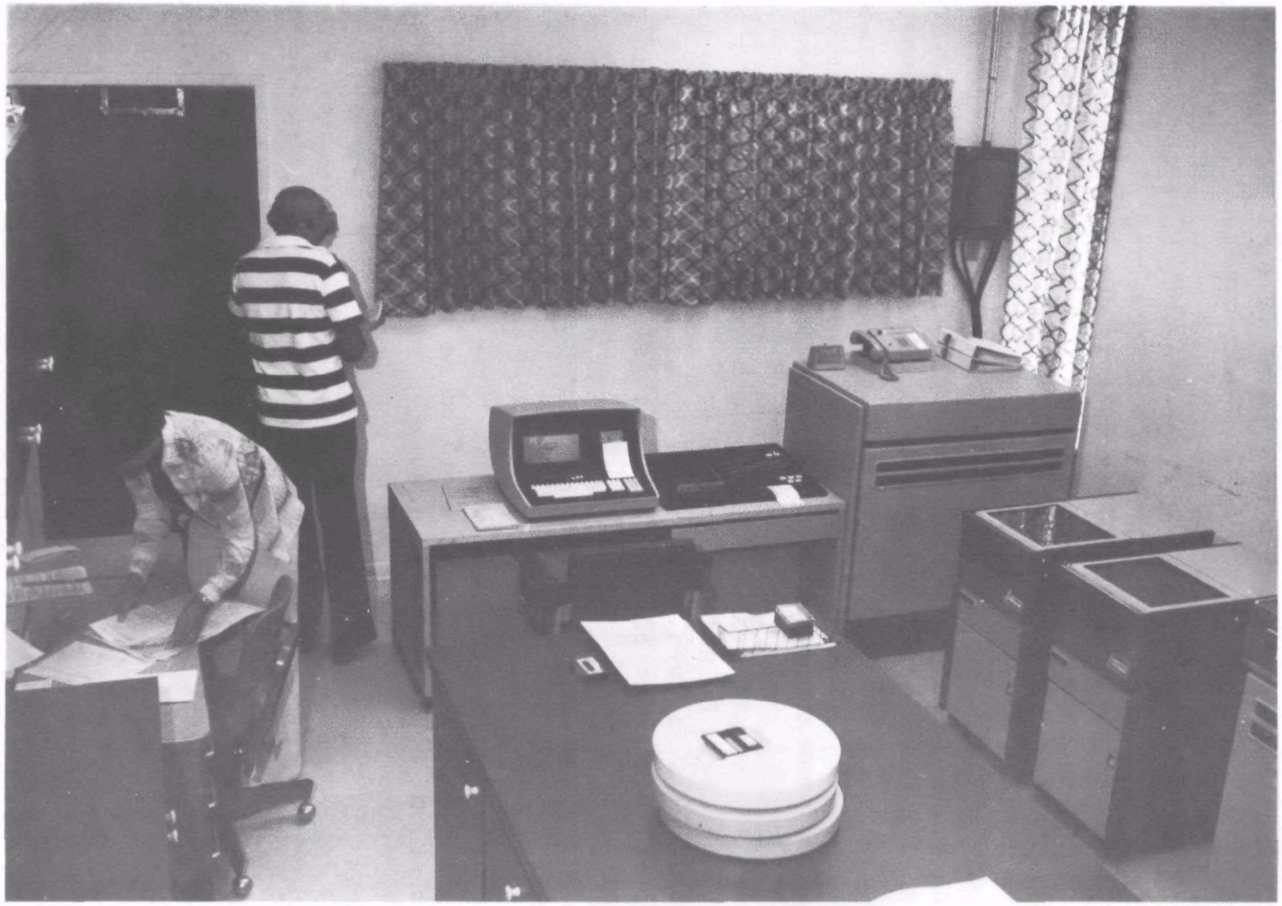

Figure 13. Billing and Records Office

9. Filters - There are 4 gravity/sand/anthracite filters with air surface wash. Surface loading is 2.3 ℓ/m^2/s (3.5 gpm/ft^2) or 3.3 ℓ/m^2/s (5.0 gpm/ft^2) with one filter being backwashed.

10. Aerobic Sludge Digesters - There are 2 rectangular tanks with coarse air diffusion having a capacity of 0.06 m^3 (2 ft^3) per capita. An air rate of 0.3 ℓ/m^3/s (20 cfm/1000 ft^3) is applied.

Figure 14 shows a schematic flow diagram of the Gulf Gate Plant. The major installed unit processes are shown in a series of pictures. Figure 15 is the 2,700 m^3 equilization tank. This tank is considered essential by the operational staff since it allows the following processes to be operated at constant flow. This is particularly important for chemical dosages and final filter and disinfection control. Figure 16 shows two of the first stage aeration tanks with turbine aerators. Figure 17 shows the second stage rotating discs on the left, suspended growth denitrification reactor in the middle background, nitrogen gas purge in the left foreground, and the final clarifiers in the right foreground. Figure 18 is a close-up view of the rotating disc inside the plastic shell. Since the discs receive a very low BOD_5 load from the first stage carbonaceous reactor, only a very thin film of biological growth occurs on the discs. There is no intermediate settling between the rotating discs and the denitrification reactor because these second stage discs do not slough solids. Figure 19 is a top view of the gravity dual-media filters. Figure 20 shows a one liter beaker of the filtered final effluent; the clarity and sparkle are characteristic of daily effluent production.

Analytical and Sampling

Two composite samples are taken daily. One is taken as a raw sample ahead of the grit chamber and the other is taken from the effluent in the tank located ahead of chlorination. Automatic samplers take a 200 ml sample every 40 minutes totaling 7,200 ml per day. A sampling and analysis schedule is shown in Table 6.

Plant Operation

1. An operator is on duty from 7:00 AM to 12:00 Midnight each day. Maintenance and control work are performed by a lead operator and three shift operators. The laboratory is staffed seven days a week by two laboratory technicians. Figure 21 is a view of the wastewater control laboratory.

2. Operator Training: Operators are encouraged to study and take classes from schools offering courses leading to certification and licensing. The company pays tuition and expenses directly related to operator training programs. On-site instruction and discussion is a daily occurrence. The Sarasota Division of Florida Cities Water Company has two "A" Wastewater Operators in staff, one "B" and one "C" Operator.

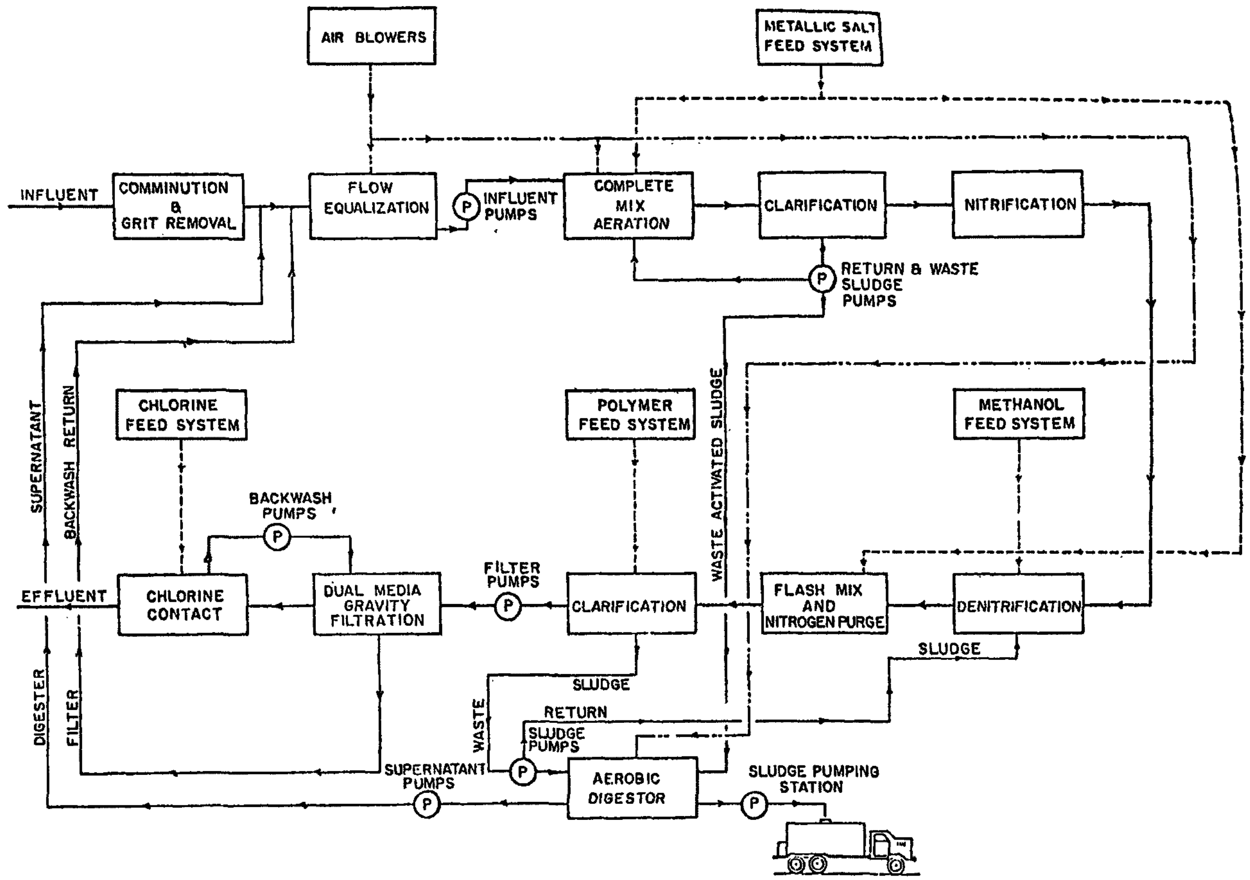

Figure 14. Gulf Gate Flow Diagram

Figure 15. Equalization Tank

Figure 16. First Stage Carbonaceous Reactors

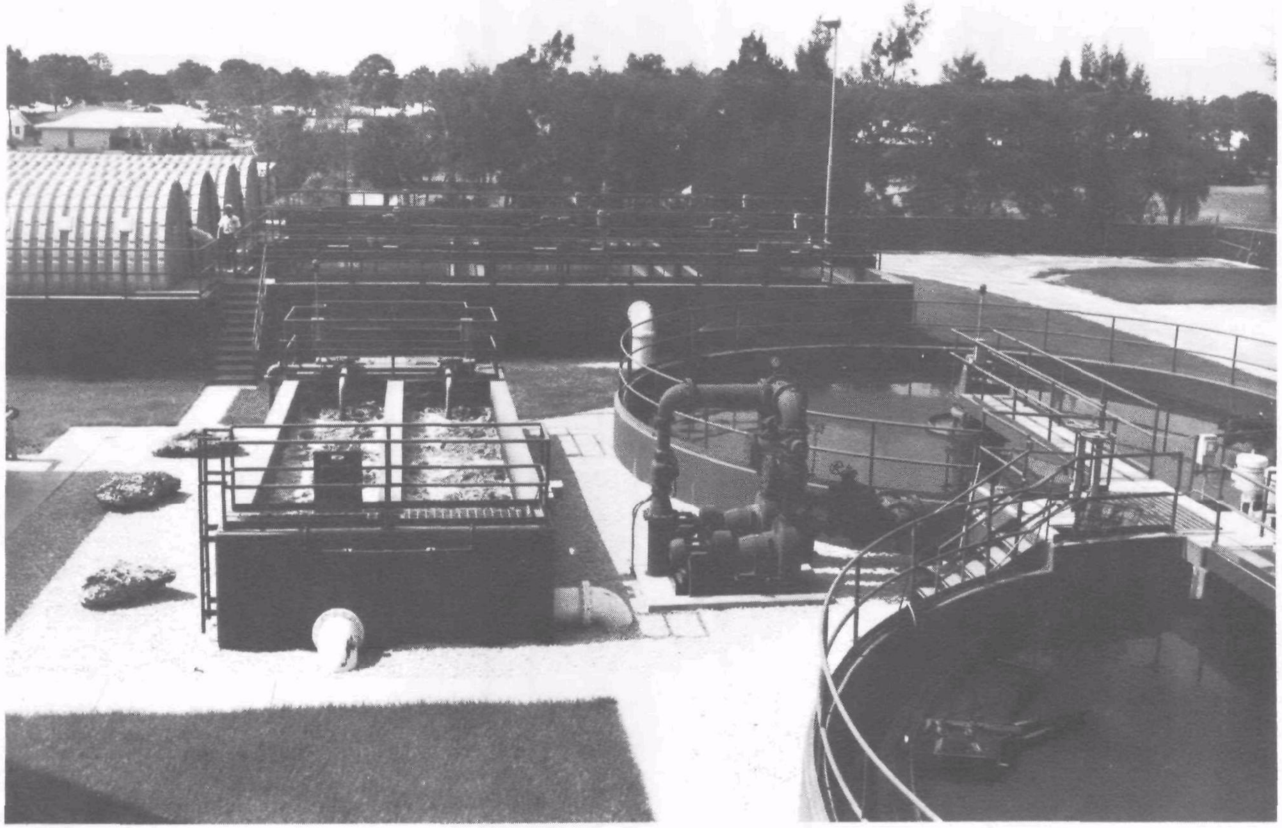

Figure 17. Denitrification Facilities

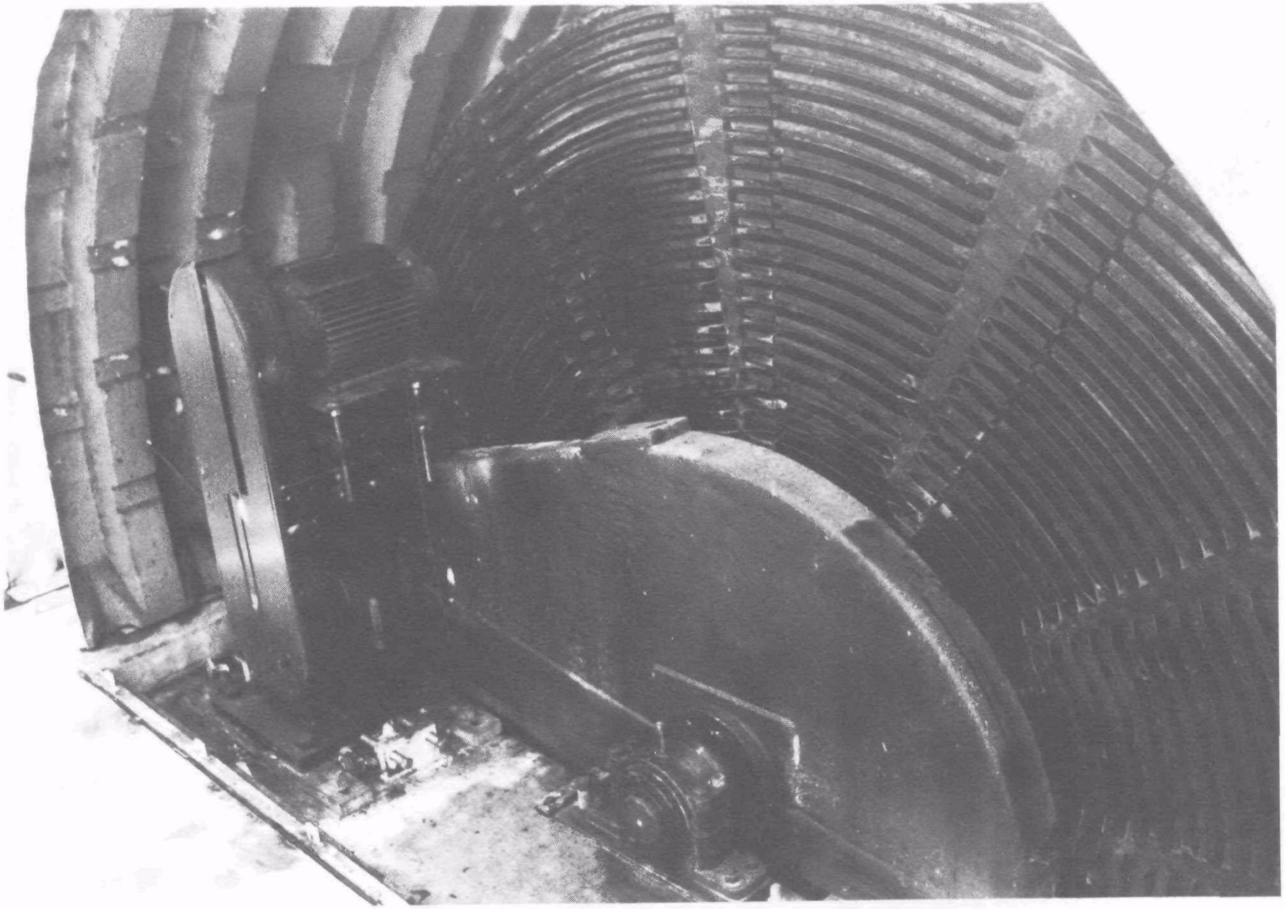

Figure 18. Rotating Disc Surface

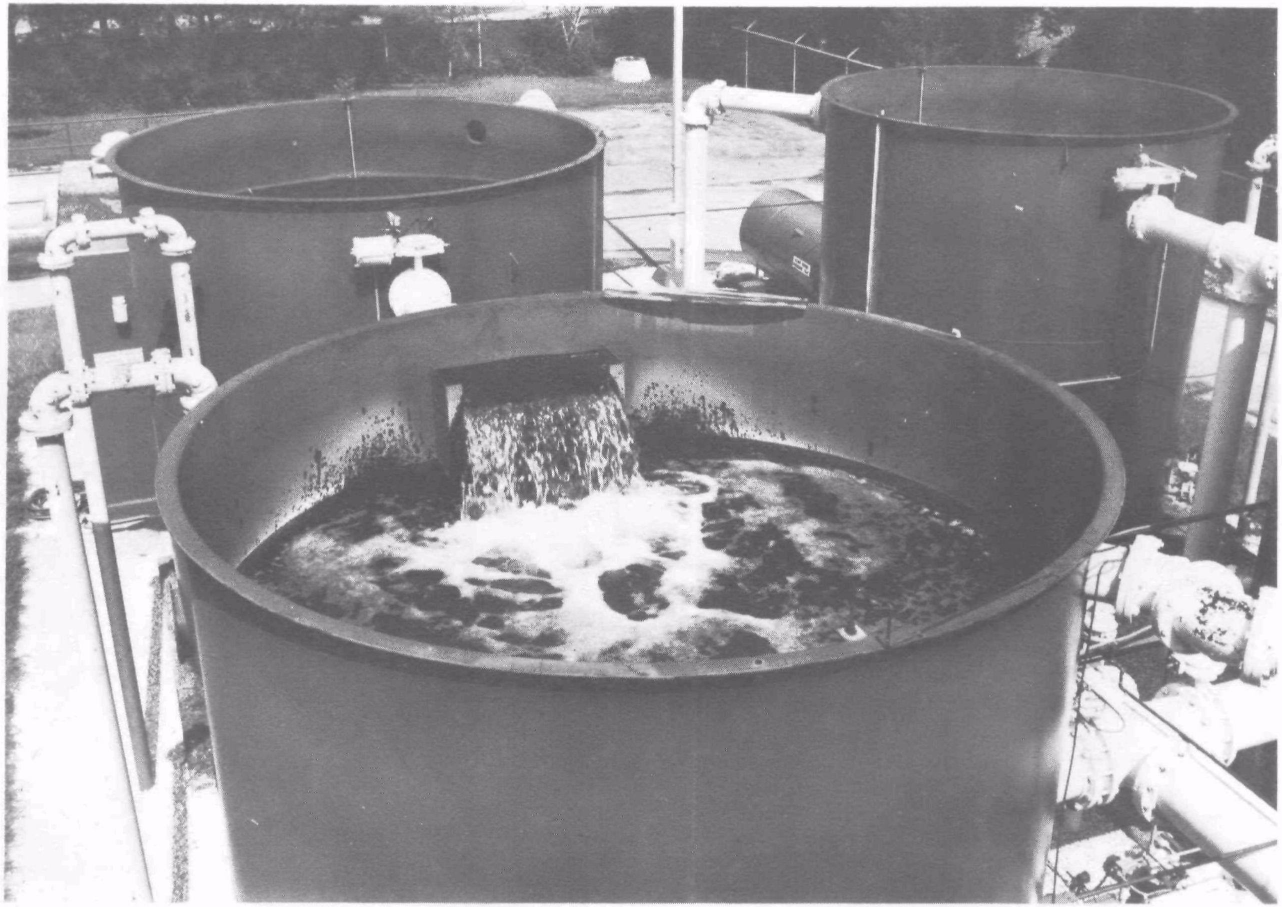

Figure 19. Gravity Dual Media Filters

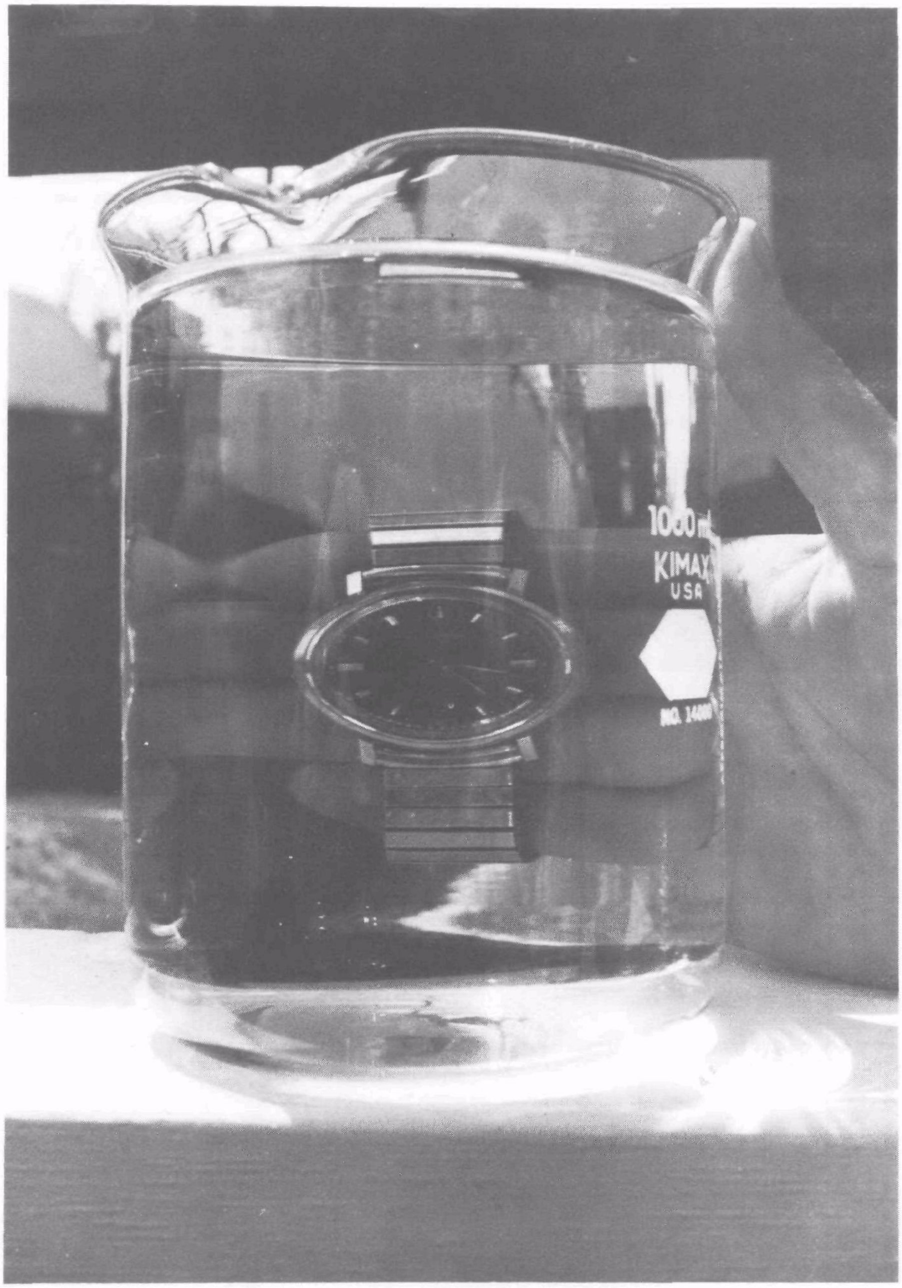

Figure 20. Filtered Final Effluent

TABLE 6. Sampling Schedule of Gulf Gate Plant

SOLIDS	BOD_5 mg/l	SS mg/l	Sett. Solids	DO mg/l	pH	Alk. mg/l	Cl_2 mg/l	TKN mg/l	NO_3-N mg/l	Total P mg/l	Fecal Coliform MPN
Raw Waste	Daily Comp.	Daily Comp.			Daily Spot						
Equal. Tank				Daily Spot		Daily Spot					
M.L. Carbon cycle		Daily Spot	Daily Spot	Daily Spot							
Inter-Sett.				Daily Spot	Daily Spot	Daily Spot					
Eff. Bio Surf						Daily Spot					
M.L.-Denite		2-weekly Spot	Daily Spot								
Final-Sett.				Daily Spot	Daily Spot	Daily Spot					
Filtered Eff.	Daily Comp.	Daily Comp.		Daily Spot	Daily Spot	Daily Spot		Weekly Comp.	Weekly Comp.	Weekly Comp.	
Chlorinated Eff.							Daily Spot				Daily Spot
Aerobic Digester		Weekly Spot									

Figure 21. Control Laboratory

3. Special Operational Techniques: Chemical inventory and feed rates are checked each day and adjusted as needed. The day shift operator reads flow totalizer, temperature and rain gauge, collects samples and runs daily D.O., pH and chlorine residual tests as well as 30 minute settleable solids tests on the two mixed liquors. Daily alkalinity tests on each process indicate the efficiency of nitrification, denitrification and filtration.

4. Carboncycle sludge is wasted to the digesters each day to maintain a constant mixed liquor concentration. The return sludge pumps are shut down for one hour after which 37 m^3 (10,000 gal) clarified underflow is pumped to digesters at 12 ℓ/s (200 gpm) rate which equates to 550 kg (1220 lbs) of solids per day.

5. Denitrification sludge return telescopic valves are checked and adjusted each hour. Sludge from this system is wasted once a week by diverting return sludge to waste for desired time. Normally 30 m^3 (5,000 gal) per week is sufficient to maintain fairly constant mixed liquor concentration. This translates to about 160 kg (354 lbs) of sludge accumulation per week or 22 kg (50 lbs) per day from the loss of carbon cycle solids plus solids made in the nitrification and denitrification of 68 kg/d (150 lbs/d).

Sludge Operations and Disposal

From the previous discussion it is known that sludge wasted to digesters amounts to about 590 kg/d (1300 lbs/d). By careful wasting the concentration of solids in the aerobic digesters is maintained at about 1.5%. Since final disposal of all solids is by hauling and spreading over pasture lands, it is important that sludge be as concentrated as possible and there be no objectionable odors when sludge is spread. At 1.5% it is necessary that two tank trailer loads per day or 14 per week at 20 m^3 (5,000 gal) be disposed of. During the rainy season in Florida this method of disposal can become very difficult to manage. Figure 22 shows the sludge tanker used for hauling.

Special Studies and Problem Solutions

1) The first vexing problem experienced after initial start-up was the attempt to use ferric chloride to precipitate phosphates. The resulting turbidity and iron precipitates leaving the plant could not be corrected through various operating changes or polymer additions. Operating personnel gave up on trying to use ferric chloride and turned to sodium aluminate. In order to control colloid loss in the effluent it was necessary to feed sodium aluminate to the aerator effluent ahead of the settlers.

2) In order to control the amount of solids build-up in the equalization tank, the plant was designed with an exposed grit chamber. The raw wastewater was aerated by the grit washer and the neighborhood was exposed to H_2S odors from the treatment plant, along with many irrigation wells in the neighborhood which also released H_2S when sprinkling. The winter of 1975-76 created further strained relations with neighbors due to noise, lights and

Figure 22. Aerobically Digested Sludge Transport

H_2S odors. The H_2S was alleviated greatly by a change in water supply. In June, 1976, the high sulfate well water was replaced by surface water from the Manatee River. However, complaints continued to be received until May, 1977 when operating personnel experimented with the use of ferrous sulfate to precipitate H_2S. It was found that the use of ferrous sulfate added to the influent flow would effectively eliminate the odor and at the same time react with the phosphate, thus reducing the amount of sodium aluminate needed. Hence the H_2S was removed at no extra cost to the Company and helped our neighborhood relations as well as our relations with the County Environmental Control staff.

3) Nitrogen purge following the denitrification tanks is absolutely necessary if sludge is to be settled and returned. The original combined air piping resulted in decreased air to the purge system when the filters were air scoured. The nitrogen-gas-lifted sludge covered both final clarifier surfaces and taxed the scum removal system. Water sprayed over the surface helped somewhat. But the problem was not solved until the purge tank was supplied with an independent air supply to constantly and violently agitate the denitrification mixed liquor. Various arrangements of air diffusers were also attempted.

Regular wasting of sludge and control of return sludge rate are very important also.

4) A special study on the effect of the equilization tank was made May 1-15, 1978. The equilization tank study revealed that adjustment of the gate regulating the flow to the Parshall flume was necessary to achieve a more uniform flow from the equalization tank. Table 7 shows the utility of the equalization tank. Analytical data adjusted for dilution from filter backwash indicated that about one third of the BOD_5 was removed in the equalization tank with average residence time of 7.5 hours. The ferrous iron was almost completely oxidized as evidenced by the drop in PO_4 and alkalinity. There was essentially no loss of TKN.

5) A special study on the operation of the final filters was concluded May 28, 1978. The data from this study is shown in Table 8. The filters were lightly loaded during the two week period.

Plant Efficiency

Table 9 shows the monthly average data for BOD_5, SS, total nitrogen and total phosphorus during the year 1977 with the plant operating at about 48 percent of hydraulic design capacity.

Only the effluent values for phosphorus and nitrogen are shown because these determinations are not routinely run on influent wastewater. Chemical dosages for phosphorus and nitrogen control are based on grab samples obtained at each respective unit process location. Reference to Table 7 can give an approximation of the concentration of nitrogen and phosphorus that occurs in the Gulf Gate raw wastewater.

TABLE 7. Gulf Gate Plant - Equalization Tank
(24 Hour Composite Samples)

1978 Date	EQUALIZED FLOW mgd*	BOD_5, mg/l		SUSPENDED SOLIDS, mg/l		$ORTHO\text{-}PO_4$ mg/l, (as p)		ALKALINITY mg/l, (as $CaCO_3$)		TKN, mg/l, (as N)	
		Raw	Eq.	Raw	Eq.	Raw	Eq.	Raw	Eq.	Raw	Eq.
5-1	0.93	200	145	234	220	9.4	4.7	210	152	--	--
5-2	.89	230	120	222	242	9.7	5.3	198	162	38.1	34.7
5-3	.95	225	143	258	248	9.3	5.3	190	158	38.0	35.8
5-4	.89	268	132	226	254	8.5	6.0	192	169	39.2	35.3
5-5	.93	288	144	218	248	8.5	6.0	182	154	38.6	34.7
5-6	.91	230	149	370	276	8.5	5.0	187	154	40.3	37.0
5-7	.88	315	184	280	256	11.5	6.0	198	165	36.4	35.8
5-8	.94	306	153	462	260	11.5	8.0	202	164	43.1	39.8
5-9	.87	205	128	202	260	8.2	5.8	220	171	39.8	35.8
5-10	.90	244	133	232	248	8.2	5.5	172	162	39.8	37.0
5-11	.92	268	187	312	252	8.0	6.0	204	173	40.9	38.1
5-12	.86	227	187	318	254	8.5	5.0	190	162	41.0	38.1
5-13	.87	278	138	310	242	8.5	5.0	184	151	44.8	37.0
5-14	.89	326	225	302	250	8.0	5.5	190	161	41.2	37.8
Avg.	.90	258	155	282	251	9.0	5.6	194	161	40.1	36.7

*mgd x 3,785 = m^3/d

TABLE 8. Gulf Gate Plant - Final Filters, Unit Removals (24 Hour Composites)

1978 Date	EQUALIZED FLOW mgd	BOD_5 mg/l		SUSPENDED SOLIDS, mg/l		ALKALINITY mg/l (as $CaCO_3$)		TURBIDITY NTU	
		Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
5-15	0.86	2.6	1.0	1.6	0.4	135	136	3.4	1.3
5-16	.88	2.6	1.4	3.6	0.8	128	127	2.5	1.1
5-17	.88	1.3	1.0	1.6	0.4	127	126	2.7	1.2
5-18	.88	0.7	0.4	1.6	0.4	128	125	1.8	1.0
5-19	.91	1.7	0.9	5.2	0.4	126	124	1.6	0.9
5-20	.89	1.3	0.3	4.8	1.2	128	128	1.5	0.7
5-21	.87	1.8	0.6	4.0	0.8	127	127	2.2	0.8
5-22	.93	5.9	0.8	3.6	0.4	126	124	3.7	0.9
5-23	.96	6.4	0.4	1.6	0.4	128	114	2.9	2.3
5-24	.84	3.8	2.5	3.6	0.8	133	129	2.6	1.3
5-25	.86	1.6	1.0	2.0	0.8	127	132	1.9	1.0
5-26	.88	1.1	0.6	2.0	0.4	128	127	--	--
5-27	.68	1.2	0.8	1.6	0.4	128	127	2.0	0.8
5-28	.89	0.6	0.2	0.8	0.4	134	128	1.3	1.3
Avg.	0.87	2.3	0.8	2.7	0.6	129	127	2.3	1.1

Note: Hydraulic rate 0.9 $l/m^2/S$ (1.3 gpm/ft^2)
Solids loading 0.4 $kg/m^2/d$ (0.08 lb/ft^2)

TABLE 9. Gulf Gate Plant Efficiency, Monthly Average Values

MONTH 1977	FLOW, mgd*	BOD_5, mg/l		PERCENT REMOVAL	SS, mg/l		PERCENT REMOVAL	EFFLUENT TP mg/l	EFFLUENT TN mg/l
		Inf.	Eff.		Inf.	Eff.			
Jan.	0.864	177	1.3	98	278	1.1	99	0.7	1.5
Feb.	0.860	198	2.7	98	279	1.5	99	0.8	2.3
March	0.853	195	2.2	98	274	1.6	99	0.5	2.0
April	0.792	190	1.0	99	288	1.7	99	0.8	1.0
May	0.760	198	0.7	99	309	1.0	99	0.6	1.4
June	0.783	183	0.5	99	282	1.0	99	0.5	1.7
July	0.786	217	0.6	99	338	0.5	99	0.4	1.8
Aug.	0.900	207	0.7	99	245	0.6	99	0.8	2.1
Sept.	1.134	233	1.1	99	242	0.8	99	0.6	0.9
Oct.	0.900	272	1.0	99	293	1.0	99	0.5	1.2
Nov.	0.890	310	1.0	99	346	0.8	99	0.4	1.3
Dec.	1.001	251	1.4	99	251	0.3	99	0.2	1.7
Avg. Year	0.877	219	1.2	99	285	1.0	99	0.6	1.6

*mgd x 3,785 = m^3/d

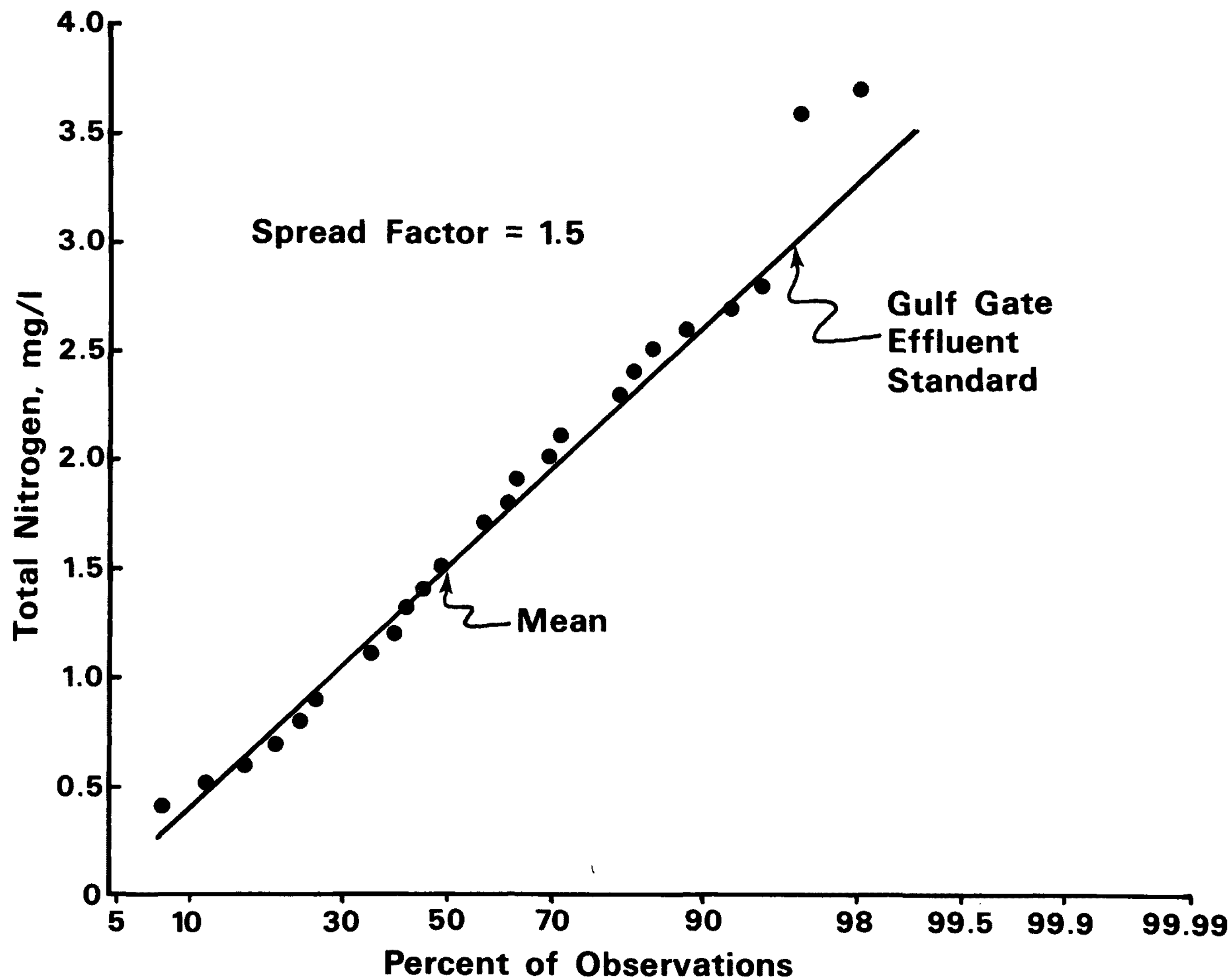

Figure 23. Total Nitrogen Content of Gulf Gate Final Effluent

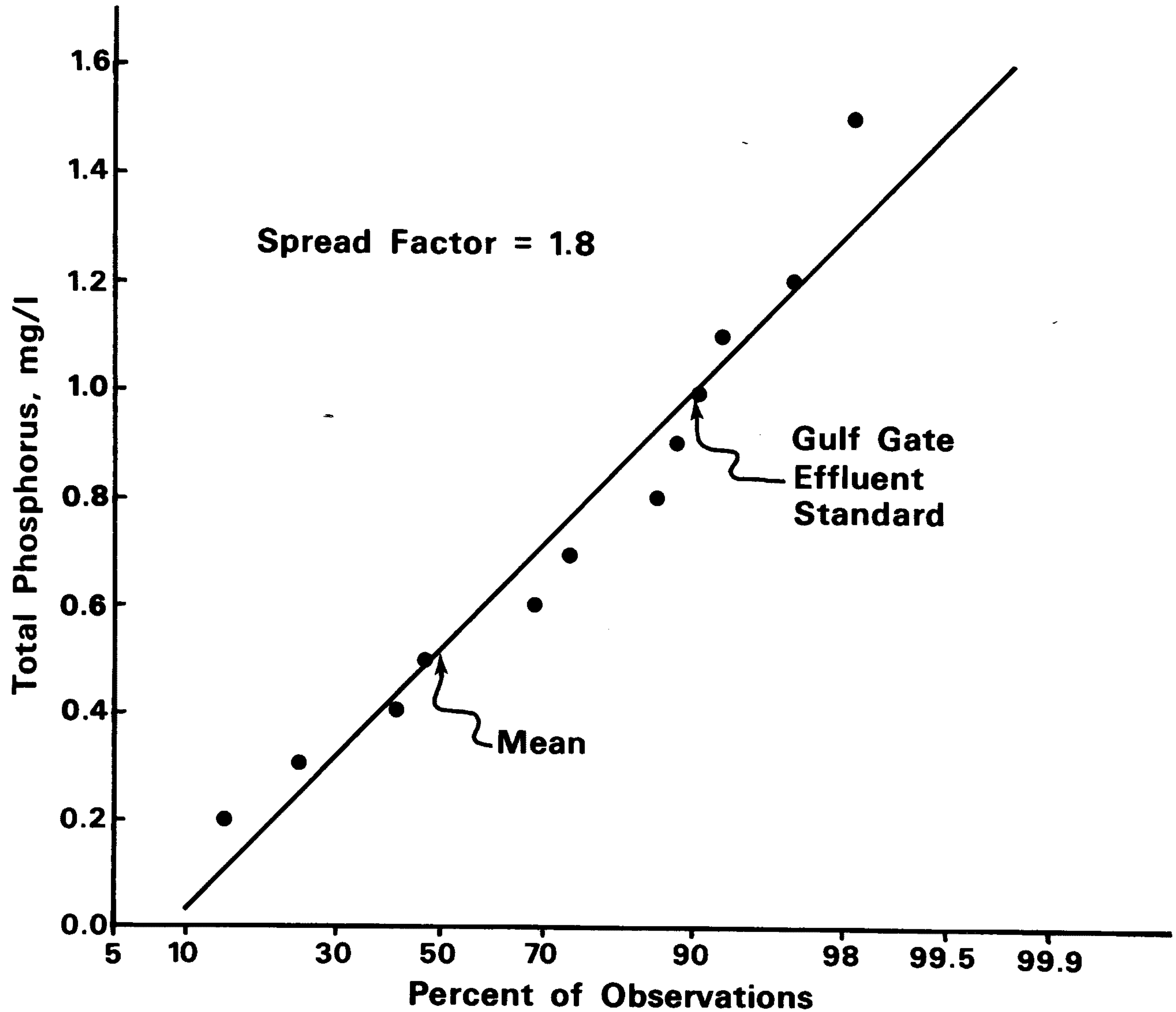

Figure 24. Total Phosphorus Content of Gulf Gate Final Effluent

The effluent residuals for weekly average values of nitrogen and phosphorus during 1977 were plotted as frequency distributions. Figure 23 contains the nitrogen data. Gulf Gate produces an effluent with a mean total nitrogen content of 1.5 mg/l, and achieves the effluent standard of 3 mg/l 96 percent of the time. The spread factor for the data is about the same as the River Oaks plant for nitrogen control.

The residual phosphorus data on Figure 24 indicates a mean total phosphorus effluent concentration of 0.5 mg/l and the effluent standard of 1.0 mg/l is achieved 90 percent of the time. The spread factor of 1.8 is slightly better than the 2.4 factor for River Oaks. The equalized flow at Gulf Gate probably aids in more consistent chemical dosages and consequent lower spread factors for both nitrogen and phosphorus control.

Considering the analytical variability of BOD_5, SS, TP, NO_3-N and TKN, as reported in the 14th edition of Standard Methods for The Examination of Water and Wastewater,* both plant effluents are of excellent high quality.

Figures 10, 11, 23, 24 and Tables 5 and 9 indicate both facilities are conscientiously striving to achieve stringent Federal, State and local effluent limitations.

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Project Officer: Edwin F. Barth, (513) 684-7641

16. ABSTRACT

Municipal wastewater treatment plants employing multi-stage processes can be operated to consistently produce high quality final effluents.

Data for both the 11,400 m^3/d Hillsborough County, Florida and the 6,813 m^3/d Florida Cities Water Company facilities are presented in tabular and geographic form.

These data show that both utilities can achieve the stringent State of Florida effluent limitations. These limitations, for selected sites in the State, require that the effluent shall not contain more than 5 mg/l five day Biochemical Oxygen Demand, 5 mg/l suspended solids, 3 mg/l total nitrogen and 1 mg/l total phosphorus.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Activated Sludge Process* Nitrification Wastewater* Nitrogen cycle	Phosphorus removal* Nitrogen removal* Tampa Bay Attached Growth * Denitrification	13B

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