TECHNICAL ASSISTANCE PROJECT
AT THE
MAIN WASTEWATER TREATMENT PLANT
MT. PLEASANT, SOUTH CAROLINA

EPA 904/9-77-031

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MT. PLEASANT, SOUTH CAROLINA

ENVIRONMENTAL PROTECTION AGENCY
SURVEILLANCE AND ANALYSIS DIVISION
ATHENS, GEORGIA

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INTRODUCTION

A technical assistance study of operation and maintenance problems at the Main Wastewater Treatment Plant, Mt. Pleasant, South Carolina was conducted July 25-29, 1977 by the U.S. Environmental Protection Agency (US-EPA) Region IV, Surveillance and Analysis Division. Operation and maintenance technical assistance studies are designed to assist wastewater treatment plant personnel in maximizing treatment efficiencies as well as assisting with special operational problems.

The selection of this plant was based on a request from the South Carolina Department of Health and Environmental Control (SC-DHEC). The study was coordinated with the US-EPA Enforcement and Water Divisions and SC-DHEC. The specific study objectives were:

(1) To optimize treatment through control testing and recommended operation and maintenance modifications;

(2) To introduce and instruct plant personnel in new operation control techniques;

(3) To determine influent and effluent wastewater characteristics;

(4) To assist laboratory personnel with any possible laboratory procedure problems; and

(5) To compare design and current loading data.

A follow-up assessment of plant operation and maintenance practices will be conducted through utilization of data generated by plant personnel. If necessary, subsequent visits to the facility will be made. The follow-up assessment will determine if recommendations were successful in improving plant operations and if further assistance is required.

The cooperation of personnel from the SC-DHEC is gratefully acknowledged. The technical assistance team is also especially appreciative for the cooperation and assistance received from personnel of the City of Mt. Pleasant, South Carolina.

SUMMARY

The 1.4 mgd Main WTP was originally placed in operation in 1970 as a contact stabilization activated sludge process. The average flow during the study was 0.83 mgd, essentially all of which was domestic wastewater. The reductions in BOD5 and TSS during the study period were 87 and 86 percent, respectively.

Major study observations are listed below:

(1) The contact and reaeration basins contained an excessive quantity of what appeared to be old sludge.

(2) Aerators in the contact and reaeration basins were operated on timers. Dissolved oxygen concentrations were generally low and dropped rapidly to critically low concentrations when the aerators were off.

(3) A thick mat of foam completely covered all aeration basins and clarifiers.

(4) Filamentous organisms were observed in the foam and activated sludge which partially accounted for the observed sludge settleability.

(5) Equal flow to each of the four final clarifiers was difficult to maintain. Solids were often observed flowing out of individual basins as flows to the clarifiers became unbalanced, especially during evening high flows when the WTP was not staffed.

(6) No sludge blanket was present in the final clarifiers.

(7) Excessive oil and grease was present in the influent wastewater.

(8) The average total chlorine residual was 3.3 mg/l based on the amperometric back titration method. Analysis of the same samples by WTP personnel using the orthotolidine color comparater yielded 1.5 mg/l chlorine.

RECOMMENDATIONS

Based on observations and data collected during the study, it is recommended that the following measures be taken to improve wastewater treatment and plant operation. By observing treatment responses to gradual process changes, optimum treatment efficiency can be obtained.

1. The rate of sludge wasting should be increased. This will reduce the sludge age and assist in removing the filamentous organisms. The target range for the F/M ratio should be 0.2 to 0.6.

2. The return sludge flow rate should be reduced in order to develop a sludge blanket and greater return sludge solids concentration.

3. The dissolved oxygen concentrations in the aeration and reaeration basins should be maintained at about 1-2 mg/l. This will require operating the aerators continuously.

4. The WTP should be staffed at least 16 hours per day. An operator could maintain approximate equal flow to the clarifiers during evening high flows.

5. Foam, scum and other floatable material should not be returned to the head of the WTP. Reduction of the sludge age should relieve the foaming problem especially if the existing material could be wasted or removed from the system.

6. Restaurants and other possible sources of oil and grease should be inspected to assure adequate grease removal at these sources.

7. Use of the amperometric back titration method for chlorine residual would effect a monetary savings through a reduction in chlorine usage.

TREATMENT FACILITY

TREATMENT PROCESSES

A diagram of the 1.4 mgd Main WTP is presented in Figure 1 and design data are listed in Table I. The influent wastewater was primarily domestic in origin. The WTP was completed in 1970 as a 1.1 mgd contact stabilization activated sludge process. In 1976 the WTP was upgraded to a 1.5 mgd facility by the addition of a grit chamber, an additional return sludge pump and larger return sludge lines.

Return sludge was stabilized in the reaeration basin and then returned to the contact basin to react with the raw wastewater. Biological solids were removed by four secondary clarifiers operated in parallel. Clarified wastewater was chlorinated and discharged into the Intracoastal Waterway. Scum, foam and other floatable materials were returned to the main influent pump station. Waste solids were conditioned in an aerobic digester and then dewatered on sand drying beds.

The digester aerator remained on at all times. Aerators in the contact and reaeration basins were on timers. The contact basin aerator was operated on a 15-minute cycle. The two reaeration basin aerators were operated on a 30-minute cycle, with at least one aerator on at all times.

PERSONNEL

The WTP was manned eight hours per day by eight persons who also had additional responsibility for 30 lift stations, 2 package treatment plants, 1 lagoon and a 0.3 mgd activated sludge WTP. The staff held the following wastewater classifications: 1-A, 1-B, 2-C, 1-D, 2-trainees and one laborer.

FIGURE 1
Main Wastewater Treatment Plant
Mt. Pleasant, South Carolina

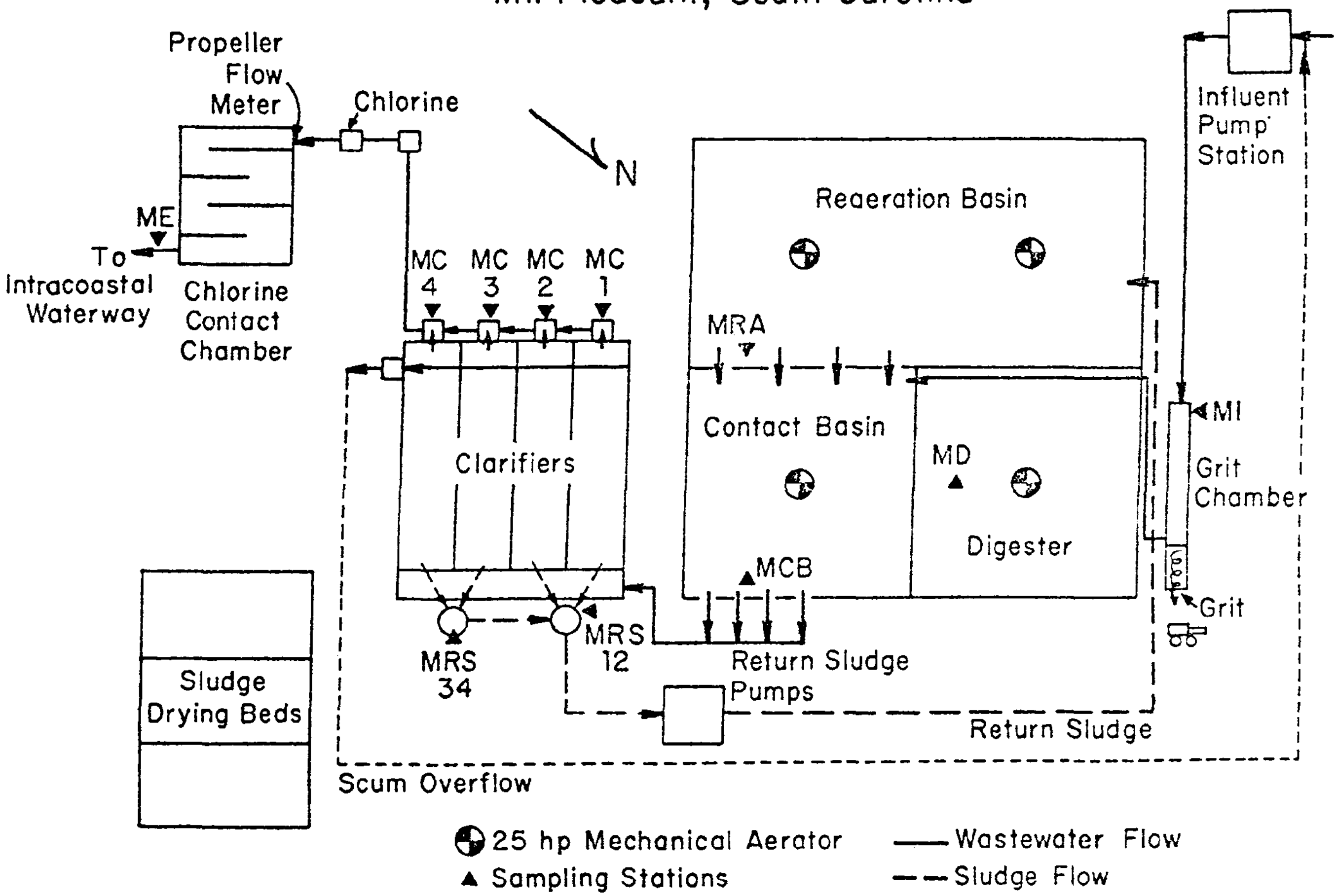


TABLE I
DESIGN DATA

FLOW MEASUREMENT	
Design Flow	1.4 mgd
Effluent	Propeller Meter
Return Sludge	None
Waste Sludge	None
CONTACT BASIN	
Dimensions	48.7 x 48.7 x 9 ft.
Volume	21,390 cu. ft. (0.16 m.gal)
Aeration	1 - 25 hp (mechanical)
REAERATION BASIN	
Dimensions	48.7 x 100 x 9 ft.
Volume	43,875 cu. ft. (0.33 m.gal)
Aeration	2 - 25 hp (mechanical)
FINAL CLARIFIERS	
Number	4
Dimensions	48.7 x 12 x 8.5 ft.
Total Surface Area	2,338 sq. ft.
Total Volume	19,870 cu. ft. (0.15 m.gal.)
Weir Length	180 lin. ft.
CHLORINE CONTACT CHAMBER	
Dimensions	25 x 25 x 5 ft.
Volume	3,125 cu. ft. (0.02 m. gal.)
DIGESTER	
Dimensions	48.7 x 48.7 x 9 ft.
Volume	21,390 cu. ft. (0.16 m. gal.)
Aeration	1 - 25 hp (mechanical)
PUMPS	
Influent	2 - 1,710 gpm variable speed
Return Sludge	3 - 500 gpm variable speed
DRYING BEDS	
Number	3
Dimensions	35 x 80 ft.
Total Area	8,400 sq. ft.

STUDY RESULTS AND OBSERVATIONS

A complete listing of all analytical data and general study methods are presented in the Appendices. Significant results and observations made during the study are discussed in the following sections.

FLOW

Plant flow was measured by a propeller meter located at the entrance to the chlorine contact chamber and transmitted to a recorder and totalizer. The average flow during the study and for the month of July 1977 was 0.83 and 0.71 mgd, respectively. Plant personnel stated that excessive inflow and infiltration were a problem during wet weather and high tides.

A rough check of the flow meter, using the rectangular weir located at the effluent from the grit chamber, indicated the meter and recorder to be operating properly.

There was no means available to measure return sludge and waste sludge flows. Flow devices for these waste streams were initially constructed into the WTP, but cronic malfunction made them useless and led to their removal.

WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES

The pH throughout the plant varied from 7.0 to 7.4 except for a single effluent sample on July 28, which had a pH of 6.4.

A chemical description of the influent and effluent wastewaters with calculated percent reductions is presented in Table II.

Analyses were conducted on 24-hour, flow proportional, composite samples, collected on three consecutive days during the study period; and percent reductions were calculated from the averaged results. Chlorine residual analyses were conducted on grab samples and the results were averaged. Oil and grease was analyzed from a single grab sample.

The influent BOD_5 (139 mg/l), TS (3,408 mg/l) and TSS (429 mg/l) concentrations indicated a low organic strength waste with a high solids content. The influent chloride concentration (1,324 mg/l) represented 39 percent of the total solids and 44 percent of the total soluble solids concentrations. This chloride concentration was extremely high for domestic waste and indicated an infiltration problem. The WTP reduced the influent BOD_5 and TSS by 87 and 86 percent. NPDES permit limits were exceeded for TSS primarily due to excessive solids lost during evening high flows. The influent oil and grease concentration (43 mg/l) was exceptionally high for domestic wastewater (14).

TABLE II
WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES
MT. PLEASANT MAIN WTP

PARAMETER	INFLUENT (mg/1)	EFFLUENT (mg/1)	REDUCTION (%)
BOD_5	139	18	87
COD	529	145	73
TOC	94	19	80
TS	3,408	2,764	19
TVS	637	340	47
TSS	429	62	86
VSS	297	33	89
TKN-N	21.8	10.6	51
NH_3-N	16.2	9.1	44
NO_3-NO_2-N	<0.01	0.77	--
TOTAL PHOSPHORUS	12.2	6.4	48
LEAD	0.076	<0.050	>34
CHROMIUM	<0.080	<0.080	--
COPPER	0.390	0.057	85
CADMIUM	<0.010	<0.010	--
ZINC	0.249	0.069	72
Cl_2 RESIDUAL	- - -	3.30	--
CHLORIDE	1,324	1,158	13
OIL AND GREASE	43	- - -	--

CONTACT AND REAERATION BASINS

Grab samples were collected daily from the contact and reaeration basins and analyzed for TSS, VSS and percent solids as determined by the centrifuge. Settleability of the activated sludge in the contact basin was determined by the settlometer. Presented in Table III are various activated sludge operational parameters based on data collected during the study and the corresponding recommended values for the contact stabilization activated sludge process.

TABLE III
ACTIVATED SLUDGE OPERATIONAL PARAMETERS

	MEASURED	RECOMMENDED (2)(5)(9)
Contact Detention Time (min)	*	30 - 60
Reaeration Detention Time (hrs)	*	2 - 6
Contact TSS Concentration (mg/1)	2,387	1,000 - 3,000
Reaeration TSS Concentration (mg/1)	7,422	4,000 - 10,000
Lbs. BOD_5/day/1b VSS (F/M)	0.06	0.2 - 0.6
Lbs. COD/day/1b. VSS	0.22	0.5 - 1.0
Lbs. BOD_5/day/1000 cu. ft. aeration basin	15	40 - 75
Return Sludge Rate (% of average plant flow)	*	25 - 100

* Could not be measured.

The F/M ratio of 0.06 indicates excessive solids in the aeration and reaeration basins for the waste load received. The solids concentrations should be reduced in order to maintain an approximate F/M ratio of 0.3.

Air was supplied to the contact basin by a single 25 hp mechanical aerator and to the reaeration basin by two 25 hp mechanical aerators. Dissolved oxygen (DO) concentrations measured in these basins are presented in Appendix B. Generally, DO concentrations were less than the optimum range of 1-2 mg/l. Dissolved oxygen concentrations dropped rapidly to critically low concentrations when the aerators were off. According to plant personnel, leaving the aerators on at all times resulted in tremendous accumulations of foam.

Activated sludge settleability was determined by the settlometer test. The results are presented in Figure 2. The top three curves represent settling characteristics of well mixed samples from the contact basin. These samples exhibited slower than optimum settling but the supernatant was extremely clear. The bottom curve (July 27) exhibited settling characteristics different from other tests, the cause of which was uncertain. On July 28, a settlometer test was run on a sample collected 5 minutes after the aerator shut off. Settling similar to the July 27 curve was observed. These two samples settled much faster and left an extremely turbid supernatant. Further testing will be necessary to firmly establish a trend. However, these data indicate that a portion of the suspended solids settle out when the aerator shuts off. The remaining solids which flow out of the contact basin exhibit a drastically different settling characteristic.

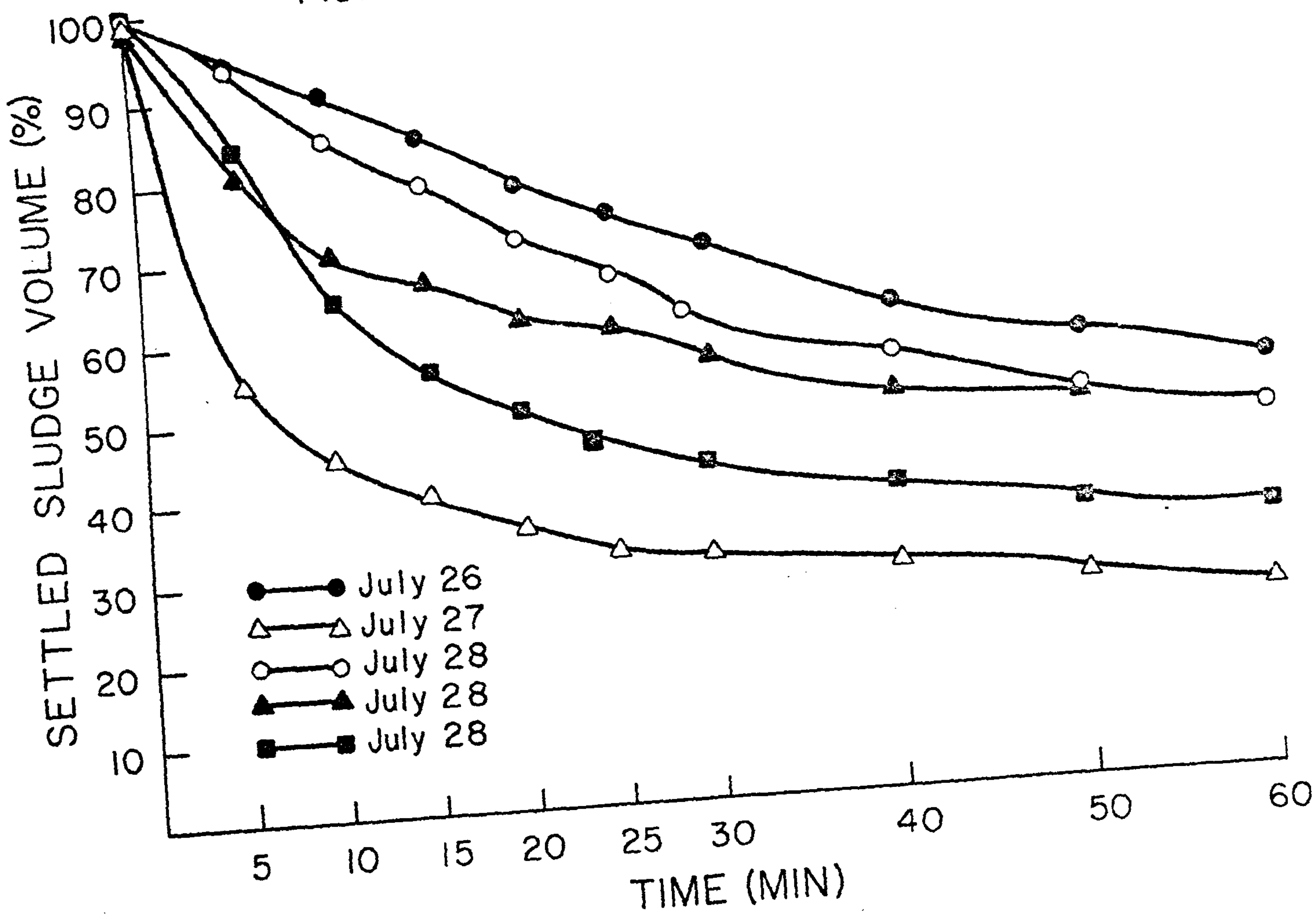
Microscopic examination of return sludge and foam showed an extensive population of filamentous organisms, which typically exhibit the observed settling characteristics. Observations of the activated sludge and large quantities of foam on the aeration basins and clarifiers indicate an old sludge and/or excessive grease which coupled with low DO concentrations would favor filamentous growths. Observation of the protozoan population indicated that the elimination of the filaments would result in a good low BOD, low suspended solids effluent. The mixed liquor contained a diverse population of protozoans which included ciliates of all types (free swimming, crawling, stalked) rotifers and a small population of flagellates. A mixed community of these organisms indicate a treatment system attempting to recover from a stress condition. Increasing sludge wasting and DO in the aeration basins should reduce the sludge age and provide an environment for growth of more favorable micro-organisms.

Activated sludge quality was further determined by measuring the oxygen uptake rate of the sludge by the procedure presented in Appendix E. The sludge activity may be measured by mixing return activated sludge with influent (fed) and non chlorinated effluent (unfed) wastewater and determining the uptake rate. The load ratio (LR) may be calculated by equation 1.

$$LR = \frac{\Delta DO(mg/l/min) \text{ fed sludge}}{\Delta DO(mg/l/min) \text{ unfed sludge}} \qquad (1)$$

FIGURE 2

Activated Sludge Settleability



Assuming a 50 percent return sludge flow, the LR was determined to be 1.7. A small LR (<2) may indicate dilute feed, sick sludge, poorly acceptable feed, or other unfavorable conditions (12). These results corroborate earlier observations of old excessive sludge and low D.O.

CLARIFIERS

The major problems with the clarifiers were solids carryover and excessive foam and scum. The entire clarifier surface was covered with foam. Foam and scum were collected in troughs and returned to the head of the plant. Measured and recommended operating parameters for secondary clarifiers following the contact stabilization activated sludge process are presented in Table IV.

TABLE IV
SECONDARY CLARIFIER OPERATIONAL PARAMETERS

	MEASURED	RECOMMENDED (3)(4)(7)
Hydraulic Loading (gpd/sq. ft.)	335	400 - 800
Solids Loading (lbs/day/sq.ft.)	11	20 - 30
Hydraulic Detention (hrs)	4.3*	2.5
#1	1.4+	
#2	1.4+	
#3	1.4+	
#4	1.7+	
Weir Overflow Rate (gpd/lin.ft.)	4,610	<15,000

* - Calculated as volume/flow
\+ - Measured by dye

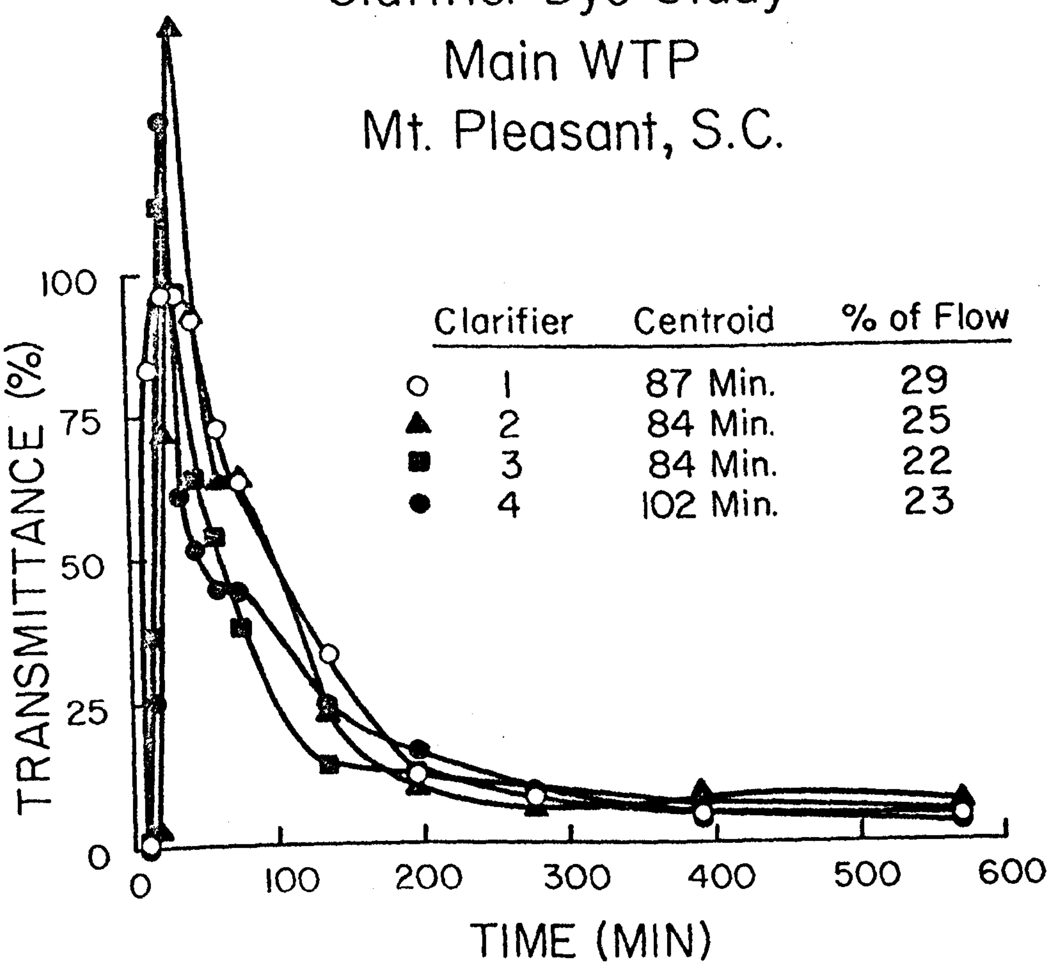
Several clarifier hydraulic properties were investigated using a fluorescent dye. The hydraulic detention times measured by the dye were significantly less than the calculated values. Dye peaks were observed about 30 minutes after dye addition which indicate short-circuiting. Further results of the dye study are presented in Figure 3. These data show that clarifier #1 received the major portion of flow. The operator attempted to equalize flows to the four clarifiers by changing influent gate openings during the day as flows varied. Solids were often observed flowing over the weirs of individual basins as flows to the basins became unbalanced. Also solids were lost in the effluent during evening high flow periods when the WTP was not manned.

There was no means to measure the return sludge flow (RSF). No sludge blanket was observed during the study period indicating an excessive RSF.

The effluent varied from extremely good to poor, depending whether or not solids were washing out. The average effluent turbidity was 3 NTU, except for a single sample, indicating excellent treatment. At times, based on observations, the turbidity reached 120 or greater showing the difficulty of holding solids in the clarifiers.

FIGURE 3

Clarifier Dye Study
Main WTP
Mt. Pleasant, S.C.



Significant quantities of grit collected daily in the influent channel to the final clarifiers. Daily deposition altered flows to the individual clarifiers. This condition further complicated the problem of balancing clarifier flows.

CHLORINATION

Effluent from the final clarifiers was disinfected in the chlorine contact chamber (CCC) prior to discharge into the Intracoastal Waterway. The hydraulic detention time was about 35 minutes at a flow of 0.83 mgd. Chlorine was added at the average rate of 35 pounds/day. The average total chlorine residual was 3.3 mg/l and ranged from 2.6 to 4.2 mg/l, based on the amperometric back titration method. During the same period, WTP personnel measured chlorine residuals of about 1.5 mg/l based on the orthotolidine color comparater. Use of the amperometric back titration method could reduce chlorine usage resulting in a substantial monetary savings.

AEROBIC DIGESTER

Waste activated sludge was conditioned in the aerobic digester. Dissolved oxygen in the basin was greater than 5 mg/l (Appendix B). The TSS and VSS concentrations were 9,688 and 6,000 mg/l, respectively. The volatile content was 62 percent.

LABORATORY

The laboratory was located in the main control building at the Mt. Pleasant WTP. Laboratory personnel collect samples and conduct routine analyses for the Main WTP and three other WTPs. These routine analyses include BOD_5, DO, pH, temperature, settleable solids, TSS, TS, fecal coliform, and residual chlorine. In addition, laboratory personnel conduct control tests on the Mt. Pleasant WTP.

While at the Mt. Pleasant WTP various analytical procedures were discussed, however, the following observations were specifically noted:

1. BOD_5 test: (1) effluent samples collected after chlorination were not seeded or dechlorinated. The lack of seeding and dechlorinating on chlorinated samples may lead to erroneously low BOD_5 results; (2) calculations were made on samples with DO depletions outside the recommended range of 40 to 70 percent (8).

2. The orthotolidine method was used to determine residual chlorine in the plant effluent. The determination of residual chlorine in samples containing organic matter presents special problems, therefore <u>Standard Methods</u> (8) recommends a back titration method for determining <u>residual chlorine</u> in wastewater.

3. TSS samples were dried in an oven set on a temperature of 112° C. <u>Standard Methods</u> recommends drying TSS samples at 103°-105° C for at least <u>1 hour or until</u> the samples reach constant weight.

A quality control (QC) program is desirable in all laboratories. A good QC program would include setting up duplicates on approximately 20 percent of the samples, and analyzing standards, if available, approximately 10 percent of the time. This would help the analyst in determining the precision and accuracy of his data.

The Mt. Pleasant in-plant control testing program included aeration basin TSS, TS, SVI, SDI, and DO (surface); and aerobic digester TSS and TS. It was suggested that the following tests be included in their program: (1) settlometer in place of the graduated cylinder since the settlometer better represents clarifier conditions; (2) clarifier sludge blanket depth; (3) aeration basin DO at various depths; (4) aeration basin and return sludge VSS; and (5) centrifuge. The centrifuge test gives a quick indication of the solids content in the aeration basin. It was further suggested that trend charts be established and maintained. Useful parameters for plotting include MLSS, sludge settleability, significant influent and effluent waste characteristics, flow, depth of clarifier sludge blanket, and F/M. Experience will dictate which of these parameters are necessary for successful plant operations. These suggested parameters should serve only as a guide and are intended to establish trends so that gradual changes in plant conditions can be noticed prior to deterioration in effluent quality.

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APPENDIX A
LABORATORY DATA

APPENDIX A
LABORATORY DATA
MT. PLEASANT MAIN WTP
CHARLESTON, S. C.

INFLUENT AND EFFLUENT

D+M SAD #	STATION	MONTH	DAY	YEAR	TIME	BOD5 mg/l	COD mg/l	TOG mg/l	TOTAL SOLIDS mg/l	TOTAL VOLATILE SOLIDS mg/l	TOTAL SUSPENDED SOLIDS mg/l	VOLATILE SUSPENDED SOLIDS mg/l	TKN - N mg/l	NH3-N mg/l	NO3-NO2-N mg/l	TOTAL PHOSPHORUS mg/l	Pb mg/l	Cr mg/l	Cu mg/l	Cd mg/l	Zn mg/l	Cl2 Residual mg/l	Oil and Grease mg/l	Chloride mg/l
1858	MI	7	26	77	1600	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	43	–
1863	↓	7	26/27	77	24-hr. Comp.	150	562	109	2,558	702	310	265	21.2	20.5	<0.01	12.0						–	–	86.8
1894	↓	7	27/28	77	24-hr. Comp.	117	460	87	3,701	564	463	293	24.3	15.0	–	12.6	0.015	<0.08	0.412	<0.01	0.227	–	–	1469
1926	↓	7	28/29	77	24-hr. Comp.	150	566	87	3,964	644	513	333	20.0	13.0	–	12.0	0.066	<0.08	0.370	<0.01	0.271	–	–	1636
1851	ME	7	26	77	1600	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	4.20	–	–
1864	↓	7	26/27	77	24-hr. Comp.	22	106	15	2,366	434	11	8	11.4	10.0	1.2	6.3	<0.05	<0.08	0.029	<0.01	0.047	–	–	835
1895	↓	7	27/28	77	24-hr. Comp.	22	119	18	2,526	250	59	31	11.1	10.0	0.93	6.3	<0.05	<0.08	0.056	<0.01	0.062	–	–	1035
1905	↓	7	28	77	1000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.60	–	–
1912	↓	7	28	77	1300	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.10	–	–
1927	↓	7	28/29	77	24-hr. Comp.	9.2	211	24	3,401	337	117	60	9.45	7.3	0.19	6.5	<0.05	<0.08	0.087	<0.01	0.099	–	–	1603

APPENDIX A
LABORATORY D
MT. PLEASANT MAIN WTP

CHARLESTON, S. C.

CLARIFIERS

[illegible] #	STATION	MONTH	DAY	YEAR	TIME	TURBIDITY NTU	TURBIDITY @ 1 hr. NTU
1834	MC-1	7	26	77	1000	3	3
1852		7	26	77	1530	3	–
1874		7	27	77	1330	6	5
1918		7	28	77	0950	2	–
1835	MC-2	7	26	77	1000	3	3
1853		7	26	77	1530	2	–
1875		7	27	77	1331	5	4
1897		7	27	77	2100	120	16
1919		7	28	77	0951	2	–
1836	MC-3	7	26	77	1000	2	2
1854		7	26	77	1530	2	–
1876		7	27	77	1332	4	3
1920		7	28	77	0952	2	–
1837	MC-4	7	26	77	1000	2	2
1855		7	26	77	1530	3	–
1877		7	27	77	1333	5	4
1921		7	28	77	0953	2	–

APPENDIX A
LABORATORY DATA
MT. PLEASANT MAIN WTP
CHARLESTON, S. C.

CONTACT AND REAERATION BASINS, RETURN SLUDGE, AND AEROBIC DIGESTER

[illegible]	STATION	MONTH	DAY	YEAR	TIME	TOTAL SUSPENDED SOLIDS mg/1	VOLATILE SUSPENDED SOLIDS mg/1	% SOLIDS (V/V) CENTRIFUGE	SETTLOMETER 5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN	40 MIN	50 MIN	60 MIN	COMMENTS
1832	MCB	7	26	77	1000	2540	2,020	5.0	97	90	85	77	73	68	60	56	52	CLEAR SUPERNATANT - SLUDGE ROSE IN 2½ HRS.
1880	↓	7	27	77	0945	1,520	1,260	4.0	95	84	78	71	66	60	55	49	45	CLEAR SUPERNATANT
		7	27	77	0955	—	—	4.0	83	64	55	50	45	42	38	35	33	—
1913	↓	7	28	77	0945	3,100	2,280	4.5	80	70	67	62	60	55	50	49	45	CLEAR SUPERNATANT THICK LAYERS OF SOLIDS ON SURFACE
1829	MRA	7	26	77	1000	7,533	5,384	11.5	—	—	—	—	—	—	—	—	—	—
1878	↓	7	27	77	1334	7,233	5,367	11.5	—	—	—	—	—	—	—	—	—	—
1917	↓	7	28	77	0949	7,500	5,067	10.0	—	—	—	—	—	—	—	—	—	—
1830	MRS-12	7	26	77	1000	7,100	5,000	11.5	—	—	—	—	—	—	—	—	—	—
1881	↓	7	27	77	1337	8,733	6,567	13.0	—	—	—	—	—	—	—	—	—	—
1915	↓	7	28	77	0947	10,333	7,067	14.0	—	—	—	—	—	—	—	—	—	—
1833	MRS-34	7	26	77	1000	5,500	4,133	9.5	—	—	—	—	—	—	—	—	—	—
1879	↓	7	27	77	1335	7,900	6,000	13.0	—	—	—	—	—	—	—	—	—	—
1914	↓	7	28	77	0946	8,233	5,933	11.0	—	—	—	—	—	—	—	—	—	—
1831	MD	7	26	77	1000.	8,900	5,400	13.5	—	—	—	—	—	—	—	—	—	—
1916	↓	7	28	77	0948	10,475	6,600	13.0	—	—	—	—	—	—	—	—	—	—

APPENDIX B
DISSOLVED OXYGEN DATA

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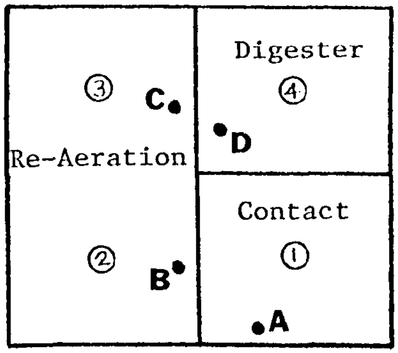
DISSOLVED OXYGEN DATA



STATION	DATE JULY '77	TEMP °C	DO (mg/1) 1 ft.	DO (mg/1) 5 ft.	COMMENTS
A	26	29	1.0	1.1	#1 Aerator on
A	26	29	0.1	0.15	#1 Aerator off
B	26	27	0.15	0.4	#2 Aerator on
B	26			0.3	#2 Aerator on
B	26			0.2	#2 Aerator off 1 min.
B	26			0.15	#2 Aerator off 2 min.
B	26			0.1	#2 Aerator off 4 min.
C	26	27	0.5	0.7	#3 Aerator off
D	26	26	5.5	6.1	#4 Aerator on
MI			0.3		Plant influent
A	27	28	1.5	1.3	#1 Aerator on
B	27	27	0.3	0.6	#2 Aerator off
C	27	27	1.4		#3 Aerator on
C	27	27	0.4		#3 Aerator off 1 min.
C	27	27	0.15		#3 Aerator off 2 min.

APPENDIX C
GENERAL STUDY METHODS

APPENDIX C
GENERAL STUDY METHODS

Methods used to accomplish the stated objectives included extensive sampling, physical measurements and daily observations. ISCO model 1392-X automatic samplers were installed on the influent and final effluent wastewater streams. Samples were collected for three consecutive 24-hour periods. Aliquots of sample were pumped at hourly intervals into individual refrigerated glass bottles which were composited proportional to flow at the end of each sampling period. An influent grab sample for oil and grease was collected.

All flows were measured from plant recorders and totalizers. All dissolved oxygen measurements were determined using the YSI model 57 dissolved oxygen meter. Temperatures and pH were measured at various stations throughout the WTP with a thermometer and portable pH meter. Depth of the secondary clarifier sludge blankets were determined daily using equipment suggested by Alfred W. West, EPA, Cincinnati (13). Sludge activity was determined by the oxygen uptake procedure presented in Appendix E.

A series of standard operational control tests were run daily:

(1) Settleability of mixed liquor suspended solids (MLSS) as determined by the settlometer test;

(2) Percent solids of the mixed liquor and return sludge determined by centrifuge;

(3) Suspended solids and volatile suspended solids analysis on the aeration basin mixed liquor and return sludge and

(4) Turbidity of each final clarifier effluent.

Daily effluent total chlorine residual concentrations were determined using an amperometric titrator (Fischer and Porter Model 1771010).

The procedure for the BOD_5 determination deviated from Standard Methods (8). Samples were set up and returned to Athens, Georgia in an incubator where the analyses were completed.

Visual observations of individual unit processes were recorded.

Mention of trade names or commercial products does not constitute endorsement of recommendation for use by the Environmental Protection Agency.

APPENDIX D
PROJECT PERSONNEL

APPENDIX D
PROJECT PERSONNEL

Charles Sweatt	Sanitary Engineer
Ronald Barrow	Sanitary Engineer
Herb Barden	Microbiologist
Lavon Revells	Chemist
Tom Sack	Technician
Eddie Shollenberger	Technician
Richard Rehm	Student Trainee
Bill Cosgrove	Student Trainee

APPENDIX E
OXYGEN UPTAKE PROCEDURE

APPENDIX E
OXYGEN UPTAKE PROCEDURE 1/

A. Apparatus

1. Electronic DO analyzer and bottle probe
2. Magnetic stirrer
3. Standard BOD bottles (3 or more)
4. Three wide mouth sampling containers (approx. 1 liter each)
5. DO titration assembly for instrument calibration
6. Graduated cylinder (250 ml)
7. Adapter for connecting two BOD bottles

B. Procedure

1. Collect samples of return sludge, aerator influent and final clarifier overflow. Aerate the return sludge sample promptly.
2. Mix the return sludge and measure that quantity for addition to a 300 ml BOD bottle that corresponds to the return sludge proportion of the plant aerator, i.e. for a 40% return sludge percentage in the plant the amount added to the test BOD bottle is:

$$\frac{300 \text{ X } .4}{1.0 + .4} = \frac{120}{1.4} = 86 \text{ ml}$$

3. Carefully add final clarifier overflow to fill the BOD bottle and to dilute the return sludge to the plant aerator mixed liquor solids concentration.

4. Connect the filled bottle and an empty BOD bottle with the BOD bottle adapter. Invert the combination and shake vigorously while transferring the contents. Re-invert and shake again while returning the sample to the original test bottle. The sample should now be well mixed and have a high DO.

5. Insert a magnetic stirrer bar and the previously calibrated DO probe. Place on a magnetic stirrer and adjust agitation to maintain a good solids suspension.

6. Read sample temperature and DO at test time t=). Read and record the DO again at 1 minute intervals until at least three consistent readings for the change in DO per minute are obtained (ΔDO/min). Check for the final sample temperature. This approximates sludge activity in terms of oxygen use after stabilization of the sludge during aeration (unfed sludge activity).

7. Repeat steps 2 through 6 on a replicate sample of return sludge that has been diluted with aerator influent (fed mixture) rather than final effluent. This Δ DO/minute series reflects sludge activity after mixing with the new feed. The test results indicate the degree of sludge stabilization and the effect of the influent waste upon that sludge.

APPENDIX (Continued)

The load factor (LF), a derived figure, is helpful in evaluating sludge activity. It is calculated by dividing the DO/min of fed sludge by the DO/min of the unfed return sludge. The load ratio reflects the conditions at the beginning and end of aeration. Generally, a large factor means abundant, acceptable feed under favorable conditions. A small LF means dilute feed, incipient toxicity, or unfavorable conditions. A negative LR indicates that something in the wastewater shocked or poisoned the "bugs".

1/ Taken from "Dissolved Oxygen Testing Procedure,: F.J. Ludzack and script for slide tape XT-43 (Dissolved Oxygen Analysis - Activated Sludge Control Testing) prepared by F.J. Ludzack, NERC, Cincinnati.