EPA 904/9-76-024

TECHNICAL ASSISTANCE PROJECT AT THE COLUMBIA, KENTUCKY WASTEWATER TREATMENT PLANT

APRIL 1976

Environmental Protection Agency
Region IV
Surveillance and Analysis Division
Athens, Georgia

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INTRODUCTION

A technical assistance study of operation and maintenance problems at the wastewater treatment plant (WTP) serving Columbia, Kentucky, was conducted April 19-20, 1976, by the Region IV, Surveillance and Analysis Division, U.S. Environmental Protection Agency. Operation and maintenance technical assistance studies are designed to assist local WTP operators in maximizing treatment efficiencies as well as assisting with special operational problems. Municipal wastewater treatment plants are selected for technical assistance studies after consultation with state pollution control authorities. Visits are made to each prospective plant prior to the study to determine if study efforts would be productive.

The major problem at the Columbia, Kentucky, facility was periodic solids losses which resulted in a poor quality effluent. This study was conducted at the request of state and plant personnel in an effort to:

- Optimize treatment through control testing and recommended operation and maintenance modifications,
- Introduce and instruct plant personnel in new operational control techniques,
- Determine influent and effluent waste characteristics,
- Assist laboratory personnel with any possible laboratory procedure problems, and
- Compare design and current loadings.

A follow-up assessment of plant operation and maintenance practices will be made at a later date. This will be accomplished by utilizing data generated by plant personnel and, 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. Contact by phone has been maintained with plant personnel since the study in order to relate preliminary study findings and stay abreast of process changes. Some of the recommendations contained in this report have already been implemented.

The cooperation of the Kentucky Department for Natural Resources and Environmental Protection in planning the study is gratefully acknowledged. The technical assistance team is especially appreciative of the cooperation and assistance received from plant personnel.

SUMMARY

The Columbia, Kentucky Wastewater Treatment Plant (WTP) is a 0.395 mgd activated sludge facility. The facility was found not to be hydraulically or organically overloaded. According to plant personnel, there are no industrial wastewaters discharged into the Columbia sewerage system.

The influent magnetic flow meter, which is the only flow measuring device in the plant, was inoperative during the study. Plant flows measured utilizing EPA equipment ranged from .13 mgd to .42 mgd, with an average of .25 mgd.

The plant was designed with two rectangular aeration basins, however, one of the two aerobic sludge digesters was being operated as an additional aeration basin. The suspended solids data collected during the study indicated that an unequal loading was being placed on this third basin. Settlometer analyses revealed poor settleability in all basins with apparent denitrification and subsequent floating sludge after 75 to 90 minutes.

Initial dissolved oxygen (D.O.) profiles indicated low levels of oxygen present in the aeration basins. This profile was taken at peak flow conditions. Later, the aeration rate was increased with subsequent increase in D.O. concentrations as revealed by a later D.O. profile. This indicated the need for additional aeration during peak loading conditions.

The rectangular final clarifier had floating solids and subsequent carryover during high flow periods. Return sludge was removed from the sludge hopper by an airlift system.. The major problem at the facility, in addition to a poor quality sludge, seems to be inadequate sludge removal from the clarifier.

Laboratory operations were very limited at the Columbia WTP. Training is badly needed in laboratory procedures.

RECOMMENDATIONS

1. Plant personnel should receive training in laboratory procedures and plant operations so that an effective process control testing routine can be established and utilized. This training will be necessary in order to implement some of the following recommendations.

2. Flow measuring equipment should be installed to monitor total plant flow, return sludge flow to each influent stream, and waste sludge flow.

3. Dissolved oxygen should be monitored and maintained in the aeration basins, preferably from 1.0 mg/l to 2.0 mg/l. It will be necessary to run both blowers to the diffusers and increase the mechanical aeration speed during periods of higher flow. A portable dissolved oxygen meter and probe should be used to monitor the dissolved oxygen levels in the aeration basins.

4. Sludge wasting should be decreased in order to increase mixed liquor volatile suspended solids to approximately 2,000 mg/l, thereby obtaining a food to microorganism ratio within recommended ranges.

5. A portable sludge pump, rated at approximately half the average daily plant flow, would be useful as a temporary measure to aid in removing sludge from the secondary clarifier.

TREATMENT FACILITY

Treatment Processes

A diagram of the Columbia WTP is presented in Figure I. The activated sludge facility was designed for a flow of 0.395 mgd and has both mechanical and diffused aeration. Presently, the facility treats no industrial wastewater.

Wastewater flow is received from the city collection system in a wet well at the plant. The wastewater is pumped by two 250 gal/min. pumps from the wetwell into the influent channel. Wastewater influent flow is ultimately split into three unmetered portions for each of the three aeration basins. A Foxboro magnetic flow meter, installed on the influent stream, was inoperative during the study.

The aeration system was operated as an extended aeration process during the study. Two of the aeration basins have diffused air supplied by two 25 h.p compressors. The third aeration basin was originally designed as an aerobic digester. This basin is smaller than the other aeration basins and has one 7.5 h.p. mechanical aerator.

Clarification is achieved in a rectangular clarifier with a mechanical flight sludge collection system. Return sludge is pumped by an airlift system from a hopper on the effluent end of the clarifier to a splitter box where the flows are separated into each influent stream. There was no flow measurement on the return sludge. Accumulated scum from a surface skimmer in the clarifier is pumped back to the aeration basins. Clarified effluent flows over four 12 ft. weirs into troughs where it is ultimately discharged unchlorinated into Russell Creek.

Waste sludge is conditioned in one aerobic digester with a 7.5 h.p. mechanical aerator and subsequently discharged onto one of two drying beds.

Personnel

The plant staff includes a superintendent (class II operator certified) and one operator (class III operator certified). The superintendent's duties are divided between the WTP and the city water plant.

FIGURE I
COLUMBIA WASTEWATER TREATMENT PLANT
COLUMBIA, KENTUCKY

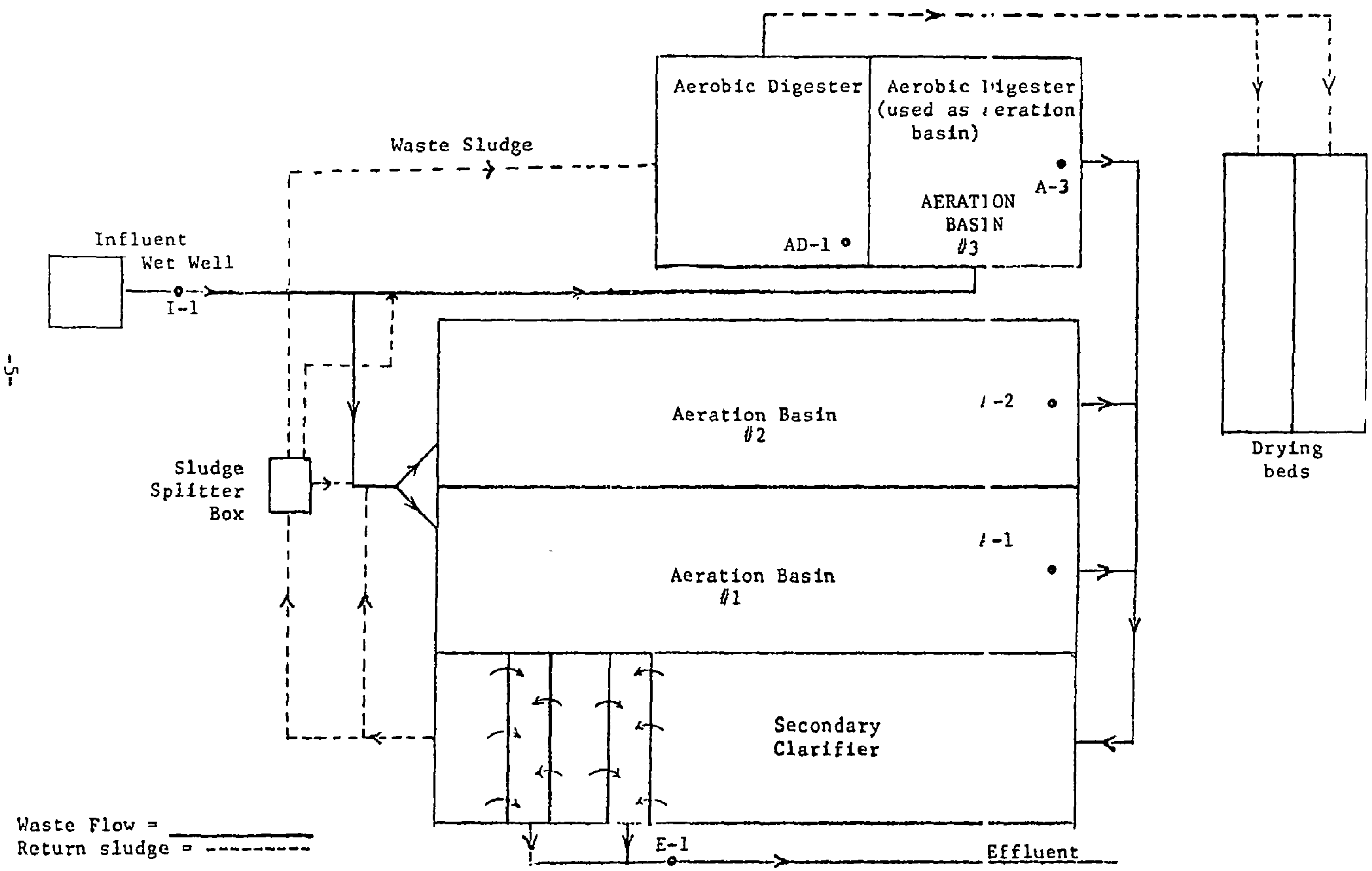
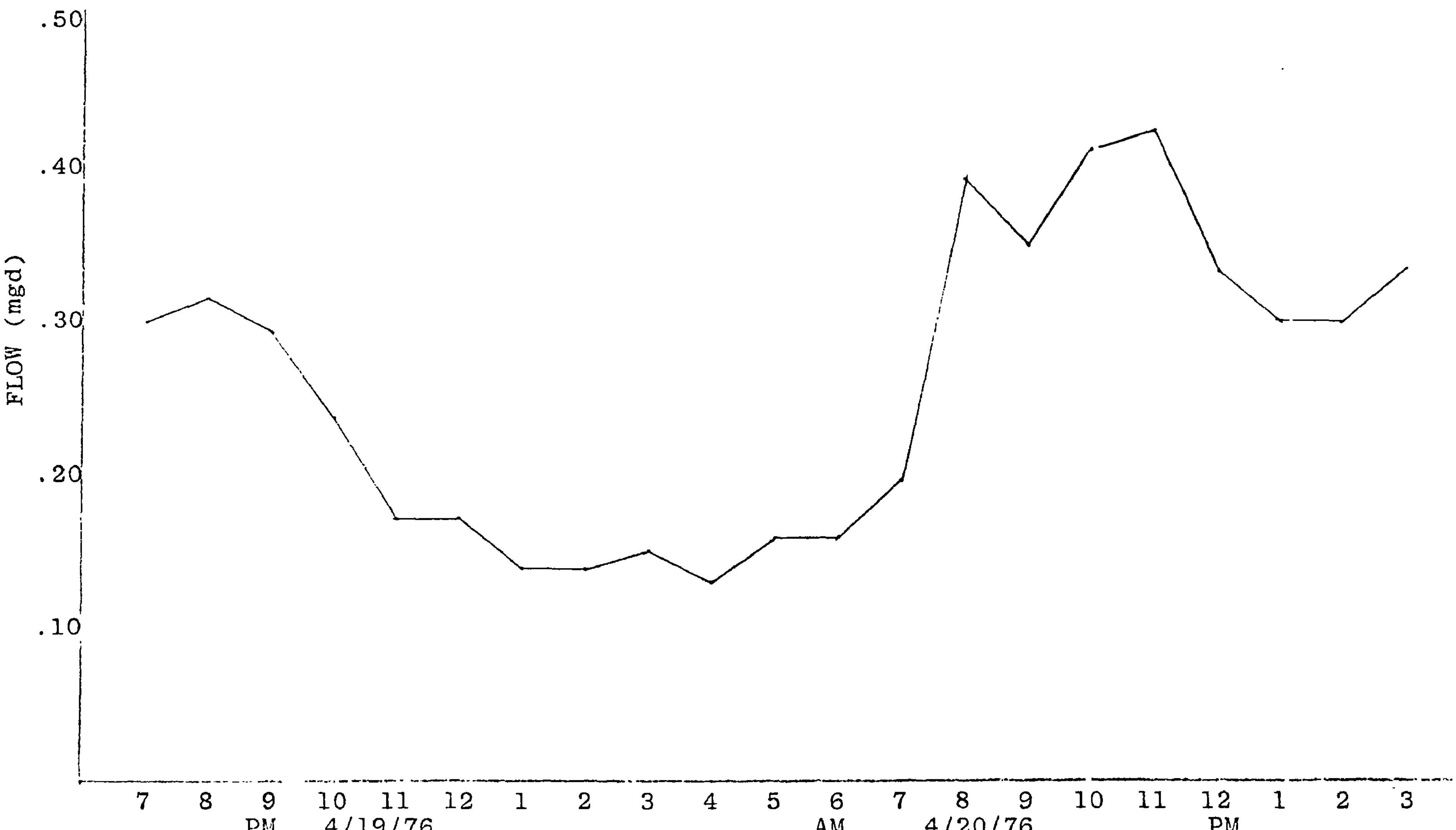


FIGURE II
PLANT FLOW



STUDY RESULTS AND OBSERVATIONS

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

Flow

EPA personnel determined plant flows during the study by placing an 8-inch rectangular weir in the effluent channel and measuring gage height with a Stevns Model-F stage recorder. Figure II gives a graphic representation of the flows measured. The peak flow was .42 mgd measured at 11:00 a.m. on April 20, and the minimum flow at 4:00 a.m. on April 20 was .13 mgd. The average plant flow for the 24-hour period was .254 mgd.

Waste Characteristics and Removal Efficiencies

The following gives a chemical description of the plant wastewater influent and effluent along with treatment efficiencies. The data is based on one 24-hour proportional to flow composite sample.

Parameter	Influent	Effluent	% Reduction
COD (mg/l)	537	197	63
Suspended Solids (mg/l)	133	122	8
TKN-N (mg/l)	30.6	14.5	53
NH_3-N (mg/l)	19.5	3.8	80
NO_3-NO_2 (mg/l)	.03	.26	-
Total P (mg/l)	10.5	11.6	-
Pb (ug/l)	120	<80	-
Cr (ug/l)	<80	<80	-
Cd (ug/l)	<20	<20	-
Cu (ug/l)	64	41	36
Zn (ug/l)	260	190	27

The nitrogen data indicates that the nitrification stage of treatment had been reached, with almost complete denitrification taking place in the final clarifier.

Aeration Basins

A detention time of 21.8 hours was calculated using the average plant flow and an assumed 50% return sludge rate. Recommended extended aeration detention times are 18-36 hours (1). During the study, sludge was wasted for a total of 90 minutes per day, but the flow rates were unknown. A mean cell residence time (MCRT) of 11 days was calculated assuming a waste rate of 50 percent of total plant flow for the 90 minute period. The recommended MCRT for extended aeration is 20-30 days (1). Large amounts of solids lost in the effluent, as well as the high sludge wasting rate, caused the low MCRT. At present, sludge wasting needs to be decreased in order to increase the MCRT. As the sludge settleability improves, wasting rates may have to be increased to maintain a workable MCRT.

Mixed liquor suspended solids (MLSS) concentrations in the basins averaged 2020 mg/l for Basin #1 (A-1), 1810 mg/l for Basin #2 (A-2), and 3090 mg/l for Basin #3 (A-3) (See Figure 1) with corresponding mixed liquor volatile suspended solids (MLVSS) concentrations of 1515 mg/l, 1320 mg/l, and 2240 mg/l. A food to microorganism ratio (F/M) of .25 lb COD per day/lb MLVSS was calculated for the sludge based on the influent COD value. The recommended F/M for extended aeration using COD values is <0.2 lb COD per day/lb MLVSS (2). Based on these results, MLVSS levels need to be increased to approximately 2000 mg/l in Basin #1 and #2 and maintained at the 2000 mg/l level in Basin #3.

Basin #3 (A-3) contained a disproportionate amount of solids at the time of the study. This was probably caused by an excessive amount of return sludge. Flow measuring equipment is badly needed to measure the influent streams and return sludge flows. With this capability, unequal loading to the aeration basins can be prevented.

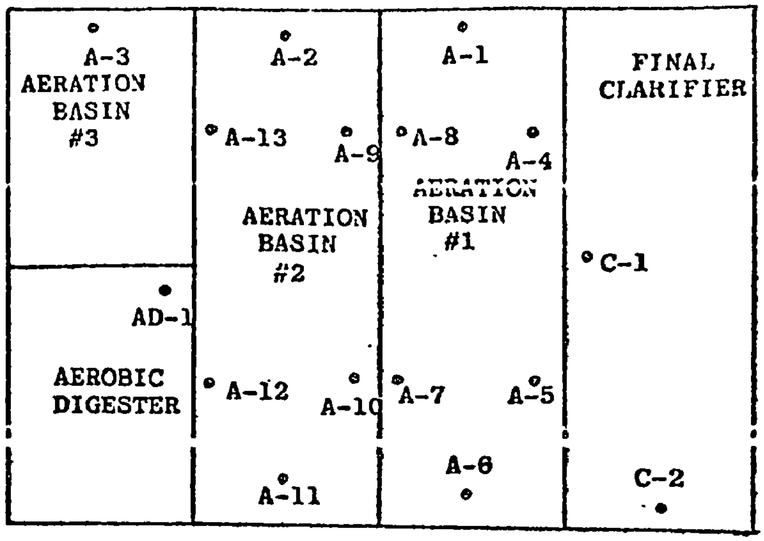
Settleability of the activated sludge was determined by the 60-minute settlometer test. The sludge slowly settled to 60, 64 and 87 percent of the original volume in 60 minutes for stations A-1, A-2, and A-3 respectively. After a period of 75 to 90 minutes, the solids floated to the surface, indicating that denitrification was taking place.

Dissolved Oxygen

Dissolved oxygen (D.O.) profiles in the aeration basins were run once in the morning and once in the afternoon on April 20, 1976. The initial profile was made during peak loading conditions, with one compressor supplying air to Basins #1 and #2. At 11:00 a.m., the additional blower was started and the mechanical aerator speed in Basin #3 was increased. A list of all data is given in Table I. The data clearly indicated that it was necessary to increase the aeration during higher loading conditions. As the flow decreases at night, a single blower may maintain adequate D.O.

A check of the D.O. in the aerobic digester and final clarifier revealed a sufficient supply of oxygen in the digester and only a trace of D.O. in the clarifier.

TABLE I
DISSOLVED OXYGEN PROFILES
COLUMBIA WASTEWATER TREATMENT PLANT
COLUMBIA, KENTUCKY



Station	Depth (ft)	Dissolved Oxygen (mg/l) 4-20-76 1015	Dissolved Oxygen (mg/l) 4-20-76 1400	Station	Depth (ft)	Dissolved Oxygen (mg/l) 4-20-76 1015	Dissolved Oxygen (mg/l) 4-20-76 1400
A-1	1	-	.8	A-2	1	.2	1.2
	5	-	.8		5	.3	1.1
	10	-	.6		10	.4	1.0
	13	-	.6		13	.4	.9
A-4	1	.2	1.2	A-9	1	.2	1.6
	5	.1	1.1		5	.2	1.3
	10	.2	1.1		10	.3	1.2
	13	.2	1.1		13	.3	1.2
A-5	1	.2	.5	A-10	1	.2	1.4
	10	.2	.6		10	.3	1.4
	13	.2	.5		13	.3	1.4
A-6	1	.4	1.0	A-11	1	.5	.8
	5	.2	.6		5	.3	.9
	10	.3	.5		10	.4	.9
	13	.3	.6		13	.4	.7
A-7	1	.2	.8	A-12	1	.2	1.0
	5	.2	.8		5	.4	1.0
	10	.2	.7		10	.7	1.0
	13	.2	.8		13	.6	1.6
A-8	1	.3	1.1	A-13	1	.4	1.1
	5	.2	.8		5	.4	1.1
	10	.2	.8		10	.4	1.1
	13	.2	.8		13	.5	1.1
AD-1	1	1.5	-	A-3	1	.2	.2
	5	1.4	-		5	.2	.2
	10	1.7	-		10	.3	.3
	13	1.8	-		13	.3	.4
				C-1	1	-	.3
					5	-	.2
					8	-	.2
				C-2	1	-	.4
					5	-	.3
					8	-	.3

Secondary Clarifier

Surface loading and the weir overflow rates are within recommended design criteria, as shown in Table II.

TABLE II

ACTUAL AND DESIGN PARAMETERS FOR SECONDARY CLARIFIERS

	Actual	Recommended (3) (4) (5)
Hydraulic Loading (gpd/sq. ft.)		
Average	480	200-400 ; 600
Peak	583	800
Weir Overflow rate (gpd/lin. ft.)	6,125	<15,000
Detention Time (hrs.)	2.6 *	3 ; 2.0-2.5

* The detention time was calculated assuming a return sludge flow of 50 percent of the average plant flow.

With the exception of the early morning hours on April 20, 1976, floating sludge with subsequent solids carryover was observed. Poor sludge settleability is part of the problem. Denitrification, as exhibited in the settleometer test, further compounds the problem. During the study, the return sludge system was being operated at the maximum return rate, however, this system was unable to get the sludge out of the clarifier before the dissolved oxygen (D.O.) was depleted, resulting in denitrification and a floating sludge blanket. This is more prevalent as the organic loading increases with the increased flow. The operation of both diffused air blowers during high loading periods should help increase the D.O. and delay denitrification in the clarifier. With increased D.O., sludge quality should improve and ultimately, settleability, should increase. As this occurs, the removal system will become more efficient, i.e., will return a thicker sludge.

As a temporary measure a portable sludge pump should be installed in the final clarifier to aid in returning sludge. A pump flow rated at about half the average daily flow should be sufficient. If this measure proves successful, installation of a permanent unit should be considered.

Sludge Wasting and Aerobic Digestion

During the study activated sludge was routinely wasted from the system for two 45 minute periods per day. Wasted sludge flows by gravity into the aerobic digestor. Stabilized sludge was ultimately placed on one of two drying beds. Dewatered solids were then disposed of by hauling to a sanitary landfill.

Laboratory

Laboratory operations at the Columbia facility are very limited. The analyses being conducted routinely at the time of the study were BOD_5 (using a manometric procedure), solids by centrifuge (using a hand turned centrifuge), sludge settleability (using a liter graduated cylinder) and D.O. in the aeration basins by the Winkler titration. It should be noted that the manometric BOD_5 test is not an approved procedure per the Federal Register of approved procedures, volume 38, number 199, October 16, 1973.

The sodium thiosulfate titrant used in the Winkler D.O. determination was checked by EPA personnel and found to be inaccurate. New reagent was prepared and standardized. Plant personnel were instructed on proper procedure in preparing fresh titrant.

At present, there is limited understanding by plant personnel of laboratory procedures. Training is badly needed for the WTP staff in this area.

REFERENCES

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2. "Operation of Wastewater Treatment Plants", A Field Study Training Program, US-EPA, Technical Training Grant No. 5TT1-WP-16-03.
3. "Process Design Manual for Suspended Solids Removal", US-EPA Technology Transfer, January 1975.
4. "Standards for Sewage Works", Upper Mississippi River Board of State Sanitary Engineers, Revised Edition, 1971.
5. "Sewage Treatment Plant Design", American Society of Civil Engineers, Manual of Engineering Practice. No. 36, 1959.

APPENDIX A
LABORATORY DATA
COLUMBIA, KENTUCKY

O&M SAD #	STATION	MONTH	DAY	YEAR	TIME	SETTLOMETER — SETTLED SLUDGE VOLUME % 5min	10min	15min	20min	25min	30min	40min	50min	60min	COMMENTS	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Total Solids mg/l	Total Volatile Solids mg/l	% Solids by Centrifuge
0932	A-1	4	20	76	0910	98	93	86	84	-	-	69	64	61	Clear Supernatant,	2080	1590	-	-	4.0
0937	↓	4	20	76	1300	92	85	79	75	72	65	63	62	60	Denitrification	1960	1440	-	-	4.0
0933	A-2	4	20	76	0910	99	97	92	90	-	-	78	73	69	occured on	1900	1380	-	-	4.0
0938	↓	4	20	76	1300	95	89	84	80	77	68	64	62	60	samples from	1720	1260	-	-	3.9
0934	A-3	4	20	76	0910	99	99	99	98	-	-	93	90	88	all three basins.	3380	2440	-	-	6.8
0939	↓	4	20	76	1300	100	99	98	97	95	92	88	87	86		2800	2040	-	-	6.5
0940	AD-1	4	20	76	1300	-	-	-	-	-	-	-	-	-	- - - -	7150	4700	7278	4350	9.1
0936	RS-1	4	20	76	0910	-	-	-	-	-	-	-	-	-	- - - -	4800	3560	-	-	10.5
0941	↓	4	20	76	1300	-	-	-	-	-	-	-	-	-	- - - -	5267	3933	-	-	11.0

APPENDIX A
LABORATORY DATA
COLUMBIA, KENTUCKY

O&M SAD #	STATION	MONTH	DAY	YEAR	TIME	COD - mg/l	TKN-N mg/l	NH_3-N mg/l	NO_3-NO_2-N mg/l	Total-P mg/l	Pb ug/l	Cr ug/l	Cd ug/l	Cu ug/l	Zn ug/l	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Total Solids mg/l	Total Volatile Solids mg/l
0942	I-1	4	19/20	76	24 hr. Comp.	537	30.6	19.5	.03	10.5	120	<80	<20	64	260	133	93	620	242
0943	E-1	4	19/20	76	24 hr Comp.	197	14.5	3.8	.26	11.6	<80	<80	<20	41	190	122	86	518	154

APPENDIX B

General Study Methods

To accomplish the stated objectives, the study included sampling, physical measurements, visual observations, and discussions with the plant operator.

One 24-hour proportional to flow composite sample was taken from the influent (Station I-1) and from the effluent (Station E-1) by an ISCO model 1392-X automatic sampler. These samples were used to characterize the waste being treated by the facility and to observe treatment efficiencies.

Grab samples were taken throughout the system for routine control testing. These control tests consisted of:

- sludge settleability as determined by the 60-minute settlometer test,
- percent solids by centrifuge on the mixed liquor and return sludge,
- TSS and VSS analyses on the mixed liquor and return sludge,
- depth of the clarifier sludge blanket.

The aerobic digester was grab sampled for total solids and total volatile solids.

Dissolved oxygen in the aeration basins and aerobic digester was determined using a YSI model 51A dissolved oxygen meter with field probe, standardized against a Winkler titration.

Plant flow was determined by placing an 8-inch rectangular weir in the effluent channel and measuring gage height with a Stevens model F stage recorder.

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