SUMMARY REPORT

OPERATOR TRAINING
ACTIVATED SLUDGE SEWAGE TREATMENT
HELD AT THE
FITCHBURG PILOT PLANT

October • 1971

CAMP DRESSER & McKEE Inc.

Consulting Engineers

Boston, Massachusetts

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON. MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

December 1, 1971

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DIVISION OF
WATER POLLUTION CONTROL

Mr. Thomas C. McMahon
Commonwealth of Massachusetts
Division of Water Pollution Control
State Office Building
100 Cambridge Street
Boston, Massachusetts 02202

Operator Training Course
Summary Report
CDM 448-3-CG

Dear Mr. McMahon:

In accordance with the contract between the Commonwealth of Massachusetts Division of Water Pollution Control and Camp Dresser & McKee Inc., dated March 9, 1971, we have prepared a "Manual of Instruction for Activated Sludge Treatment of Municipal Wastewaters" and have operated the Fitchburg Pilot Plant as an operator training school. During the period from May 3, 1971 to July 2, 1971, thirty-three (33) men attended the operator training school in five (5) different courses. This included five operators and two engineers from Fitchburg, five operators and three engineers from Marlboro, eight engineers from the Division of Water Pollution Control and ten others from other cities, towns and industries.

This report evaluates and describes the operator training program.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Charles A. Parthum

Charles A. Parthum

AER/dlm

COMMONWEALTH OF MASSACHUSETTS
CHARLES A. PARTHUM
No 7907
REGISTERED PROFESSIONAL ENGINEER

SUMMARY REPORT

ON

OPERATOR TRAINING

ACTIVATED SLUDGE SEWAGE TREATMENT

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CHAPTER 1

LECTURE MATERIAL

General

During each day of the training session a period was set aside for a more or less formal lecture. This lecture was given in the morning and normally lasted between 1 and 1-1/2 hours. The material generally covered the previous night's reading assignment in the manual. Approximately 50 percent of the time the material presented was to illustrate some aspect of activated sludge or to supplement material in the manual. It was during this lecture period that homework problems and reading assignments were discussed.

It soon became evident that the students had relatively little difficulty in understanding the concept of activated sludge sewage treatment. They would readily accept any statement of fact regarding the process as put forth by the instructor, but this should not imply that the students were gullible. It is our feeling that the students were receptive to the instruction because the general education level was equivalent to high school or less and the material presented was often of a technical nature so they were not able to question as freely as might have been expected.

It was evident that there were two major problems in training the operators. The students could not, or generally found it quite difficult, to make the mathematical calculations required in the analyses of the activated sludge process. Secondly, there was the general difficulty in making an interpretation of the laboratory results and a reluctance to act upon these results.

Mathematical Difficulties

Generally the students could multiply numbers like 22 x 32 and get the correct answer, but difficulties arose when asked to multiply 2.2 x 32 or 0.02 x 3.2. Similar difficulties arose in dividing. In multiplication and division by 10,000, 1,000 or 1,000,000 the placing of the decimal point very often was not made correctly. The course was started on the premise that a slide rule or an electronic calculator could be used for making the routine arithmetic computations. Since, however, such computations are not routine for these men, it was decided to eliminate the use of automatic devices and concentrate on long-hand calculations. Also, it was noted that the slide rules and calculators would not normally be available at small sewage treatment plants. Trainees who desired it were given instructions in the use of a slide rule and several indicated that they felt it would be very good to learn as they were suitably impressed by the rapidity of making calculations. The biggest problem, however, still remained in placing the decimal point. To familiarize the students with calculation, homework problems were assigned which received a mixed response. Those really interested and involved did the work. Others copied the answers in class the next day. One man wanted overtime pay for homework. A comprehensive example of such a problem is illustrated in Table 1.

Interpretation of Data

The second problem encountered was the interpretation of the laboratory results and operating data. Once the operator had a firm idea of what the normal ranges for a particular parameter were (i.e., suspended solids, BOD, recirculation ratio, sludge depth, etc.), he was better able to draw correct conclusions from his data. It was not uncommon for a student to determine a raw sewage BOD which was less than the effluent BOD and not wonder why the results were such. Granted this is probably due to mathematical errors, but his experience should show him that such a value is much too low for the raw sewage coming into the plant and that the plant would not increase BOD.

After a while the men began to perform the tests correctly, but it was relatively difficult to overcome their lack of confidence. They were reluctant to effect a change based on their results. This may often be tied to the politics of a particular treatment plant. Several men indicated that if they made a mistake, they felt it would reflect on them personally and they would be called on the carpet to make an accounting for his error. This is, of course, what does and should happen, except the operator often sees himself only as the underdog and not a member of the management of the facility. As a result, there is a general reluctance to make a decision and act upon it.

If the object of the course is to train operators and not just laborers, then this decision-making process, whether on a large or small scale, must be instilled into the trainees. Once the students realized that this was only a 30 gpm pilot plant and that disasterous ecological effects or more importantly, a tongue lashing from the instructor would not result from a foul up, there was less reluctance to make decisions. For example, if the dissolved oxygen (DO) content in the aeration tank was too low, we encouraged the students to take steps to increase that level. This could be done by adjusting the diffusers, or in a critical case, to increase the speed of the air compressors. In the lecture material we stressed that a low DO was harmful as it often caused bulking but on the other hand, a high DO, of say 5 or 6, might create a condition known as boundwater which would result in a poorly settled sludge. When the data was reviewed, we often found that the DO had run all day at 0.3 mg/l and no corrective steps were taken to increase the DO. In the more common instance, the dissolved oxygen was 5 mg/l and accordingly, the diffusers should have been shut down slightly to decrease the dissolved oxygen to approximately 1 to 2 mg/l. They should have been encouraged to take more direct action and not worry so much about the consequences.

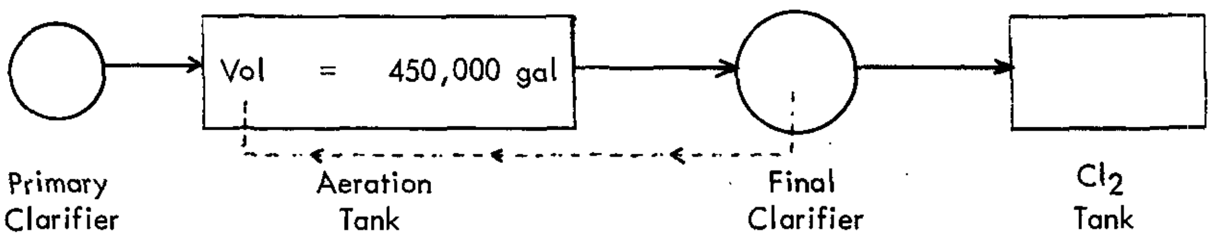
TABLE 1. HOMEWORK PROBLEM

GIVEN

Flow = 2.7 mgd

SS = 180 mg/l

BOD = 150 mg/l



1. Assuming 30% removal of BOD and SS in primary clarifier and 2,500 mg/l MLVSS in aeration tank:

   (a) What is concentration of BOD and SS going to aeration tank?

   (b) What is the F/M ratio?

   (c) If the recirculation rate = 600 gpm, calculate the recirculation ratio.

   (d) What will be the resultant RSSS?

   (e) If 85% of BOD and SS is removed in the aeration system, calculate the BOD and SS in the effluent.

2. (a) If it was desired to operate at an F/M = 0.3, what would be the MLVSS and MLSS required? Assume MLVSS = 80% of MLSS.

   (b) How much wasting would be required? Assume RSSS = 10,000 mg/l.

CHAPTER 2

PILOT PLANT PROCEDURE

Laboratory Procedures

During the training course, the students were split into two groups and worked alternately at the pilot plant or in the laboratory. During the first of the two weeks of instruction, two days were spent in the laboratory followed by two days at the pilot plant, or vice versa. During the second week of instruction, the students alternated locations daily.

Tests

In the laboratory, the following daily analyses were routinely made on the raw sewage, the extended aeration process effluent and the conventional activated sludge process effluent: pH temperature, turbidity, suspended solids (SS), volatile suspended solids (VSS), biochemical oxygen demand (BOD) later chemical oxygen demand (COD) and settleable solids. The following tests were run on the extended and conventional activated sludge mixed liquors: mixed liquor suspended solids (MLSS), mixed liquor volatile suspended solids (MLVSS) and oxygen uptake.

At frequent intervals, the microscope was used to view the micro-organisms present in the activated sludge. The scope could only be used qualitatively as Camp Dresser & McKee personnel are not biologists. It was possible to point out those typical micro-organisms normally found in activated sludge, bulking organisms and those organisms normally found in very stabilized environments of low organic matter and large amounts of dissolved oxygen. It became evident during the early classes that the microscope examinations tended to make the operation of the aeration units more relevant to the students, for they could see the biological processes responsible for sewage treatment. Experiments were also conducted with bench units, where the students observed that with the addition of methanol, the microbial population appeared to be entirely wiped out. One other bench unit had sugar added and the students observed the relatively rapid formation of bulking organisms. They also measured the very poor settleability of the mixed liquor.

Data Logging

In order to illustrate the interrelationship of all the parameters normally measured during these courses, laboratory data was plotted on a daily basis. A large graph was posted in the laboratory on which was plotted the suspended solids, BOD, COD, food to micro-organism ratio (F/M) and oxygen uptake rate. In this manner, the performance of the extended aeration and conventional activated sludge units was graphically illustrated, and variations in a particular parameter were readily discernible. This chart also illustrated the effect on treatment plant efficiency after process adjustments. The chart also served as an aid in evaluating the operation of the treatment units. The students could utilize this chart to study the previous data and to come to conclusions as to why the treatment plant was operating as it was. Decisions as to the future operation of the process could then be made.

Pilot Plant Operation

It was the responsibility of those students assigned to the pilot plant to completely maintain and operate both the extended aeration and conventional activated sludge treatment units. The daily maintenance normally included washing down weirs, headboxes and walkways of any accumulations of sludge. Occasionally other maintenance including the changing of pump sheaves to increase or decrease the sludge recirculation rate, cleaning sludge pumps and chlorine feed pump was required.

For effective operation, the following tests were made at the trailer body located at the pilot plant: mixed liquor settleable solids, sludge settleability rate, mixed liquor suspended solids, mixed liquor oxygen uptake rate, chlorine residual, temperature, pH and dissolved oxygen of the mixed liquor, raw sewage and effluents. Data on sludge flows, the recirculation ratio and clarifier sludge depth were also collected. The data sheets used for the first three classes are shown in Table 2, complete with typical data. The last class used a data sheet shown in Table 3. The larger, more complete sheet was used to give the students additional practice in handling data as there was a general problem of mathematics, as described earlier. Here again, the desire was to initiate changes in treatment plant operation immediately in order to effect the most optimum treatment process. Figure 1 shows the results of a typical mixed liquor settleability test. Forms showing the relative degrees of bulking were provided.

The students assigned to the pilot plant for any particular day were responsible for all data collection and all sampling. Points sampled included the raw sewage, extended aeration tank effluent, conventional activated sludge effluent and each mixed liquor and return sludge. In order to insure that representative composite samples were collected, the City of Fitchburg provided personnel to collect samples during the nighttime, although this was on a less frequent basis than the day sampling.

Bench Unit Operations

Several bench units, which simulated certain operating conditions, were carried out for each of the last three 2-week courses. The bench unit consisted of a 5-gallon glass jug filled with mixed liquor. The air source was tapped off the main header at the pilot plant and brought into the laboratory building by a 1/2-in flexible hose. Diffusion of the air was accomplished by using a fish tank aquarium air diffuser. The unit was operated on the fill and draw procedure and was normally fed twice daily. After settling for a period of 30 minutes, the desired amount of clarified effluent was drawn off by means of the siphoning tube, and a like amount of raw sewage was then added and aeration restarted. By varying the volume of feed in the fill-and-draw operation, we could approximate any particular aeration time. It should be kept in mind that these bench studies were not rigorous laboratory experiments to investigate theories, but were used to qualitatively demonstrate the effect of a particular pollutant on the activated sludge system.

In the first unit, mixed liquor from the extended aeration tank was aerated and fed raw sewage twice daily, resulting in a theoretical detention time of approximately three to four days. After a week of operation, it was decided to investigate the effect of a toxic waste (methanol) on the micro-organisms. Up to this time, observations indicated a multitude of stalked ciliates and a few free swimming ciliates in the mixed liquor. We added an amount of methanol such that the COD of the waste was increased to approximately 10,000 mg/l. The next day, the effect of this toxic waste was readily apparent. The effluent became very cloudy, and microscopic examination indicated that there were no living micro-organisms. Discussion was then held as to what possible steps one might take to counteract the effects of this toxic waste, or how one might handle any toxic waste in an actual treatment plant situation.

In the second two-week course, the bench unit was used to show that an activated sludge could be started entirely from the micro-organisms present in raw sewage. A sample of raw sewage was collected and aeration commenced. Every 24 hours thereafter, the sewage was allowed to settle for half an hour and then all the clarified liquid was withdrawn, leaving a fractional amount of sludge in the jug. Fresh sewage was then added and aeration commenced for another 24 hours. After a week of this schedule, the mixed liquor suspended solids had increased from 200 mg/l to approximately 1,100 mg/l. Microscopic examination showed a marked increase in free swimming ciliates. After two weeks of aeration, the free swimming ciliates had given way to the stalked ciliates indicating a more stable sludge. Routine analysis performed on this mixed liquor included determination of MLSS, SS (influent and effluent) and COD (influent and effluent).

In the third two-week course, the bench unit from the pervious session was used to evaluate the effect of a very high shock loading of organic material, which may be readily assimilated by the micro-organisms. For this experiment, we added one gram of sugar daily to the jar for three days. By the third day, a distinct bulking had started in the mixed liquor, and the stalked ciliates had decreased in number considerably. Serious bulking had set in by the sixth day, and accordingly, the students ran sludge settleability and mixed liquor suspended solids analyses and then calculated the sludge volume index, which was about 300 mg/l. During the second week after the feeding of sugar had ceased, the microscopic examination showed that the spaghetti, like bulking organisms, was starting to decrease although the sludge settleability was still poor. By the end of the second week, the students saw the reappearance of the stock ciliate type protozoa. The effluent suspended solids also started to decrease.

After observing the interest the students had in operating the bench units, an attempt was made to create the same condition in the conventional activated sludge plant. With only several days remaining in the course, we dumped 5 lbs of sugar into the conventional activated sludge aeration tank. Much to our surprise, nothing happened. In fact, the last few days of the course resulted in a better effluent than before adding the sugar. This approach generated much more interest in the course, although the students expected to see drastic immediate results of this addition of sugar.

From the students' comments, it appears that although the planned upset of the plant failed, such a procedure may still be a propitious program to follow. The students enjoyed the opportunity to take the steps to remedy the situation created. This approach should not, however, be done in the first week of instruction as the students are generally overwhelmed with the new material being presented.

Field Trips

Three distinctive types of field trips were afforded the students: a trip to the Leominster sewage treatment plant, a visit to an industrial wastewater treatment plant, and a stream survey. All groups had the opportunity to visit the Leominster sewage treatment plant, which is a conventional activated sludge sewage treatment facility. The intent of this trip was to familiarize the students with a working activated sludge plant (if they had not previosly been exposed to it) and to gain an insight into the full-sized operation that one might normally expect from this process. The trip was scheduled on those days when the plant vacuum filter was in operation to afford the students a view of typical sludge handling procedures. [Sludge handling was not an integral part of our training operation.] No attempt was made by the student to evaluate the effectiveness of the Leominster facility, although it is recommended that this be done in the future. This, according to the students' comments, would make the field trip more germane, even though the grab samples collected for this evaluation would not indicate average conditions.

In the second two-week course, one of the students was from the Digital Equipment Corporation of Westminster, Massachusetts. This electronics plant treats its domestic waste using a small extended aeration sewage treatment plant. The operator was having considerable difficulty operating this unit, and he intimated that there was considerable objectionable odor coming from the plant. Further discussions and tests of the mixed liquor indicated that the mixed liquor was not aerated sufficiently. We talked about the situation in class and asked the students to determine what might be done to remedy the situation. Over the course of a week, it became evident that the plant was starting to regain its healthy state after increasing the amount of aeration.

As there was considerable interest among the students about the recovery of this plant, we went to the facility to view its operation. [During Course III the majority of the students were from small extended aeration plants and hence were eager to see another unit which was experiencing difficulties.] At this plant, samples were collected and microscopic examinations were made of the mixed liquor. This was followed up over the next day or two with additional samples and examinations. Fortunately, the mixed liquor continued to improve and the effluent was improving.

The problem was traced to the fact that the operator had decided to use his sludge holding tank for aeration as the flow was extremely low as compared to the design flow. The sludge holding basin did not have adequate capacity to aerate the waste. He decided to switch over to his regular aeration tank, and in this manner had adequate facilities to maintain a dissolved oxygen level of 1 to 2 mg/l. By increasing the dissolved oxygen to an acceptable level, normal operation was restored to this facility. The students were fortunate to be able to witness such operating problems.

The third two-week class was given a field trip along sections of the Nashua River in Fitchburg and Leominster. Several points along the river (in various states of pollution) were sampled and monitored for dissolved oxygen, temperature and pH. Although the samples were only a grab type, the trip and sampling served to illustrate the massive pollutional load being deposited into the Nashua River and that in effect, the Nashua River was actually acting like a very long, thin settling tank.

At the pilot plant laboratory, the samples were analyzed for SS, VSS, COD and a microscopic examination was done. As completely anaerobic conditions existed in the bottom sediment, the students were not too surprised to find no normal types of protozoa such as that found in an activated sludge plant.

This type of field trip tends to give the trainee the impression that his duties as an operator do not begin with the incoming sewage and end with the effluent. The plant operator should be cognizant of the fact that his responsibilities are system-wide and also include the responsibility for monitoring the receiving stream. This field trip and lecture illustrated that effect of the plant effluent was evident many miles downstream, not just at the plant discharge.

DAILY OPERATING DATA

EXTENDED AERATION

Time	Flow (gpm)			Dissolved Oxygen (mg/l)			Settleable Solids (ml/l)	Sludge Depth (ft)
	Raw Sewage	Return Sludge	Waste Sludge	Raw Sewage	Mixed Liquor	Final Effluent		
0300	5.1	2.3		3.0	3.4	2.8	275	
0600								
0900	5.1	2.1		2.2	4.4 4.2	5.8 1.3	360	5-in
1200	7.2	1.9		2.3	3.9	0.3	325	2-in
1500	7.2	1.9		2.4	3.5 3.3	1.5 1.3	340	2-in
1800	7.2	2.1		2.7	4.1	3.8		
2100	7.2	2.3		2.7	3.9	3.8	350	
2400								

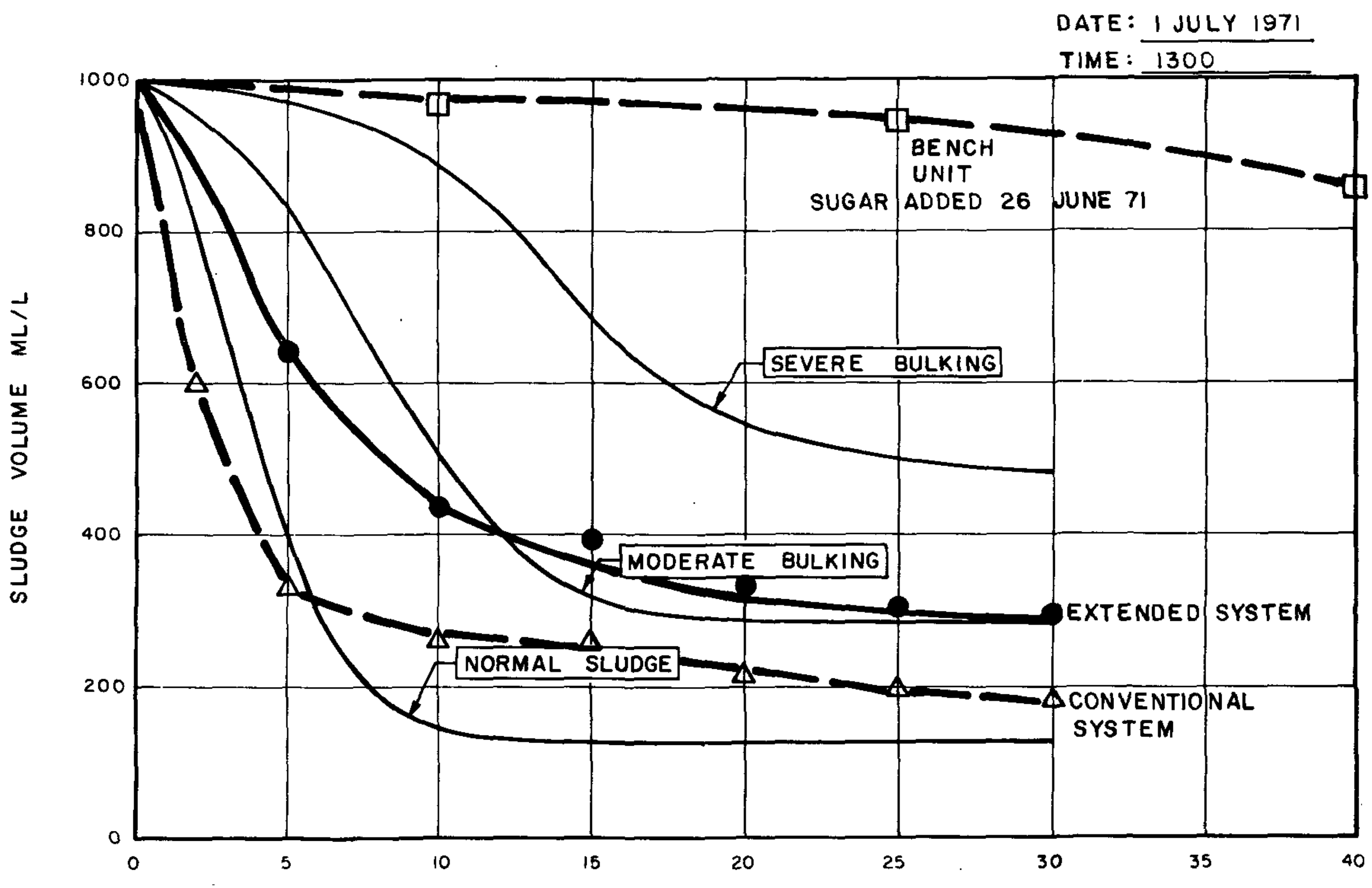
CONVENTIONAL ACTIVATED SLUDGE

Time	Raw Sewage	Return Sludge	Waste Sludge	Raw Sewage	Mixed Liquor	Final Effluent	Settleable Solids (ml/l)	Sludge Depth (ft)
0300	19.7	5.5		3.0	1.0	0.8	325	
0600								
0900	34.5	5.5		2.2	0.3 Inf. 0.2 Eff.	0.15 Inf. 0.2 Eff.	330	24-in
1200	34.5	5.7		2.3	0.4 0.3	0.4 0.2	290	18-in
1500	29.0	6.7	200	2.4	0.9 0.6	0.7 0.2	280	24-in
1800	19.7	5.5		2.7	1.1	0.9		
2100	19.7	5.7		2.7	1.3	0.8	240	
2400								

TABLE . REVISED DAILY OPERATING DATA

Date July 1, 1971

Time	FLOW (gpm) Raw	FLOW (gpm) Ret. Sludge	FLOW (gpm) % Recir.	DISSOLVED OXYGEN (mg/l) Raw	DO Mixed Liquor Inf.	DO Mixed Liquor Eff.	DO Clarifier Top	DO Clarifier Bottom	pH Raw	pH Mixed Liquor	pH Eff.	Chlorine Residual (mg/l)	Turbidity (JTU) Raw	Turbidity (JTU) Eff.	Sludge Depth (in.)	Sett. Solids (ml/l)	Waste Sludge (gals)
EXTENDED AERATION																	
0900	2.8	1.6	57	1.2	0.5	0.5	0.3	0.2	6.7	6.1	6.5	3	38	11	12	450	
1100	10.0	1.7	17	1.5	0.3	1.1	0.2	0.2	6.8	6.5	6.6	3	72	10	12	345	
1300	8.6	1.8	21	1.8	0.5	0.8	0.2	0.2	6.9	6.7	6.7	0.2	68	8	40	300	303
1500	5.0	1.6			0.2	1.8	0.3	0.1	6.5	6.9	6.8	2	70	11	12	285	
CONVENTIONAL ACTIVATED SLUDGE																	
0900	18.8	3.3	17	0.7	1.0	4.5	1.1	1.5	6.5	6.3	6.5		40	15	18	195	
1100	25.0	3.5	14	0.4	0.3	1.4	1.0	0.4	6.9	6.7	6.8		70	16	18	200	
1300	19.4	3.2	16	1.0	0.7	0.8	0.6	0.5	7.0	6.8	6.9		69	14	18	190	251
1500	25.0	3.0			0.4	1.1	0.2	0.2	6.4	6.8	6.7		70	12	3	160	



* 1000 ml GRADUATE USED

FIG. MIXED LIQUOR SETTLEABILITY TEST *

CHAPTER 3

TESTING PROGRAM

By the time this course was given five times, we were convinced that some positive method must be adopted to evaluating the progress of each of the individual students. The concept of testing had been discussed by the steering committee in the planning stages of this training course, but it was felt at that time that a testing program might tend to make the students uneasy.

A test was prepared to give to the students in Course V, and is illustrated in Table 4. The material in this test came directly from the course manual each student had or from material discussed during the lecture periods. The students were given one hour to complete this exercise. We have included the original test papers in the manual to illustrate the diversity of scores and depth of answers received. Generally speaking, the test marks were below the level expected for this training course, although if all test questions had been weighted the same amount, the results would have been higher. If the tests were in fact testing the aptitude of the students, then the low scores indicated a failure on the part of the instructor to put forth the material necessary to be covered in this type of operation. That being the case, it would probably be better to follow a more intensive laboratory-lecture type format with less time spent in the pilot plant. Perhaps a system could be set up whereby the students spend one day in the laboratory, one day in the pilot plant, and one day evaluating the data and results derived from the two previous days. Part of the failure of the students to do well on the test may be due to the time constraint, the general inability of most individuals to work well under pressure.

TABLE 4

TEST GIVEN DURING COURSE V

	Weight (%)	
1.	5	Calculate the BOD of sample.
2.	10	Write out the basic biological reaction for the decomposition or organic matter under aerobic conditions.
3.	20	Describe the basic difference between extended ane conventional activated sludge plants.
4.	5	Calculate the SS and VSS of sample in mg/l.
5.	10	What steps would you take to counter the effect of a shock load of acid?
6.	5	If the raw SS = 290 mg/l and effluent SS = 42 mg/l, what is the percent removal?
7.	5	If Q sewage = 27 mgd and you desire 40 percent recirculation, what will be the rate in gpm?
8.	15	Why does better settleability occur at low F/M ratios?
9.	15	What are the reasons for keeping the mixed liquor DO at 1-2 mg/l? Include effects of low and high DO.
10.	10	Why do we use seeded dilution water?

Data for question 1:

Sample		Blank	
Initial DO	= 8.3 mg/l	Initial DO	= 8.3 mg/l
Final DO	= 3.1 mg/l	Final DO	= 7.4 mg/l

Volume of sample = 15 ml

Data for question 4:

Volume of sample	= 200 ml
Weight of paper	= 0.3800 g
1st weighing	= 0.7436 g
2nd weighing	= 0.6000 g

CHAPTER 4

SUMMARY AND RECOMMENDATIONS

Based on our experience in training students at the Operator Training School, held at the Fitchburg Pilot Plant adjacent to the Fitchburg Sewage Treatment Plant, it is our feeling that the type of instruction offered during this course was a viable approach for training plant operators in the methodology of activated sludge sewage treatment. This statement must be qualified to the extent that the operator to be trained has either had: (1) prior training in a basic sewage treatment course covering the general aspects of the subject, or (2) has had at least one year of operating experience in an activated sludge sewage treatment plant. Appended to this report are notes taken during the discussion sessions held on the last day of each training session and also the individual critiques submitted by the students themselves. Review of this material indicates that the students had a favorable feeling towards this type of instruction, and also indicated a willingness to return on a yearly basis for a brush-up course.

In order to establish and operate the activated sludge training course at the Fitchburg Sewage Treatment Plant on a full time basis, the following suggestions are made to implement such a procedure.

1. A full time instructor will be required. Such an instructor should have had considerable operating experience in an actual activated sludge sewage treatment plant, and who at the same time has the ability to present the theoretical aspect of activated sludge in a simple manner such that the material is readily understood by the students. The full time instructor, at periods when courses are not being given, should have the responsibility for reevaluating the course objectives and be responsible for revising and updating the instruction manual. It is also recommended that he establish and conduct a follow-up program, possibly instruct at various treatment plants, which would insure that the material covered in the training course was being applied in actual operating situations.

2. A part time helper would be required to insure proper operation of the pilot plant facility, to perform maintenance of the facility and most importantly, to provide instruction of a general nature during those periods when the students are operating the pilot plant facility and when the full time instructor is not available for duties in the laboratory. This helper, however, would general spend most of his time in the pilot plant rather than the laboratory.

3. The maximum number of students that can be conveniently handled by one instructor is six (6). It was found that three students could alternately be receiving instruction in the laboratory or pilot plant. Experience in teaching the two-week courses indicated that the first week is hectic for the instructor is involved with laboratory instruction and it is not practical for him to divorce himself from this phase and go to the pilot plant for that operational phase of instruction. Accordingly, the helper is needed, especially in this first week.

4. The training school should be operated on a clinic basis. This would allow a particular operator who has encountered a treatment problem at his plant the opportunity to avail himself of the facilities at the school and concentrate his learning efforts on a solution to his particular problem. During such "clinics" the student might stay a maximum of three days.

5. The course of instruction should be flexible, but we have found that more time should be spent in the laboratory generally analyzing the operating and laboratory data than spending one half of the time at the pilot plant. With installation of the new returned sludge systems and raw sewage pump, the maintenance in the pilot plant facility has been cut to a minimum. Generally, after a week of instruction the students found that they had time on their hands when assigned work at the pilot plant, while they felt they needed more time on the lab. Start-up of a new series of courses might consider two days in the laboratory and one day at the pilot plant.

6. All students generally agreed that it would be desirable to have more field work such as trips to operating sewage treatment plants with prob-

lems. The students felt that the evaluation of a particular sewage treatment plant or stretch of river would be especially applicable to this course. The field work would tend to make the sewage treatment process relevant to the environment as a whole.

7. It is recommended that definite steps be taken to radically upset the operation of the pilot plant and then allow the students to correct the situation the best way they can with minimal help and advice from the instructor. (In the long run it would be wise to revise the return sludge system by using an adjustable sheave drive so that the return sludge rate could be rapidly changed to accommodate varying conditions of flow and organic loading.) It is also recommended that the capacity of the air compressor system be increased. Although adequate DO in the conventional aeration tanks was never a problem, an increased aeration capacity would allow the students to investigate the effects of over-aeration.

8. The possibility of using a fee to cover the cost of the manuals and incidental expenses is recommended.

9. It is felt that the best way to insure a steady source of students would be for the State Division of Water Pollution Control to "insist" that cities and towns send the operators. If the course content were consistently high in quality, then the operators themselves would get the word around and start using the facility as an active training center.

Acknowledgements

This report was prepared for the Commonwealth of Massachusetts, Department of Natural Resources, Water Resources Commission, Division of Water Pollution Control by the firm of Camp Dresser & McKee Inc., under the general direction of Charles A. Parthum, Senior Vice-President. Alan E. Rimer was Project Engineer and Warren W. Terrell was Engineer-inCharge and served as instructor and supervisor of operations. He was assisted by Craig B. Morgan and Roland W. Wentworth.

Our appreciation is extended to Mr. Jack Elwood and members of the steering committee including: Americo Dori, Alfred F. Ferullo, John J. Hartley and Donald S. Pottle. Their time and valuable assistance in evaluating the course and course material was sincerely appreciated.

Special appreciation is expressed to Mr. George J. Lanides, Fitchburg Commissioner of Public Works, who assisted us in numerous ways.

APPENDIX A

TRAINEES AT THE OPERATOR TRAINING SCHOOL

ACTIVATED SLUDGE SEWAGE TREATMENT

Course	Name	Employer
I	Robert M. Cady	Massachusetts DWPC
	Americo Dori	Fitchburg STP
	Lawrence W. Gil	Massachusetts DWPC
	Ray Godin, Jr.	Fitchburg (Engineering Dept)
	Charles Keyser	Marlboro (STP)
	Francis H. Zania	Marlboro (Engineering Dept)
II	Maurice J. Caron	Fitchburg (Water Dept)
	Ernest J. Cormier	Fitchburg (STP)
	John T. Harrington	Marlboro (STP)
	Paul R. Levine	Massachusetts DWPC
	Frank P. Robinson	Massachusetts DWPC
	Richard P. Sharon	Marlboro (Engineering Dept)
III	George F. Averill	Sunderland
	Donald Caldwell	Digital Equipment Corp.
	William J. Colyer	Raytheon (Sudbury)
	Francis J. Cormier	Fitchburg (STP)
	Peter A. Dore	Massachusetts DWPC
	Jack Hawkins	Massachusetts DWPC
	Roy Mangs	Marlboro (STP)
	Kenneth M. McIluin	Chatham
IV	Lawrence S. Bevis	Billerica
	Joseph R. Burby	Fitchburg (STP)
	William Cashins	Massachusetts DWPC
	Donald R. Doane	Manchester
	Roland J. Dupuis	Massachusetts DWPC
	William J. Fitzgerald	Marlboro (STP)
	Robert D. McRae	Dana F. Perkins & Sons, Inc.
V	Richard H. Baldelli	Marlboro (Engineering Dept)
	Leo G. Farrenkopf	Chatham
	Edmond Fitzgibbons	Fitchburg (STP)
	James E. Houghton	Marlboro (STP)
	Robert G. Richardson	South Essex Sewerage District
	John Svrcek	Billerica

APPENDIX B

SUGGESTIONS BY STUDENTS FOR MODIFYING COURSE CONTENT

The following is a summary of comments from all the students regarding the courses. Steps have been taken to implement many of the suggestions. Not all students have commented.

Course I

May 3-7, 1971

Robert M. Cady

- Provide time to review day's operations.
- Follow quality of instruction by assigning problems for homework
- Go over homework next day
- Simulate operating problems (by bench-scale tests)
- Several bench units beneficial
- Check DO probes at least weekly
- DO-$CuSO_4$ - Sulfuric test

Americo Dori

- Small class better than large
- Student should not have to wash glassware, etc. (i.e., night men should sweep lab, etc.)
- Concentrated classwork better than long night course (this was much better than Worcester)

Lawrence W. Gil

- Initially establish longer period in lab and at the pilot plant - then go to 1/2 day setup if desired
- Have students sample, then go to the lab - each individual should run a complete set of samples

Ray Godin, Jr.

- Relate person's job (i.e., administrator or operator) to the use of course
- Prior to using lab, give tour of lab facility showing what each item does
- Discuss social-economic impact of treatment
- Impress about cost to aerate, etc. - operate to optimize efficiency and minimize operating cost

Charles Keyser

- How sludge bulking differs from sludge rising
- Frothing - what causes it and how it can be controlled
- Modifications of the activated sludge process, but not on the first day

Francis H. Zania

- Firm up administration of course - attend to details
- Students think that manual should be sent in advance
- Pay closer attention to student's lab work
- Students like one day at pilot plant then one day at lab instead of continual shifting around
- First several days spend 5 hours per day in lab
- More demonstration of actual lab procedures
- Computer plot of first stage operations to give students better idea of what type results to expect from plant
- List of common elements, sewage treatment plant chemicals used
- Time schedule okay for this group, but might need 2 weeks for others
- Explain what to do if sludge is wiped out completely
- The informal approach for the instruction is better

Course II

May 10-14, 1971

Maurice J. Caron

- Not enough time to assimilate information, the various test procedures and relate them to actual operations
- Feels it is more important to know concepts of operation than actual mechanical operation of this pilot plant
- Should hit more on significance of particular operation
- Feels he can explain system (process) in general terms, but not down to fine points
- Does not understand significance of tests

Ernest J. Cormier

- Show use of slide rule
- Give more explanation of BOD, Winkler test - give demonstration on BOD, SS, etc.
- Make sure that every man does every test
- Set up crucibles, dilution waters before lecture in the morning
- Have pilot plant men start sampling data right off in the morning before lecture
- Field trip to Leominster would be good
- Multiple choice questions for homework would be good (Don Pottle did this at Worcester)
- Turbidity not explained too well - explain to whole group

John T. Harrington

- Demonstrate each test step by step
- Do all computations long hand
- Designating sample points was good idea
- Correlate test results to what they should do to affect a certain change in operation

Paul R. Levine

- Demonstrate the functioning of a valve, pump, diffuser, etc. - he realizes main function of course is activated sludge
- Groups of 3-4 OK - more than 4 are too many
- Do not channel a person who works in a particular area into that same area for the course
- Give detailed list of lab duties to team leaders - daily duty sheet would be helpful

Paul R. Levine (Continued)

- Explain commonly used conversion factors and how to use slide rule
- Round table discussion of a hypothetical problem each day would be helpful
- Start up a bench unit from scratch so student can see actual buildup of mixed liquor
- Keep separate chart for each plant; include flow, F/M ratio, etc.

Frank P. Robinson

- Repeat and summarize material covered - group discussion good
- Get across to people who will administer plants the great amount of time to perform tasks, etc.
- Minimum time for switching groups between lab and pilot plant should be one day
- Introduce problem but not before second week
- Take DO at end of "off" and "on" cycle of the aerator
- Measure pH more often
- Compare difference between grab and composite samples
- Eliminate Gooch crucibles - use filter paper with Buchner funnel
- New SS data sheet

Richard P. Sharon

- Enjoyed morning lectures
- Homework problems tend to stimulate discussion next day
- He would lean heavily on material in manual
- Thinks bench units added to confusion

Course III

May 24 - June 4, 1971

George F. Averill

- Upset bench units as example of operating problems
- Tour of Digital sewage treatment plant in Westminster more relative than tour of Leominster sewage treatment plant
- More on applying data to treatment principles
- Have men who run plant give status report of plant and have teachers make corrections
- More material on microbiology - more on BOD absorption; i.e., number of bugs eating the organic material

Donald Caldwell

- More desired on F/M ratio and BOD calculations
- Might be better to have one man do individual tests two or three days in a row
- Combine lab and math work - would like more definite list of what tests required

William J. Colyer

- Problems very beneficial as homework. Gives individual student chance to sit down and think about treatment process
- Punch list of trouble shooting (i.e., bulking caused by .....)

Francis J. Cormier

- Small conversion table to carry around would be helpful
- Cut down on man at pilot plant and put him in lab

Kenneth M. McIluin

- Problems should be given initially on conversion factors only
- Concept better put forward if just one plant run instead of two
- Like to see drastic changes in plant operations (i.e., upset plant and then fix)
- Digressions from the set morning lectures (i.e., on various STP problems) were valuable

Course IV

June 7-18, 1971

Lawrence S. Bevis

- More advanced course than that held at Merrimac College. Would have had a difficult time if I had not had the (basic) course at Merrimac.
- Determined effort of instructor and assistant to assist students appreciated

Donald R. Doane

- Provided excellent groundwork for the beginner.

William J. Fitzgerald

- Course much too complicated for non-aeration plant operators
- Eliminate slide rule techniques - too involved for normal plant operators
- Limit course to plant operators only; simplify course for plant operators
- Course schedule should progress as fast as the slowest pupil in class

Unsigned

- Plant operators should be kept apart from engineers as the rate of progress differs from each group
- One week on pilot plant, one week in lab
- Plant operators should know only how to perform tests, not interpret them
- Field trips good
- Continue training at treatment plant like Leominster or Billerica
- Look into simplification of waste sludge form

Course V

June 21 - July 2, 1971

Richard H. Baldelli

- Shorten day
- Have each student eventually do each test entirely by himself

Edmond Fitzgibbons

- Explain each calculation sheet
- Make more use of charts or nomographs
- More decision-making based on lab results is needed

James E. Houghton

- Make course three weeks: (1) learn where equipment is; (2) work at pilot plant; and (3) work in laboratory

Robert G. Richardson

- Lengthen course to three weeks
- Have experienced operator as a part-time lecturer or third teacher
- Supply list of students in each class
- Field trip excellent - stream sanitation work tied schooling together

John Svrcek

- Should be more standardization in lab procedures
- Felt instructor was too arbitrary and authoritarian in first week
- Instructor must handle each student individually
- Mood relaxed in second week
- BOD form caused confusion - each student should make BOD form for comparison
- Course more laboratory than operations orientated
- Better use of pilot plant for training than full-scale plant
- General consensus that in first week students just learning what's there
- In testing, show value of each question

APPENDIX C

STUDENT CRITIQUES

Course I
May 3-7, 1971

Robert M. Cady

1. Have plant team spend about five (5) hours (most of the day) at both plants to perform maintenance, sludge weighing, sludge waste-calculations and cleaning. Also, have lab group spend 5 hours doing composite data acquisitions and recordings.

2. Spend one hour at end of day recalling days work and significance thereof with the entire group (both teams). This activity should be a "directed" discussion led by the CDM course director. The discussion should focus on such things as:

(a) Raw influent BOD, SS, COD trends
(b) F/M fatios in both plants
(c) Plant efficiency (BOD & reductions) and how to increase efficiency
(d) Mechanical breakdowns should be "induced" for selected short-periods and recovery should be simulated and followed by the students.

3. Give one or two problems (homework) based on discussions, daily feedback of instructor on plant performance.

4. $CuSO_4$ sulfuric DO parallel readings for each DO probe should be done.

Lawrence W. Gil

1. Lab and plant maintenance periods should be extended.

2. Have individuals take a set of samples and do tests on MLVSS, BOD, DO uptake. Do all the calculations, etc., and show the students what effect this has on the plant and what his results indicate.

3. Do more of the repair work on the pumps, electric motors, etc. Have an electric motor apart, show what wears out and how to fix it.

4. List of daily tests and checklist on all tests

Lawrence W. Gil (Continued)

5. Course is a good idea. Would have liked to have been in the two-week course because it would have been more of a routine and also it would have enabled me to become more familiar with the whole setup.

Ray Godin

Entering this training course I knew nothing of the "activated sewage treatment" process in the plant or the laboratory. Today I feel I can satisfactorily answer the "layman's" questions on how and why Fitchburg is proposing to build such a plant. Therefore, I would personally deem this course a success.

As for possible changes on additions in the course, my thoughts are as follows:

1. More discussion (if time and student background permits) concerning the social and economic impact of such large and expensive projects upon a community. The main ideas derived from such a discussion should be to promote better understanding and relations with the people (citizens).

2. Should a class contain few or no men knowledgeable in this field, assigned lab work should be greatly reduced.

3. A tour of the lab naming all articles and apparatus should be made the first day.

4. Relate (in discussion) each student's present position with the subject of sewage treatment. Example: Engineer role as a public relations man selling "modern sewage treatment" to the citizens.

5. Continue to alternate lab and plant work by the day rather than the 1/2 day.

At this time, I would like to thank Warren Terrell and Al Rimer for putting up with me; doing a great job trying to get an insurmountable abundance of material across in one short week. They may be reassured that I no longer believe COD is a fish in the Nashua River or that BOD means a "body odor deodorant," although MLVSS will bug me forever.

This past week, I believe has been a profitable and enjoyable experience.

Charles Keyser

1. Provide manual of instruction for sewage treatment plant operators.

2. Provide simplified lab procedures for wastewater exam (put out by WPCF)

3. Text should be provided at least one week before class starts to prospective students. I found that I had a hard time finding time to read all there was and absorb it. It happened that by going to school for 8 or 9 hours and coming home to other commitments, my time was cut short. I feel that the one week of reading in advance would help the student.

4. More time with classwork instruction with the text.

5. More concentrated time in the lab and in the pilot plant (one day at lab for 5 hours, one day at plant for 5 hours)

6. I found that my inexperience in the lab took time away from my group leader's time to show me what laboratory procedures to use for the different experiments. I found that by the end of the week, I had learned a lot about the experiments. (more lab supervision during the beginning days)

7. I got mixed up on the correct range of values that are acceptable on the pilot plant operation. Example: SS - VSS analyses. Maybe a chart would help?

8. We used a lot of chemical equations which a short introduction would have been helpful in understanding.

9. Class time 8:30 - 4:30 okay — gave us plenty of time to arrive at the plant.

10. If you lost all bugs, how long does it take you to grow them again?

In conclusion, I think the course was very informative to me. I learned more this week than I have for 16 weeks (nights) on sewage analysis and sludge treatment.

Course II

May 10-14, 1971

Maurice J. Caron

1. Course content and material is good. However, in my case, I feel that one week is not enough to completely understand the process and relative worth of sampling as regards to the operation of the plant. Example: I can understand the terms BOD, O_2 uptake, DO, etc., but I am not sure just where they fit in the big picture. I think that with an additional week I could understand this.

2. I think that if more direct supervision was included, more points would be brought out and followed through.

3. I would have to say that the present staff is excellent. The point I would like to bring out is that there is just too much for two people to handle.

This has been an extremely interesting week for me. I have learned a lot and I am sure that with additional time I could learn more.

Paul R. Levine

1. Some time should be directed to definitions, commonly used conversion factors and use of the slide rule.

2. Try to break up groups and assign tasks to people who are not used to that particular task.

3. Some time should be spent on dismantling pumps, valves and aeration equipment.

4. Round table discussions on hypothetical operational problem.

5. Typed daily duties for different groups.

Frank P. Robinson

1. New data sheet for suspended solids should be made, and data sheet for suspended solids determination should be made. Dissolved oxygen readings should be obtained at the end of the "off" cycle and at the end of the "on" cycle to obtain the minimum and maximum DO. Also, since the loading is less at night, the aeration should be on less (or the volume of air supply reduced) at night and increased during day operation.

Frank P. Robinson (Continued)

2. Believe that low DO (0.5 mg/l) or low pH (6.0) can create conditions favorable to growth of filamentors organisms. Since the plant is now loaded with these filamentors growth, might try chlorinating the return sludge to produce a residual of 10 mg/l. Make sure that you have no Cl_2 residual in sludge.

3. Will take time for men to become familiar with lab procedures. More supervision is needed in the lab. May be overwhelmed in one day running all the tests and determining significance of test results. Each "student" should run through each test completely. Lab manuals, when available, will help.

4. For two-week course, might try two days in pilot plant and two days in lab to begin with. Then cut down to 1 and 1. May find that cutting down to 1/2 and 1/2 not advisable since lab work is time consuming. It is better not to change hours in the middle of course.

5. Might try running 2 or 3-hour composites during day for mixed liquors to eliminate errors from variable sludge concentration at different locations in tank and other factors.

6. Students should see, if possible, how plant normally is expected to run before introducing further complicating situations.

7. Include pH as routine test along with DO.

8. For those administrators attending the course, try to emphasize time involved in maintaining and operating a plant (conducting tests, etc.). Many of the plant operators have other duties related to the plant.

9. Repeat and summarize material covered from previous day.

10. Change BOD form.

Richard P. Sharon

Supervision: Ideal condition if only two instructors are going to be available would be to have assigned group leaders from the class to assist one of the instructors. I found that we leaned too much on the group leader to accomplish the assigned tasks and he has very little time to be consulted or to oversee our work. If, however, future plans for the two week classes involve just one instructor, I recommend groups of four, one man assigned as group leader to just assign and oversee the duties of his group. This will give the instructor the opportunity to roam between the plant and the lab to see that things are running smoothly.

Richard P. Sharon (Continued)

Duties: Should be prepared in some orderly manner by staff so that group leader should just have to enforce them; after all, he is cheap labor and should not have to set up his own schedule too!

Assignments: I approve of assigning a few problems during the course. They always bring up questions the following day that prove to be very helpful to the group as a whole. Also, teach a person how to apply results of tests to the solution of some of their problems.

Created Conditions: Such as bench tank are unnecessary to my way of thinking, enough problems can be created in pilot plant itself for a two-week period. Just adds to confusion.

Now that you have read my comments, I want you to know that although I am not a pilot operator, I can fully understand the problems you are confronted with trying to set up course for same. I have absorbed a great deal of knowledge about complete treatment in a very short amount of time and am grateful to you and the staff for your help.

Course III

May 24 - June 4, 1971

William J. Colyer

During my training course at the Fitchburg pilot plant, I was very impressed by the skill of the instructors, the training program and the equipment available for training. Any difficulties I experienced was converting from the English to the metric system and becoming familiar with terminology. I was surprised when I realized my math was weak and left something to be desired. I was having a problem relating liquid and dry measures. As the course progressed and we were given problems to solve as homework, I felt more confident.

Roland J. Dupuis

The writer attended a school at the Fitchburg STP on activated sludge and extended aeration. In the writers opinion, the overall course was quite a success. A school of this sort should be a yearly event. The writer feels that plant operators should be required to attend such schools, and return every so often for refresher courses. However, the writer feels that these courses should be situated in locations that would not be inconvenient for operators to commute daily.

The theoretical part of the course was very well taught. However, the operators taking the course could not put the theory into practice. If a course of this nature were to be given again, more emphasis should be placed here. Secondly, the writer felt that the plant operators were deficient in the math required to do the theoretical calculations. A short course prior to the school or during the school should be given.

The writer thought the actual operation of the pilot plant was an excellent experience for all concerned.

Unsigned

Fine job done by Warren, Craig and Al. It's been a pleasure to know these men. It's nice to see a group of men (students) eager to learn.

Suggest more discussion on measurement on first or second day.

Still feel that a single plant would simplify course.

Would like to see drastic upset in plant operation and see visual correction.

Biggest asset — the way Warren and Craig responded to answers completely.

Course IV

June 7-18, 1971

Lawrence S. Bevis

The initial day consisted of getting acquainted with the instructors, other students, pilot plant and laboratory. Therefore, to establish a firm opinion of the complete two-week course is not justifiable.

From the second day of instruction to the present, I have found the training to be interesting (though sometimes confusing possibly due to my not being familiar with certain subjects taught), and, I feel that I have benefited by attending the training program.

In comparison with the Wastewater Treatment Plant Operators Training Course recently held at Merrimac College, North Andover, Massachusetts, I determine this presently attended training program at Fitchburg to be an advanced course.

I also feel that it is proper to state that if I did not attend the (basic) course held at Merrimac College, I would not have been able to complete the full two-week course at Fitchburg.

A word of appreciation is extended on my behalf to Mr. Warren Terrell and his associate, Mr. Craig Morgan for the instructions received from them and their determined effort to assist all the students with any problems or questions pertaining to the course.

I enjoyed it and would attend again next year if the possibility arises.

Donald R. Doane

The two-week training course at Fitchburg has offered me much help towards being a treatment plant operator.

I do not at this time, work at a treatment plant, but will be operating one in August of this year. Had I been operating a plant, I think I would have benefited more in this course. I have, however, learned the basic groundwork and have done various tests, so this course has offered me much. I feel now, with this two-week training course, I have a much better knowledge of a treatment plant and its operations. I would also like to say that I think this course was advanced for me, where I have very little experience in treatment plant operations.

Donald R. Doane (Continued)

I would like to thank the two instructors, Mr. Terrell and Mr. Morgan for the time they gave me in explaining and showing me things in the pilot plant and laboratory. I look up to these two men as fine instructors for this course.

William F. Fitzgerald

In reference to the Fitchburg Sewage Treatment Plant School I offer the following:

1. Course is much too complicated for non-aeration plant operators.

2. Do away with slide-rule techniques — this is too involved for normal plant operators.

3. Limit courses to plant operators only and not District Aides because of the fact that plant operators are usually only high school graduates and are taught on a different level than District Aides who usually possess college diplomas.

4. Simplify course for plant operators because of the lower education standards that plant operators possess.

5. Course schedule should progress as fast as the slowest pupil in the class.

Unsigned

1. Treatment plant operators should be kept together, engineers separated from operators; progress as fast as slowest man.

2. One week in pilot plant, one week in lab.

3. Grade 1 and 2 operators should know only how to perform tests, not interpret them.

4. Continue Leominster trip.

5. Have training school at treatment plant like Leominster or Billerica.

6. Look into simplification of Waste Sludge form.

Course V

June 21 - July 2, 1971

Richard H. Baldelli

My critical evaluation would have to begin by having more time in the lab and less time out in the plant. There also should be some charts made up for calculating waste sludge time instead of making an operator multiply large numbers out by hand.

The course, as it is now, is good as long as it is limited to people with a good amount of experience; otherwise, it will be too deep. A little more rotation in the lab might help. For example, BOD's and COD's should be done more than once, and to make it easier on what to do, maybe an outline could be made up of each experiment.

Leo G. Farrenkopf

1. Give basis first.

2. More lab work instead of pilot plant.

3. Combined (somehow) extended and conventional tanks to the individual who has one or the other.

4. More time on each category.

5. Have a correspondence course to help operator on a continued basis.

6. Have the training school where each operator is working.

7. Make nomograph for quick calculations.

Edmond Fitzgibbons

Eliminate some, or all of the math involved in the forms. Use instead short formulas or nomographs. More lab work and less maintenance of the pilot plant.

Better public relations (visitors often remark that they were unaware of the school).

Explain all forms (BOD, COD, sludge wasting) on a sample form drawn on the blackboard. Include a completed sample form for each in the manual.

More field trips to include conventional and extended activated sludge and an industrial waste treatment plant.

Edmond Fitzgibbons (Continued)

Replace Mr. Lesperance's general approach to activated sludge with material less technical, such as the explanation in the New York manual, or the Powers report.

James E. Houghton

I believe that the course was well presented. I think more attention should be given to various operational problems that might arise and less time devoted to lab work.

I don't recall that at any time there was a description of the complete function of an activated sludge plant such as grit chambers, comminutors, etc., and the problems that might arise concerning them.

I liked the way the two teams were rotated in the various phases of pilot plant operation.

Robert G. Richardson

Pilot Plant Operation: Being in the unique position of not yet working in a sewage treatment plant, I found this portion of the training program very informative. I particularly enjoyed being able to experiment with problems that arose, "or were created," as this is the basis of the learning process.

My only criticism of this portion of the training is that taking of samples and data can become quite routine. I know that this sample and data collection is important, however, I feel that less time should be spent in this area.

Laboratory Analysis: I thoroughly enjoyed this portion of the training program. As I worked on various types of laboratory analysis, I began to realize that I would like to follow up on this particular type of work and most probably make this my vocation in life.

I feel that the training in this area was handled very well. Instruction and explanation of laboratory analysis was complete; and if the situation arose that I had to perform these tests in a laboratory, I feel that I could do so with ease.

My only criticism of this portion is that I could not spend enough time on laboratory analysis. This is not the fault of the instructor or the program, but the desire of one person to work in this particular field.

Personnel: Instruction both in the pilot plant and laboratory analysis was more than adequate. Both Warren and Roland were most cooperative and their enthusiasm in the training program helped me to better understand the activated sludge process.

Robert G. Richardson (Continued)

General Comments: I believe this course should be conducted for a three week period instead of a two week period. There doesn't seem to be enough time to absorb all the information in a two week period.

In future courses, I feel that in conjunction with the lab instructor and a pilot plant instructor, a competent, experienced plant operator should be hired to instruct the trainee in every day problems that arise, whether they be operational, laboratory or maintenance problems. This person has experienced these problems and his handling of such is invaluable information that could be passed on to the trainee.

The pilot plant seems to have some built-in limitations; such as too small an extended aeration studge return pump, too small air compressors and under-capacity to handle all flows. These limitations make operational training difficult at times and in the future, I would hope that they could be corrected.

In summation, these past two weeks of training have been most informative and enjoyable. If I am given the chance to repeat this program in the future, I would be pleased to do so. I hope this program is carried on in the immediate future.

John Svrcek

My general feelings of the course are that it was very well handled in both lab and operation. There was an equilibrium of work theory and lab practice. The only problem was that there is a difference between the teacher and the students. With that note, there should be less time spent on technicalities.

APPENDIX D

73

#3 Basic difference between Ext & Conv system is the organic loading ✓

#2 BOD Growth Decomposition End Products Recycle -7

#1 SS

1136
3800
2) 3636 = 1818 mg/l ✓

VSS

6000
3800
2) 2200 = 1100 mg/l ✓

#5 Add lime to raise pH ✓

#6 $\frac{290 - 42}{290} \times 100$

85% ✓

290) 24800
2320
1600
1450
150

POOR ORIGINAL COPY

8 Better settling occurs at low F/M because bacteria are less active and tend to merge together

#7 Low DO in aeration tank bacteria less active do not consume organic matter at desired rate, tank could become anaerobic -3
High DO may cause bulking floc-forming

#10 Use seed in dilution water to assure that there will be a depletion of of oxygen in BOD -10

#9 17,000,00 / 4 = 108,000,00 = 11 mgd 1440 / 11 / 1440 / 1440 / 1584 = 1584 gpm ~~-10~~ -5

10

POOR ORIGINAL COPY

(73)

1.)

8.3
7.4
.9

285
2)570
14
17
16
10

7.8 aver. of Blank
15 ml

2
15)300

8.3
-3.1
5.2
0.9
4.3

$\frac{4.3 (285)}{300} =$

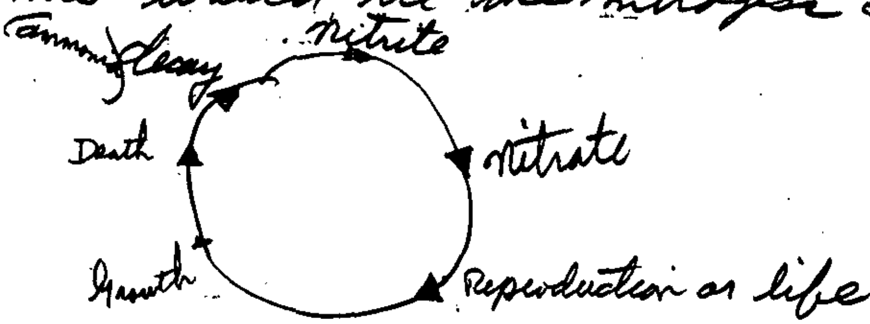
285
4.3
855
1140
2225.5

8.4
300)2225.5
2100
1255
1200

7.4
20
148.0

✓ BOD = 148 mg/l

2.) This would be the nitrogen cycle.



-5

Organic matter → Decay → $CO_2 + H_2O$ → Reproduction → life

3.) Basic difference is the detention time in the aeration tank; extended time being 6 to 8 hours & conventional time being usually 24 hours.

-30

4.)
0.7436
0.3800
.3636 SS.

.6000
.3800
.2200 VSS

$\frac{(.3636)(1{,}000{,}000)}{200} =$ ✓
1818 mg/l SS.

$\frac{(.2200)(1{,}000{,}000)}{200}$ ✓
1100 mg/l VSS

5.) a.) Take a pH reading with meter ✓
b.) Make a lime slurry & add to raise the pH
c.) Recheck with pH meter

6.) $\frac{290 - 42}{290} = \frac{248}{290} = 290\overline{)248.000}$ = .85

2320
1600
1450
1500

$.85 \times 100 = 85\%$ ✓

7.) 27
.40
10.80

10.8 mgd

1440 min/day

1440
10.8
11520
14400
15,552.0

15,552 gpm
flow rate of sludge recirculation

-2

8.) At a low F/M Ratio; the bacteria are less energetic, the food portion of the ratio is low, causing the bacteria to adhere together resulting in a better settling. This phase is called the endogenous respiration.

9.) a.) Both high + low D.O. can cause bulking
b.) High D.O. can cause a foaming condition
c.) Low D.O. can cause the tank to become septic resulting in a condition of nitrification, which in turn will result in a condition of rising sludge.

10.) We use a seed in our dilution water to assure a condition of bacteria in our sample, in the case of no bacteria being present in sample. If no bacteria were present in sample, at the end of 5 days, no results could be figured in the BOD test.

62

(1) 8.3 − 7.4 = .9

15)300 = 20

8.3 − 3.1 = 5.2 − .9 = 4.3

300 − 15 = 285

$\frac{4.3 \times 285}{300} = 14.8$ ✓

(2) Living Org. - Ammonia - ~~Nitrate~~ - Nitrites - Nitrates −10

(3) Ext. act. sldg. operates without primary settling and at longer detention time. and Ext requires less space. −10
Ext. works on smaller flows, Conv. ~~is~~ required on large ~~plants~~ flows

(4) .7436 − .3800 = .3636 SS

6000 − 3800 = 2200 VSS

$\frac{.3636 \times 1{,}000{,}000}{200} = 1811$ mg/L SS ✓

$\frac{.2200 \times 1{,}000{,}000}{200} = 1100$ mg/L VSS

(5) Monitor pH. and add lime to neutralize ✓

$$\frac{mg/L\ in - mg/L\ out}{mg/L\ in} \times 100$$ ✓

(6) 290 − 42 = 248 $\frac{248}{290}$ = 86%

(7) 2.27 Mgd
.40
10.80 Mgd recv.

1440
10.8
11520
14400
15,552

15,552 gpm recv −5

(8) Less ratio means less oxygen demand, floch sticks together and settles better and more dense. Conv. operates best in the endogenic phase. −3

(9) In some cases both will cause bulking, but usually low D.O. will. High D.O. causes floch to break up. D.O. range should be between 1.0 − 3.0 ppm ✓

(10) Seeded dil. water insures that some ~~D.O. will ...~~ nourishment will be available for bact. in case of industrial waste present. −10

(58)

1) 8.3 − 7.4 = 0.9 = 0.5   In. 8.3, Fin. 3.1 → 5.2 − .9 = 4.3

$(4.3)\frac{285}{300} = (7.4)(20) = 148$ mg/l ✓

2) Growth → Death → Decay → Nitrate → Nitrite → Grow   −10

3) Basic difference between ext. & Con. is the aeration time in the mix liquior tanks.   −20

4) a) 1st weighing 0.7436 g
wt of paper 0.3800 g
$\frac{3.636}{2} = 1.818$ S.S. mg/l   −5

b) 2nd weighing 0.6000 g
wt of paper 0.3800 g
$\frac{0.2200}{2} = 1.100$ VSS mg/l

5) Add lime to nutralize the acid and bring down to Ph. desired. ✓

6) Raw SS = 290 mg/l
EFF SS = -42 mg/l
248

$$290\overline{)248.00}$$ = 85 (.85)

2320
1600
1450
250

85 % ✓

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7) Sewage flow = 27 mgd
10,800,000.40 ≈ 11 mgd -2
(11 mgd) (1440 mpd) 15,840 gpm.

8) In an Ext. Aer. plant the settleability occurs best in the endogenious stage which is a low F/M ratio. the Con Aer. plant also has a " " " but not as low as Ext. (-10) -5

9) With a low D.O. the microorganisms will die off causing poor aerobic digestion of sludge. With a high D.O. the you will have a tending of the sludge to foam, bulk or shear the floc which is made by the microgenisms ✓

10) Seed is used in dilution water in case the sample you are using dose not have any bug in it. After 5 days you will still get a Do. with the Seed. ✓

(43)

① CALC BOD

INITIAL DO: 8.3

FINAL DO = 3.1

5.2 − .9 = 4.3

BLANK

VOL = 15 mL

INITIAL DO = 8.3

FINAL DO = 7.4

.9

$$\frac{(4.3)(285)}{300} = 148$$ ✓

BOD = 148 mg/l

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② [illegible] −10

③ THE BASIC DIFF BETWEEN THESE TWO VERY GOOD SYSTEM IS THE AERATION TIME 15

EXT = 6 CON. = 24

④ .7436 − 3800 = .3636 SS 6000 − 3800 = 2200 USS

$$\frac{363900}{200}$$ ✓

1820 mg/l

$$\frac{220000}{200}$$ ✓

1100 mg/l

(5) Add lime to PH up ✓

(6) RAW 290

EFF 42

248

$\frac{248}{290} = 85\%$ ✓

(7) 27 x 40 = 11 mgd

(11 mgd)(1440 min/day) = 15,800 gpm −5

−10

8 There is better settling because the bugs have less food therefore they sticks together better

(9) with a low DO you could kill off all the bacteria with a high DO we would get bugs that are too active and cause bulking. −7

(10) YOU SEED THE SOLUTION TO INSURE THAT THERE WILL BE SOME BACTERIA LEFT TO RECOVER

−10

33

(1) = 148 mg/l ✓

(10) TO CALULATE YOUR BOD in 5 days −10

(8) MORE BUG Than FOOD (BOD) −7

(4) 18.18 mg/l −5

(5) add Lime to raise Ph. ✓

(6) 8570 ✓

(3) Extended - Longer (24 hrs) aeration than Conventional (6 hrs) −15

(7) 1508 −5

(9) Low (To many Bugs - High = NOT enough Food −15

(2) growth of decomposition + recycling of Bugs. −10