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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation of activated sludge wastewater treatment plants. Included are objectives, instructor guides, student handouts and transparency masters. This is the second level of a three module series and considers aeration devices, process control procedures, microorganisms and data trend chart plotting. (Author/RH)

INTERMEDIATE ACTIVATED SLUDGE

Training Module 2.116.3.77

Prepared for the

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by

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September, 1977

SUMMARY

Module No.	Module Title: Intermediate Activated Sludge
	Topics:
Approx. Time 13 hours	1. Review - Design and Operation Parameters 2. Review - Aeration Devices 3. Control - Constant Mixed Liquor 4. Control - Constant F/M Ratio 5. Control - Constant Sludge Age 6. Control - Return Sludge Flow Control 7. Microorganisms 8. Data Trend Charts

Overall Objectives:

Upon completion of this module the student will have reviewed "traditional" process calculations and trend chart plotting, gained additional knowledge of control procedures, and should be able to calculate and plot process control parameters.

Instructional Aids:

Handouts
Transparancies
Calculator

Instructional Approach:

Lecture
Discussion
Exercise

References:

1. Water Pollution Control Federation MOP 11.
2. Recommended Standards for Sewage Works.
3. Operational Control Procedures for the Activated Sludge Process.

   A. Part III A
   B. Part III B
   C. Appendix
   D. Return Sludge Flow Control

4. Operator's Pocket Guide to Activated Sludge Parts I and II.
5. Basic Activated Sludge Module

Class Assignments:

1. Read handouts
2. Solve problems
3. Plot trend charts

Module No:	Topic: Intermediate Activated Sludge

Instructor Notes:	Instructor Outline:
	1. Handouts should be distributed as they appear in the module. 2. The module includes lecture, in class problem solutions and trend chart plotting. 3. 12 x 20 division per inch graph paper should be made available to the student for trend chart plotting. 4. A typical classroom setting is appropriate for delivery of this module. An overhead projector and screen is required. 5. Basic Activated Sludge is a suggested prerequisite 6. Recommended Standards for Sewage Works may be obtained from: (Nominal charge). Health Education Service P. O. Box 7283 Albany, N. Y. 12224 7. Operational Control Procedures for the Activated Sludge Process, Parts III A, III B, Appendix, and Return Sludge Flow Control may be obtained from: Environmental Research Center U. S. Environmental Protection Agency 26 W. St. Clair Street Cincinnati, Ohio 45268 8. Operator's Pocket Guides for the Activated Sludge Process, Parts I & II, may be ordered from: (Nominal charge). Stevens, Thompson & Runyan, Inc. 5505 S. E. Milwaukee Ave. Box 02201 Portland, Oregon 97202

Module No:	Topic: Intermediate Activated Sludge

Instructor Notes:	Instructor Outline:
	9. The evaluation includes the written examination and each student must plot data trend charts to the satisfaction of the instructor. 10. The instructor should at the close of the workshop encourage operators to begin trend charting process control data. The Advanced Activated Sludge Module is in part dependent on attendees bringing their trend charts to the Advanced Workshop.

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Review from Basic Activated Sludge
Approx. Time: 2 hours	Topic: Design and Operation Parameters

Objectives:

1. Given aeration tank dimensions, clarifier dimensions, flows and appropriate plant data; calculate: (a) Aeration tank detention time, (b) Clarifier surface overflow rate, (c) Pounds of BOD to aeration, (d) Pounds of solids under aeration, and (e) F/M.
2. List the three common process controls of the activated sludge facility.

Instructional Aids:

1. Student handout

Instructional Approach:

1. Lecture
2. Discussion
3. In class problem solution

References:

1. Basic Activated Sludge Module
2. Appendix, Operational Control Procedures for the Activated Sludge Process
3. Recommended Standards for Sewage Works (10 State Standards)

Class Assignments:

Module No:	Topic: Design and Operation Parameters
Instructor Notes:	**Instructor Outline:**
Student Handout I Review Problem	I. The Intermediate Activated Sludge Workshop begins with a review problem. Student Handout I contains the data required to solve for:

1) Aeration tank detention time
2) Clarifier surface overflow
3) Pounds of BOD to aeration
4) Pounds of solids under aeration
5) F/M

Solution:

Aeration tank volume = 25 x 75 x 12

= 22,500 cu. ft.

= 168,300 gallons

Clarifier surface area = 3.14 x 35 x 35/4

= 962 sq. ft.

Clarifier volume = 962 x 10

= 9,720 cu. ft.

= 71,958 gallons

Aeration tank detention time at flow alone

= 168,300 x 24/510,000

= 7.9 hours (design standard 6 - 8 hrs.)

Aeration tank detention time at total flow

= 168,300 x 24/(510,000 + 170,000)

= 5.9 hours

Pounds of BOD = 160 x 0.51 x 8.34

= 681 lbs. BOD

STUDENT HANDOUT 1

Given: Aeration tank 25' x 75' x 12'

Clarifier 35' diameter

10' mean depth

Raw sewage flow = 510,000 gal./day

Return sludge flow = 170,000 gal./day

Primary effluent BOD = 160 mg/l

Mixed liquor volatile suspended solids (MLVSS) = 2,200 mg/l

Find:
1. Aeration tank detention at flow alone and total flow
2. Pounds of BOD to aeration
3. Pounds of volatile solids under aeration
4. F/M
5. Clarifier surface overflow rate

Module No:	Topic: Design and Operation Parameters

Instructor Notes:	Instructor Outline:
	Pounds of MLVSS = 2,200 x 0.1683 x 8.34 = 3,088 lbs. MLVSS F/M = 681/3,088 = 0.22 (accepted range .2 - .5) Clarifier surface overflow rate = 510,000/962 = 530 gal./sq. ft./day (range 600 - 800) The design values from "10-State Standards" are shown in parentheses. Note that all of these values except clarifier surface overflow rate fall within the "accepted" ranges. It is to the "good" to have an overflow rate on the order of 500 gal/sq. ft./day. However, it is not the intent of this workshop to address design concepts, rather it is operational parameters and control. A few of the important operational parameters were reviewed in the first problem worked. Before expanding this list, address the common process controls available to the operator.
	II. Process Controls
10-State Standards	1. Air A) Design - 1,500 cu. ft./lb. BOD B) Operation - Maintain minimum of 2 mg/l of dissolved oxygen
10-State Standards	2. Return sludge flow A) Design - 15 to 75 percent of raw flow rate B) Removal of settled solids from secondary clarifier at a rate to allow optimum settling, to prevent undue accumulation of solids, and to satisfy the "needs" of the aeration tank.

Module No:	Topic: Design and Operation Parameters.

Instructor Notes:	Instructor Outline:
10-State Standards	3. Waste sludge flow Design - maximum capacity of not less than 25 percent of design average sewage flow. Capability of functioning at rate of 0.5 percent of average sewage flow or a minimum of 10 GPM, whichever is larger. Operation - primarily a function of the plant control methodology i.e. control to constant solids level or to a "sludge age". 4. Mode of operation Some operators are blessed with an additional degree of operational flexibility. The facility (activated sludge units or the secondary treatment system) may have the appropriate piping, valves and meters which allow "mode of operation" to be controlled. The conventional system with adjustments can be a step-feed system or even a contact stabilization system as process demands. The advantages of this flexible plant may be lost if the operator does not take advantage of the flexibility and incorporate sufficient process control testing and analyses into his control methodology. The operator has to turn the valves, the good operators turns the valves as a function of <u>process demands</u>. The operator who shrugs off less than acceptable treated effluent quality as "one of the periodic upsets" that all activated sludge facilities have, tends not to turn valves for reasons other than panic.
Attendees of the workshop should be encouraged to come to this workshop with tank dimensions of their facility and lab data. This section should include using some of	III. Process Parameters The wastewater treatment facility that is well operated generally routinely collects data, records data, plots trend charts, interprets data and charts and incorporates all of the above into a process control methodology.

Module No:	Topic: Design and Operation Parameters

Instructor Notes:	Instructor Outline:
the data from the students, calculating process parameters, and posting them on a data sheet.	This particular module will focus on the activated sludge secondary treatment parameters. That is not to say the pre-treatment and primary treatment parameters should be ignored. It is extremely important to document primary treatment, for example. Primary influent and effluent BOD and suspended solids should be routinely analyzed, the volume of primary sludge pumped, weight or volume of grit collected. Don't hide the data. Data recorded on matchbook covers and on coffee and acid stained yellow pads is data that frequently is ignored.
	Process data should be posted or plotted and displayed so that the data becomes an integral part of process control decision making.
Appendix, Operational Control Procedures for the Activated Sludge Process	Figure 6, Figure 3 of the Appendix displays how process data could be posted. On Page 2 of the same manual notice how trended (plotted) data charts and posted data can easily be viewed and used in making process control decisions. At least three additional parameters should be added to those shown on Figure 3, primary sludge flow, primary effluent BOD and mixed liquor suspended solids. COD values and ammonia nitrogen data are also appropriate for posting.

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Review from Basic Activated Sludge
Approx. Time: 1 hour	Topic: Aeration Devices

Objectives:

1. List the two usual type of blowers for supplying air to diffusers.
2. List three types of fine bubble diffusers.
3. List two types of large bubble diffusers.
4. Explain two alternatives for varying dissolved oxygen levels in aeration tanks provided with mechanical aerators.

Instructional Aids:

1. Transparancy

Instructional Approach:

Lecture
Discussion

References:

1. WPCF MOP 11

Class Assignments:

Module No:	Topic: Aeration Devices

Instructor Notes:	Instructor Outline:
	The Basic Activated Sludge Workshop briefly introduced how oxygen may be supplied to the aeration tank. Briefly review the diffused air system and mechanical aerators.
	I. Diffused air
A diagram of examples of fine and coarse bubble diffusers is provided.	A. Blowers, positive displacement or centrifugal
	B. Low pressure, 8 - 10 psi or less
	C. Large or small bubble, sparger or diffuser
	II. Mechanical Aerators
	A. Fixed platform mounted or floating
	B. Adjustment capability, weir adjustment or motor speed adjustment.
	C. Vertical draft tube
	D. Used in combination with diffused air
	III. Diffusers - plates, tubes, synthetic material
	IV. Spargers
	The purpose of the aeration device is to make oxygen available and to mix to assure that microorganisms come into contact with food.
	As energy conservation is of everyone's concern and the cost of energy continues to rise, the proper operation and maintenance of the aeration system is of prime importance.
	Panel mounted current measuring devices (ammeters) should be considered for every motor in a wastewater treatment facility, especially positive displacement and centrifugal blowers. Routine recording of what current a blower is drawing would greatly magnify the importance of cleaning filters and synthetic fiber

Module No:	Topic: Aeration Devices

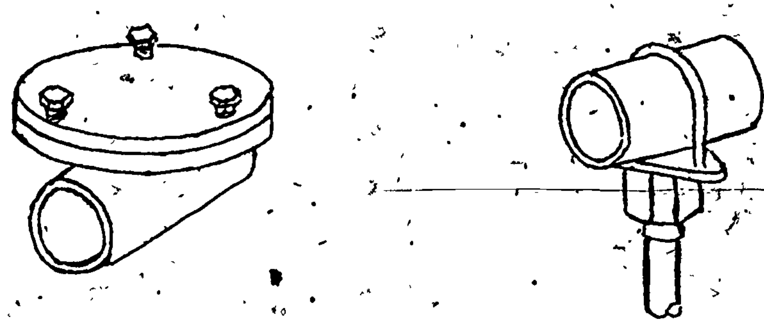
Instructor Notes:	Instructor Outline:

diffusers, for example. Such readings might alert the operator to potential trouble or break downs. At the very least a portable ammeter (amp-clamp) should be available and used to record blower performance. Pressure gauges on diffused air systems should also be maintained and routine readings recorded. A system which has been providing sufficient air at 8 psi whose operating pressure begins increasing may require diffuser cleaning. The same system whose operating pressure decreases probably has "blown" a diffuser and a type of short circuit has resulted with a lot of air going through the relatively larger opening created when the diffuser comes free or blows. A visual observation of the aeration tank will generally confirm this and the location of the blown diffuser.

Mechanical aerators also should be checked for the amount of electrical current the motors are drawing. The current increases as the depth of submergence of the "blades" of the mechanical aerator increases. There is a point at which the increased depth of submergence would result in little if any increase in the amount of oxygen supply to the aeration tank contents.

A dissolved oxygen probe should be given serious consideration. A level of dissolved oxygen (generally 2 mg/l) must be maintained, however, if dissolved oxygen measurements consistently run at 5 or 6 mg/l, dollars could probably, in fact undoubtedly, be saved by decreasing depth of submergence or cutting back on the diffused air system. The ammeter would confirm if reduced current is in fact being drawn.

FINE BUBBLE DIFFUSERS



COARSE BUBBLE DIFFUSERS

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Control Procedures
Approx. Time: 1 hour	Topic: Constant Mixed Liquor Volatile Suspended Solids (MLVSS)

Objectives:

1. Define MLVSS.
2. List the prime limitation in controlling at a constant MLVSS.
3. List the process control parameter used to maintain a constant MLVSS.
4. List the anticipated volume (gallons) of sludge to be wasted per million gallon of raw waste flow and the percentage.

Instructional Aids:

1. Student handout

Instructional Approach:

1. Lecture
2. Discussion
3. In class problem solving

References:

1. WPCF MOP 11

Class Assignments:

Module No:

Topic:

Control Procedures - Constant MLVSS

Instructor Notes:

Instructor Outline:

The basic activated sludge workshop briefly focused on three control methodologies. Each of these will be addressed and in some areas expanded.

Control to a constant Mixed Liquor Volatile Suspended Solids (MLVSS) concentration (or Mixed Liquor Total Suspended Solids, MLTSS) is one of the most common control methodologies practiced in activated sludge wastewater treatment facilities. The prime limitation to this control technique lies in the fact that it is based on the consistency of the raw waste load. Stated another way, a facility that experiences wide variations in the raw waste organic load (BOD) will probably not be able to be controlled successfully by maintaining a constant aeration tank solids concentration. A second limitation lies in the fact that return sludge flow control adjustments may not be made when needed, or as a function of process demand. Typically, facilities controlled by this technique rarely adjust return flows. The return sludge flow rate generally is set somewhere in the range of 25 to 33 (up to 50) percent of raw flow. Subsequent discussion of the "mass balance" equation will help explain this return sludge flow rate.

The primary process control parameter used to maintain the constant aeration tank solids concentration is waste sludge flow. Simply stated if the target solids concentration has been exceeded waste. If solids concentrations fall below target, decrease waste sludge flow. The volume of sludge that must be removed (wasted) will vary from plant to plant and is a function of the character of the waste and type of facility among other things. Generally a good starting point is between 0.5 and 1.5 % of the average daily sewage flow. Expressed in other terms the volume would range generally between 5,000 gallons and 15,000 gallons per day per million gallons of raw sewage flow.

Module No:	Topic: Control Procedures - Constant MLVSS
Instructor Notes:	**Instructor Outline:**

Instructor Notes:

Student Handout 2 - Problem to solve for aeration tank solids under a "constant MLTSS" mode of operation. It would also be appropriate to use data from any student who has "real world" data with him.

Instructor Outline:

The final topic is the determination of the optimum solids level that should be maintained. Recall that this control methodology is based on the premise that the raw waste load is reasonably consistent. It then remains to select an F/M ratio, measure the load (F) coming in, and calculate the concentration of solids necessary to satisfy the required value for M. The plant should then be operated at level for preferably one month. If effluent quality is good, maintain that level of solids. If effluent quality is not acceptable, select a new F/M ratio, confirm the load (F), and recalculate the required concentration of solids necessary to satisfy the required M.

Solution to Student Handout 2 Problem

Aeration tank volume = 16 x 32 x 12 x 7.48

= 45,957 gallons each

F = 0.3 x 165 x 8.34

F = 413 lbs. BOD

F/M = 0.3

M = 413/0.3

M = 1,377 lbs. solids

MLVSS = 1,377/2 x 0.045957 x 8.34

MLVSS = 1,800 mg/l

To increase MLVSS a decreased F/M must be selected. Therefore replace 0.3 with 0.2. Assume for this problem that the load has not changed.

F = 413 lbs. BOD

F/M = 0.2

M = 413/0.2

Module No:	Topic: Control Procedures - Constant MLVSS

Instructor Notes:	Instructor Outline:
	M = 2065 lbs. solids MLVSS = 2,065/2 x 0.045957 x 8.34 MLVSS = 2,690 mg/l

STUDENT HANDOUT 2

Given: Two aeration tanks, each 16' x 32' x 12'

Sewage flow BOD = 165 mg/l

Raw flow = 300,000 gallons per day

Select: F/M ratio (0.1 to 0.5)

Say 0.3

Find: Mixed liquor volatile suspended solids concentration required.

1. MLVSS = ________

Final effluent quality not acceptable. The appearance of the final clarifier indicates a higher concentration of solids would improve final effluent quality.

Select a revised F/M which would result in a higher concentration of solids and then solve for the new concentration.

2. MLVSS = ________

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Control Procedures
Approx. Time: 2½ hours	Topic: Constant F/M Ratio

Objectives:

1. List the process control parameters used to maintain a constant F/M ratio control and testing. (The flows and the laboratory analysis)
2. List the usual range of "accepted" F/M ratios.
3. List three disadvantages to control by this method.
4. Given appropriate data, calculate; a) Food (F), b) Micoorganisms (M), and c) F/M.
5. Given a basic conventional activated sludge schematic, label flows and concentrations, and list the mass balance equations.
6. Given appropriate data, utilizing the mass balance equation, solve for return sludge concentration needed for a given level of mixed liquor suspended solids.
7. Given appropriate data, calculate sludge weight to concentration ratio.

Instructional Aids:

1. Transparancies

Instructional Approach:

1. Lecture
2. Discussion
3. In class problem solution

References:

1. WPCF MOP 11
2. Part III A - Operational Control Procedures for the Activated Sludge Process

Class Assignments:

Module No:	Topic: Control Procedures - Constant F/M

Instructor Notes:	Instructor Outline:

The second control procedure to be reviewed is control to a constant F/M ratio. In order to control by maintenance of a constant F/M ratio it is necessary to routinely determine the strength of the load (BOD, COD, TOC e.g.), the concentration of solids under aeration (MLVSS or MLSS), raw sewage flow, and calculate values for F and M in order to determine if increased or decreased waste sludge flow is in order.

It is generally accepted that values for F/M should fall within the range of 0.1 to 0.5.

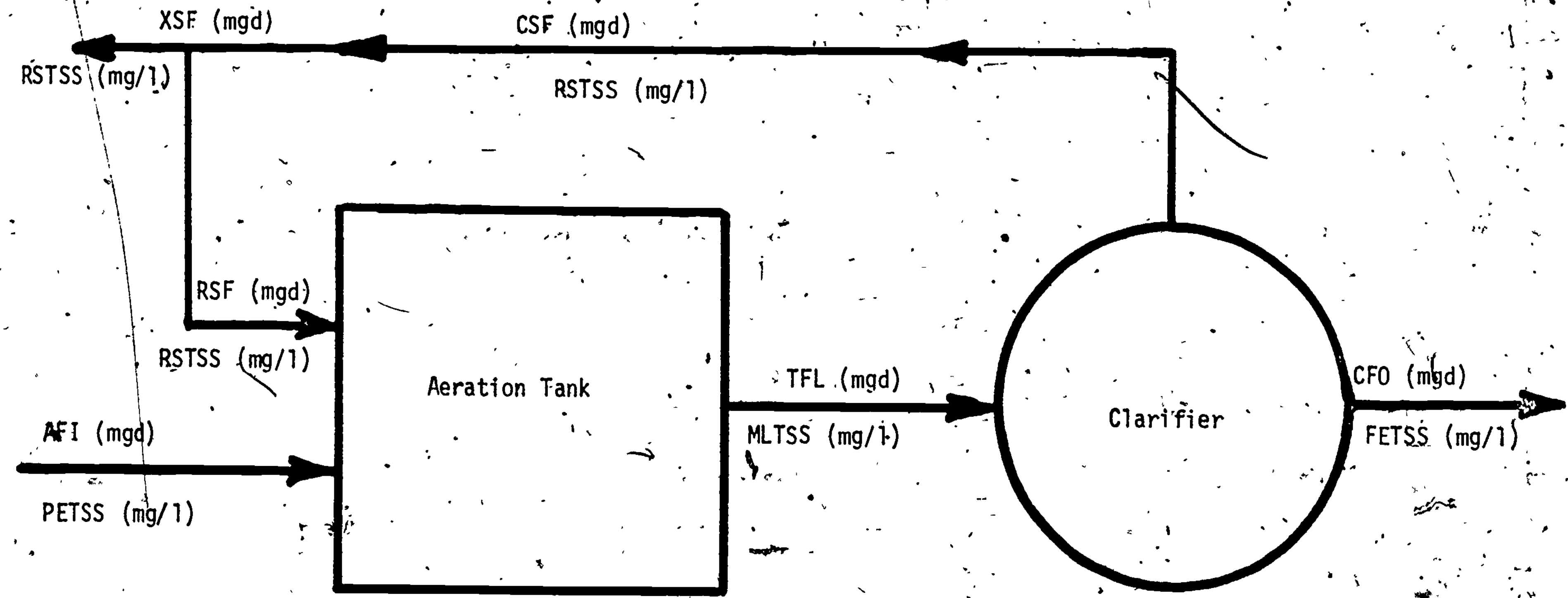
The disadvantages to control by this technique include:

1. The difficulty in obtaining a timely value of F (BOD is 5 day determination).
2. MLVSS determinations are not necessarily true measures of M (paper and dead cells show up as MLVSS).
3. Inability to make instantaneous changes in aeration tank solids concentrations.
4. F/M by itself gives little assistance to operator relative to return sludge flow adjustments.

The workshop began with a problem from Student Handout 1. If there was no difficulty with the problem, proceed. If there are any questions with solving for F or M or the F/M ratio, work another problem using data from the students.

One of the most significant parts of this module deals with the "mass balance equation". The operator must come to grips with this equation if he is to rise to an improved understanding of the activated sludge process. The starting point is the process flow schematic. The second step is to label all flows and to assign symbols to these flows and the concentration of solids in each "pipe".

Figure 1 - Conventional Activated Sludge Process Schematic



CONVENTIONAL ACTIVATED SLUDGE

PROCESS SCHEMATIC
Figure 1

Module No:	Topic: Control Procedures - Constant F/M

Instructor Notes:	Instructor Outline:

Recall that there is an equation which has been used in this module to solve for pounds, pounds of BOD or solids. You should recognize the following equations:

1. Pounds solids = Conc. (mg/l) x Volume (mg) x 8.34
2. Pounds solids per day = Conc. (mg/l) x Flow (mgd) x 8.34

The mass balance equation has as its simple premise:

Mass in equals mass out

Figure 2 - Flow Balance

Let's take one step backward before moving ahead. A flow balance should be readily understood. The flow balance premise is: Flow in equals flow out. Notice the different relationships which exist. The size of the clarifier and aeration tank do not change the relationships when the tanks are full. Flow balance is important in that sometimes process flow data can be calculated on occasion if some measured flow data is available. Flow balance equations should be done in your (the student's) facility.

Figure 3 - Mass Balance

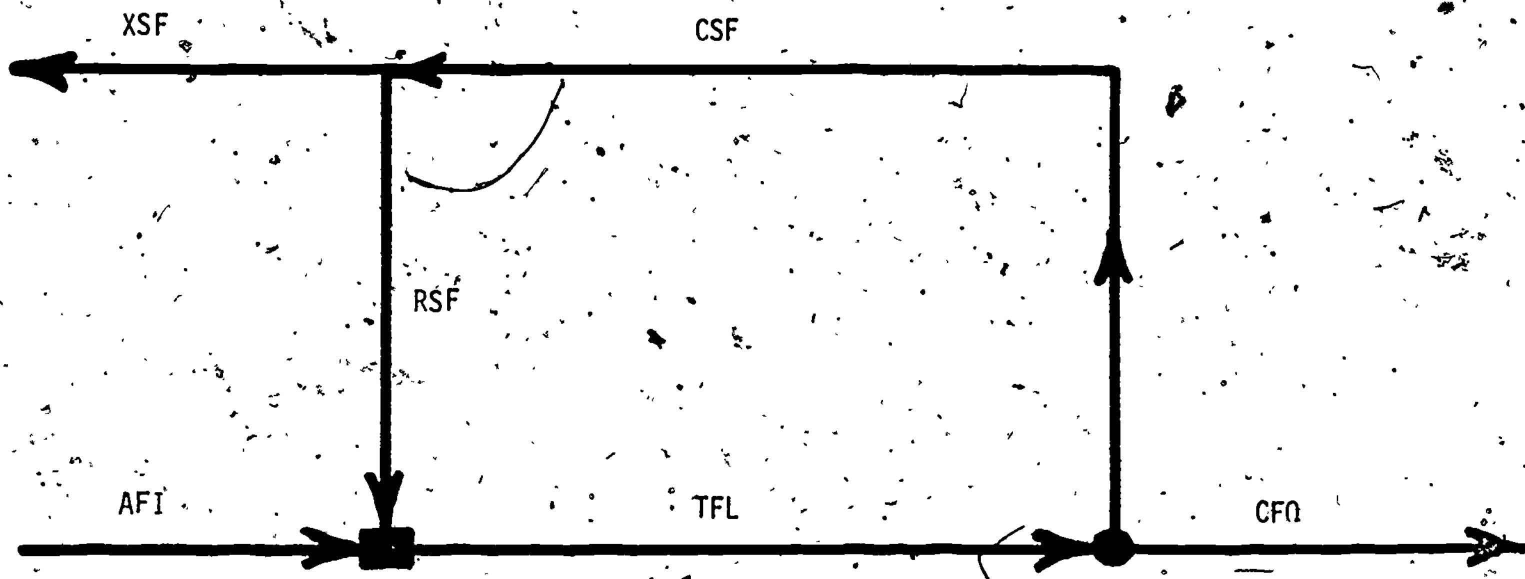
Return now to the mass balance equation:

Mass in equals mass out

Pounds will be the units of mass for our use. The equation now becomes:

Pounds in equals pounds out

Figure 3 is identical to Figure 1 except the aeration tank and clarifier have shrunk. The mass (pound) balance relationships should now be evident. The mass balance around the clarifier results in the following:



Flow in = Flow out

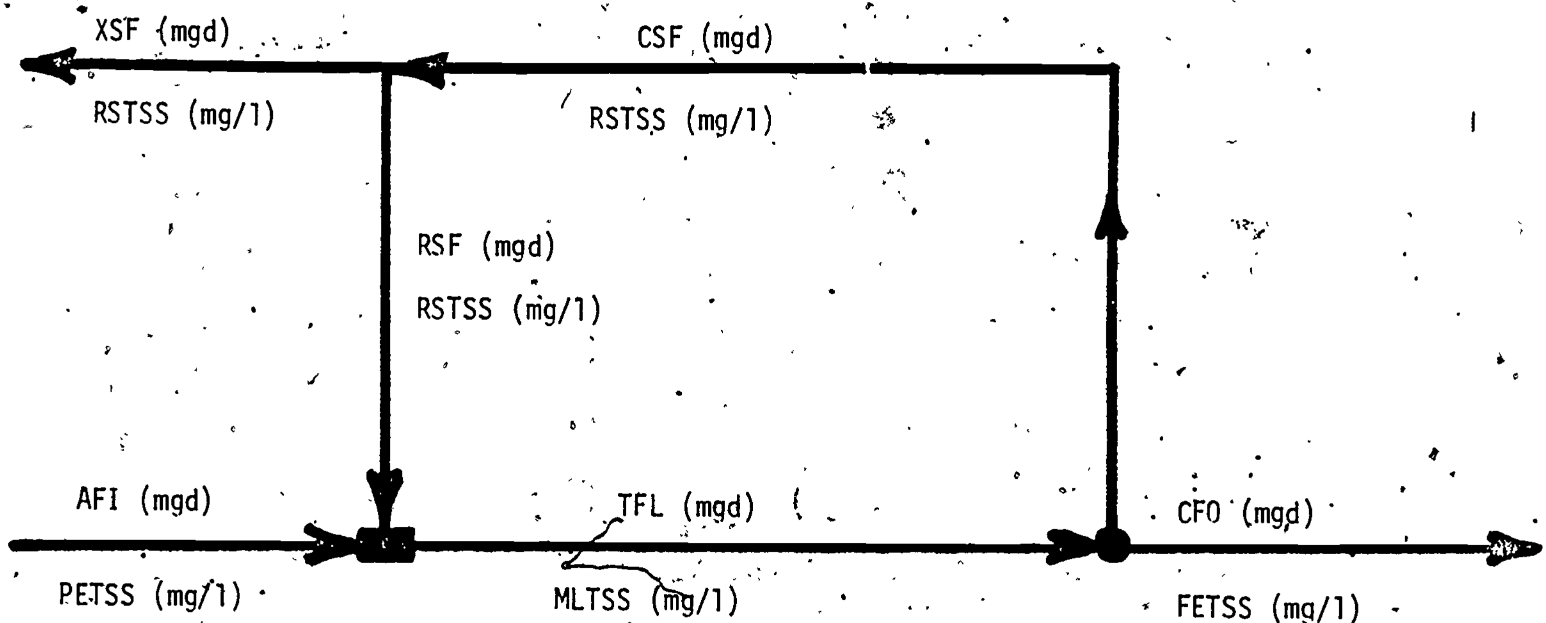
TFL = AFI + RSF

TFL = CFO + CSF

CSF = RSF + XSF

Figure 2

Flow Balance



Pounds/day = Flow (mgd) x Conc. (mg/l) x 8.34

Pounds in = Pounds out

Figure 3

MASS BALANCE

Module No:	Topic: Control Procedures - Constant F/M
Instructor Notes:	Instructor Outline:

TFL x MLTSS x 8.34 = CSF x RSTSS x 8.34 + CFO x FETSS x 8.34

First the 8.34 can be divided out resulting in:

TFL x MLTSS = CSF x RSTSS + CFO x FETSS

Next, FETSS, if final effluent quality is good, approaches zero. (At the very least it is very much smaller than either MLTSS and/or RSTSS).

The equation then becomes:

TFL x MLTSS = CSF x RSTSS

Moving around the system:

CSF x RSTSS = RSF x RSTSS + XSF x RSTSS

If there is no sludge being wasted, XSF = 0

CSF x RSTSS = RSF x RSTSS

Finally the mass balance around the aeration tank:

TFL x MLTSS = RSF x RSTSS + AFI x PETSS

These equations do have significance for the operator. The mass balance around the clarifier resulted in the following equation:

TFL x MLTSS = CSF x RSTSS

If XSF = 0

(AFI + RSF) x MLTSS = RSF x RSTSS

AFI x MLTSS + RSF x MLTSS = RSF x RSTSS

RSF x (RSTSS - MLTSS) = AFI x MLTSS

RSF = (AFI x MLTSS)/(RSTSS - MLTSS)

Module No:	Topic: Control Procedures - Constant F/M

Instructor Notes:	Instructor Outline:

This relationship can be of assistance to the operator trying to control to a constant aeratic tank solids concentration of F/M control. It is most important to understand that this relationship presumes no accumulation of solids in the clarifier. Other relationships can be derived and will be in subsequent topics of this module.

The centrifuge can be utilized as an operational test device and its use should be incorporated. It does not replace gravimetric solids determinations. It rather expands the operator' capability.

There are accepted, even required procedures for "self-monitoring" data. But, that does not mean that a test or analysis not in "Standard Methods" is not appropriate as a control test. Use of the centrifuge for solids concentration determinations falls into this catagory. Percent solids by volume can be easily determined using American Petroleum Institute (API) centrifuge tubes. Determine aeration tank concentration (ATC) and Return Sludge Concentration (RSC). The equation:

RSF = (AFI x MLTSS)/RSTSS - MLTSS)

Becomes:

RSF = (AFI x ATC)/(RSC - ATC)

The centrifuge values can be rapidly determined and this test and equation can be made a part of control procedure.

This relationship can be manipulated to give an expression for the return sludge concentration (RSC). The expression is:

RSC = (AFI + RSF) x ATC/RSF

The expression for RSF implies that given mixed liquor and return sludge concentrations and a level of flow into the aeration tank, the return

Module No:	Topic: Control Procedures - Constant F/M

Instructor Notes:	Instructor Outline:

sludge flow to maintain that system in balance can be found.

The expression for RSC implies that given the flow values and mixed liquor concentration, the return sludge concentration necessary to maintain a balanced system can be found.

However, there is nothing quite so simple. First of all the activated sludge process is a biological (living) process. The mass balance presented does not take into account the growth of new sludge in the aeration tank. The second concern is that the expression does not take into account the storage of sludge on occasion in the secondary clarifier. Finally the substitution for ATC = MLTSS and RSC = RSTSS assumes an identity relationship.

In other words ATC times a constant = MLTSS and RSC times a constant = RSTSS. If such were the case, gravimetric solids determinations could be replaced with solids determination by centrifuge, which is much easier. Such is generally not true, but the relationship and its relative change is worthy of consideration. Part III A terms this the "Sludge weight-to-concentration ratio" (WCR). The key is not the exactness of the numbers shown, rather the trend. In other words a WCR of 800 does not necessarily mean that your sludge is "normal". Your centrifuge may not rotate at the identical RPM's to the one used in Part II A. The operator watches the trend of the WCR in his plant. Increasing WCR's indicate the sludge is becoming relatively "older". Decreasing WCR's indicate the sludge is becoming relatively "younger".

Instructor note: Part III A, Operational Procedures for the Activated Sludge Process, Page 5.

To solve for WCR requires only the gravimetric mixed liquor solids determination and solids by centrifuge.

WCR = MLTSS/ATC

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Control Procedures
Approx. Time: 1 hour	Topic: Constant Sludge Age

Objectives:

1. Given appropriate data and the equations, solve for sludge age (cell residence time).
2. List two reasons why a "control" sludge age level might have to be adjusted.

Instructional Aids:

Instructional Approach:

1. Lecture
2. Discussion
3. In-class problem solving

References:

1. New York Manual
2. WPCF MOP 11
3. Part III.A
4. Operator's Pocket Guide

Class Assignments:

Module No:	Topic: Control Procedures - Constant Sludge Age
Instructor Notes:	Instructor Outline:

Probably two of the most difficult aspects of control to a constant sludge age are:

1. What equation should be used.
2. What sludge age value should be selected.

This module will not make your decision. It does seem appropriate to use the equation you the operator are most comfortable with. It also seems appropriate that more than one equation should be used and a selection then made based on which seems to work best or which best parallels process change.

With reference to a starting value for sludge age, once again no value is offered. Rather only that a value must be selected and then adjusted as a function of process demands.

WPCF MOP 11 offers the following equation for sludge age (S.A.):

S.A. = X (Va + Vc)/Qw Xu

Where

X = Average active microbrial solids concentration in the aeration tank, mg/l. (Or percent by centrifuge).

Va = Volume of aeration tank(s), gal.

Vc = Volume of final settling tank(s), gal.

Qw = Flow rate of sludge being wasted, GPD.

Xu = Average concentration of activated sludge in final settling tank underflow, mg/l. (Or percent by centrifuge).

The New York Manual states:

S.A. = V x A/Q x C

Where

V = Volume of aeration tank(s), gal.

Module No:	Topic: Control Procedures - Constant Sludge Age

Instructor Notes:	Instructor Outline:

A = Concentration of suspended solids in the aeration tank(s), mg/l.

Q = Sewage flow, GPD

C = Concentration of suspended solids in the sewage entering the aeration tank in mg/l exclusive of returned sludge.

The Operator's Pocket Guide suggests:

Cell Residence Time (CRT) = Total Solids/Solids Wasted

Where

Total solids = Lbs. solids in aeration tanks

Solids wasted = Lbs. solids wasted per day

NFIC Procedures uses centrifuge values and offers:

S.A. = (ASU + CSU)/TXU/Day

Where

ASU = % solids in aeration tank(s) times volume of aeration tank(s)

CSU = % solids in clarifier sludge blanket times the volume of the clarifier occupied by sludge

TXU/Day = % solids of sludge wasted times the volume of sludge wasted per day plus the % solids in the final effluent times the volume of final effluent per day.

WPCF MOP 11 states the one "truth" relative to each of these four equations, "The wasting procedure will affect the effectiveness of the activated sludge plant".

Module No:	Topic: Control Procedures - Constant Sludge Age

Instructor Notes:	Instructor Outline:

One additional comment relative to control by maintenance of a constant sludge age. This is a control methodology and that equation selected should lend itself to "control". For that reason the technique incorporating use of the centrifuge, its relative ease of solids determination, the ability to rapidly check the concentration of the solids being wasted, and thus to adjust the rate of waste sludge flow as frequently as desired seems quite appropriate.

Final comments address adjustment of the selected sludge age value itself.

Control to a constant sludge age implies an associated F/M. If the sludge age selected results in a process unrealistic F/M with final effluent quality unacceptable, a new sludge age would be selected.

A change in the sewage flow i.e., a seasonal variation, loss of or addition of a significant sewage flow contributor would require sludge age value adjustments.

Process indicators might dictate a change such as:

A. Denitrifying sludge in final clarifiers.

B. Sludge accumulation to excess in final clarifiers.

C. Appearance of great volume of white foam on aeration tanks.

D. Appearance of dark, greasy foam on aeration tanks.

E. Other process indicators which the operator should document in his own facility.

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Control Procedures
Approx. Time: 1 hour	Topic: Return Sludge Flow Control

Objectives:

1. Given appropriate data, calculate the return sludge flow demand.

Instructional Aids:

1. Handouts

Instructional Approach:

1. Lecture
2. Discussion
3. In-class problem solution

References:

1. Operational Control Procedures for the Activated Sludge Process, USEPA, Part III-A.
2. Return sludge flow control, USEPA.

Class Assignments:

Module No:	Topic: Control Procedures - Return Sludge Flow Control

Instructor Notes:	Instructor Outline:
	Activated sludge plants have the capability to adjust return sludge flow. If the operator is working at a facility whose flow is constant, whose sewage strength is constant, where everything is the same throughout the day and throughout the year, there is undoubtedly one value for return sludge flow. When this value was found, there would undoubtedly be no further need to adjust the return sludge flow. Having yet to see such a facility, it would seem appropriate to address a methodology for adjusting return (clarifier) sludge flow.
Part III A, Operational Control Procedures for the Activated Sludge Process	Consider the two extremes of sludge withdrawal from the clarifier. If clarifier sludge flow is too slow, sludge will accumulate in the clarifier until solids wash over the weir and are discharged. If sludge flow is too rapid, clear (treated) liquid is returned to the aeration tank. There would appear to be an optimum sludge flow somewhere within the extremes. The methodology described in Part III A is a logical approach to clarifier sludge flow control. A control test, mixed liquor allowed to settle, is observed. The sample's ability to concentrate is calculated. The clarifier sludge flow is adjusted to the end of matching the concentration of the clarifier sludge to the demonstrated ability to concentrate as shown by the settling test.
	The calculation procedure is quite simple, given the "target" time. Assume the clarifier sludge flow is being controlled to the sixty minute demand, sixty minute settled sludge concentration as determined from the settleometer and centrifuge tests. The equation and a sample problem are shown on Pages 40 and 41 of Part III A.
	Until such time that the "Part IV - "Process Control" pamphlet becomes available the following guidelines are suggested:

Module No:	Topic: Control Procedures - Return Sludge Flow Control

Instructor Notes:	Instructor Outline:
	1. Demand time selection (sixty minute demand means the settled sludge concentration calculated from the sixty minute settling value). Demand times will vary from plant to plant and even within one plant. Factors which influence demand time selection include secondary clarifier overflow rates, organic load, sludge quality, and hydraulic limitations. Clarifiers operating at high overflow rates generally dictate that relatively short (low) demand times be selected - thirty minutes, for example. Low overflow rates allow for relatively higher demand times - sixty to ninety minutes. In general the exactness of the calculated clarifier sludge flow demand is not as important as the direction of adjustment the result indicates, increase or decrease in clarifier sludge flow. Excessive adjustments should not be made. Adjustments should be limited to no more than 20 - 25% change. Hydraulic limitations must be determined for your facility. An example would be not reducing sludge flow to a level which results in plugging draft tubes or piping. For that matter sludge flows should not be raised to levels that result in excessive turbulence in the clarifier which would impede solids separation (settling). Other process indicators must not be ignored. Process control requires total process evaluation, judgment of process demands, control adjustment, continued testing, evaluation, and judgment etc.

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title:
Approx. Time: 1 hour	Topic: Microorganisms

Objectives:

1. Given pictures of microorganisms, match the picture of the organism to the name and what it might indicate.

Instructional Aids:

1. Transparencies

Instructional Approach:

1. Lecture
2. Discussion

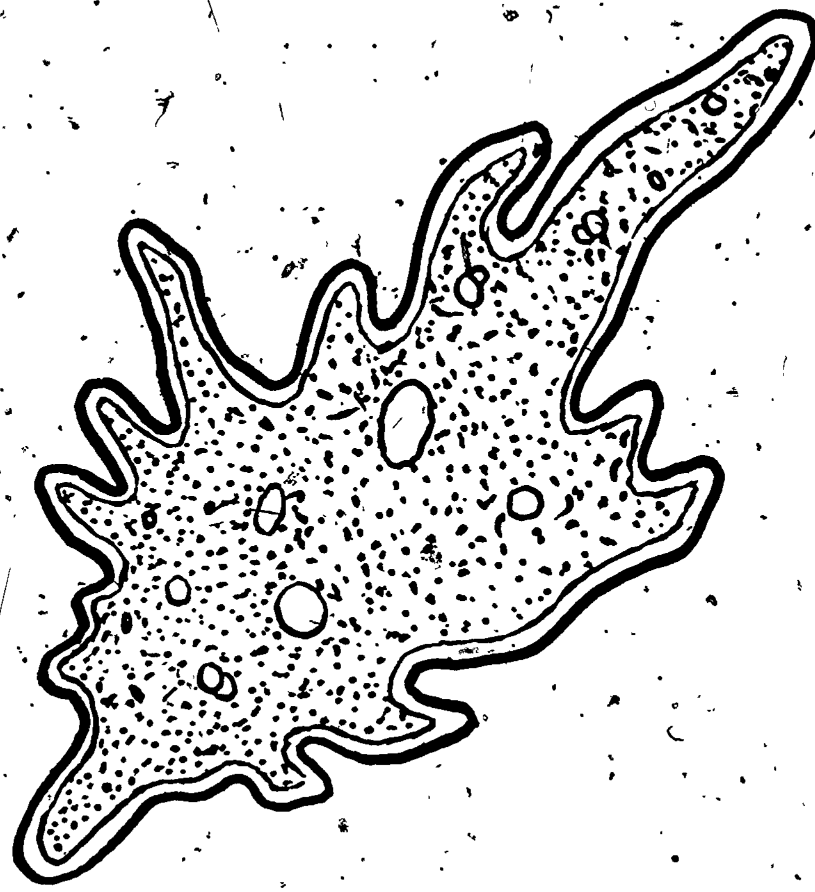
References:

1. WPCF MOP 11

Class Assignments:

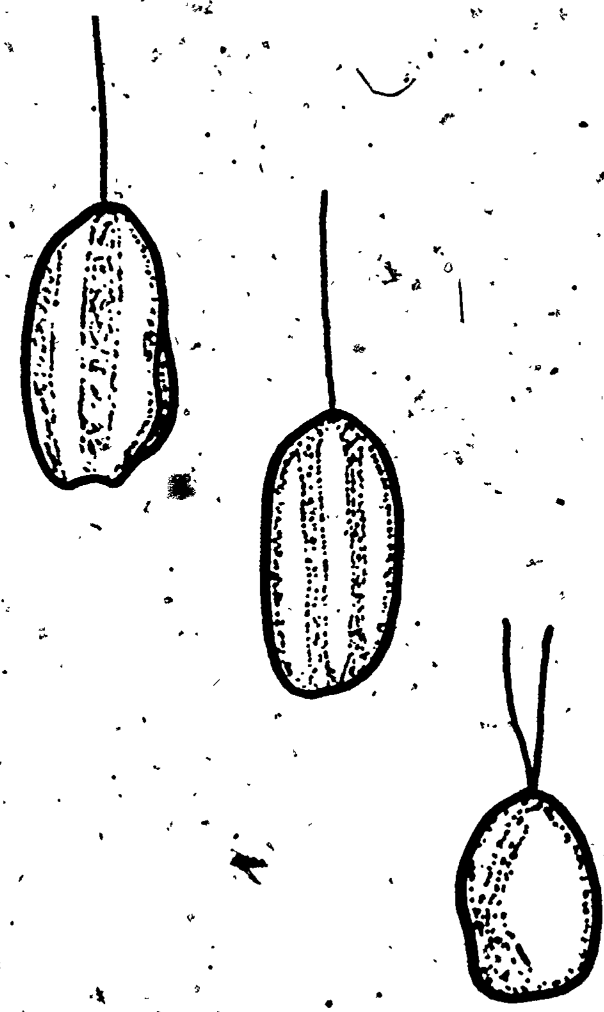
Module No:	Topic: Microorganisms

Instructor Notes:	Instructor Outline:
WPCF MOP 11	Every activated sludge treatment facility would be well advised to consider the purchase of a relatively inexpensive microscope. Daily microscope examination of a drop of the aeration tank contents can provide the operator information relative to process status. A notebook should be available to daily note the results of the observation, what organisms are noted, how the sludge floc appears, etc.
	WPCF MOP 11 offers the following general guide as to relative predomination of protozoa and efficiency in an activated sludge system:
Figure 4	1. Sarcodina predominate rarely and usually only in systems starting up or recovering from complete toxicity.
Figure 5	2. Holophytic flagellates occur at low efficiency when the organic waste concentration is high. In some high BOD concentration systems, the efficiency may be mathematically high, but there will still be a high concentration of organic matter remaining in the effluent.
Figure 5	3. Holozoic flagellates follow the decrease in holophytic flagellates. They indicate a slightly more efficient system. The holophytic and holozoic flagellates are flagellated protozoa.
Figure 6	4. Ciliates are found when there are a large number of free-swimming bacteria. When accompanied by flagellates, the free-swimming ciliates indicate a somewhat lower efficiency, while the presence of some stalked ciliates indicates a higher efficiency.
Figures 7 & 8	5. Stalked ciliates predominating indicate an activated sludge with a low BOD effluent. A very stable, well-operated conventional plant will have few stalked ciliates and, usually, no other protozoa forms.
Figure 9	6. Rotifers are present at a condition of very low BOD loading and high efficiency, indicating an approach toward total oxidation as represented by extended aeration treatment.



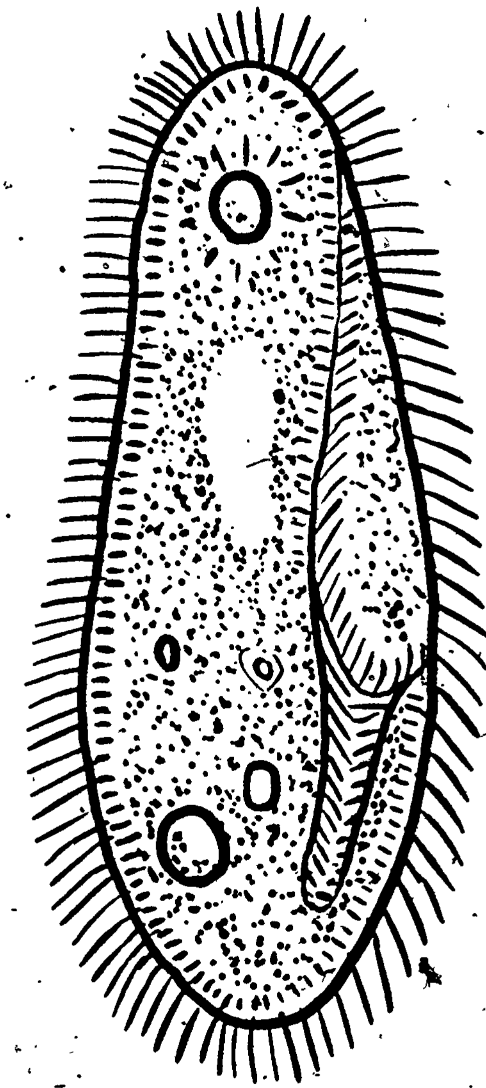
SARCODINA

Figure 4



Flagellates

Figure 5

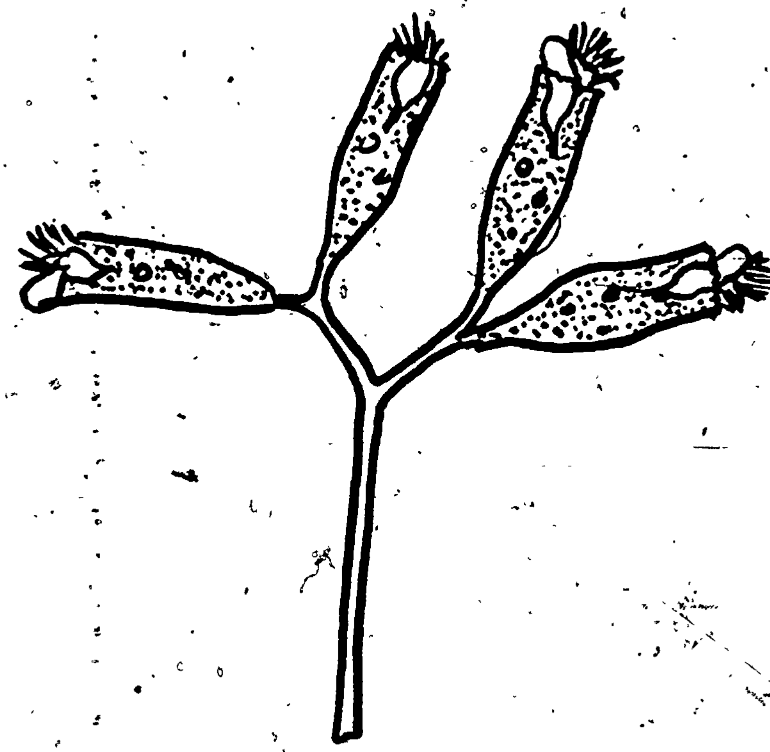


Ciliate

Figure 6

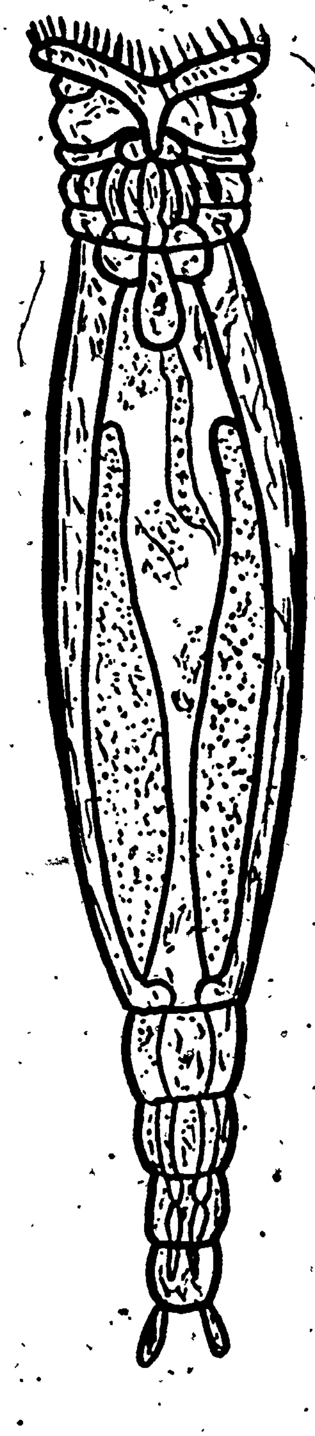
STALKED CILIATES

Figure 7



STALKED CILIATES

Figure 8



ROTIFER

Figure 9

Module No:	Topic: Microorganisms

Instructor Notes:	Instructor Outline:
	It is very important to note the relationship of sludge age to predominant micro-organisms. The listing above begins with "young" sludge and moves toward "old" sludge. It can then assist the operator in his waste sludge flow decisions to document through microscopic investigation, the predominate microorganisms.

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title: Data Trend Charts
Approx. Time: 3 hours	Topic:

Objectives:

1. Given appropriate data, plot trend charts:
   - A. Settling Test (SSV)
   - B. Concentrations (ATC, RSC, SSC)
   - C. Depth of sludge blanket (DOB)
   - D. Turbidity
   - E. Flows
   - F. Sludge age

Instructional Aids:

1. Transparencies
2. Handouts

Instructional Approach:

1. Lecture
2. Classroom problem solving

References:

1. Operator's Pocket Guide
2. Part III A

Class Assignments:

Module No:	Topic: Data Trend Charts

Instructor Notes:	Instructor Outline:

Instructor Notes:

Student handouts 3-1 through 3-12.

The instructor should provide graph paper, 12 x 20 divisions per inch.

Instructor Outline:

Ten days of data has been provided for trend chart plotting.

Plotting of the parameters A through D as noted in the "objectives" is a review exercise for those who have attended the Basic Activated Sludge workshop.

Recall the calculation procedure for the SSC values:

$$SSC_t = 1000 \times ATC/SSV_t$$

Graph paper, 12 x 20 divisions per inch should be available to the student.

The trending of flow data should present no great problem. The flow data shown on the operator's logs just below the "test time" are instantaneous flow rates in gallons per minute. Total flows in <u>thousand gallons per day</u> are noted on the bottom of the log sheets.

The sludge age trend chart could be plotted from data calculated from any of the four equations given in the "Control Procedures - Constant Sludge Age" topic of this module. With the understanding that trend charts are primarily an aid to process control it would seem appropriate to at least begin with the data and calculations that are relatively simple, use them and determine if the resultant trend charts truly become a part of your process control. If not, given a reasonable time (minimum of three months, preferably longer), abandon doing those trend charts which do not give you insight or assistance in process control decision making.

Sludge Age, actually cell residence time (CRT) in the Operator's Pocket Guide was defined as:

$$\frac{\text{Lbs. solids in aeration tanks}}{\text{Lbs. solids wasted per day}} = \text{CRT}$$

This parameter can also be calculated by using centrifuge values in place of gravimetric solids determinations. As a process control parameter consider the following equation:

Module No:	Topic: Data Trend Charts

Instructor Notes:	Instructor Outline:

Where

Aeration tank solids concentration % by volume = ATC

Aeration tank volume in million gallons = AVG

Concentration of solids being wasted % by volume, assuming a portion of return sludge is wasted = RSC

Rate of waste sludge flow in million gallons per day = XSF

$$\frac{ATC \times AVG}{RSC \times XSF} = CRT \text{ (Sludge Age)}$$

Note how easily this parameter can be calculated, two centrifuge values (ATC and RSC), a constant (AVG), and one flow (XSF). Student handout 3-12 contains sufficient data to practice calculating this parameter. Those facilities controlling to a constant sludge age should consider the merits of utilization of centrifuge data.

Notice that the units of volume can be gallons or million so long as the same units are used consistently. In other words if million gallons are used, use them all of the time.

Part III A identifies the product of a concentration, % by volume, times a volume as a "sludge unit".

Other operational control process parameters are readily calculated using centrifuge values. Return sludge concentrations can vary dramatically. Handout 3-11 displays this fact, the trend chart begun from the data sheets included in Handout 3. It should also provide process insight to plot what is termed return sludge units (RSU) in Part III A. Handout 3-12 contains sufficient data for this calculation also.

The incorporation of process control parameter calculations suggested in Part III A and data trend charts should be given strong consideration in activated sludge facilities.

Module No:	Topic: Data Trend Charts

Instructor Notes:	Instructor Outline:
	It is conceivable that not all would be necessary at all facilities, however, data trending should assist the operator in maintaining or improving treatment plant efficiency if a conscientious attempt is made to incorporate this methodology into process control decision making. Finally, Part III A contains many abbreviations. They represent a logical "shorthand" notation and should not be feared. For example the concentration of the aeration tank contents are labelled ATC, aeration tank concentration. The remaining time should be spent completing Handouts 3-1 through 3-12 and plotting trend charts.

DATE	1. RAW FLOW (MGD)	2. RETURN FLOW (MGD)	3. WASTE FLOW (MGD)	4. AVERAGE ATC (%)	5. AVERAGE RSC (%)	6. RSU (2×5)	7. ASU (AV×4)	8. XSU (3×5)	9. SLUDGE AGE (7/8)
4/27	.648	.358	.0216	8.23	17.67	6.33	3.465	.382	9
4/28	.595	.401	.0216	8.00	18.33	7.35	3.368	.396	8
4/29	.583	.386	.0173	7.80	17.27	6.67	3.284	.299	11
4/30	.624	.299	.0149	7.30	19.93	5.96	3.073	.297	10
5/1	.583	.257	.0072	7.13	19.63	5.04	3.002	.141	21
5/2	.566	.286	.0086	7.67	19.93	5.70	3.229	.171	19
5/3	.698	.310	.0086	8.07	23.07	7.15	3.397	.198	17
5/4	.691	.353	.0134	7.90	20.93	7.39	3.326	.280	12
5/5	.643	.353	.0163	8.07	20.20	7.13	3.397	.329	10
5/6	.631	.350	.0173	7.67	18.53	6.49	3.229	.321	10

GIVEN: AERATION TANK VOLUME = 0.421 MILLION GALLONS

SAMPLE CALCULATIONS:

RSU = .358 × 17.67 = 6.33

ASU = .421 × 8.23 = 3.465

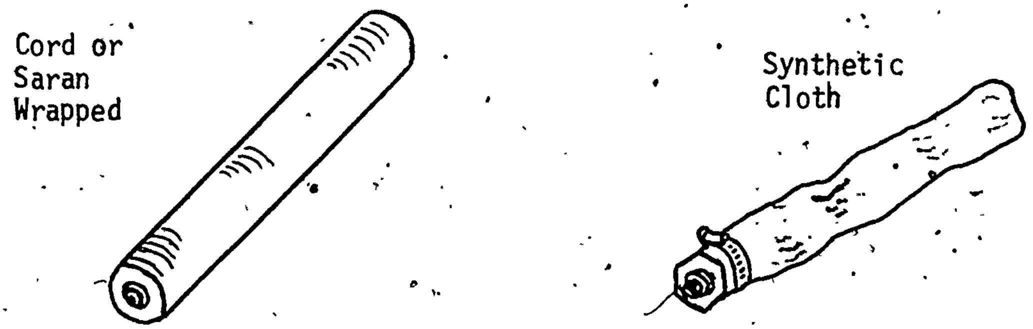
XSU = .0216 × 17.67 = .382

SLUDGE AGE = 3.465 ÷ .382 = 9

Module No:	Topic:

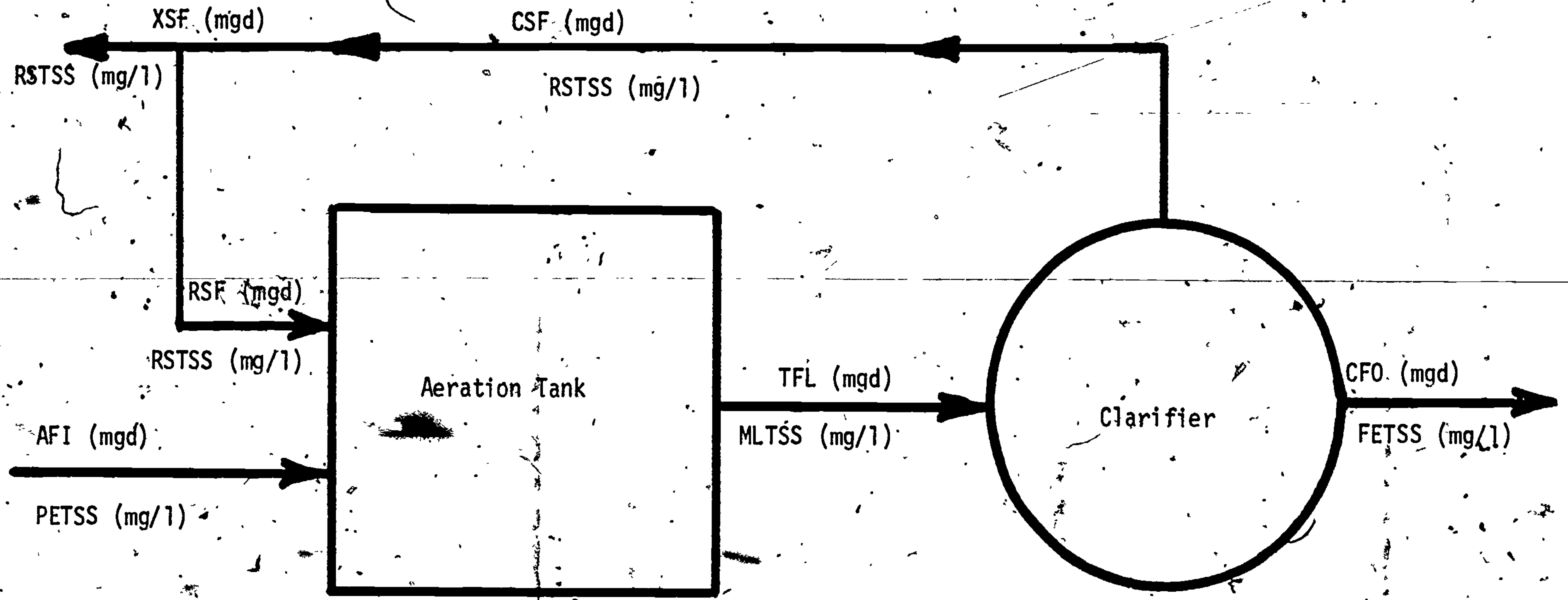
Instructor Notes:	Instructor Outline:
	The following materials are appended from which student handouts may be duplicated and transparancies produced:

	- Diffusers
Figure 1	- Conventional Activated Sludge Process Schematic
Figure 2	- Flow Balance
Figure 3	- Mass Balance
Figure 4 through 9	- Microorganisms
Student Handout 1	- One page
Student Handout 2	- One page
Student Handout 3	- Twelve pages



FINE BUBBLE DIFFUSERS

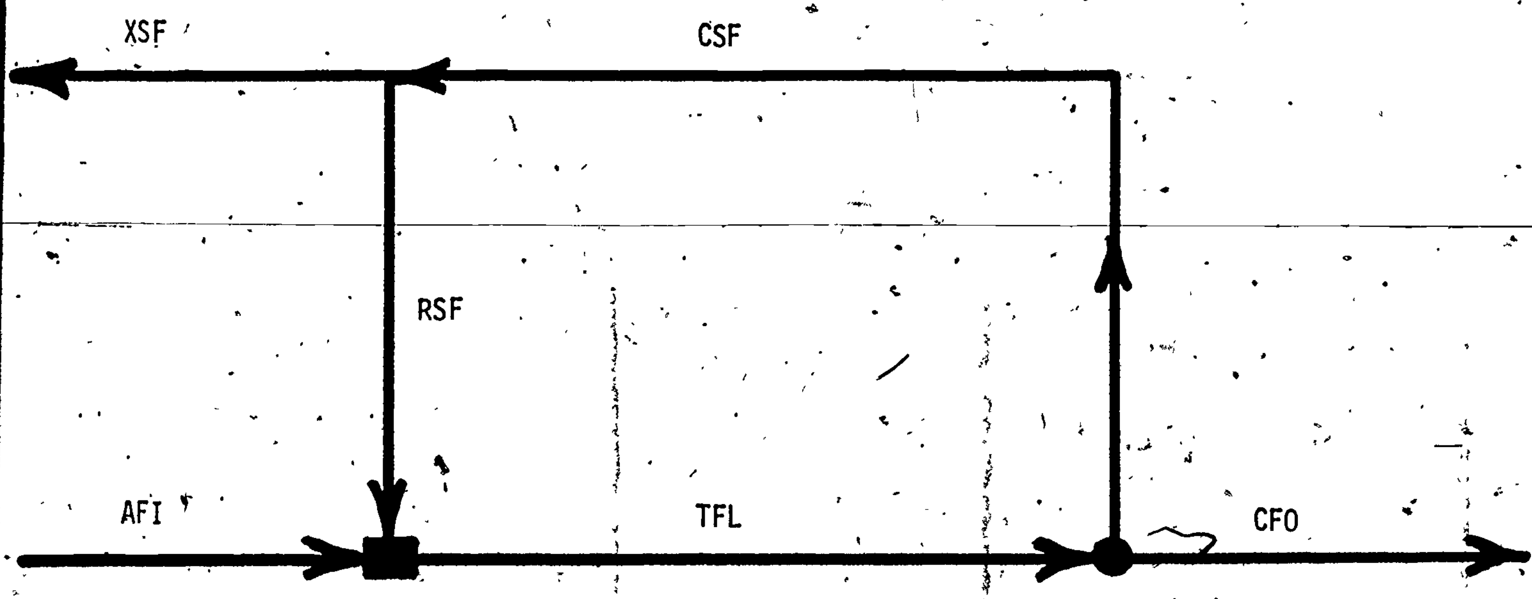
COARSE BUBBLE DIFFUSERS



CONVENTIONAL ACTIVATED SLUDGE

PROCESS SCHEMATIC

Figure 1



Flow in = Flow out

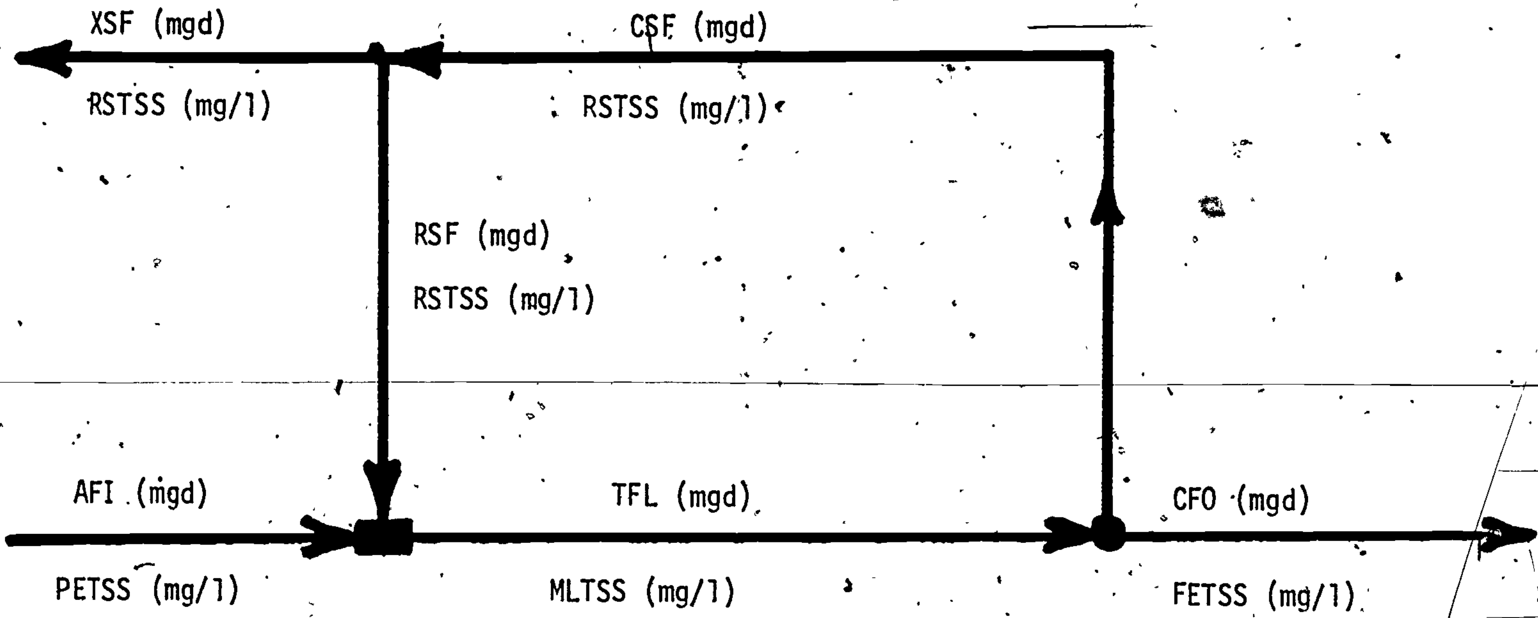
TFL = AFI + RSF

TFL = CFO + CSF

CSF = RSF + XSF

Figure 2

Flow Balance

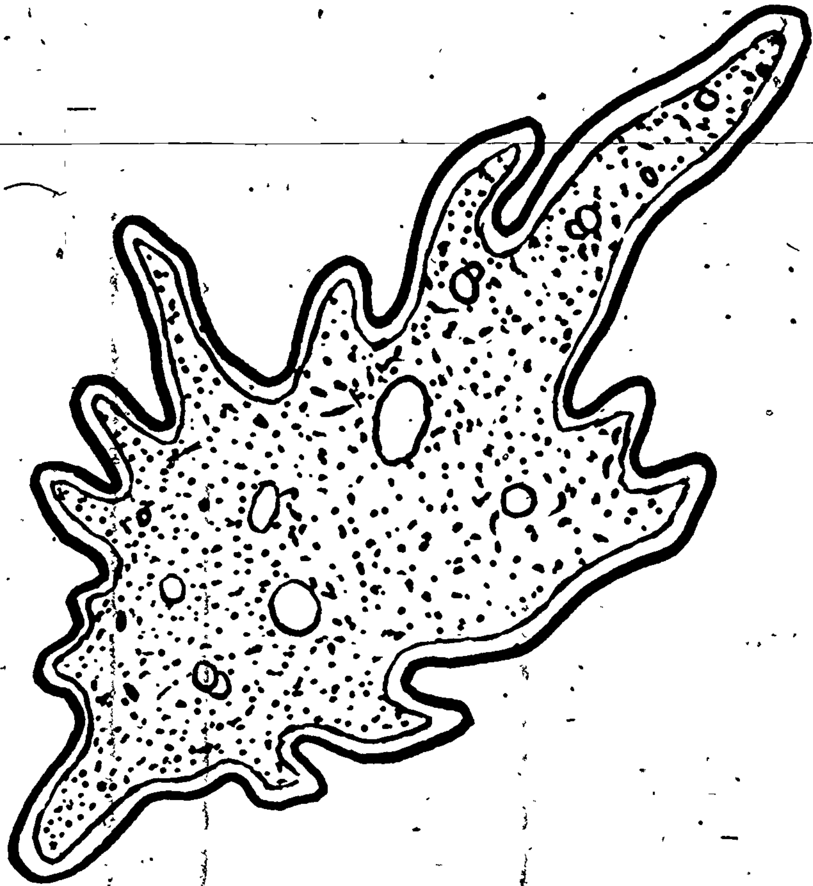


Pounds/day = Flow (mgd) x Conc. (mg/l) x 8.34

Pounds in = Pounds out

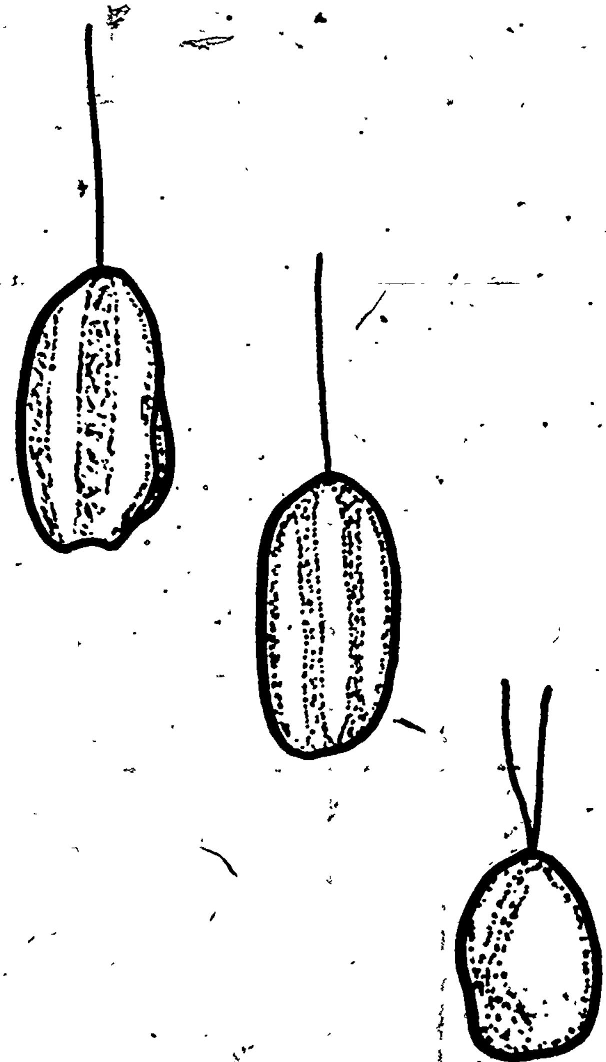
Figure 3

MASS BALANCE



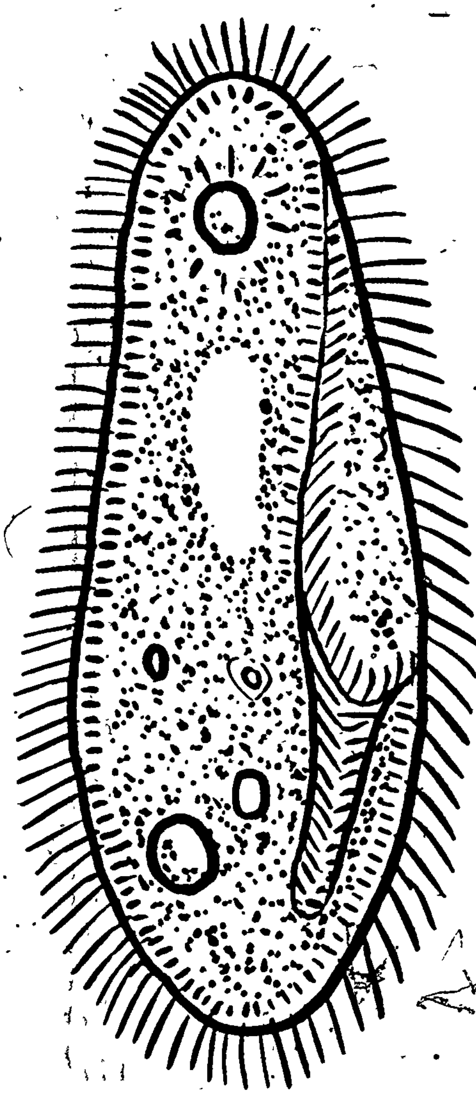
SARCODINA

Figure 4



Flagellates

Figure 5

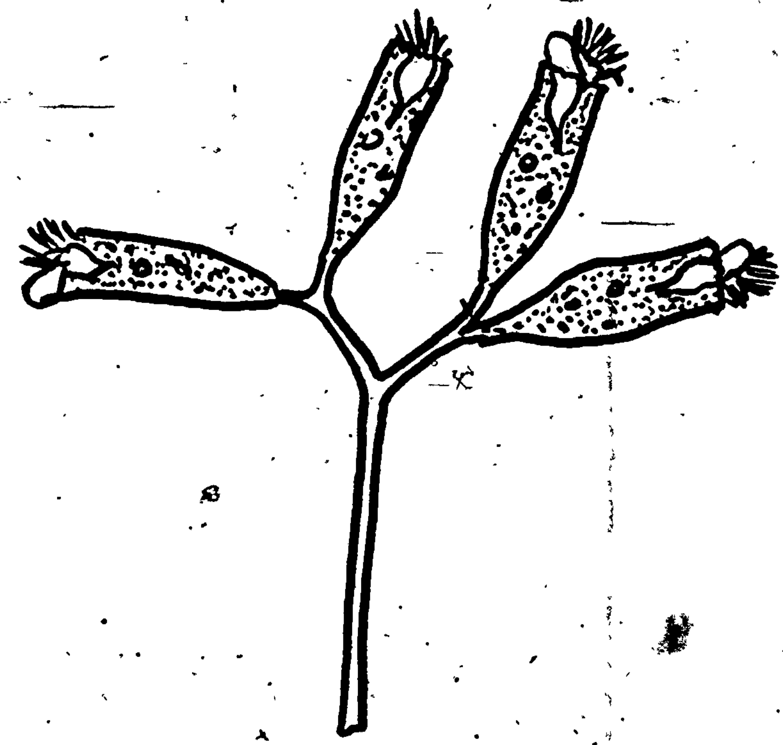


Ciliate

Figure 6

STALKED CILIATES

Figure 7



STALKED CILIATES

Figure 8

ROTIFER

Figure 9

STUDENT HANDOUT 1

Given: Aeration tank 25' x 75' x 12'

Clarifier 35' diameter

10' mean depth

Raw sewage flow = 510,000 gal./day

Return sludge flow = 170,000 gal./day

Primary effluent BOD = 160 mg/l

Mixed liquor volatile suspended solids (MLVSS) = 2,200 mg/l

Find:
1. Aeration tank detention at flow alone and total flow
2. Pounds of BOD to aeration
3. Pounds of volatile solids under aeration
4. F/M
5. Clarifier surface overflow rate

STUDENT HANDOUT 2

Given: Two aeration tanks, each 16' x 32' x 12'

Sewage flow BOD = 165 mg/l

Raw flow = 300,000 gallons per day

Select: F/M ratio (0.1 to 0.5)

Say 0.3

Find: Mixed liquor volatile suspended solids concentration required.

1. MLVSS = ________

Final effluent quality not acceptable. The appearance of the final clarifier indicates a higher concentration of solids would improve final effluent quality.

Select a revised F/M which would result in a higher concentration of solids and then solve for the new concentration.

2. MLVSS = ________

DATE 4/27/76

DAY

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 450			RAW FLOW 460			RAW FLOW 440		
RETURN FLOW 280			RETURN FLOW 245			RETURN FLOW 220		
WASTE FLOW 15			WASTE FLOW 15			WASTE FLOW 15		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000	8.3	0	1000	8.0	0	1000	8.4
5	700	11.86	5	900	8.89	5	850	9.88
10	590		10	820		10	720	
15	530		15	745		15	630	
30	450	18.44	30	580	13.80	30	500	16.80
45	420		45	500		45	460	
60	400	20.75	60	460	17.39	60	420	20.00
90			90			90		
ATC 8.3			ATC 8.0			ATC 8.4		
RSC 18.5			RSC 15.5			RSC 19.0		
DOB 6.8			DOB 5.5			DOB 6.5		
INITIAL TURBIDITY 17			INITIAL TURBIDITY 20			INITIAL TURBIDITY 12		
FINAL TURBIDITY 15			FINAL TURBIDITY 16			FINAL TURBIDITY 11		

Raw Flow 648
Return 358
Waste 21.6

DATE 4/28/76

DAY

TEST TIME 0800	TEST TIME 1600	TEST TIME 2400
RAW FLOW 370	RAW FLOW 420	RAW FLOW 450
RETURN FLOW 250	RETURN FLOW 280	RETURN FLOW 305
WASTE FLOW 20	WASTE FLOW 5	WASTE FLOW 20

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000	8.0	0	1000	8.0	0	1000	8.0
5	890	8.99	5	920	8.70	5	900	8.89
10	790		10	840		10	830	
15	710		15	770		15	770	
30	560	14.29	30	600	13.33	30	600	13.33
45	420		45	520		45	500	
60	460	17.39	60	460	17.39	60	450	17.78
90			90			90		

ATC 8.0	ATC 8.0	ATC 8.0
RSC 19.0	RSC 18.0	RSC 18.0
DOB 6.3	DOB 6.4	DOB 6.0
INITIAL TURBIDITY 14	INITIAL TURBIDITY 11	INITIAL TURBIDITY 14
FINAL TURBIDITY 12	FINAL TURBIDITY 8	FINAL TURBIDITY 11

RAW FLOW 595
RETURN 401
WASTE 21.6

DATE 4/29/76

DAY ______

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 420			RAW FLOW 475			RAW FLOW 320		
RETURN FLOW 290			RETURN FLOW 255			RETURN FLOW 260		
WASTE FLOW 12			WASTE FLOW 12			WASTE FLOW 12		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000	7.7	0	1000	7.7	0	1000	8.0
5	700	11.00	5	860	8.95	5	890	8.99
10	580		10	760		10	800	
15	510		15	680		15	730	
30	430	17.91	30	510	15.10	30	550	14.55
45	400		45	450		45	480	
60	380	22.00	60	420	18.33	60	440	18.18
90						90		
ATC 7.7			ATC 7.7			ATC 8.0		
RSC 16.8			RSC 19.0			RSC 16.0		
DOB 7.1			DOB 6.1			DOB 7.4		
INITIAL TURBIDITY 4.0			INITIAL TURBIDITY 3.8			INITIAL TURBIDITY 2.5		
FINAL TURBIDITY 3.6			FINAL TURBIDITY 3.0			FINAL TURBIDITY 2.2		

RAW FLOW 583

RETURN 386

WASTE 17.3

DATE 4/30/76

DAY ________

TEST TIME	0800	1600	2400
RAW FLOW	405	435	460
RETURN FLOW	190	208	225
WASTE FLOW	10	10	11

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000	7.6	0	1000	7.0	0	1000	
5	850	8.94	5	800		5	870	
10	750		10	680		10	770	
15	650		15	600		15	670	
30	510	14.90	30	460		30	500	
45	450		45	420		45	420	
60	410	18.54	60	390		60	390	
90			90			90		

ATC	7.6	7.0	7.3
RSC	19.8	21.0	19.0
DOB	6.8	6.8	6.0
INITIAL TURBIDITY	4.0	5.4	5.8
FINAL TURBIDITY	3.4	3.7	5.2

Raw Flow 624
Return 299
Waste 14.9

DATE 5/1/76

DAY ____

TEST TIME 0800
RAW FLOW 420
RETURN FLOW 170
WASTE FLOW 5

TIME	SSV	SSC
0	1000	
5	840	
10	700	
15	590	
30	450	
45	400	
60	380	
90		

ATC 7.0
RSC 21.0
DOB 7.8
INITIAL TURBIDITY 5.0
FINAL TURBIDITY 4.5

TEST TIME 1600
RAW FLOW 370
RETURN FLOW 190
WASTE FLOW 5

TIME	SSV	SSC
0	1000	
5	840	
10	710	
15	620	
30	490	
45	430	
60	400	
90		

ATC 7.0
RSC 18.9
DOB 7.5
INITIAL TURBIDITY 5.5
FINAL TURBIDITY 4.7

TEST TIME 2400
RAW FLOW 425
RETURN FLOW 175
WASTE FLOW 5

TIME	SSV	SSC
0	1000	
5	850	
10	710	
15	610	
30	480	
45	430	
60	390	
90		

ATC 7.4
RSC 19.0
DOB 7.8
INITIAL TURBIDITY 5.0
FINAL TURBIDITY 4.4

RAW FLOW 583
RETURN 257
WASTE 7.2

DATE 5/2/76

DAY

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 360			RAW FLOW 415			RAW FLOW 405		
RETURN FLOW 190			RETURN FLOW 190			RETURN FLOW 215		
WASTE FLOW 6			WASTE FLOW 6			WASTE FLOW 6		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	890		5	900		5	930	
10	800		10	800		10	850	
15	710		15	700		15	770	
30	540		30	530		30	580	
45	460		45	460		45	490	
60	420		60	410		60	440	
90			90			90		
ATC 8.0			ATC 7.4			ATC 7.6		
RSC 18.0			RSC 22.0			RSC 19.8		
DOB 7.7			DOB 6.5			DOB 7.0		
INITIAL TURBIDITY 7.2			INITIAL TURBIDITY 25			INITIAL TURBIDITY 22		
FINAL TURBIDITY 5.8			FINAL TURBIDITY 23			FINAL TURBIDITY 20		

Raw Flow 566

Return 286

Waste 8.6

DATE 5/3/76

DAY ______

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 465			RAW FLOW 490			RAW FLOW 500		
RETURN FLOW 190			RETURN FLOW 210			RETURN FLOW 245		
WASTE FLOW 6			WASTE FLOW 6			WASTE FLOW 6		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	930		5	900		5	800	
10	860		10	800		10	690	
15	800		15	690		15	600	
30	620		30	520		30	490	
45	530		45	460		45	440	
60	450		60	420		60	410	
90			90			90		
ATC 7.5			ATC 8.6			ATC 8.1		
RSC 22.0			RSC 24.0			RSC 23.2		
DOB 5.0			DOB 5.5			DOB 7.0		
INITIAL TURBIDITY 27.0			INITIAL TURBIDITY 10			INITIAL TURBIDITY 7.0		
FINAL TURBIDITY 23			FINAL TURBIDITY 7.1			FINAL TURBIDITY 6.5		

RAW FLOW 698

RETURN 310

WASTE 8.6

DATE 5/4/76

DAY ______

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 500			RAW FLOW 480			RAW FLOW 460		
RETURN FLOW 250			RETURN FLOW 230			RETURN FLOW 255		
WASTE FLOW 8			WASTE FLOW 8			WASTE FLOW 12		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	800		5	830		5	940	
10	650		10	710		10	880	
15	560		15	620		15	820	
30	450		30	490		30	670	
45	410		45	440		45	550	
60	390		60	410		60	480	
90			90			90		
ATC 8.0			ATC 8.0			ATC 7.7		
RSC 19.0			RSC 23.0			RSC 20.8		
DOB 5.1			DOB 6.0			DOB 6.8		
INITIAL TURBIDITY 18			INITIAL TURBIDITY 12			INITIAL TURBIDITY 12		
FINAL TURBIDITY 15			FINAL TURBIDITY 10			FINAL TURBIDITY 11		

RAW FLOW 691
RETURN 353
WASTE 13.4

DATE 5/5/76

DAY ______

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 450			RAW FLOW 450			RAW FLOW 440		
RETURN FLOW 280			RETURN FLOW 220			RETURN FLOW 235		
WASTE FLOW 12			WASTE FLOW 12			WASTE FLOW 10		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	860		5	790		5	910	
10	720		10	650		10	820	
15	630		15	560		15	740	
30	480		30	460		30	560	
45	430		45	410		45	510	
60	390		60	390		60	430	
90			90			90		
ATC 8.0			ATC 7.8			ATC 8.4		
RSC 17.8			RSC 20.8			RSC 22.0		
DOB 5.9			DOB 6.5			DOB 7.1		
INITIAL TURBIDITY 14			INITIAL TURBIDITY 14			INITIAL TURBIDITY 6.0		
FINAL TURBIDITY 12			FINAL TURBIDITY 11			FINAL TURBIDITY 5.5		

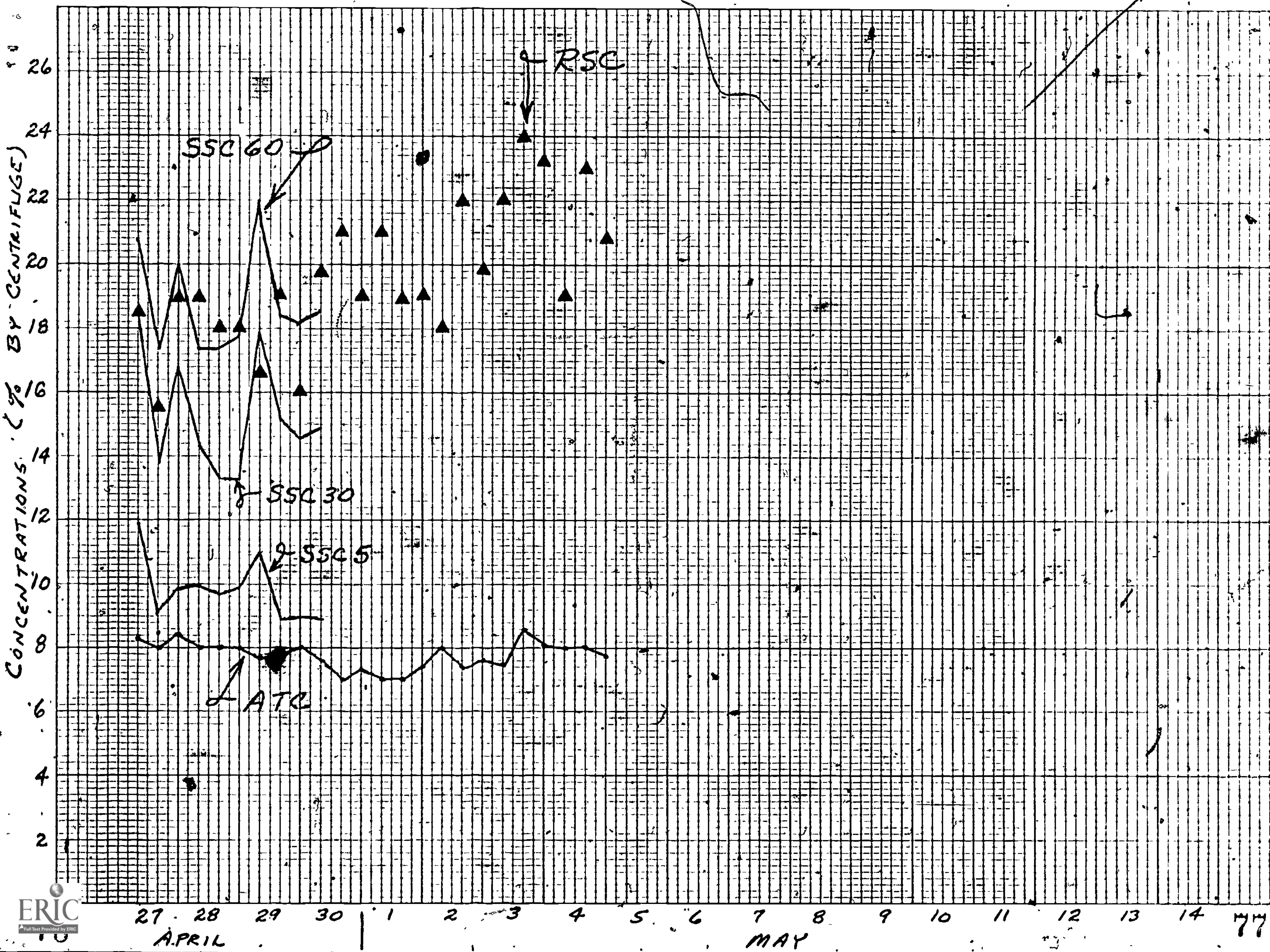
RAW FLOW 643
RETURN 353
WASTE 16.3

DATE 5/6/76

DAY ____

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 430			RAW FLOW 450			RAW FLOW 435		
RETURN FLOW 225			RETURN FLOW 250			RETURN FLOW 255		
WASTE FLOW 12			WASTE FLOW 12			WASTE FLOW 12		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	770		5	490		5	910	
10	640		10	450		10	830	
15	560		15	430		15	750	
30	450		30	410		30	580	
45	410		45	400		45	490	
60	390		60	390		60	440	
90			90			90		
ATC 8.3			ATC 7.1			ATC 7.6		
RSC 18.5			RSC 20.0			RSC 17.1		
DOB 6.6			DOB 7.0			DOB 7.0		
INITIAL TURBIDITY 6.7			INITIAL TURBIDITY 3.5			INITIAL TURBIDITY 4.6		
FINAL TURBIDITY 5.1			FINAL TURBIDITY 3.2			FINAL TURBIDITY 4.2		

RAW FLOW 631
RETURN 350
WASTE 17.3



CONCENTRATIONS (% BY CENTRIFUGE)
26
24
22
20
18
16
14
12
10
8
6
4
2
RSC
SSC 60
SSC 30
SSC 5
ATC
27
28
29
30
1
2
3
4
5
6
7
8
9
10
11
12
13
14
APRIL
MAY

DATE	1. RAW FLOW (MGD)	2. RETURN FLOW (MGD)	3. WASTE FLOW (MGD)	4. AVERAGE ATC (%)	5. AVERAGE RSC (%)	6. RSU (2×5)	7. ASU (AV×4)	8. XSU (3×5)	9. SLUDGE AGE (7/8)
4/27	.648	.358	.0216	8.23	17.67	6.33	3.465	.382	9
4/28	.595	.401	.0216	8.00	18.33	7.35	3.368	.396	8
4/29	.583	.386	.0173	7.80	17.27				
4/30	.624	.299	.0149	7.30					
5/1	.583	.257	.0072						
5/2	.566	.286							
5/3	.698	.310							
5/4	.691	.353							
5/5	.643								
5/6	.631								

GIVEN: AERATION TANK VOLUME = 0.421 MILLION GALLONS

SAMPLE CALCULATIONS:

RSU = .358 × 17.67 = 6.33

ASU = .421 × 8.23 = 3.465

XSU = .0216 × 17.67 = .382

SLUDGE AGE = 3.465 ÷ .382 = 9

Module No:	Module Title: Intermediate Activated Sludge
	Submodule Title:
Approx. Time:	EVALUATION

Objectives:

The learner will demonstrate that he has achieved the objectives of the module by correctly answering 75% of the following questions:

1. Given:

   Two aeration tanks each 30' x 30' x 11'

   Two final clarifiers each 12' x 52' x 8'

   Flow = 460,000 gal./day

   BOD = 118 mg/l

   MLTSS = 3100 mg/l

   Calculate:

   A. Aeration tank detention time ________

   B. Clarifier surface overflow rate ________

   C. Pounds of BOD to aeration ________

   D. Pounds of solids under aeration ________

   E. F/M ________

2. List the three common process controls variables available at the typical activated sludge facility.

   ____

   ____

   ____

3. Match the following:

   Types of blowers which supply air to diffusers.

   A. ____

   A. ____

   A. Synthetic sock

   B. Porous plate

   C. Positive displacement

Coarse bubble diffusers

B._____

B._____

Fine bubble diffusers

C._____

C._____

C._____

D. Sparger

E. Porous tube

F. Centrifugal

G. Large hole diffuser

4. An aeration tank has been provided with a surface mechanical aerator. Explain two possible alternatives for varying the dissolved oxygen level.

____

____

5. BOD is biochemical oxygen demand. What is MLVSS?____________

6. What is the prime limitation in controlling a constant MLVSS?

____

____

7. What is the primary process control variable (parameter) used to maintain a constant MLVSS?

____

8. An activated sludge plant is treating one million gallons of wastewater per day. What is the anticipated volume of waste sludge flow at this conventional activated sludge?

__________ gal./day

__________ % of raw flow

9. A conventional activated sludge facility is controlling to a constant F/M ratio. What are the primary process control variables (parameters) and

PAGE 3 of 7 MISSING PRIOR TO BEING SHIPPED TO EDRS FOR FILMING.

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2500 mg/l, concentration of return sludge of 6,000 mg/l and is wasting from the return sludge flow at a rate of 40,000 gallons per day. Calculate the sludge age.

SA = ______________________

15. List two reasons why a "conrol" sludge age level might have to be adjusted.

____

____

16. An activated sludge facility is controlling return sludge flows by the "return sludge flow demand". Control is being adjusted to meet the ninety minute demand time. The current Return Sludge Flow is 1.0 MGD.

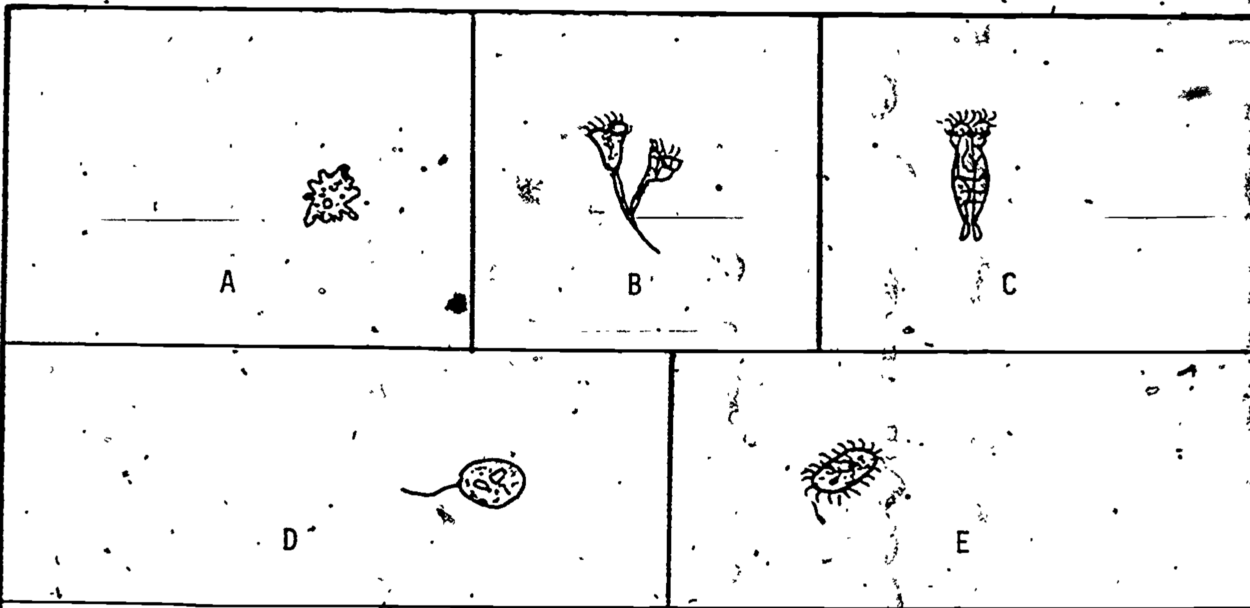
SSC 90 = 15.9%

ATC = 4.5%

RSC = 14.5%

If RSFD = FSF (RSC - ATC)/(SSC 90 - ATC), calculate the value for the Return Sludge Flow demand.

RSFD = ______________________



17. Match the names to the appropriate pictures:

A._____	A. Flagellate
B._____	B. Rotifer
C._____	C. Stalked ciliates
D._____	D. Sarcodina (amoeboid)
E._____	E. Ciliate

18. Arrange the organisms in order of those which would indicate the "youngest" to the "oldest" sludge.

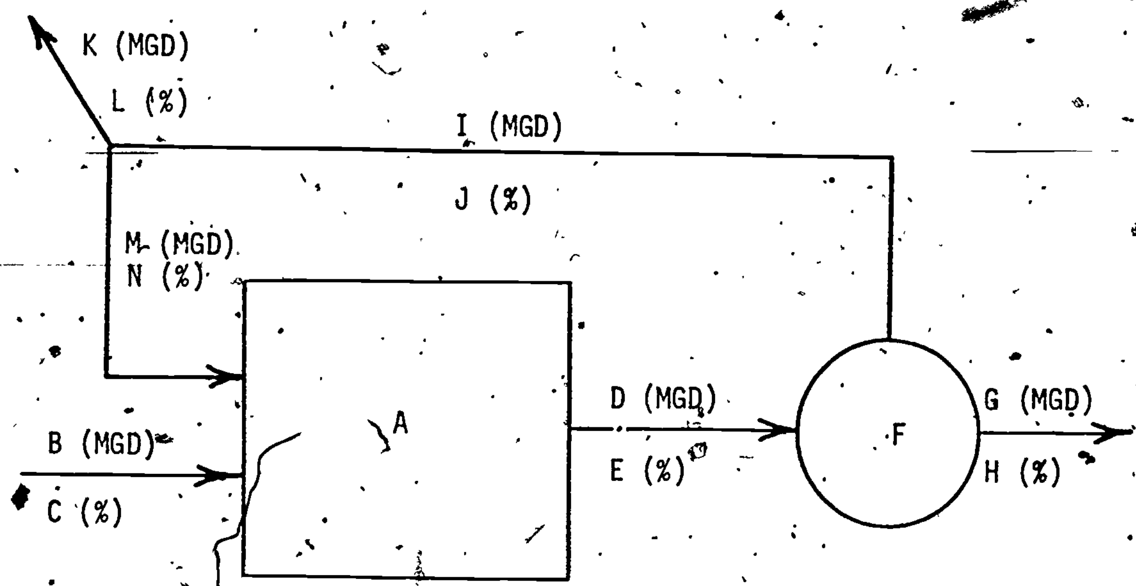
A._____

B._____

C._____

D._____

E._____



19. Match the following:

A._____	A. Concentration of wolids in waste sludge flow (XSC).
B._____	B. Secondary (final) clarifier.
C._____	C. Concentration of solids in clarifier sludge flow (RSC)
D._____	D. Raw waste flow into aeration tank (AFI).
E._____	E. Concentration of solids in return sludge flow into aeration tank (RSC).
F._____	F. Clarifier overflow (CFD).
G._____	G. Concentration of solids in raw waste flow into aeration tank (PEC).
H._____	H. Aeration tank.
I._____	I. Return sludge flow into aeration tank (RSF).
J._____	J. Concentration of solids in final clarifier overflow (FEC).
K._____	K. Concentration of aeration tank contents (ATC).
L._____	L. Total flow out of aeration tank (TFL).
M._____	M. Waste sludge flow (XSF).
N._____	N. Clarifier sludge flow (CSF)

20. List the mass balanee around:

A. Aeration tank

B. Final clarifier

21. Using the mass balance relationship, assuming the concentration of solids in the raw flow into the aeration tank is 0% by centrifuge and given:

ATC = 5%

RSC = 15%

AFI = 1.0 MGD

Find: RSF = ____________

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:
	1. A. 7.7 hrs. B. 369 gal/sq. ft./day C. 453 lbs./day D. 3,829 lbs. E. 0.12 2. Air (oxygen) Return sludge flow Waste sludge flow 3. A. C. A. F. B. D. B. G. C. A. C. B C. E. 4. Weir adjustment (depth of submergence) Motor speed 5. Mixed liquor volatile suspended solids 6. It is based on a consistent level of loading. 7. Waste sludge flow 8. 5,000 - 15,000 gal./day 0.5 - 1.5%

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:

9. Waste sludge flow

   BOD or COD or TOC (load)

   Solids Determination

10. 0.1 to 0.5

11. Difficulty in getting a value for F. (Food).

    Difficulty of obtaining a realistic value of M.

    Inability to instantaneously change M.

12. A. 3,009 lbs./day

    B. 18,431 lbs.

    C. 0.16

13. 667

14. 10

15. Denitrifying sludge

    Sludge accumulation

    White foam on aeration tank

    Dark, greasy foam on aeration tank

16. 0.88 MGD

17. A. D.

    B. C.

    C. B.

    D. A.

    E. E.

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:

18. A. A.
    B. D.
    C. E.
    D. B
    E. C.
19. A. H.
    B. D.
    C. G.
    D. L.
    E. K.
    F. B.
    G. F.
    H. J.
    I. N.
    J. C.
    K. M.
    L. A.
    M. I.
    N. E.
20. A. AFI x PEC + RSF x RSC = TFL x ATC or
    B x C + M x N = D x E
    B. TFL x ATC = CRO x FEC + CSF x RSC or
    D x E = G x H + I x J

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:
	21. AFI x PEC + RSF x RSC = TFL x ATC 1.0 x 0 + RSF x 15 = (1.0 + RSF) 5 RSF = 0.5 MGD