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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation and maintenance of a trickling filter wastewater treatment plant. Included are objectives, instructor guides, student handouts and transparency masters. This is the second level of a three module series and considers types of filters, filter loadings, recirculation ratios, design evaluation and normal and abnormal conditions. References needed are listed on the summary pages at the first of the module. (Author/RH)

INTERMEDIATE TRICKLING FILTERS

Training Module 2.111.3.77

Prepared for the

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by

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September, 1977

SUMMARY

Module Number 113H22	Module Title Intermediate Trickling Filters
Apx. Time 20 Hours	Submodule Titles: 1. Types of Trickling Filters and Their Application. 2. Hydraulic Loadings for Filters. 3. Organic Loadings for Filters. 4. Recirculation Ratios - Calculation. 5. Measuring Trickling Filter Performance Including Records & Sludge Volumes: 6. Materials and Design of Filters. 7. Abnormal Trickling Filter Performance. 8. Field Work and Visit to Two Trickling Filter Systems.

Overall Objectives: The trainee will be able to calculate organic loadings, recirculation ratios and % removal for trickling filter operations. The trainee will also identify types of filters, normal and abnormal performance by correctly completing 70% or more of the corresponding examination section.

Instructional Aids: Overhead Transparencies
Handouts and Workbooks
Diagrams
Check Lists
Instructor Key Points

Instructor Approach: Submodules 1-7
Lecture and Discussion
Submodule 8
Demonstration, Discussion and Short Lecture

References:

1) WPCF - MOP 11, 1977. "Operation of Wastewater Treatment Plants".
2) Fair, Geyer, and Okun. "Water and Wastewater Engineering".
3) EPA-Technology Transfer Series - "Land Disposal of Sludge, Estimating Laboratory Needs for Wastewater Treatment Plants".
4) R. Layton. Personal Notes and Teaching Outlines, 1970-1977.
5) G. Fair, J. Geyer, and D. Okun, 1971. "Elements of Water Supply and Wastewater Disposal".
6) Public Works Journal, 1970. "Handbook of Trickling Filter Design".

7) R. Antonie, 1976. "Fixed Biological Surfaces-Wastewater Treatment".
8) Metcalf & Eddy, 1972. "Wastewater Engineering, Collection Treatment Disposal".
9) EPA-1973. Environmental Protection Technology Series. "Application of Plastic Media Trickling Filters for Biological Nitrification Systems".
10) EPA-1971. "Trickling Filter Treatment of Fruit Processing Waste Waters". Water Pollution Control Research Series.
11) NAVFAC-1969. "NTTC Course 216, Intermediate Sewage".

ADDITIONAL COMMENT

1) Instructor will follow detailed audio visual presentations and checklists - distributing material to trainee as indicated.

2) Instructor will evaluate trainee objectives accomplishment by (a) field trip assignment, and (b) 50 question examination (written) at end of the basic trickling filter module. All six of the sub-modules use the same type of instructional aids and instructional approach and references.

Module No. 113H22	Module Title Intermediate Trickling Filters
2 Hours (1& 2 of 20)	Submodule Title: Types of Trickling Filters and Their Application.

Objectives: The trainee will:

1) Describe the four types of trickling filters.
2) Identify normal characteristics of each of the four types of trickling filters.
3) List examples of uses of the four types of trickling filters in wastewater treatment.
4) List expected performance levels for the four types of trickling filters and differences expected among the four.
5) List area communities or industries using each of the four types of trickling filters.
6) Describe the terms; hydraulic loading, organic loading, and wetting rate.
7) Describe energy uses for support systems used for the four trickling filter types.

END.

BASIC TRICKLING FILTER - 113H22 MODULE
Instructor Lession Guide
Hours 1 & 2 of 20

Overhead Slide #	Slide Description	Instructor Key Points
1	Trickling Filter Does Not "Filter	1) Stress Aerobic, Biological Action From Previous Module-Review
2	Food (Sewage) Oxygen (air) Bugs (growth on media)	1) Reemphasize aerobic Nature and Process Function of Converting Non-settleable Solids To Settleable Solids (Humus)-Review
3	BOD/N/P 100/2/1	1) Reemphasize this Concept - Review
4	Trickling Filter Optimum Conditions	1) No Toxics, Sewer Use Ordinance Enforced and Correct Conditions Essential for Optimum Filter Action (Review)
5	Trickling Filter Types by Application Rates 1) "Roughing " Filter 2) Low Rate 3) High Rate 4) "Super" High Rate	1) Read Slide-Refer To WPCF MOP 11, (reference) 2) Discussion of Each Type Will Follow
6	Roughing Filter: Rock or Plastic Media Up to 20 Ft. Deep Used to Pretreat High BOD Wastes Hydraulic Loading 60-180 mgd/acre OR 1400 to 4200 gpd/ft.^{2} Organic Loading >100 lb/BOD/day/1000 cu.ft.	1) Word Slide-Define Term-Give Specifics of Unit 2) Explain "mgd" million gallons/day 3) Explain gpd and ft.^{2} 4) Explain the terms hydraulic (flow) and organic (solids) loadings

Continued.......

6 cont'd	May or May Not Have Recirculation	5) Stress Recirculation Idea as Key to Optimum Trickling Filter BOD Removal
7	Examples of Roughing Filter Uses: 1) Breweries 2) Food Processing Wastes 3) Poultry, Eviceration, Slaughtering Wastes 4) Milk, Cheese & Whey Processes 5) Toxic Waste Handling (Phenols)	1) Stress High BOD of These Industries. Examples of up to 100,000 ppm BOD 2) Describe Use of Trickling Filter for Treatment of Phenolic Wastes. Small Levels of Phenol Gradually Increased to Higher Levels.
8	Normal "Roughing Filter Performance" What is Expected?	1) Ask question (Word Slide)
9	Expected Performance: 1) Low % Removal of BOD, (40 to 65) but Very High Total Removal 2) Low Nitrate Levels Some Nitrite and Ammonia or Ammonium Ion Present 3) Some Odors (Difficult to Keep Aerobic) Few Flies 4) Sloughing - Usually Continuous	1) Show that BOD to Filter of 1000 mg/l with 500 mg/l in Effluent is only 50% Removal, But Represents Many Pounds (4170)/Day of BOD Removed. 2) Review Nitrification Process $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$ Only Partially Complete 3) Stress BOD and Oxygen Relationship 4) Define "Sloughing" and Why Continuous. Redefine "Humus"
10	Where Have You Seen Roughing Filters Used?	1) Stimulate Class Participation in Where Roughing Filters are Used and What Problems are Observed. 2) Instructor Should be Familiar With Specific Roughing Filter Installations and Those Close to Area, if Possible.

11	Low Rate Filters: (Same as "Standard" Rate) Usually Rock Media. 6 to 8 Feet Deep. Used in Domestic Sewage Treatment. Hydraulic Loading: 1 to 4 mgd/acre OR 25 to 90 gpd/sq.ft. Organic Loading: 200 to 1000 lb. BOD/day/acre ft. OR 5 to 25 lb. BOD/day/1000 cu. ft. Usually Does Not Have Recirculation. Usually Has Dosing Tanks or Siphon.	1) Discuss Problems with Rock-Breaking, Clogs, ect. 2) Define "Domestic" as 204 ppm BOD, 0.17 pounds/capita/day. 3) Answer questions About Hydraulic and Organic Loads (Terminology Only). 4) Dosing Siphon Means Standard Rate
12	Normal Low Rate Filter Performance. What is Expected?	1) Ask Question (Word Slide)
13	Expected Performance: 1) High BOD Removal 85-90%. 2) Seasonal Variation in Performance. 3) High Nitrate (NO_3^-) Levels-Low Nitrite and Ammonia 4) Some Odors-Some Filter Flies 5) Sloughing- Intermediate and Seasonal in Nature.	1) Stress Seasonal and Uncontrollable Operation. 2) Re-emphasize Nitrification. 3) Odor Control - Good Housekeeping-Aerobic Conditions Maintained. 4) Fly Control Discussed Later. 5) Humus and "Slugs" Obtained-(Not a particular problem unless snails-discussed later).
14	Where are Standard or Low Rate Trickling Filter Plants Located Near Here?	1) Stimulate Class Participation in Locations, Problems, Solutions, etc. 2) Instructor Should Be Familiar With the Plants In the Area.

15	"High Rate Trickling Filters" Usually Rock Media. 3 to 8 feet Deep. Used in Domestic and Industrial Waste Treatment. Hydraulic Loading: 5 to 40 mgd/acre 100 to 900 gpd/ft.^{2} Organic Loading: 1000 to 1300 lb./BOD/day/acre ft. OR 25 to 300 lb. BOD/day/1000 ft.^{3} Almost always Has Recirculation. No Dosing Tanks. Requires Pumping and Electrical Costs.	1) Stress Difference Between Low and High Rate Filters 2) Answer Questions on Concept of Hydraulic and Organic Loading. 3) Discuss Energy Considerations for High vs Low Rate Filters, Pumping & Electricity Costs
16	Normal "High Rate" Filter Performance. What is Expected?	1) Ask Question (Word Slide)
17	Expected Performance: 1) Good BOD Reduction 85-90% 2) Seasonal Variations Not as Great as Low Rate but Still Exist. 3) Good Nitrification, However, Some Nitrite and Ammonia Present. 4) Few Odors and Few Flies, But Depends Upon Operational Control. 5) Sloughing-Continuous-Seasonal Variation	1) Use Word Slides and Stress Key Points.

18	Where Are "High Rate" Trickling Filter Plants Located?	1) Word Slide-Ask Question 2) As Before- Locations, Problems, Solutions 3) Instructor Familiar With Area Plants.
19	"Super High Rate" Trickling Filters: Usually Plastic Media. Up to 40 feet Used in Many Domestic and Industrial Applications. Hydraulic Loading: 15 to 90 mgd/acre. 350 to 1000 gpd/ft.^{2} Organic Loading: 300 lb.BOD/day/1000 ft.^{3} Usually Has Recirculation. No Dosing Tanks. Requires Pumping and Electrical costs. Forced Ventilation Often Used. "Wetting Rate" of 0.6 gal/min/ft^2 Important in Many Plants	1) Stress These as The Trickling Filters Being Installed at Most New Trickling Filter Plants. 2) Plastic Forms Good Surface for Growth. 3) Emphasize Hydraulic and Organic Loads 4) Stress "Wetting Rate" Concept. 5) Stress Energy Concept of Electrical and Pumping Costs and Forced Ventilation Costs (where used)
20	Normal Performance of "Super High Rate Filters" What is Expected?	1) Ask Question, Word Slide
21	Expected Performance for "Super High Rate Filters". What is Expected? 1) Good BOD Removal 65-90% -- Depends Upon Loading 2) Some Seasonal Variation 3) Intermediate to Excellent Nitrification-Depends on Loading. 4) Few Odore, Few Flies 5) Sloughing Continuous (Seasonal) 6) Media Breaking and Clogging Less common than Rock Media 7) Towers (40 ft.) Often Used-Filter Ventilation Can Be A Problem - If Septic-Problem!	1) Stress Loadings vs Performance for Each Item

22	Where are "Super High Rate" Filters Located?	1) Ask Question, as Before 2) Instructor Input
23	What are the Four Basic Types of Trickling Filters?	1) Ask Question
24	Right! 1) "Roughing Filter" 2) Low Rate or Standard Filter 3) High Rate Filter 4) "Super High Rate" Filter	1) Word Slide
25	How do We Classify Filters?	1) Word Slide
26	Right! 1) Rock or Plastic Media 2) Depth 3) Uses 4) Hydraulic Loading 5) Organic Loading 6) Recirculation 7) Support Systems - Pumps, Forced Ventilation, etc. 8) Expected Performance	1) Review
27	Questions?	1) Instructor Use Remaining Time with Questions and/or Discussion..

END

SUMMARY

Module Number 113H22	Module Title Intermediate Trickling Filters
Apx. Time Hours 3 & 4 2 Hours	Submodule Title Hydraulic Loadings for Filters

Objectives:

The Trainee Will:

1) Calculate areas of a circle and rectangle
2) Calculate trickling filter acres when given rectangular and circular measurement of length
3) Identify units of flow commonly used in trickling filter application
4) Calculate hydraulic loadings using an example trickling filter problem

Instructor Aids:

Overhead Projector with Acetate Roll and Felt Tip Marker (Alternate-use chalk board).

Handout and Workbook

One Overhead Transparency

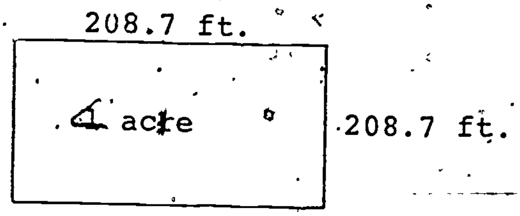
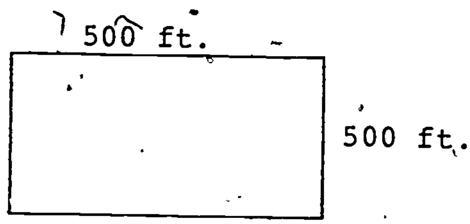
Instructor Approach:

Instructor, seated, will write and work examples on overhead projector acetate film. Have trainee work examples in workbook.

LESSON OUTLINE
Hours 3 & 4 of 20
Hydraulic Loadings for Filters

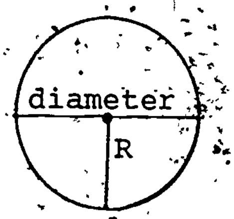
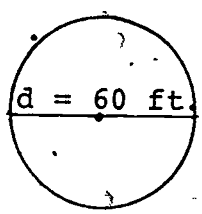
Instructor will be seated at overhead projector and lead discussion and trainee work as follows

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis
1	Hydraulic Loading - volume/time/area	Explain concept of hydraulic load- optimum removal with correct load
	Example	
	gal/minute/ft.^{2}	Explain area is square units
	or	
	million gal/day/acre mgd/acre	Explain foot x foot gives ft.^{2} or sq. ft. same as feet x feet = sq. ft.
	or	
	gallons/day/sq. ft.	Explain: gpm, mgd, cfs, as terms of flow
	Questions?	

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
2	1 acre = 43,560 ft.^{2} or 	Length x width gives surface area or 208.7 x 208.7 = 43,560 ft.^{2}
	Step 1 Now - calculate how many acres are in surface with a length of 500 ft. and a width of 500 ft. 	Allow apx. 3 or 4 minutes to have trainee get answer by slide rule, calculator, hand math
	Area = length x width area = 500 ft. x 500 ft. area = 250,000 ft.^{2}	Emphasize importance of units and factor cancellation concept. e.g. $\frac{ft.^2}{ft.^2/acre}$ = acres
	Step 2 1 acre = 43,560 ft.^{2} so $\frac{500,000\ ft.^2}{43,560\ ft.^2/acre}$ = 11.5 acres Questions?	

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
3	To calculate surface area of a rectangle: Area = length x width Area = sq. units sq. ft. acres $meters^2$ $inches^2$ Another Example: A trickling filter 25 ft. long and 20 ft. wide, has what surface area? Solution: A = l x w A = 25 ft. x 20 ft. A = 500 $ft.^2$ or 500 sq. ft. Questions?	Define rectangle ft. x ft. = $ft.^2$ or sq. ft.

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis
4	Ask students to find area of a trickling filter 200 ft. long and 400 ft. wide. Also, how many acres? Solution $A = l \times w$ $A = 200\text{ ft.} \times 400\text{ ft.} = 80000\text{ft.}^2$ and $\frac{80{,}000\text{ ft.}^2}{43{,}560\text{ ft.}^2/\text{acre}} = 1.8\text{ acres}$ Questions?	Wait 5 minutes after giving problem - give individual help - then work with overhead. Look for "lost look" on faces or those not working problem. Two concepts (a) surface area of rectangle and (b) calculation of acres - the point

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
5	Draw a circle	R = radius = ½ d d = diameter = 2 x R
	 and Show radius and diameter	Can determine in a plant by (a) estimating walking, etc. (b) tape measure and (c) blueprints (scale)
	Area = πR^2 π = 3.14 (no units) R = radius R x R = square units so A = 3.14 x R' x R' or A = 3.14 x ft.^{2} or Other area units	"Pie are round, cornbread is square". Corny, by it works!
	Example:  Trickling filter diameter = 60 ft. Find the area in square feet and the acres.	d = 2 x R so 60'/2 = 30 ft.
	<u>Step 1</u> d = 2R 60'/2 = 30 ft. = radius radius = 30 ft. A = πR^2 so A = 3.14 x 30' x 30' Work Out	Check to see if decimals can be handled.

Item 5	continued	
	3.14 x 30' 104.20 ft. and 104.2 ft. x 30 ft. 3126.0 sq. ft. Answer = 31260 $ft.^2$ Questions? Calculate Areas? $\frac{3126\ ft.^2}{43560\ ft.^2/acre}$ = 0.72 acres Questions? One More Example: Trickling Filter with 200 ft. diameter is how many surface acres? $A = \pi R^2$ A = 3.14 x 100' x 100' Area = 31,400 $ft.^2$ Acres= $\frac{31,400\ ft.^2}{43,560\ ft.^2/acre}$ = .72 acres Questions?	Check decimal division

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
6	Hydraulic Loading: volume/time/area IF: 2 gal. flowed to a filter each minute that was 1 ft. long x 1 foot wide, what is the hydraulic loading? volume = 2 gal. time = 1 minute area = 1 ft. x 1 ft. = 1 ft.^{2} so hydraulic load = 2 gpm/ft.^{2}	Compare to mininum "wetting rate" for plastic media filters.
	or 1 million gallons flowed to a filter 208.7 ft. long and 208.7 ft. wide. What hydraulic loading in mgd/acre and gpd/ft.^{2} went to the filter?	Fixed nozzles
	1 mgd = 1,000,000 gpd	Review this conversion
	Step 1 hydraulic load=volume/time/area or 1,000,000 gal./day Area = 208.7 ft. x 208.7 ft. Area = 43,560 ft.^{2} so Loading = $\frac{1,000,000 \text{ gal/day}}{43,560 \text{ ft.}^2}$ Loading = 22.9 gpd/ft.^{2}	Ask if low or high rate (Low)
	or 43,560 ft.^{2} = ? Acres $\frac{43,560 \text{ ft.}^2}{43,560 \text{ ft.}^2\text{/acre}}$ = 1 acre So loading is 1 mgd/acre (low rate) Questions?	

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
7	Calculate the hydraulic loading to a trickling filter as mgd/acre and gpd/ft.^{2} If the filter is 100 ft. long and 100 ft. wide and receives 2,500,000 gal of sewage each day? Solution: Step 1 2,500,000 gal/day is 2.5 MGD Step 2 Area = 100' x 100' = 10,000 ft^2 Acre = $\frac{10,000' \text{ ft.}^2}{43,560 \text{ ft.}^2/\text{acre}}$ = .23 Acres 2.5 MGD/.23 Acre or $\frac{2.5 \text{ MGD}}{.23 \text{ acre}}$ = 11 MGD/acre Step 3 find gpd/ft.^{2} 2,500,000 gpd Area = 10,000 ft.^{2} so $\frac{2,500,000 \text{ gpd}}{10,000 \text{ ft.}^2}$ = 250 gpd/ft.^{2}	Write the Problem. Wait 5 minutes Assist non-workers or confused trainees.
	Low Rate or High Rate?	High Rate (See Table)
	Questions?	

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis
8	Given a circular filter diameter of 200 ft. and flow = 5,000,000 gpd Find: Hydraulic loading in gpd/ft.^{2} and mgd/acre Also, what type of filter is it? Low? High? Super High? Solution: Hydraulic Loading: 5,000,000 gpd = 5 MGD diameter = 200 ft. radius = $\frac{200 \text{ ft.}}{2}$ = 100 ft. Area = πR^2 A = 3.14 x 100' x 100'=31,400ft^2 so Loading in gpd/ft.^{2} is: $\frac{5{,}000{,}000 \text{ gpd}}{31{,}400 \text{ ft.}^2}$ = 159 gpd/ft.^{2} Loading in MGD/acre MGD = 5.0 Acre = ? Area = 31,400 ft.^{2} Acres = $\frac{31{,}400 \text{ ft.}^2}{43{,}560 \text{ ft.}^2/\text{acre}}$ = .72 Acres Loading = $\frac{5.00 \text{ MGD}}{0.72 \text{ acres}}$ Loading = 6.5 MGD/acre Low or High Rate? (High) Questions?	Give Problem. Wait 5-10 minutes. Help Problem Trainees. Work Together Using Projector Review this step

SHOW OVERHEAD #1

If time permits - have trainees work the following:

Problem #	Details	Answer
1	Flow = 3 MGD Diameter of T.F. = 235 ft. Find MGD/acre What type of filter?	3.0 Low
2	Flow = 3 MGD Diameter = 100 ft. Find MGD/acre What type of filter	16.7 High
3	Flow = 10,000,000 gpd Diameter = 160 ft. Find $gpd/ft.^2$ What type of filter	497 $gpd/ft.^2$ Super High
4	How large should 2 trickling filters be to handle 10 MGD of sewage if they are designed as low rate filters? (acres & diameters)	$\frac{10\ mgd}{2}$ = 5 MGD each So, no smaller than 1.25 acres each or 132 ft. diameter

SUMMARY

Module No. 113H22	Module Title Intermediate Trickling Filters
Apx Time 2 Hours Hours 5 & 6	Submodule Title Organic Loadings for Filters

Objectives: The trainee will:

1) Calculate volumes of rectangles and cylinders.
2) Calculate Trickling Filter volumes when given filter measurements.
3) Calculate organic loadings as commonly found in trickling filters.
4) Identify and calculate "acre feet"
5) Convert mg/l to pounds/day, given flow.

Instructor Aids: Overhead projector with acetate roll and felt tip markers (alternate: use chalkboard.

Handout and workbook.

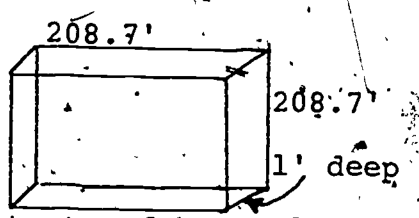
One overhead transparency.

Instructor Approach:

Instructor seated, will write and work examples on overhead projector acetate film. Have trainee work examples.

END

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis
1	Organic Loading (Food) pounds of BOD/day/volume Examples: lbs.BOD/day/acre foot and lbs.BOD/day/1000 cu.ft. Questions?	1)Food to media volume assures optimum operation 2) Too much is poor 3) Too little is poor 4) Septic or poor growth

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
2	Acre = 43,560 ft^2 1 acre foot = 43,560 ft^2  Contents of box = 1 acre/foot (1 acre foot=43,560 cu. ft.) Example: Trickling Filter is 236 ft. in diameter (118 ft. radius) and 7 feet deep. How many acre feet does it contain? Solution: Area = πr^2 A = 3.14 x 118' x 118' A = 43,721 sq. ft. Acres = $\frac{43{,}721 \text{ ft.}^2}{43{,}560 \text{ ft.}^2/\text{acre}}$ = 1.0 acre Acres x feet = acre feet 1.0 x 7.0 = 7.0 acre feet Example 2: A square filter 100 ft. long and 10 ft. deep contains how many acre feet? Solution: Area = l x w Area = 100' x 100' Area = 10,000 sq. ft. Acres = $\frac{10{,}000 \text{ ft.}^2}{43{,}560 \text{ ft}^2/\text{acre}}$ Acres = 0.23 Acre feet = acres x ft. deep acre feet =0.23 x10=2.30 ac. ft.	1) Review 2) Work together with class 3) Allow class 5 minutes to work, then work together

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
3	Organic Loading requires pounds of BOD_5/day. Given mg/l lbs. BOD_5=8.34 x mgd x mg/l BOD/day Example: Influent to filter is 135 ppm BOD_5. The flow is 1 MGD. The pounds/day os BOD is found: $\frac{\text{lbs.}}{\text{day}}$ =8.34x 135 mg/l x 1 MGD or lbs/day BOD_5 = 1126 lbs/day Example 2: Influent to filter is 180 mg/l. What is lbs.BOD/day for a 3 MGD flow? Solution: $\frac{\text{lbs. } BOD_5}{\text{day}}$=8.34 x 3 MGD x 180mg/l lbs./day = 4,504 Questions?	1) This may be a review for some trainees and new material for others. 2) Just to be sure 3) Allow 5 minutes to work; then work together.

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
4	Organic Loading is lbs. BOD_5/ day per acre foot or per 1000 cu. ft. of filter Example 1: 1126 lbs. of BOD_5/day is loaded (applied) to our 236' filter, 7' deep (7 acre ft.). What is the loading? lbs. BOD_5/day per acre ft. or $\frac{1126 \text{ lbs.BOD/day}}{7 \text{ acre feet}} = 161 \frac{\text{lbs } BOD_5}{\text{acre feet}}$ (low rate filter and low loading) Example 2: If 4,504 lbs. BOD_5 is applied to the square filter 100' each side, what is the organic loading in lbs. BOD_5/day/acre ft.? And what type filter is this? Solution: $\frac{4{,}504 \text{ lbs/day}}{2.3 \text{ acre ft.}} = 1958 \frac{\text{lbs/day}}{\text{acre ft.}}$ (Super High Rate Filter) or 3 MGD flow for 0.23 acres $\frac{3 \text{ MGD}}{0.23 \text{ acres}} = 13.0$ mgd/acre ft. Hydraulic load means a high rate with abnormal load (industry?) of BOD to the filter. Questions?	1) Review 2) Allow 5 minutes to work, then work together. 3) Discuss which type of industry might give this overload

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
5	Another way of expressing organic loading is: $\frac{\text{lbs. BOD}_5\text{/day}}{\text{1000 cu.ft. of filter}}$ so To find volume of filter (cu. ft.) just find area (as before) and multiply by depth or V in ft.^{3} = Area, ft^2 x ft. deep Example 1: Filter with diameter of 236 ft. (area of 43,721 ft^2) that is 7 ft. deep has a volume of? V = area x depth or V=43,721 ft^2 x 7 ft. V in ft^3 = 306,047 ft^3 or $\frac{\text{306,047 ft}^3}{\text{1000 ft}^3\text{/unit}}$ = 306 units of 1000 ft.^{3} To find organic loading in $\frac{\text{lbs. BOD}_5\text{/day}}{\text{1000 cu. ft.}}$ Simply Divide: $\frac{\text{1126 lbs. BOD}_5\text{/day}}{\text{306 units of 1000 ft}^3}$ or $\frac{1126}{}$ = 3.68 lbs. BOD$_5$/day per 1000 ft^3 so (Low rate filter with low BOD loading) Questions? Continued:.........	 Expect Some

Item #	Instructor Writes the Following:	Instructor Key Points of Emphasis:
5 cont'd	Another example, to be sure. 4,504 lbs. BOD_5/day (example above) applied to the square filter 100 ft. each side, that is 10 ft. deep. Find (1) the organic load in $\frac{\text{pounds of } BOD_5\text{/day}}{\text{1000 cubic feet}}$ (2) the type of filter (high, low, super high) (3) is it correctly loaded? Yes? No? Why? Solution: Step 1 ft^3 V = Area (ft^2) x depth in ft. V ft^3 = 10,000 ft^2 x 10' = 100,000 ft^3 To find units of 1000 cu.ft. 100,000 ft^3 = 100 units of 1000 cu.ft. Step 2 Organic loading = $\frac{\text{lbs.} BOD_5\text{/day}}{\text{units of 1000 cu.ft.}}$ Organic Loading = $\frac{\text{4,504 lbs.} BOD_5\text{/day}}{\text{100 units of 1000 cu.ft.}}$ Organic Loading = $\frac{\text{45 lbs.} BOD_5\text{/day}}{\text{1000 cu.ft.}}$ Filter is high rate or super high rate (loaded very low) Questions?	Allow 5 minutes to work, then work together

Show Overhead Slide # 1

OVERHEAD # 1*

Type of Filter	Organic Loading-units	
	Lbs.BOD/day/acre ft.	pounds BOD/day/1000cu.ft.
Low Rate	200-1000	5-25
High Rate	1000-1300	25-300
Super High Rate	-	up to 300

* MOP 11-WPCF Guidelines (1977)

If time permits, have trainee work the following examples:

Problem #	Details	Answer
1	Flow = 3 MGD Diameter = 236 ft Depth ≐ 10 ft. BOD = 100 mg/l to filter Find lbs.BOD/day/acre foot What type of filter?	250 lbs.BOD_5/day/acre ft. Low Rate
2	Flow = 100 MGD 5 Filters loaded equally BOD = 130 mg/l to filters Find the area of each filters to give a loading of 10 lbs. of BOD/day/1000 ft^3 of media	2,168,000 ft^3 for each of the 5 filters: each 232 ft. square and 40 ft. deep. Super Big!
3	Flow = 2 MGD BOD = 400 ppm to filter Filter = 40 ft. sq. and 20 ft. deep. What type of filter is this and is it over-loaded? Why?	Super High Rate (Plastic) Organic Load is: $\frac{6672 \text{ lbs/day}}{32 \text{ units of } 1000}$ =209 lbs/BOD_5 Organic load OK Hydraulic load: $\frac{2,000,000 \text{ gpd}}{1600 \text{ ft}^2}$ = 1250 gpd per ft^2 Hydraulic loading overloaded (Slightly)

END

SUMMARY

Module Number 113H22	Module Title Intermediate Trickling Filters
Apx. Time 2 Hours Hours 7&8	Submodule Title Recirculation Ratios - Calculation

Objectives

The Trainee Will:

1) Recognize and list the reasons for using recirculation in a trickling filter operation,
2) List common BOD concentrations to a trickling filter and corresponding recirculation ratios.
3) Define recirculation rate and calculate corresponding numerical values.
4) Demonstrate a working knowledge of operational control for a trickling filter by completion of an example problem.

Instructor Aids:

Overhead projector with acetate roll and felt tip marker (alternate-use chalkboard)

Handout and workbook

Overhead transparencies

Instructor Approach: Instructor will present overhead slides and work examples. Have trainee work examples in workbook.

END

LESSON OUTLINE
Hours 7 & 8 of 20
Recirculation Ratios - Calculations

Item #	Overhead or Write	Key Instructor Points
1	Recirculation - Why?	Ask Question, lead discussion
2	Recirculation: 1) Used for high or super high filters 2) Improves hydraulic and organic loadings (if needed) 3) Improves efficiency	Review Filter types Review wetting rate, BOD, and hydraulic loading. Will cover in next lesson, exact amount
3	Typical BOD Removal: Primary 35% Influent 204 mg/l BOD (.17 lbs/capita/day and 100 gpdc) What is normal BOD to filter?	Review these concepts. Recalculate if req'd. pounds = 8.34 x mgd x mg/l Have trainees answer.
4	Right! 130-135 mg/l 65% of 204 = 132	Review, word slide
5	Higher the BOD.... Greater the recirculation!	Word slide
6	EPA Table Recirculation rate for maximum BOD of settled wastewater BOD mg/l — 1/Recirculation Ratio 130 — 1:1 170 — 2:1 220 — 3:1 260 — 4:1	Explain Table

<table>
<tr><td>7</td><td>Recirculation ratio defined as total number of times wastewater returned plus 1.

Example:
<table>
<tr><th>mgd Flow</th><th>Recirculation Ratio</th><th>mgd. Total Hydraulic Load to Filter</th></tr>
<tr><td>5</td><td>1:1</td><td>(1+1)x5=10</td></tr>
<tr><td>5</td><td>2:1</td><td>(1+2)x5=15</td></tr>
<tr><td>5</td><td>3:1</td><td>(1+3)x5=20</td></tr>
<tr><td>5</td><td>4:1</td><td>(1+4)x5=25</td></tr>
<tr><td>5</td><td>5:1</td><td>(1+5)x5=30</td></tr>
</table></td><td>Review and explain</td></tr>
<tr><td>8</td><td>Questions?
What hydraulic loading would a 3 mgd flow with a 4 to 1 recirculation ratio be?</td><td>Word Slide
Allow 2 or 3 minutes to solve</td></tr>
<tr><td>9</td><td>15 mgd - Right!
OR
Flow = 3mgd x (1+4)
Flow = 3mgd x 5 = 15 mgd</td><td>Explain</td></tr>
<tr><td>10</td><td>What BOD range would you expect the trickling filter influent to be?</td><td>Word slide.

Ask question</td></tr>
<tr><td>11</td><td>Right! apx. 260 mg/l</td><td>Review slide 6 if required</td></tr>
<tr><td>12</td><td>(Write on overhead)
If a wastewater flow of 8 mgd contains 20,100 pounds of BOD_5, what total flow in mgd would you expect to treat? Why?</td><td>Allow 5 to 8 minutes to work, then work together</td></tr>
</table>

13	(Work on overhead, seated) $lbs.BOD_5/day = 8.34 \times mgd \times mg/l\ BOD_5$ SO $20,100\ lbs/day = 8.34 \times 8 mgd \times mg/l\ BOD_5$ SO $\frac{20,100\ lbs/day}{8.34 \times 8\ mgd} = mg/l\ BOD_5$ and $\frac{20,100}{66.7} = 304\ mg/l\ BOD$ Questions?	Work
14	-Continue- 304 mg/l BOD to filter optimum recirculation is SO total flow expected: Flow = 8 mgd x (> 4 + 1) Flow = > 40 mgd Questions?	Continue to work and and review
15	Remember higher BOD-higher recirculation high rate filters of super high improve loading improve efficiency $\frac{pounds}{day} = 8.34 \times mgd \times mg/l$ Total flow=influent flow x recirculation ratio + 1 $\%\ Removal = \frac{in-out}{in} \times 100$ Questions?	Word slide, summary

END

STUDENT WORK EXERCISE
1 Hour (Hour 8)
Recirculation Ratios Includes Hydraulic & Organic Loadings

Problem 1:

Given flow to plant = 12 mgd
Plant influent total lbs. BOD_5/day = 48,000
% Removal in primary plant = 38%
Plant has four high rate filters with 300 ft. diameters
Recirculation is practiced. Plant is mechanically in good working order.

Question: What recirculation ratio would you recommend for best plant performance? Why?
Also
1) What is the number of pounds of BOD_5/day to each of the filters?

2) What is the mg/l BOD to each filter?

3) What is the total flow into all four filters in mgd?

4) What is the hydraulic loading (after recirculation) for each filter?

5) What is the organic loading (after recirculation) for each filter?

(You have up to 1 hour to finish)
If you finish early, see the instructor to check your answer

Problem 2: (For Fast Finishers of Problem 1)

Given the following:
BOD into plant = 1000 mg/l
Primary removal = 52%
Plant flow = 1 mgd
Filters (there are 2) plastic media
Towers 40 ft. wide and 20 ft. long and 20 ft. deep

1) Would you operate the filters in parallel or series? Why?

2) What recirculation rates would you use in your operation? Why?

SUMMARY

Module Number 113H22	Module Title Intermediate Trickling Filter
Apx. Time 2 Hours Hours 9 & 10	Submodule Title Measuring Trickling Filter Performance

Objectives

The Trainee will:

1) Recognize and list the performance of a trickling filter using the parameters of settleable solids, suspended solids, dissolved oxygen, BOD/COD, nitrogen species, and pH.

2) Calculate a materials balance for an example trickling filter plant.

3) Calculate the estimated efficiency of a trickling filter performance using various recirculation ratios.

4) Work a typical problem to find optimum recirculation to achieve desired trickling filter performance.

Instructor Approach: Overhead transparencies and work at overhead projector

END

LESSON OUTLINE
Measuring Trickling Filter Performance
Hours 9 & 10 of 20

Item #	Instructor Writes or Uses the Following:	Instructor Key Points of Emphasis:
1	Trickling filter converts non-settleable to settleable solids.	Emphasize secondary settling function
2	Aerobic Treatment Needs Food (Sewage) Oxygen (air) Bugs (Bacteria + Others)	Review from Module 1
3	Trickling Filter Performance measured by: 1) Solids-suspended (& settleable. 2) BOD/COD reduction 3) Solids produced (humus) 4) Nitrogen oxidized 5) Recirculation ratio-hydraulic & organic loads 6) Oxygen-near saturation 7) No abnormal problems (odors, snails, ponding, etc.)	Word slide, review as written Answer questions
4	Typical trickling filter treatment plant.	Review flows and reference to the following example
5	Solids to Filter Suspended Solids: 35-45% of plant influent Settleable Solids: Trace (Imhoff cone) Typical Plant-suspended solids 40% of 300 mg/l = 120 mg/l (Non-settleable, colloidal) OR	Review settleable solids removed in primary Suspended solids lbs/day is important

continued.....

5 cont'd	For 1 mgd flow: lbs.ss/day = 8.34 x 1 mgd x 120 mg/l lbs.ss/day = 1000 lbs./day (converted to humus) Normal Performance: Low settleable solids and low suspended solids in effluent.	
6	BOD/COD Primary removal 35-40% Trickling filter influent 65% of 204 mg/l = 132 mg/l For 1 mgd flow: lbs.BOD_5/day = 8.34 x 1 mgd x 132 mg/l lbs. BOD_5/day = 1100 lbs./day Total BOD removed apx. 80-90% of plant influent. If influent is 204 ppm, 85% removal leaves 15%. 15% of 204 mg/l = 30 mg/l Normal BOD expected 25-50 mg/l AND $BOD_{ult.} \approx 1.6\ BOD_5$ $BOD_{ult.} \approx COD$	Review what BOD means. Review calculation of BOD Review BOD/COD, and BOD_5 and BOD_{ult} solids relationship
7	Solids produced (humus) from oxidation of dissolved and non-settleable suspended solids. Simple calculation: Part 1 Suspended solids: Plant influent 300 mg/l Primary effluent 105 mg/l (to filter) Primary effluent 30 mg/l (from filter) (90% removal) Filter removal: 105 mg/l - 30 = 75 mg/l lbs.ss/day = 75 mg/l x 8.34 x 1 mgd lbs.ss/day = 626 lbs/day (sludge)	

8	**Part 2** BOD oxidation: BOD into plant 204 mg/l Primary effluent 132 mg/l (to filter) Leaving Plant 30 mg/l BOD removed on filter: 132 - 30 = 102 mg/l 1 lb. of BOD produces 0.77 lbs. of sludge. lbs.BOD/day removed = 8.34 x 1 mgd x 102 mg/l lbs. BOD_5/day = 851 lbs./day 1 lb. BOD gives 0.77 lbs. sludge so 851 x .77 = 655 lbs.sludge/day	Work with student on problem, explain BOD-oxidation.
9.	Sludge from ss = 626 lbs/day Sludge from BOD = 655 lbs./day Total 1281 lbs/day (dry sludge based on 204 mg/l BOD and 300 mg/l suspended solids)	Review calculations Questions.
10	**Sludge Volume** lbs (dry) x $\frac{100}{\%\ \text{sludge}}$ = lbs/wet so 1281 lbs(dry) x $\frac{100}{5}$ = 25620 lb/wet $\frac{25,620\ \text{lbs(wet)}}{8.34\ \text{lbs/gal}}$ = 3071 gal. So - expect to pump apx. 3071 gal.sludge (95% water)	

11	<u>Nitrogen Oxidized:</u> 1) Find nitrogen in plant influent (say, 25 mg/l) 1 mgd = 209 lbs/day 2) Estimate 99% conversion 99% of 209 lbs = 207 lbs. Removed - 2 lbs. left OR .25 mg/l left But 1 lb. NH_3 gives 4 lbs of Nitrate- (NO_3^-) Normal values 20-50 mg/l	
12	<u>Recirculation Ratio & Performance</u> National Research Council Formula: $E = \dfrac{100}{1 + .0085\sqrt{W/VF}}$ Where E = % Removal BOD_5 W = BOD load lbs/day F = Recirculation Factor V = volume of filter media (acre-feet) AND F = Recirculation Factor $F = \dfrac{1 + r}{(1 + .01\,r)^2}$ r = recirculation ratio	See Metcalf & Eddy Reference Keep the trainees calm- tell them not to panic- that you will work out step by step

13 Write on Over-head	Example 1: Given: Flow = 250,000 gpd Filter diameter = 96 feet Depth = 6 feet (acre feet = 1) BOD to filter = 175 mg/l (lbs. BOD_5 = 366/day) $E = \frac{100}{1 + .0085 \sqrt{W/VF}}$ $E = \frac{100}{1 + .0085 \sqrt{366/1 \times 1}}$ $E = \frac{100}{1 + .0085 \sqrt{366}}$ $E = \frac{100}{1 + .0085 \times 19.1}$ $E = \frac{100}{1 + .165}$ $E = \frac{100}{1.165} = 61\%$ 61% of the BOD will be removed or 100 - 61 = 39% left Effluent will be: 39% of 175 mg/l = 68 mg/l	Show how to do square root. Show how to find .0085 x 19.1 Questions

14
Write on Overhead

Example 2:

Assume a 1:1 Recirculation ratio:
(Same data)

$$F = \frac{1 + r}{(1 + .01\ r)^2}$$

F = Recirculation factor

$$F = \frac{1 + 1}{1 + (0.1 \times 1)^2}$$

$$F = \frac{2.}{1 + (1.1)^2}$$

Show how to do this step.

$$F = \frac{2}{1 + 1.21}$$

$$F = \frac{2}{2.21} = .90$$

Questions.

$$E = \frac{100}{1 + .0085\sqrt{366/\ 1 \times .90}}$$

$$E = \frac{100}{1 + .0085\sqrt{407}}$$

$$E = \frac{100}{1 + .0085 \times 20.2}$$

$$E = \frac{100}{1 + .17}$$

$$E = \frac{100}{1.17} = 85\%$$

SO
100 - 85 = 15% left
15% of 175 mg/l = 26 mg/l BOD

One extra pass reduced BOD from 68 mg/l to 26 mg/

<table>
<tr>
<td>15
Work
On
Over-
head</td>
<td>Example 3:
Recirculation ratio of 2:1
(same data)

$F = \frac{1 + 2}{1 + 0.1 \times 2}$

$F = \frac{3}{1 + .2}$

$F = \frac{3}{1.2}$

$F = 2.5$
AND

$E = \frac{100}{1 + .0085 \sqrt{366/1 \times 2.5}}$

$E = \frac{100}{1 + .0085 \sqrt{147}}$

$E = \frac{100}{1 + .0085 \times 12.1}$

$E = \frac{100}{1 + .103}$

$E = \frac{100}{1.103} = 91\%$

BOD = 9% of 175 = 16 mg/l</td>
<td>Questions</td>
</tr>
<tr>
<td>16</td>
<td>Conclusion:
<table><tr><th>Recirculation Ratio</th><th>% Removal</th><th>mg/l BOD in Effluent</th></tr><tr><td>0</td><td>61</td><td>68</td></tr><tr><td>1:1</td><td>85</td><td>26</td></tr><tr><td>2:1</td><td>91</td><td>16</td></tr></table></td>
<td>Summarize and ask Questions</td>
</tr>
<tr>
<td>17</td>
<td>Material Balance Slide</td>
<td>Explain slide</td>
</tr>
</table>

END

STUDENT HANDOUT

Problem to be Worked

Given the following:

Flow = 1,250,000 gpd
Filter diameter = 320 feet
Depth = 7 ft.
BOD to filter = 200 mg/l
suspended solids = 280 mg/l
(to filter
High rate filter

FIND:

1) The solids removed as sludge, (assuming a 5% sludge & 95% water in gallons/day)

2) The % removal for BOD_5
a. no recirculation
b. 1:1 recirculation ratio
c. 1:2 recirculation ratio
d. 1:3 recirculation ratio
e. 1:4 recirculation ratio

3) What values would you expect for nitrate levels and dissolved oxygen levels?

Assign in class, have turned in next period!

Help Trainee with problems on individual basis

______________ (answer)

Answers:
a. ______________
b. ______________
c. ______________
d. ______________
e. ______________

Nitrate: high depends on plant influent 20-50 mg/l
DO: near saturation depends upon temperature

SUMMARY

Module Number 113H22	Module Title Intermediate Trickling Filters
Apx. Time Hours 11, 12, 13 of 20 3 Hours	Submodule Title Materials and Design of Filters

Objectives: The Trainee Will:

1) List the trickling filter growth pattern and trend to high rate filters
2) List the five key items in a Trickling Filter operation
3) List a comparison of high and low rate filters
4) List design guidelines for high and low rate trickling filter components
5) Explain design differences between low and high rate filters
6) Using a Trickling Filter design nomograph - solve three typical trickling filter design-size problems
7) Discuss and describe industrial applications of Trickling Filter treatment
8) List common design information regarding biological filters

Instructor Aids: Overhead Projector, Transparancies, "Handbook of Trickling Filter Design" by Public Works Publications Handout (cost $1.60) from Public Works Publications, 200 South Broad Street, Ridgewood, New Jersey 07451

Instructor Approach: Hour 1 - Either at home (best) or in class, read the handout cover-to-cover
Hour 2 - Follow outline, Hour 3 - Problems

LESSON OUTLINE
Hour 11 of 20 (1 Hour)
Materials and Design of Filters

Item #	Instructor Will:	Instructor Key Points of Emphasis
1	Assign and have trainees read "Handbook of Trickling Filter Design" by Public Works Publications (26-page Handout) Best if done at home before class.	Encourage them to read it and to re-read if required

END (Hours 11)

LESSON OUTLINE
Materials And Design of Filters
Hours 12 & 13 of 20

Item #	Lecture - No audiovisuals Instructor Comment
1	1. Ask question - How Many of You Read Publications? (some will not have read) 2. Explain that you will now review page by page. 3. Begin by explaining who wrote this publication and where. To get more copies (bottom of page on foreword) Cost - $1.60
2	<u>Foreword</u> 1. Rapid Growth of Trickling Filter Use in U.S. 2. Indicate What the Trickling Filter Floor Institute is all about. 3. Indicate <u>most</u> filter design today is going to plastic media rather than rock.
3	Wastewater treatment with trickling filters Page 2 1. Covers aerobic treatment (food, bugs, air (Oxygen)-questions 2. Filter needs: (1) Pre-treatment of harsh wastes (2) Good distribution of wastewater (3) Good filter media (4) Good underdrain (5) Good ventilation (Most problems in these areas) 3. Types of Filters - High, Low, "Super High" 4. Loadings Reviewed, as well as depth (covered before) Organic vs Hydraulic 5. Ask if abbreviations understood 6. Explain WPCF MOP 11 reference as cited Who WPCF is and types of manuals available

7. Review 30% removal by B.O.D.

8. Ask if terms (page 3) "Single stage filter", recirculation, primary clarifier, secondary clarifier are understood.

9. Key Point! - Must evaluate trickling filter and secondary clarifier together.

10. Other units of Expression - Questions?

11. Comparison of Filter Types
Key Point - Same design for construction of low and high rate filters - Plastic different construction - Review of effluent quality - Questions? Key idea design made to fit objectives of treatment.

12. Pre-treatment: Summary (page 3)
Primary clarifier design:
- 2-hour detention time (explain dt if needed) (variation in different states)
  Surface overflow rates and depth (vary with state)
  Help balance "shock" hydraulic, organic and toxic loads to filter
  Emphasize sewer use ordinance as key to pre-treatment

13. Intermediate and Post-treatment
Review - that they have limited use

14. Effect of Temperature
Trickling filters work best in warm climates
May be covered
Cold weather - lose B.O.D. Removal and ice
Key Point - Provide bleed valves as listed
B.O.D. of effluent often is 20% greater in winter
Design solution make filter "43%" larger
Northern U.S. design 25% bigger than Southern U.S. design
Often 3 weeks required to get good film on Trickling Filters - If cold, longer

15. Applicability (page 4)
Trickling Filters work on weak or stong domestic or industrial wastes.

4	Media, Drainage and Ventilation (page 5) 1. Five Essentials of Filter (1) Basic filter support (2) Underdrain blocks (3) Retaining walls (4) Media (5) Distribution system 2. Filter Floor and Center Channels: Firm and uniform base - Concrete on well-compacted earth - 4 to 6" thick light re-enforcement Floor slope important - Use normal flow charts for design (paraphrased) 3. Center channels - 8-inch pipe for standard rate filter, high rate 16 or 18-inch pipe. Configuration of center channels Extend center channel through filter wall into cleanout box - Questions?
5	Underdrain Blocks (page 6) 1. Stress importance of good ventilation. 2. Review types of blocks and who makes them, demenions, etc. 3. Review ASTM Specs C159 (Who ASTM is and Specs, etc.) 4. Review contractor "Specs" - laid in dry mortar bed on filter floor before stone is placed, composition of motor, angles, etc. - Questions?
6	Filter Design: 1. Depth 3 to 10 feet (plastic to 40 feet) 2. Walls reinforced concrete - 8 to 12 inches thick No walls is a poor idea! 3. Media: Review Specs as listed Clean washed - 2½ inch commonly used Uniform size - Explain Table 1 Plastic discussed - Light - High loading possible Good ventilation Media placed on filter - technique very important belt conveyor - Questions?

7	Distributors Review manufacturer's list - Questions? Standard Specifications - Example - Questions? (Pages 9 & 10)
8	Standard Rate Filters (Page 11) 1. Review loadings - B.O.D. < 600 pounds/acre foot 2. Trend toward high rate 3. Average depth 6 feet 4. Loading not depth key to nitrification 5. Hydraulic loadings - Average 1.8 mgd, but no "fixed standard" 6. Ask Question - Page 11 - Can you work (3.5 acres of filter required)? 7. Organic load often governs hydraulic loading 8. Media, underdrains, distributors discussed before 9. Rotary distributor (page 12) will operate with minimum discharge 40% of maximum, will handle flows 2½ times minimum - requires 2½ to 4 feet of head 10. Dosing tanks (page 12) - dt - 2 minutes at 2 times the average rate of flow. Drawdown 10 inches but < 12 inches. 11. Pre-treatment as discussed before 12. Filter performance as before 13. Design efficiency (NRC Formula) - As worked before Questions?
9	A Nomographic Solution For Design (Page 13) 1. Purpose to reduce time in finding size of Trickling Filter units (gives fast/rough answers). 2. Also used for estimating B.O.D. removal. 3. To use you must know: (1) % B.O.D. removal, desired (2) Pounds of B.O.D./day applied (3) Hydraulic load - mgd 4. Step 1 - Step 2 - Step 3 - Step 4 - Step 5 Step 6 - Step 7 Read sections and do, using nomograph Taken from book and placed on blackboard Do it stepwise with an example - Questions?

5. Have students use nomograph to solve the three following problems:

Problem 1

1 MGD flow, 192 mg/l B.O.D.$_5$ - want 55% removal
Effluent = 82 mg/l

Problem 2

70% removal desired - Flow = 5 MGD
B.O.D.$_5$ to filter 135 mg/l
Find the diameter and depth of standard rate filter
Answer = 200' - 3½' deep

Problem 3

Find the optimum removal (% B.O.D.) expected from a filter 167 feet in diameter, 7 feet deep, recirculation ratio of 2:1 with 2 MGD flow and B.O.D. to filter of 102 mg/l
Answer

Solution - Problem 1
(Red Lines)
55% Removal desired

1600 lbs. B.O.D./day applied
a mgd, B.O.D.$_5$ = 192 mg/l

Step 1 - Select correct lat. (40^o & 45^o) through RT - intersects at 5,200 pounds applied/acre-foot

Step 2 - Connected 5,200 lbs./acre foot to 1600 lbs. B.O.D./day (Red line) - Noted intersection at point D

Step 3 - Followed parallel line point D to point # Gave solution diameter = 50 feet, approximately 4 feet deep.

Solution - Problem 2

1. Select correct (Lats. 40° & 45° N)

2. 70% removal gives 2,000 pounds of B.O.D. applied per acre foot
Flow = 5 mgd, mg/l B.O.D. to filter = 135 pounds $B.O.D._5$/day = 5630

3. Connected 2,000 on top to 5630 (estimated on scale) On bottom (just left of point C)

4. Found point on Line RR
Approximately 2 inches below RR-TT intersection

5. Followed parallel line to TT (approximately 1 3/4" up from RR-TT intersection)

ANSWER: Solutions -

<u>Low Rate Filter</u>	Diameter -	200 ft.
	Depth -	3½ ft.

Solution - Problem 3

Given: Filter diameter 167 feet, depth 7 feet
Recirculation ratio = 2:1
Pounds applied to filter = 1700
Pounds $B.O.D._5$/day
Flow = 2 MGD, $B.O.D._5$ to filter = 102 mg/l

To find the % B.O.D. removal (optimum)

Follow green lines to Point A - Gives 85% removal

10	Design of High Rate Filters (Page 16) 1. High Rate means recirculation practiced. 2. Review organic and hydraulic loadings. 3. Review types of high rate filters discussed with various recirculation (Page 17) 4. Define "single stage" vs "two stage" filters single stage = parallel operation two stage = series 5. Recirculation and performance (Previous lesson) Brief review - Questions? Cover B.O.D. removal curve (10 state standards) 6. Cite references as listed (Pages 18 & 19) 7. Clarifiers: Detention time - 2 hours Overflow rates - 650 to 800 gpd/ft.^{2} EPA now requires scum removal! 8. Treatment results - Covered before, but review these seven items - they are important!
11	Industrial Waste Applications Review Examples: (Pages 20 & 21) 1. Cannery wastes 2. Dairy wastes 3. Fermentation wastes 4. Distillery wastes 5. Yeast factory wastes 6. Slaughterhouse and meat packing 7. Textile wastes 8. Pharmaceutical wastes 9. Phenolic wastes 10. Pulp and paper 11. Metal finishing Ask trainees where industrial applications exist in the area near the course location. Stimulate discussion (5 or 10 minutes)

12	"Design Considerations For Biological Filters" (Optional - time may be short) 1. Review NRC formulae for single vs second stage filters 2. Review 6 items on page 22 and 3 recirculation advantages on page 23. 3. Review charts (Pages 24 & 25) if time permits 4. Review conclusions on page 26 - very important! 8 key ideas!
13	Questions?

END
(Hour 13 of 20)

SUMMARY

Module No. 113H22	Module Title Intermediate Trickling Filters
Apx. Time 1 hour Hour 14 of 20	Submodule Title Abnormal Trickling Filter Performance
Objectives:	The Trainee will: 1) Recognize and list abnormal trickling filter performance
Instructor Aids:	Overhead projector Overhead transparancies
Instructor Approach:	Instructor will present overhead slides and lead discussion.

END

LESSON OUTLINE
Hour 14 of 20
Abnormal Trickling Filter Performance

Item #	Overhead or Write	Key Instructor Point
1	Abnormal Performance in: 1) Personnel 2) Grounds, Maintenance & Records 3) Filter operations	1) Word slide - Read
2	Personnel?	1) Stimulate discussion of what to look for in personnel area. (5 minutes)
3	Personnel observations 1) Personal appearance 2). Attitude and motivation 3) Technical skill 4) Certified? 5) Walking tour with operator talking	 1) Beards, clean, etc. 2) Do they want to do a good job? 3) Trained - qualified 4) Legal aspects and personal value of? Discuss 5) Listen and learn
4	Grounds & Maintenance Look For What	1) Ask questions Lead discussion
5	Grounds, Maintenance and Records 1. Grounds well kept? Flowers, grass, trees 2. Media condition - Green or other 3. Buildings painted, well-lit, well-maintained	 1) Good motivation Good housekeeping 2) Industrial loads Non-compliance with sewer use ordinance 3) Pride in operation

	4. Records - both operation and reporting are proper	4) Emphasize type of records needed and not being a "pencil chemist"
	5. Laboratory procedures correct? Using standardized procedures for permit data and reproducible O&M testing procedures	5) Stress difference in types and need for "Standard Methods" 6) Discuss trainee experience in these areas
6	Filter Operations Common Deficiencies	
	1. Media problems - Anaerobic, Grease, Broken, etc.	1) Discuss
	2. Leaks around seals	1) Review how to correct
	3. Improper distribution of sewage, flow not evenly split, clogged nozzles, splash plates incorrect	1) Discuss importance of proper distribution
	4. Poor B.O.D. removal Poor Nitrogen (NO_3^-) Production Poor Solids Removal Poor D.O. Level in Effluent, Why?	1) Question word slide - 2) Lead discussion of one at a time
7	Filter Septic - Poor D.O. Clogged Vents Toxic Wastes Kill of Biological Forms	1) Discuss each
8	Poor Solids Removal Seasonal Variation Grease Problems Poor Secondary Settling	1) Discuss - Have they seen examples of each?
9	Poor Nitrogen Oxidation $NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$ Low Oxygen Supplied B.O.D./N/P ratio off Hydraulic loading and/or organic loading incorrect	1) Word Slide

10	Poor B.O.D. Removal All of the above Low Oxygen Industrial Loads B.O.D./N/P off Media problems Distribution problems Final B.O.D. 25 to 50 mg/l	1)	Word Slide
11	<u>Common Problems</u> Ponding Odors Filter Flies Snails Uneven Distribution Industrial Shock Loads Heavy Sloughing of Growth	1)	Discuss each more detail in next module on "Trouble-shooting" Reference - EPA Course 179.2
12	Process Control Testing B.O.D. daily Suspended Solids daily Dissolved Oxygen daily Option: C.O.D. Nitrates/Nitrites/NH_3 daily	1)	Reference: "Evaluating O&M Problems at Wastewater Treatment Plants"
13	Other Useful Tests Temperature Flow Odors (Sulfides) Media Inspection Snails and other growth Organic/Hydraulic Loads	1) 2)	Discuss Questions?
14	What Have You Seen? Problems?	1)	Lead discussion of abnormal Trickling Filter Problems (10 minutes)
15	Questions?	1)	Word Slide
	END		

SUMMARY

Module No. 113H22	Module Title Intermediate Trickling Filters
Apx. Time 6 Hours (15, 16, 17, 18, 19, 20 of 20)	Submodule Title Field Work and Visit to a Trickling Filter System
Objectives:	The Trainee will: 1) Demonstrate the ability to organize a field visit to a Trickling Filter Plant when given: (1) the plant plans (as built) (2) the O & M Manual (3) copies of the NPDES monthly report (4) copies of the O & M monthly log 2) Calculate the organic loading, hydraulic loading, the recirculation ratio, the efficiency obtained and the theoretical efficiency of the plant. 3) Recognize and list normal and abnormal behavior in the Trickling Filter Plant visited
Instructor Aids:	1) An intimate knowledge of the high-rate Trickling Filter Plant to be visited 2) Copies (2 at least) of the plant plans (as built drawings) to be visited. 3) 2 copies of the plant O & M Manual 4) One copy for each trainee of the O & M daily log for the preceeding month and the last NPDES monitoring report

Instructor Approach:

1) Instructor should visit the plant (a high rate Trickling Filter Plant with recirculation and either parallel or series filter operation long before classwork Should know plant, personnel, financial constraints, performance, equipment. Copies of the trainee materials tested above must be obtained long before class use

2) Make arrangements for visit, transportation tour, and trainee assignment before visit.

3) Lecture/discussion before and after tour (4 hours) of 1 hour each - total 6 hours (could be longer)

END

LESSON OUTLINE
End 20 of 20 (6 Hours)
Field Visit To A Trickling Filter Plant

Item #	Instructor Behavior:
1	Before starting this section the trainees should have several days to review the materials for the plant to be visited.
2	Hour 1 - Day of Field Trip Review objectives of the 6 hours Review plant data - Answer questions Review expected form to be turned in to instructor Review detailes of days traveled, when, where, behavior expected, etc. Waiver of liability for each trainee (if required) Board Transportation (large group - bus preferred)
3	Outside plant gate - stop bus, detail topography, general plant appearance, etc. - short discussion Park bus out of the way Keep group together Introduce to tour person or operator Tour plant (encourage questions) Emphasize organic loading % removal Hydraulic loading Size of filters Size, condition of secondary clarifiers
4	Assemble group in quiet place with plant superintendent or operator (allow time for questions) Let students "look around" for approximately 30 minutes to help get information for form to be completed Thank Superintendent and operators for visit - encourage trainees to thank them also Re-board bus - Do head count (time apx. noon)

5	Take group to restaurant (or back to classroom) with a meeting room (pre-arranged) Over lunch, de-brief students about plant A good technique is to sketch out on acetate film on overhead or use blackboard or carry your own flip-chart and felt tip marker
6	Go through student form - item by item - Stimulate student observations and comment Check calculations required Summarize Module Questions?

END

INTERMEDIATE TRICKLING FILTER FIELD TRIP

Students Complete

________ Name ________ Class ________ Date

1. Plant Background Information

________ Name of Town ________ State
________ Population ________ Date plant constructed
________ Major industries
________ Design Flow ________ Actual Flow
________ Type of Collection System
________ Infiltration/Inflow
________ Unusual flow or toxics or shock loads
________ Collection system problems
________ Plant gounds and
________ Buildings and
________ Personnel

2. Describe pre-treatment used: ________

3. Describe primary treatment units: ________

4. Problems observed before pre-treatment: ________

5. Type of Tirckling Filter ________ Low Rate ________ High Rate
Depth ________
Diameter ________ Type of media ________
Number of units ________
Mode of operation ________ parallel ________ series
Recirculation volume pumped ________ #1 ________ #2
Recirculation ratio ________
Volume of filter ________
Hydraulic loading ________
Organic loading ________

B.O.D. into: Filter #1 ________
Filter #2 ________
B.O.D. out: Filter #1 ________
Filter #2 ________

% Removal (B.O.D.) #1 ________
#2 ________

- Actual volume of sludge pumped ________ gpd _____% solids
Calculated volume of sludge __________ gpd

Theoretical nomograph % removal expected:
________% Why different? ____
____
____

6. Trickling Filter effluent quality:

B.O.D. ______________
Suspended Solids _________
pH ________
D.O. ________
NH_3 ___________ NO_2^- ________ NO_3^-
Grease Level ____________

7. Plant problems and abnormal performance observed:

Item Observed:	Reason For Problem:	I would solve the Problem by:

END

Examination Questions
Intermediate Trickling Filters
Module 113H22 (20 Hours)

Name ______________________________ Date ____________________

1. Three classes of trickling filters are:

   1. ____________________
   2. ____________________
   3. ____________________

2. ____________________ loading and ____________________ loading are terms used to classify trickling filters.

3. Three industrial uses of trickling filter applications are:

   1. ____________________
   2. ____________________
   3. ____________________

4. Normal depth for a rock trickling filter would be ____________ and would depend upon the filter ____________________.

5. A normal % BOD_5 removal expected for a well-designed and operating trickling filter would be ________________%.

6. A trickling filter will normally give better removals of BOD_5 in the winter or in the summer? ____________________

7. ____________________ is a term related to loss of filter growth or slime in a trickling filter.

8. "Wetting Rate" is an important consideration in ____________ trickling filters.

9. A "shock" load on a trickling filter is a ____________________ ____

10. gal/min/ft.^{2} and million/gal/day acre are units of ____________ loading on a trickling filter.

11. Calculate the number of acres on a surface 500 ft. long and 500 ft. wide. (show work)

_______________ acres

12. One million gallons of wastewater flowed to a filter 209 ft. long and 209 ft. wide in one day. What is the loading in gpd/ft^2? (show work)

____

13. Find the loading in mgd/acre for a trickling filter that receives 5,000,000 gal. each 24 hours and has 200 ft. diameter. (show work)

_______________ mgd/acre

14. ~~Lbs. BOD/day/acre foot~~ and lbs. BOD/day/1000 cu. ft. of media are examples of _______________ loadings.

15. Find the loading on a filter that receives 4,504 pounds of BOD_5/day and is 100 ft. square and 10 ft. deep.

____

16. If the influent to a filter is 180 mg/l and a flow of 3 MGD, how many pounds of BOD_5 are received each day on the filter?

____

17, 18, 19. If the flow to a trickling filter is 3 MGD with a diameter of 236 feet and 10 ft. deep, find the pounds of BOD_5/day/acre ft.

____

What type of filter is it? ____________________

Why? ____________________

____

20. The greater the ____________________ to a filter the greater the recirculation.

21. ____________________ rate filters use recirculation.

22. If an influent wastewater flow is 10 MGD and the recirculation ratio is 2 to 1, what is the total wastewater flow to the filter? (show work)

____

23. If you treated 7 MGD of wastewater containing 19,500 lbs. BOD_5 each day, what would be the BOD_5 concentration in mg/l? (show work)

____________________ mg/l BOD_5

24. Normal removal of BOD_5 in a primary plant before reaching the trickling filter would be __________ % and apx. __________ % for the suspended solids.

25. Explain the relationship between BOD_5, $BOD_{ultimate}$, and COD in 25 words or less.

____

____

____

____

____

____

26. How many gallons of sludge (5% solids) would you expect for 700 pounds of trickling filter humus?

______________ gal.

27. Oxidation of nitrogen proceeds from ammonia to ______________ to ______________.

28, 29, 30. Given the formula:

$$E = \frac{100}{1 + .0085\sqrt{W/VF}}$$

Find the % removal for a flow of 250,000 gpd,
Trickling filter diameter is 96 ft.
Depth = 6 ft. (acre feet = 1)
BOD to filter = 175 mg/l
(Lbs. BOD_5 = 366/day
(Recirculation = 0)

____

31.-32. Assuming a recirculation ratio of 3:1, in the above problem, what would be the % removal of BOD?

____

33. A trickling filter must be evaluated in conjunction with a ______________________________, since these units function as a single unit.

34. List two problems with O & M of a trickling filter in extremely cold climates:

1. ____
2. ____

35. List the five component parts of a trickling filter.

1. __________________________
2. __________________________
3. __________________________
4. __________________________
5. __________________________

36. Where would you find design specifications on materials used in constructing a trickling filter?

____

____

37, 38, 39. Using the nomograph as published by "Public Works Publications" size a trickling filter plant design for 1 MGD, 192 mg/l BOD_5, wanting a 55% removal.

____

40. List three examples of abnormal trickling filter performance.

1. ____
2. ____
3. ____

41. List items used to evaluate personnel utilized in a trickling filter plant:

1. ______

2. ______

3. ______

42. List three items to be evaluated with grounds, maintenance, and records in a trickling filter plant.

1. ______

2. ______

3. ______

43. List three sources of odors in a trickling filter plant operation.

1. ______

2. ______

3. ______

44. The use of masking agents is not a recommended procedure at a trickling filter plant. True____ False____

45. List three important process control laboratory tests for trickling filter operations:

1. ______

2. ______

3. ______

46. The term "as built drawing" means: ______

______

______

47. List two pretreatment problems that interfere with good trickling filter performance.

1. ______

2. ______

48, 49, 50. Discuss how you would organize a field inspection visit to a treatment plant. (Who would you call? Why? What records would you look at? Why? What would you evaluate? Why?) 50 words or less:

51, 52, 53. Write a word relationship for aerobic sewage treatment, explaining what happens when the system goes septic. (50 words or less)

57, 58, 59. Why is establishment and enforcement of a sewer use ordinance important in good trickling filter performance? (50 words or less)

____

60. List two things that a well maintained trickling filter plant, with flowers, etc. would indicate to you.

1. ____

2. ____

Does it mean the effluent is meeting NPDES requirements?

Yes____ No_____

Why____

S L I D E 1

TRICKLING

FILTER

DOES NOT

"FILTER"

SLIDE 2

FOOD (SEWAGE)

OXYGEN (AIR)

BUGS (GROWTH ON MEDIA)

SLIDE 3

BOD/N/P

100/2/1

SLIDE 4

TRICKLING

FILTER

OPTIMUM

CONDITIONS

SLIDE 5

TRICKLING FILTER TYPES BY APPLICATION RATES:

1) "ROUGHING" FILTER

2) LOW RATE

3) HIGH RATE

4) "SUPER" HIGH RATE

SLIDE 6

ROUGHING FILTER:

ROCK OR PLASTIC MEDIA

UP TO 20 FEET DEEP

USED TO PRETREAT HIGH BOD WASTES

HYDRAULIC LOADING:

60 TO 180 MGD/ACRE OR

1400 TO 4200 GPD/FT.^{2}

ORGANIC LOADING:

$>$100 LB/BOD/DAY/1000 CU. FT.

MAY OR MAY NOT HAVE RECIRCULATION

S L I D E 7

EXAMPLES OF ROUGHING FILTER USES:

1) BREWERIES

2) FOOD PROCESSING WASTES

3) POULTRY, EVICERATION, SLAUGHTERING WASTES

4) MILK, CHEESE & WHEY PROCESSES

5) TOXIC WASTE HANDLING (PHENOLS)

SLIDE 8

NORMAL "ROUGHING FILTER PERFORMANCE"

WHAT IS EXPECTED????

SLIDE 9

EXPECTED PERFORMANCE:

1) Low % REMOVAL OF BOD, (40 TO 65) BUT VERY HIGH TOTAL REMOVAL

2) LOW NITRATE LEVELS SOME NITRITE AND AMMONIA OR AMMONIUM ION PRESENT

3) SOME ODORS (DIFFICULT TO KEEP AEROBIC) FEW FLIES

4) SLOUGHING - USUALLY CONTINUOUS

SLIDE 10

WHERE HAVE YOU SEEN ROUGHING FILTERS USED?

SLIDE 11

LOW RATE FILTERS:
(SAME AS "STANDARD" RATE)

USUALLY ROCK MEDIA

6 TO 8 FEET DEEP

USED IN DOMESTIC SEWAGE TREATMENT

HYDRAULIC LOADING:
1 TO 4 MGD/ACRE OR
25 TO 90 GPD/SQ. FT.

ORGANIC LOADING:
200 TO 1000 LB. BOD/DAY/ACRE FT. OR
5 TO 25 LB. BOD/DAY/1000 CU. FT.

USUALLY DOES NOT HAVE RECIRCULATION

USUALLY HAS DOSING TANKS OR SIPHON

SLIDE 12

NORMAL LOW RATE FILTER PERFORMANCE

WHAT IS EXPECTED?

SLIDE 13

EXPECTED PERFORMANCE:

1) HIGH BOD REMOVAL 85-90%

2) SEASONAL VARIATION IN PERFORMANCE

3) HIGH NITRATE (NO_3) LEVELS - LOW NITRITE AND AMMONIA

4) SOME ODORS - SOME FILTER FLIES

5) SLOUGHING - INTERMEDIATE AND SEASONAL IN NATURE

S L I D E 14

WHERE ARE STANDARD OR LOW-RATE TRICKLING FILTER PLANTS LOCATED NEAR HERE?

S L I D E 15

HIGH RATE TRICKLING FILTERS:

USUALLY ROCK MEDIA

3 TO 8 FEET DEEP

USED IN DOMESTIC AND INDUSTRIAL WASTE TREATMENT

HYDRAULIC LOADING:

5 TO 40 MGD/ACRE

100 TO 900 GPD/FT.^{2}

ORGANIC LOADING:

1000 TO 1300 LB./BOD/DAY/ACRE FT. , OR

25 TO 300 LB.BOD/DAY/1000 FT.^{3}

ALMOST ALWAYS HAS RECIRCULATION

NO DOSING TANKS

REQUIRES PUMPING AND ELECTRICAL COSTS.

S L I D E 16

NORMAL "HIGH RATE" FILTER PERFORMANCE.

WHAT IS EXPECTED?

SLIDE 17

EXPECTED PERFORMANCE:

1) GOOD BOD REDUCTION 85-90%

2) SEASONAL VARIATIONS NOT AS GREAT AS LOW RATE BUT STILL EXIST

3) GOOD NITRIFICATION, HOWEVER, SOME NITRITE AND AMMONIA PRESENT

4) FEW ODORS AND FEW FLIES, BUT DEPENDS UPON OPERATIONAL CONTROL

5) SLOUGHING - CONTINUOUS - SEASONAL VARIATION

S L I D E 18

WHERE ARE "HIGH RATE" TRICKLING FILTER

PLANTS LOCATED?

S L I D E 19

SUPER HIGH RATE TRICKLING FILTERS:

USUALLY PLASTIC MEDIA

UP TO 40 FEET

USED IN MANY DOMESTIC AND INDUSTRIAL APPLICATIONS

HYDRAULIC LOADING:

15 TO 90 MGD/ACRE

350 TO 1000 GPD/FT.^{2}

ORGANIC LOADING:

300 LB.BOD/DAY/1000 FT.^{3}

USUALLY HAS RECIRCULATION

NO DOSING TANKS

REQUIRES PUMPING AND ELECTRICAL COSTS

FORCED VENTILATION OFTEN USED

WETTING RATE OF 0.6 GAL/MIN./FT.^{2}

IMPORTANT IN MANY PLANTS

S L I D E 20

NORMAL PERFORMANCE OF "SUPER HIGH RATE FILTERS"

WHAT IS EXPECTED?

SLIDE 21

EXPECTED PERFORMANCE FOR "SUPER HIGH RATE" FILTERS

1) GOOD BOD REMOVAL 65-90% - DEPENDS UPON LOADING

2) SOME SEASONAL VARIATION

3) INTERMEDIATE TO EXCELLENT NITRIFICATION - DEPENDS ON LOADING

4) FEW ODORS, FEW FLIES

5) SLOUGHING CONTINUOUS (SEASONAL)

6) MEDIA BREAKING AND CLOGGING- LESS COMMON THAN ROCK MEDIA

7) TOWERS (40 FT.) OFTEN USED - FILTER VENTILATION CAN BE A PROBLEM - IF SEPTIC A PROBLEM.

SLIDE 22

WHERE ARE " SUPER HIGH RATE FILTERS LOCATED?

SLIDE 23

WHAT ARE THE FOUR BASIC TYPES OF TRICKLING FILTERS?

SLIDE 24

RIGHT.

1) "ROUGHING FILTER"

2) LOW RATE OR STANDARD FILTER

3) HIGH RATE FILTER

4) "SUPER HIGH RATE" FILTER

SLIDE 25

HOW DO WE CLASSIFY FILTERS?

SLIDE 26

RIGHT:

1) ROCK OR PLASTIC MEDIA

2) DEPTH

3) USES

4) HYDRAULIC LOADING

5) ORGANIC LOADING

6) RECIRCULATION

7) SUPPORT SYSTEMS - PUMPS, FORCED VENTILATION, ETC.

8) EXPECTED PERFORMANCE

SLIDE 27

QUESTIONS??

END

******

SLIDE 1

	Hydraulic Loading	
	MGD/acre	GPD/ft.^{2}
Low Rate	1 to 4	25 to 90
High Rate	5 to 40	100 to 900
Super High Rate	15 to 90	350 to 1000

OVERHEAD # 1*

Type of Filter	Organic Loading-units	
	Lbs.BOD/day/acre ft.	pounds BOD/day/1000cu.ft.
Low Rate	200-1000	5-25
High Rate	1000-1300	25-300
Super High Rate	-	up to 300

* MOP 11-WPCF Guidelines (1977)

SLIDE 1

RECIRCULATION

WHY?

SLIDE 2

RECIRCULATION:

1) USED FOR HIGH OR SUPER HIGH FILTERS

2) IMPROVES HYDRAULIC AND ORGANIC LOADINGS (IF NEEDED)

3) IMPROVES EFFICIENCY

SLIDE 3

TYPICAL BOD REMOVAL:

PRIMARY 35%

INFLUENT 204 MG/L BOD

(.17 LBS/CAPITA/DAY AND 100 GPDC)

WHAT IS NORMAL BOD TO FILTER?

SLIDE 4

RIGHT.

130-135 MG/L   65% OF 204 = 132

SLIDE 5

HIGHER THE BOD - GREATER THE RECIRCULATION

SLIDE 6

RECIRCULATION RATE FOR MAXIMUM BOD OF SETTLED WASTEWATER

BOD/MG/L	1/RECIRCULATION RATIO
130	1 : 1
170	2 : 1
220	3 : 1
260	4 : 1

RECIRCULATION RATIO DEFINED AS TOTAL NUMBER OF TIMES WASTEWATER RETURNED, PLUS 1

MGD FLOW	RECIRCULATION RATIO	MGD TOTAL HYDRAULIC LOAD TO FILTER
5	1 : 1	(1 + 1) x 5 = 10
5	2 : 1	(1 + 2) x 5 = 15
5	3 : 1	(1 + 3) x 5 = 20
5	4 : 1	(1 + 4) x 5 = 25
5	5 : 1	(1 + 5) x 5 = 30

S L I D E 7.

SLIDE 8

QUESTIONS?

WHAT HYDRAULIC LOADING WOULD A 3 MGD FLOW WITH A 4 TO 1 RECIRCULATION RATIO BE?

SLIDE 9

RIGHT.

15 MGD

OR

FLOW = 3 MGD x (1 + 4)

FLOW = 3 MGD x 5 = 15 MGD

SLIDE 10

WHAT BOD RANGE WOULD YOU EXPECT THE

TRICKLING FILTER INFLUENT TO BE?

SLIDE 11

RIGHT.

APX. 260 MG/L

SLIDE 1

AEROBIC TREATMENT NEEDS:

FOOD (SEWAGE)

OXYGEN (AIR)

BUGS (BACTERIA + OTHERS).

SLIDE 2

AEROBIC TREATMENT
NEEDS

FOOD (SEWAGE)
OXYGEN (AIR)
BUGS (BACTERIA + OTHERS)

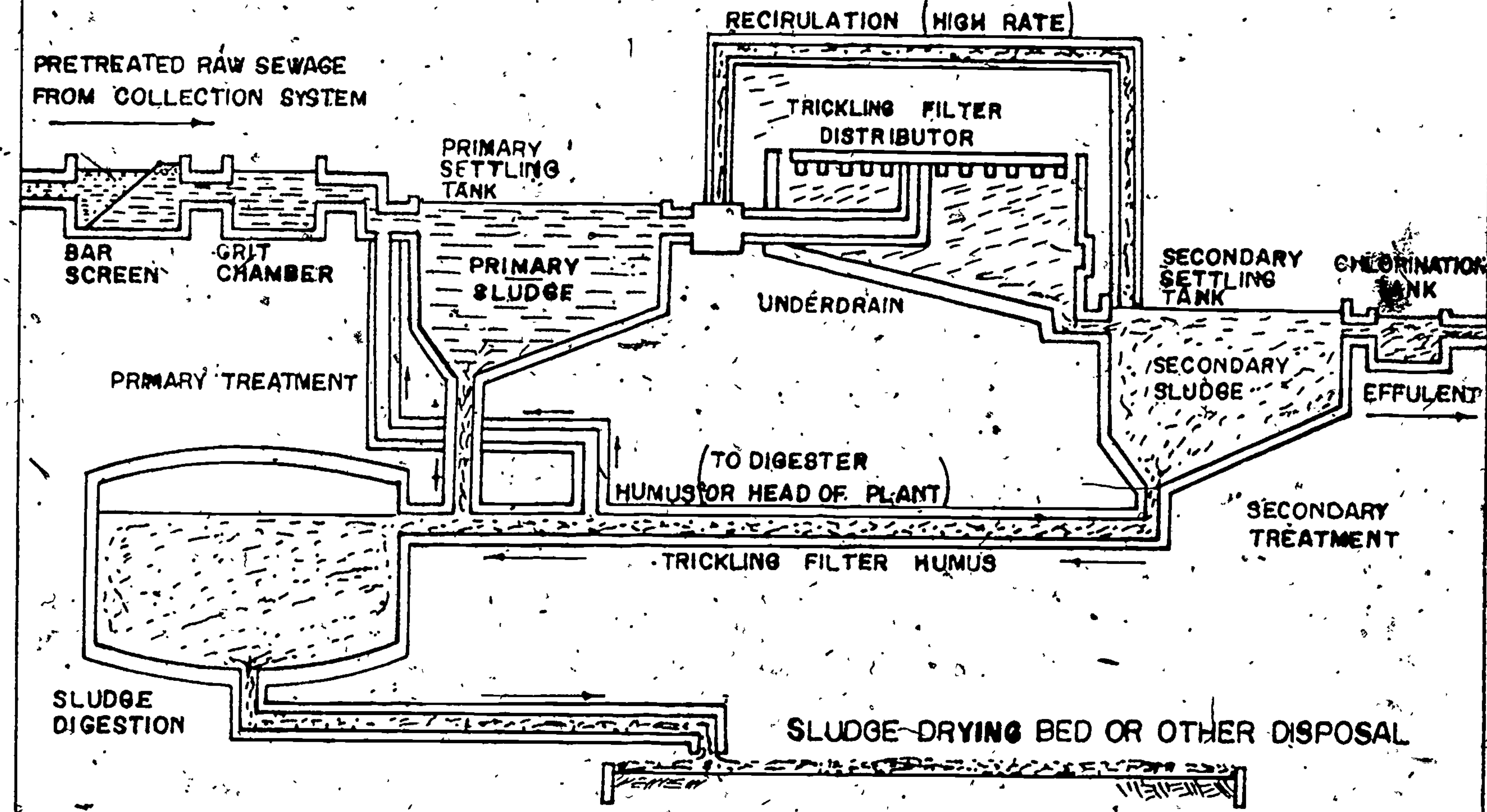
SLIDE 3

TRICKLING FILTER PERFORMANCE MEASURED BY:

1) SOLIDS - SUSPENDED & SETTLEABLE
2) BOD/COD REDUCTION
3) SOLIDS PRODUCED (HUMUS)
4) NITROGEN OXIDIZED
5) RECIRCULATION RATIO - HYDRAULIC & ORGANIC LOADS
6) OXYGEN - NEAR SATURATION
7) NO ABNORMAL PROBLEMS (ODORS, SNAILS, PONDING, ETC.)

SLIDE - 4

TYPICAL TRICKLING FILTER SEWAGE TREATMENT PLANT



SLIDE 5

SOLIDS TO FILTER

SUSPENDED SOLIDS	SETTLEABLE SOLIDS
35-45% OF PLANT INFLUENT	TRACE (IMHOFF CONE)

TYPICAL PLANT - SUSPENDED SOLIDS 40% OF 300 MG/L =

120 MG/L (NON-SETTLEABLE, COLLOIDAL)

OR

FOR 1 MGD FLOW:

LBS. SS/DAY = 8.34 X 1 MGD X 120 MG/L

LBS. SS/DAY = 1000 LBS./DAY

(CONVERTED TO HUMUS)

NORMAL PERFORMANCE:

LOW SETTLEABLE SOLIDS AND LOW SUSPENDED SOLIDS IN EFFLUENT

SLIDE 6

BOD/COD

PRIMARY REMOVAL 35-40%

TRICKLING FILTER INFLUENT 65% OF 204 MG/L = 132 MG/L

FOR 1 MGD FLOW:

LBS. BOD_5/DAY = 8.34 X 1 MGD X 132 MG/L

LBS. BOD_5/DAY = 1100 LBS./DAY

TOTAL BOD REMOVED APX. 80-90% OF PLANT INFLUENT.

IF INFLUENT IS 204 PPM, 85% REMOVAL LEAVES 15%.

15% OF 204 MG/L = 30 MG/L

NORMAL BOD EXPECTED 25-50 MG/L

AND

$BOD_{ULT} \approx 1.6\ BOD_5$

$BOD_{ULT} \approx COD$

SLIDE 7

SOLIDS PRODUCED (HUMUS) FROM OXIDATION OF DISSOLVED AND NON_ SETTLEABLE SUSPENDED SOLIDS.

SIMPLE CALCULATION:

PART 1

SUSPENDED SOLIDS:

PLANT INFLUENT 300 MG/L

PRIMARY EFFLUENT 105 MG/L (TO FILTER)

PRIMARY EFFLUENT 30 MG/L (FROM FILTER) (90% REMOVAL)

FILTER REMOVAL:

105 MG/L - 30 = 75 MG/L

LBS.SS/DAY = 75 MG/L X 8.34 X 1 MGD

LBS.SS/DAY = 626 LBS/DAY (SLUDGE)

SLIDE 8

PART a:2:

BOD OXIDATION:

BOD INTO PLANT 204 MG/L

PRIMARY EFFLUENT 132 MG/L (TO FILTER)

LEAVING PLANT 30 MG/L

BOD REMOVED ON FILTER:

132 - 30 = 102 MG/L

1 LB. OF BOD PRODUCES 0.77 LBS. OF SLUDGE.

LBS. BOD/DAY REMOVED = 8.34 X 1 MGD X 102 MG/L

LBS. BOD_5/DAY = 851 LBS./DAY

1 LB. BOD GIVES 0.77 LBS. SLUDGE

SO

851 X .77 = 655 LBS. SLUDGE/DAY

SLIDE 9

SLUDGE FROM SUSPENDED SOLIDS	=	626 LBS/DAY
SLUDGE FROM BOD	=	655 LBS/DAY
TOTAL		1281 LBS/DAY

(DRY SLUDGE BASED ON 204 MG/L BOD AND 300 MG/L SUSPENDED SOLIDS)

SLIDE 10

SLUDGE VOLUME

$$\text{LBS. (DRY)} \times \frac{100}{\%\ \text{SLUDGE}} = \text{LBS/WET}$$

SO

$$1281\ \text{LBS. (DRY)} \times \frac{100}{5} = 25620\ \text{LBS./WET}$$

$$\frac{25{,}620\ \text{LBS. (WET)}}{8.34\ \text{LBS/GAL}} = 3071\ \text{GAL.}$$

SO

EXPECT TO PUMP APX. 3071 GAL. SLUDGE (95% WATER)

SLIDE 11

NITROGEN OXIDIZED:

1) FIND NITROGEN IN PLANT INFLUENT (SAY, 25 MG/L)

1 MGD = 209 LBS./DAY

2) ESTIMATE 99% CONVERSION

99% OF 209 LBS. = 207 LBS. REMOVED

2 LBS. LEFT

OR

.25 MG/L LEFT

BUT

1 LB. NH_3 GIVES 4 LBS. OF NITRATE (NO_3^-)

NORMAL VALUES 20-50 MG/L

SLIDE 12

RECIRCULATION RATIO AND PERFORMANCE

NATIONAL RESEARCH COUNCIL FORMULA:

$$E = \frac{100}{1 + .0085\sqrt{W/VF}}$$

WHERE :

E = % REMOVAL BOD_5

W = BOD LOAD LBS./DAY

F = RECIRCULATION FACTOR

V = VOLUME OF FILTER MEDIA (ACRE FEET)

AND

F = RECIRCULATION FACTOR

$$F = \frac{1 + R}{(1 + .01 R)^2}$$

R = RECIRCULATION RATIO

NO SLIDES 13-14

SLIDE 15

REMEMBER

HIGHER THE BOD, HIGHER THE RECIRCULATION.

HIGH RATE FILTERS OR SUPER HIGH RATE FILTERS

IMPROVE LOADING

IMPROVE EFFICIENCY

$$\frac{\text{POUNDS}}{\text{DAY}} = 8.34 \times \text{MGD} \times \text{MG/L}$$

TOTAL FLOW = INFLUENT FLOW X (RECIRCULATION RATIO + 1)

$$\text{\% REMOVAL} = \frac{\text{IN-OUT}}{\text{IN}} \times 100$$

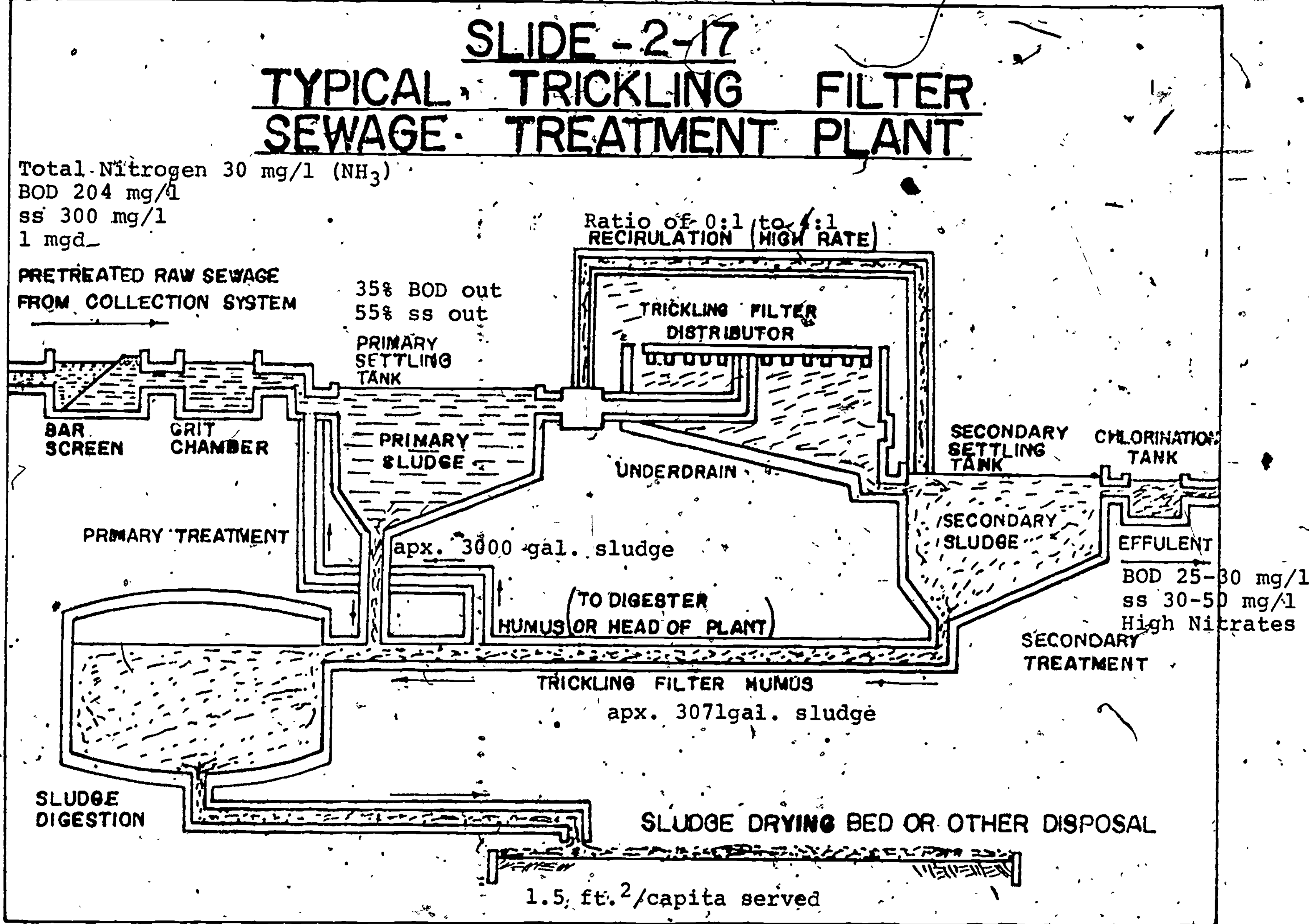
QUESTIONS?

END

SLIDE 16

CONCLUSION:

RECIRCULATION RATIO	% REMOVAL	MG/L BOD IN EFFLUENT
0	61	68
1:1	85	26
2:1	91	16


SLIDE - 2-17
TYPICAL TRICKLING FILTER SEWAGE TREATMENT PLANT
Total Nitrogen 30 mg/l (NH3)
BOD 204 mg/l
ss 300 mg/l
1 mgd
PRETREATED RAW SEWAGE FROM COLLECTION SYSTEM
35% BOD out
55% ss out
PRIMARY SETTLING TANK
Ratio of 0:1 to 4:1
RECIRULATION (HIGH RATE)
TRICKLING FILTER DISTRIBUTOR
BAR SCREEN
GRIT CHAMBER
PRIMARY SLUDGE
UNDERDRAIN
SECONDARY SETTLING TANK
CHLORINATION TANK
PRIMARY TREATMENT
apx. 3000 gal. sludge
SECONDARY SLUDGE
EFFULENT
BOD 25-30 mg/l
ss 30-50 mg/l
High Nitrates
(TO DIGESTER
HUMUS OR HEAD OF PLANT)
SECONDARY TREATMENT
TRICKLING FILTER HUMUS
apx. 3071gal. sludge
SLUDGE DIGESTION
SLUDGE DRYING BED OR OTHER DISPOSAL
1.5 ft.2/capita served

SLIDE 1

ABNORMAL PERFORMANCE IN:

PERSONNEL

GROUNDS, MAINTENANCE & RECORDS

FILTER OPERATIONS

SLIDE 2

PERSONNEL?

SLIDE 3

PERSONNEL OBSERVATION:

1) PERSONAL APPEARANCE
2) ATTITUDE AND MOTIVATION
3) TECHNICAL SKILL
4) CERTIFIED?
5) WALKING TOUR WITH OPERATOR TALKING

SLIDE 4

GROUNDS & MAINIENANCE

LOOK FOR WHAT?

SLIDE 5

GROUNDS, MAINTENANCE AND RECORDS

1) GROUNDS WELL KEPT? - FLOWERS, GRASS, TREES
2) MEDIA CONDITION - GREEN OR OTHER
3) BUILDINGS PAINTED, WELL-LIT, WELL-MAINTAINED

SLIDE 6

FILTER OPERATIONS COMMON DEFICIENCIES

1) MEDIA PROBLEMS - ANAEROBIC, GREASE, BROKEN VENTS, ETC.
2) LEAKS AROUND SEALS
3) IMPROPER DISTRIBUTION OF SEWAGE, FLOW NOT EVENLY SPLIT, CLOGGED NOZZLES, SPLASH PLATES INCORRECT
4) POOR B.O.D. REMOVAL
   POOR NITROGEN (NO_3) PRODUCTION
   POOR SOLIDS REMOVAL
   POOR D.O. LEVEL IN EFFLUENT, WHY?

SLIDE 7

FILTER SEPTIC - POOR D.O.
CLOGGED VENTS
TOXIC WASTES
KILL OF BIOLOGICAL FORMS

SLIDE 8

POOR SOLIDS REMOVAL
SEASONAL VARIATION
GREASE PROBLEMS
POOR SECONDARY SETTLING

SLIDE 9

POOR NITROGEN OXIDATION

$NH_3 \longrightarrow NO_2^- \longrightarrow NO_3^-$

LOW OXYGEN SUPPLIED

B.O.D./N/P RATIO OFF

HYDRAULIC LOADING AND/OR ORGANIC LOADING INCORRECT

SLIDE 10

POOR B.O.D. REMOVAL

ALL OF THE ABOVE

LOW OXYGEN

INDUSTRIAL LOADS

B.O.D./N/P OFF

MEDIA PROBLEMS

DISTRIBUTION PROBLEMS

FINAL B.O.D. 25 TO 50 MG/L

SLIDE 11

<u>COMMON PROBLEMS</u>

PONDING

ODORS

FILTER FLIES

SNAILS

UNEVEN DISTRIBUTION

INDUSTRIAL SHOCK LOADS

HEAVY SLOUGHING OF GROWTH

SLIDE 12

PROCESS CONTROL TESTING

B.O.D. DAILY

SUSPENDED SOLIDS DAILY

DISSOLVED OXYGEN DAILY

OPTION: C.O.D.

NITRATES/NITRITES/NH_3 DAILY

SLIDE 13

OTHER USEFUL TESTS

- TEMPERATURE
- FLOW
- ODORS (SULFIDES)
- MEDIA INSPECTION
- SNAILS AND OTHER GROWTH
- ORGANIC/HYDRAULIC LOADS

SLIDE 14

WHAT HAVE YOU SEEN?

PROBLEMS?

SLIDE-15

QUESTIONS?