



SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Wastewater Operator Training Series

Session 17: Wastewater Math Part 3 – Flow, Detention Time and Loading

03/03/2026

Your trainers for today:



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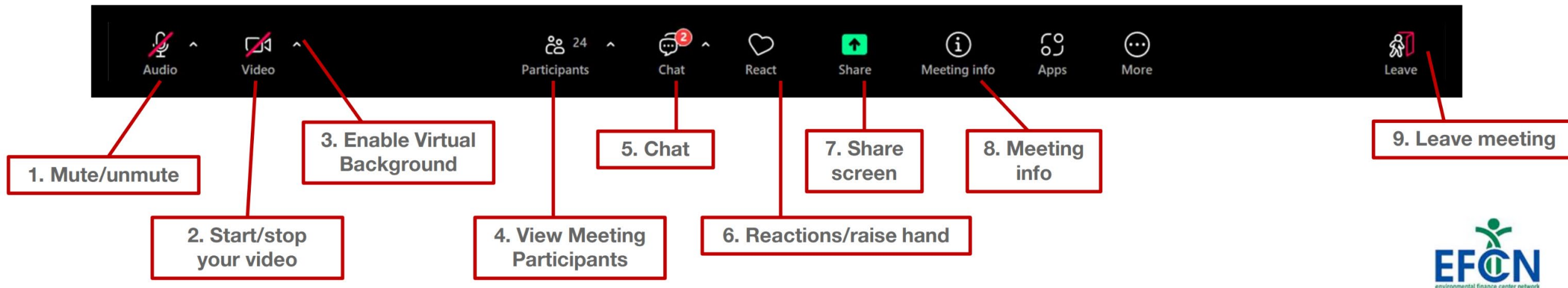
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This training series is funded by the EPA

Attendee Meeting Controls

- Locate your control bar
- All attendees will see a black horizontal bar on their screen
- If your control bar is not visible, it may be hidden
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WPI/ABC Operator Certification

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Standardized Wastewater Treatment Operator Exams

Wastewater Treatment Operator Need-to-Know Criteria

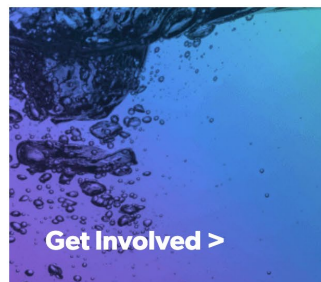
Need-to-Know Criteria outline the content that will be covered on WPI's standardized examinations provided through [ABC Testing](#), a WPI service.

- [Wastewater Treatment Operator Class I](#)
- [Wastewater Treatment Operator Class II](#)
- [Wastewater Treatment Operator Class III](#)
- [Wastewater Treatment Operator Class IV](#)

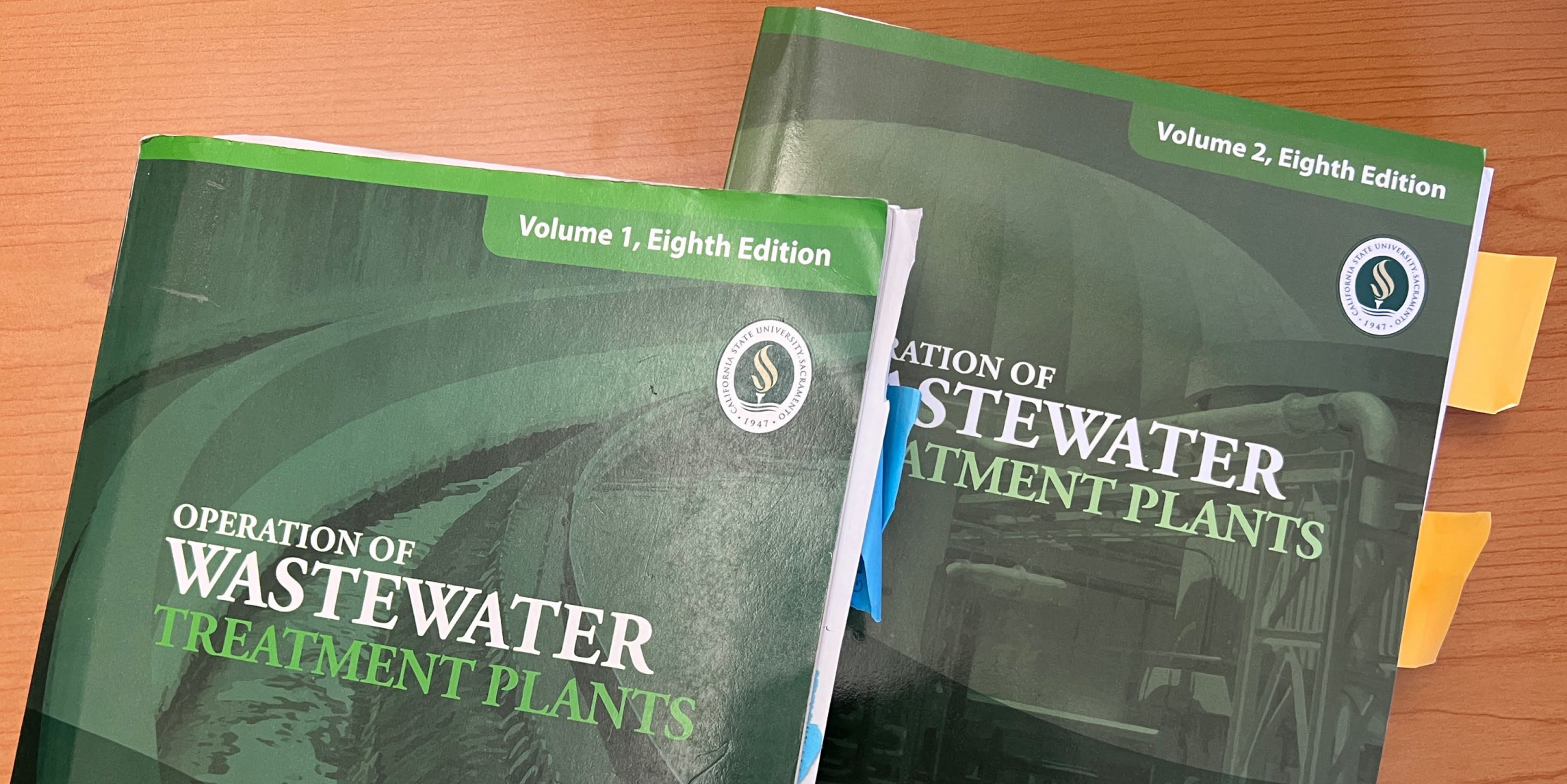
Wastewater Treatment Operator Formula/Conversion Table

WPI standardized exams are administered with a Formula/Conversion Table containing mathematical formulas and common abbreviations that may be present on the exam.

- [Wastewater Treatment Operator Formula/Conversion Table](#)



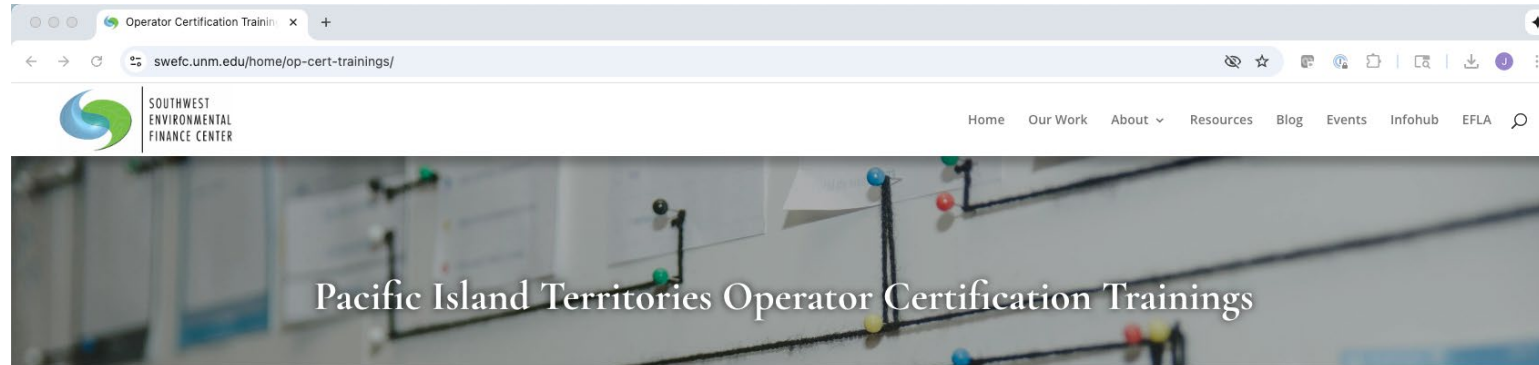
Use all your resources



Schedule for 2026:

Date	Topic
1/20/26	Concept and Math Review Session
2/3/26	Disinfection Part 1 (chlorination/dechlorination) + related math
2/17/26	Disinfection Part 2 - UV and other methods
3/3/26	WW Math Part 3 (Flow, Detention Time)
3/17/26	WW Math Part 4 (BOD Math /Advanced WW Math)
3/31/26	Solids Handling Part 1 (Mechanical Solids Separation)
4/14/26	Solids Handling Part 2 (Solids Handling)
4/28/26	Sampling
5/12/26	Regulations (NPDES Permits and Discharge Limitations)
5/26/26	Treatment System Maintenance
6/9/26	Lab Procedures/Analysis/Interpretation or alternate topic
6/23/26	Using Technology in daily operations (SCADA, Computer, Tablets, CMMS, AI, etc.)
7/7/26	Course Review Session - Short sample exam?

https://swefc.unm.edu/home/op-cert-trainings/



This page is a repository of Wastewater and Drinking Water Operator Certification (Op Cert) Training Webinars offered by the SW EFC for systems in the Pacific Territories. Below you will find the **training webinar schedules (wastewater, then drinking water)** followed by a **training webinar recordings library**.

[Jump to Wastewater Trainings](#)[Jump to Drinking Water Trainings](#)

Wastewater Training Schedule

Please note all times are local to CNMI and Guam. The times in American Samoa are one day earlier at 11 am.

Session	Date	Training Topic & Link to Recording (click to view)	Supporting Materials (click to download)
1	6/25/2025	Program Overview, Test Format, Study & Test Tips	PPT slides
2	7/9/2025	Treatment Overview	PPT slides
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	PPT slides
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	PPT slides
5	8/20/2025	Collection Systems – Gravity systems	PPT Slides
6	9/3/2025	Collection Systems – Pumping & Force Mains	PPT Slides
			Collection Systems (Grades 1 – 2) Course #401
			Tech Brief – Reading Centrifugal Pump Curves
			Grundfos E-cademy – Pump Selection Basics
7	9/17/2025	Collection System Maintenance	Pennsylvania Department of Environmental Protection Module 9: Basics of Pumps and Hydraulics
8	10/1/2025	Operator Safety/OSHA/Chemical Safety & Inventory	PPT Slides
9	10/15/2025	Preliminary Treatment	PPT Slides
10	10/29/2025	Primary Treatment: Sedimentation	

Sign in for every session to ensure you get credit for attending



**US Territories Water & Wastewater Operator Certification
Virtual Training Series Group Attendance Sheet**

Session Title: _____

Session Date: _____

Training Location: _____

Attendee Name	Attendee Signature	Arrival Time	Departure Time

I hereby certify that the individuals listed above attended the referenced training session.

Name: _____
Signature: _____
Title: _____
Date: _____

Please scan this sheet after each training session and email it to swefc@unm.edu with the subject line: "US Territories Op Cert Attendance Sheet"

Overview

- Velocity
- Flow Rates
- Detention Times
- Loading Rates
- Practice problems
 - Pencil and paper needed
 - ABC Formula Sheet helpful
 - <https://gowpi.org/services/abc-testing/formula-conversion-tables/>



Velocity and Flow Rates

How Fast and How Much

OR

Speed and Volume

Velocity vs Flow rates

Velocity: How fast water flows through a pipe in a given time; How far something travels in a given amount of time.

- Feet per second (ft/s)
- Meters per sec (m/s)

Flow: Volume of water flowing through a pipe in a given time.

- Gallons per minute (gpm)
- Cubic feet per second (ft³/sec)
- Million gallons per day (MGD)



$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3 / \text{sec}}{\text{Area, ft}^2}$$

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$\text{Flow Rate, ft}^3/\text{sec}^* = (\text{Area, ft}^2)(\text{Velocity, ft/sec})$$

Velocity = ft/sec
Flow = ft³/sec

Velocity

You put a rubber ducky at the beginning of a pipe that is 520 feet long. It comes out the end in 142 seconds. How fast is water flowing through your pipe?

(assuming water is flowing the same speed as the ducky)

$$V = \text{distance} / \text{time}$$

$$V = \frac{520 \text{ ft}}{142 \text{ sec}}$$

$$V = 3.7 \text{ ft/sec}$$

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3 / \text{sec}}{\text{Area, ft}^2}$$

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$$



- (A) 378 ft/sec
- (B) 73,840 ft/sec
- (C) 0.28 ft/sec
- (D) 3.7 ft/sec

Velocity vs Flow rates

Velocity: How fast water flows through a pipe in a given time; How far something travels in a given amount of time.

- Feet per second (ft/s)
- Meters per sec (m/s)

Flow: Volume of water flowing through a pipe in a given time.

- Gallons per minute (gpm)
- Cubic feet per second (ft³/sec)
- Million gallons per day (MGD)



$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3 / \text{sec}}{\text{Area, ft}^2}$$

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$\text{Flow Rate, ft}^3/\text{sec}^* = (\text{Area, ft}^2)(\text{Velocity, ft/sec})$$

Velocity = ft/sec

Flow = ft³/sec

Flow

Your flow meter for your lift station pump is broken, but you want to figure out the pump's capacity. You open up the blow off and fill up 5-gallon buckets. You fill up 8 buckets in one minute. What is the capacity of your pump in GPM?



Flow = volume / time

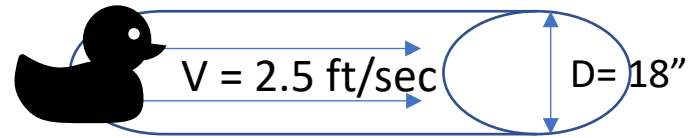
$$\text{Flow} = \frac{5 \text{ gal}}{\text{Bucket}} \times \frac{8 \text{ Buckets}}{\text{min}}$$

$$\text{Flow} = 40 \text{ gal / minute}$$

- (A) 13 gal/min
- (B) 40 gal/min
- (C) 400 gal/min
- (D) 130 gal/min

Flow

What is the flow in gpm in an 18-inch diameter line when your rubber ducky is moving through it at a velocity of 2.5 ft/sec?



Diameter = 18"

Diameter = 18"/12 = 1.5 ft

Radius = 1.5 ft/2 = 0.75 ft

Flow = Velocity x Area

Flow = 2.5 ft/sec x 1.77 ft²

Flow = 4.42 ft³/sec

Conversion factors:
7.48 gallons = 1 ft³
60 secs = 1 min

Area = 3.14 * r²

Area = 3.14 * (0.75 ft)²

Area = 3.14 * 0.56 ft²

Area = 1.77 ft²

$$\frac{4.42 \text{ ft}^3}{\text{sec}} \times \frac{7.48 \text{ gals}}{1 \text{ ft}^3} \times \frac{60 \text{ sec}}{1 \text{ min}} = 1984 \text{ gpm}$$

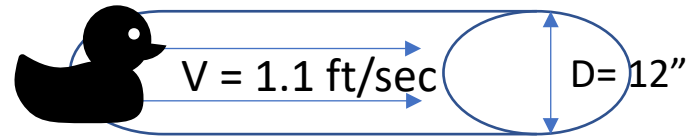
Flow Rate, ft³/sec* = (Area, ft²)(Velocity, ft/sec)

Area of Circle* = (0.785)(Diameter²)

Area of Circle = (3.14)(Radius²)

Flow – you try it

What is the flow in gpm in a 12-inch diameter line when your rubber ducky is moving through it at a velocity of 1.1 ft/sec?



Diameter = 12"

Diameter = 12"/12 = 1 ft

Radius = 1 ft/2 = 0.5 ft

Flow = Velocity x Area

Flow = 1.1 ft/sec x 0.785 ft²

Flow = 0.864 ft³/sec

Conversion factors:
7.48 gallons = 1 ft³
60 secs = 1 min

Area = 3.14 * r²

Area = 3.14 * (0.5 ft)²

Area = 3.14 * 0.25 ft²

Area = 0.785 ft²

(A) 388 gal/min

(B) 9,293 gal/min

(C) 775 gal/min

(D) 1984 gal/min

$$\frac{0.864 \cancel{\text{ft}^3}}{\cancel{\text{sec}}} \times \frac{7.48 \text{ gals}}{1 \cancel{\text{ft}^3}} \times \frac{60 \cancel{\text{sec}}}{1 \text{ min}} = 388 \text{ gpm}$$

Flow Rate, ft³/sec* = (Area, ft²)(Velocity, ft/sec)

Area of Circle* = (0.785)(Diameter²)

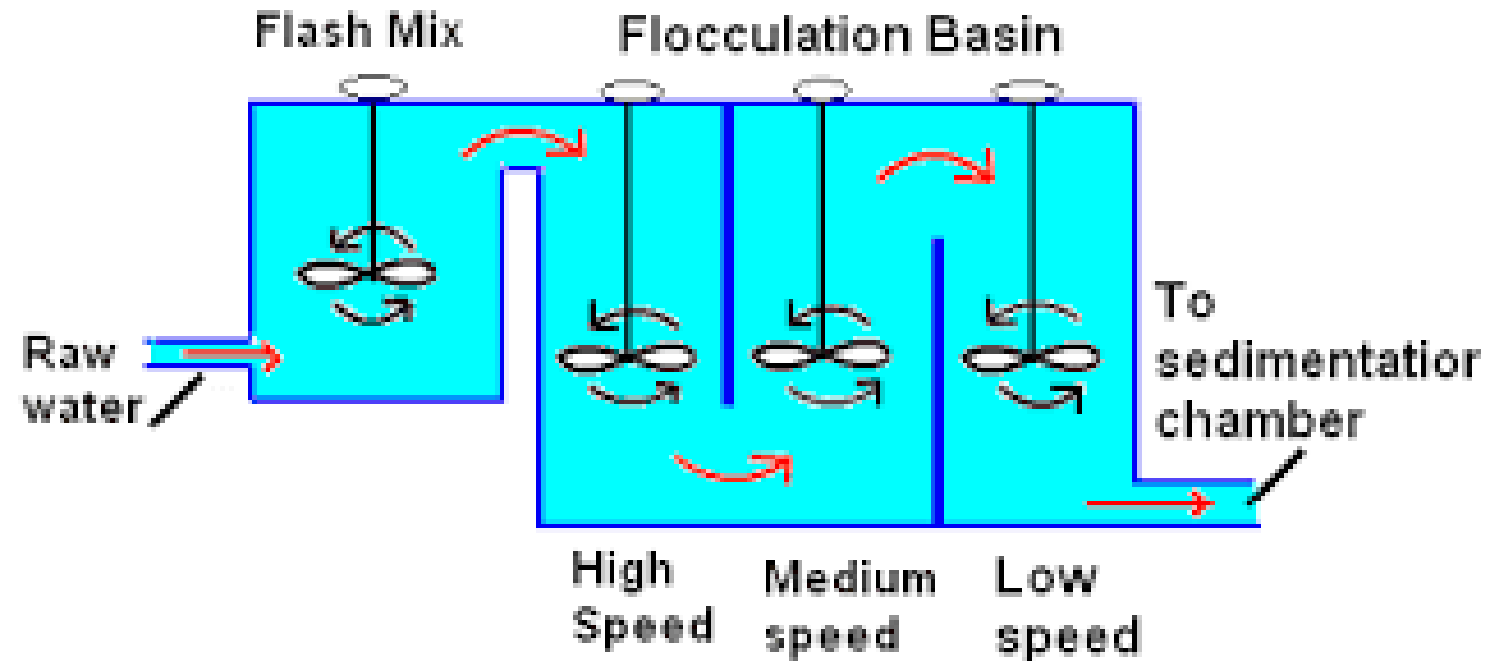
Area of Circle = (3.14)(Radius²)



Detention Time

Detention Time

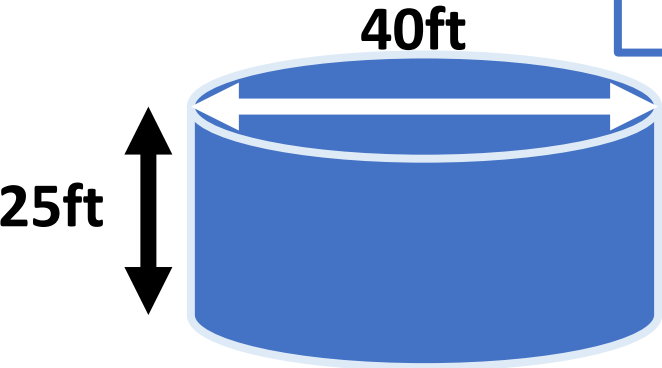
- The time water stays in a given reservoir or treatment process.



$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

Units must be compatible

Your secondary clarifier is 40 ft in diameter and 25 ft deep. Your max daily flow is 1.2 MGD. To determine if your clarifier meets the recommended detention time, you need to calculate the detention time of the clarifier in hours.



Diameter = 40 ft
Radius = 40 ft/2 = 20 ft

Detention Time = $\frac{\text{Volume}}{\text{Flow}}$
Units must be compatible

Volume = $\pi * r^2 * \text{Height}$
Volume = $3.14 * (20 \text{ ft})^2 * 25 \text{ ft}$
Volume = $3.14 * 400 \text{ ft}^2 * 25 \text{ ft}$
Volume = 31,400 ft³

$\frac{31,400 \cancel{\text{ft}^3}}{1} \times \frac{7.48 \text{ gal}}{1 \cancel{\text{ft}^3}} = 234,872 \text{ gal}$

$\frac{234,872 \cancel{\text{gal}}}{1.2 \cancel{\text{MGD}}} \times \frac{1 \text{ MG}}{1,000,000 \cancel{\text{gal}}} \times \frac{24 \text{ hours}}{1 \cancel{\text{day}}} = 4.7 \text{ hours}$

$\frac{1}{\text{day}}$

- (A) 1 day
- (B) 4.7 hours
- (C) .20 days
- (D) .20 hours

> 2-3 recommended design DT

Find the detention time in hours for the following WWTP:

- 4 rectangular clarifiers each 40.0 ft long, 30.0 ft wide, and with an average water depth of 21.00 ft.
- 1 oxidation ditch 295 ft long, 80.0 ft wide, and with a water depth of 11.0 ft.
- Flow is 3.50 MGD

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible}$$

■ **4 Clarifiers = 40' x 30' x 21'**

$$\text{Volume of Rectangular Tank}^* = (\text{Length})(\text{Width})(\text{Height})$$

$$\text{Vol of One Clarifier} = 40 \text{ ft} \times 30 \text{ ft} \times 21 \text{ ft} = 25,200 \text{ ft}^3$$

$$\text{Vol of One Clarifier, gal} = \frac{25,200 \cancel{\text{ft}^3}}{1} \times \frac{7.48 \text{ gal}}{1 \cancel{\text{ft}^3}} = 188,496 \text{ gal}$$

$$\text{Vol of 4 Clarifiers, gal} = 188,496 \text{ gals} \times 4 \text{ Clarifiers} = \mathbf{753,984 \text{ gal}}$$

Find the detention time in hours for the following WWTP:

- 4 rectangular clarifiers each 40.0 ft long, 30.0 ft wide, and with an average water depth of 21.00 ft.
- 1 oxidation ditch 295 ft long, 80.0 ft wide, and with a water depth of 11.0 ft.
- Flow is 3.50 MGD

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible}$$

■ 1 Oxidation Ditch = 295' x 80' x 11'

$$\text{Volume of Rectangular Tank}^* = (\text{Length})(\text{Width})(\text{Height})$$

$$\text{Vol of Oxidation Ditch} = 295 \text{ ft} \times 80 \text{ ft} \times 11 \text{ ft} = 259,600 \text{ ft}^3$$

$$\text{Vol of Oxidation Ditch (gal)} = \frac{259,600 \cancel{\text{ft}^3}}{1} \times \frac{7.48 \text{ gal}}{1 \cancel{\text{ft}^3}} = 1,942,000 \text{ gal}$$

Find the detention time in hours for the following WWTP:

- 4 rectangular clarifiers each 40.0 ft long, 30.0 ft wide, and with an average water depth of 21.00 ft.
- 1 oxidation ditch 295 ft long, 80.0 ft wide, and with a water depth of 11.0 ft.
- Flow is 3.50 MGD

■ Vol of Oxidation Ditch = 1,942,000 gals ■ Vol of Clarifiers = 753,984 gals

$$\text{Vol of WWTP} = 1,942,000 \text{ gal} + 753,984 \text{ gal} = 2,695,984 \text{ gal}$$

$$\text{Vol of WWTP (MG)} = \frac{2,695,984 \text{ gal}}{1} \times \frac{1 \text{ MG}}{1,000,000 \text{ gal}} = 2.695984 \text{ MG} \approx 2.70 \text{ MG}$$

Find the detention time in hours for the following WWTP:

- 4 rectangular clarifiers each 40.0 ft long, 30.0 ft wide, and with an average water depth of 21.00 ft.
- 1 oxidation ditch 295 ft long, 80.0 ft wide, and with a water depth of 11.0 ft.
- Flow is 3.50 MGD

- Vol of WWTP = $V = 2.7 \text{ MG}$
- Flow = $Q = 3.5 \text{ MGD}$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible}$$

$$\text{WWTP Detention Time} = \frac{V}{Q} = \frac{2.7 \text{ MG}}{3.5 \text{ MGD}} = 0.77 \text{ days}$$

$$\text{WWTP Detention Time} = \frac{0.77 \text{ days}}{1} \times \frac{24 \text{ hour}}{1 \text{ day}} = 18.5 \text{ hours}$$

18.5 hours is the detention time for treatment in the WWTP.

Detention Time Rearranged

A circular clarifier is being designed to accommodate an average flow of 76,250 gpd. To accommodate the space restrictions of the plant the diameter of the clarifier must not exceed 13 feet. What must the designed depth be to achieve a detention time of 2.5 hours?

$$DT = \frac{V}{Q} \rightarrow V = DT \times Q = \frac{2.5 \cancel{\text{hour}}}{1} \times \frac{\cancel{\text{day}}}{24 \cancel{\text{hour}}} \times \frac{76,250 \cancel{\text{gal}}}{\cancel{\text{day}}} \times \frac{\text{ft}^3}{7.48 \cancel{\text{gal}}} = 1062 \text{ft}^3$$

$$V = \pi r^2 h \rightarrow h = \frac{V}{\pi r^2} = \frac{1062 \text{ft}^3}{\pi (6.5 \text{ft})^2} = \frac{1062 \cancel{\text{ft}^3}}{132.665 \cancel{\text{ft}^2}} = \underline{8.0 \text{ft}}$$

Your Turn – Practice Detention Time

A rectangular sedimentation basin is **75 feet long, 30 feet wide, and 20 feet deep**. If the treatment plant has a daily flow rate of **2.25 million gallons per day (MGD)**, what is the detention time in hours?

What do we know?

- Dimensions: 75 (L), 30 (W), 20 (D)
- Flow Rate: 2.25 MGD

What are we looking for?

- Detention Time in hours

What do we need?

Equations:

- $DT = \text{Volume} / \text{Flow}$
- $\text{Volume} = L \times W \times D$

Conversions:

- $1 \text{ ft}^3 = 7.48 \text{ gallons}$

Step 1: Calculate the volume of the basin

Volume = length x width x depth

Volume = 75 ft x 30 ft x 20 ft

Volume = 45,000 ft³

Step 2: Convert volume from ft³ to gallons

$45,000 \text{ ft}^3 \times \frac{7.48 \text{ gallons}}{1 \text{ ft}^3} = 336,600 \text{ gallons}$

Step 3: Calculate Detention Time

$DT = \text{Volume} / \text{Flow}$

$DT = 336,600 \text{ gal} / 2,250,000 \text{ gallons per day}$

$DT = 0.1496 \text{ days}$

Step 4: Convert to hours

$0.1496 \text{ days} \times \frac{24 \text{ hours}}{1 \text{ day}}$

3.6 hours

Weir Loading Rate

- Measures the amount of water leaving a settling tank per linear unit of length of weir per day
- Used to ensure weirs are not hydraulically overloaded, efficient sedimentation is occurring, and solids do not infiltrate clarifier effluent
- Recommended 10,000-20,000 gpd/ft (124,100-248,200 Lpd/m)
- Typically correlates with a correct detention time
- *Weir Loading Rate or Weir Overflow Rate* = $\frac{\text{Flow Rate}}{\text{Weir Length}} = \frac{Q}{L}$
- **Use “weir” as indicator that weir length is involved**

Weir Loading Rate Example

The flow for a circular clarifier is 1.2 MGD with a 26-foot diameter. What is the weir overflow rate in gallons per foot of weir length per day?

$$\text{Weir Loading Rate} = \frac{\text{Flow Rate}}{\text{Weir Length}} = \frac{Q}{L}$$

$$L = \text{Clarifier Circumference} = \pi D = \pi \times 26 \text{ ft} = 81.68 \text{ ft or } 26\pi \text{ ft}$$

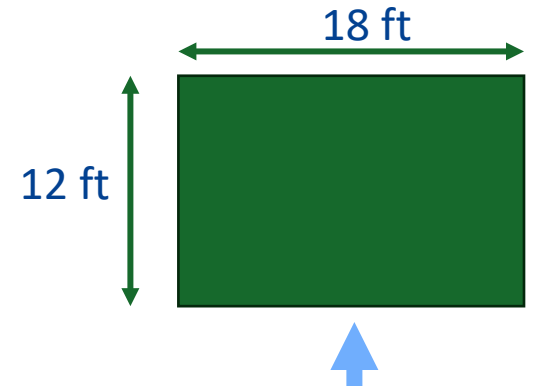
$$\text{Weir Loading Rate} = \frac{Q}{L} = \frac{1,200,000 \text{ gpd}}{26\pi \text{ ft}} \text{ or } \frac{1,200,000 \text{ gpd}}{81.68 \text{ ft}} = 14,691 \text{ gpd/ft} = \sim 14,700 \text{ gpd/ft}$$

Weir Loading Rate Practice 1

A rectangular sedimentation tank with a length of 12 ft, a width of 18 ft, and a depth of 11 ft has a flow of 190,000 gpd. What is the weir overflow rate of this this sedimentation tank if influent enters on one wide side of the tank and effluent exits on the other?

$$\text{Weir Loading Rate} = \frac{\text{Flow Rate}}{\text{Weir Length}} = \frac{Q}{L}$$

$$\text{Weir Loading Rate} = \frac{Q}{L} = \frac{190,000 \text{ gpd}}{18 \text{ ft}} = 10,556 \text{ gpd/ft}$$



Surface Loading Rate

- Measures the amount of water passing over a unit of surface area per day
- Another parameter that indicates clarifiers are not hydraulically overloaded and has a direct relationship to the settleable solids removal efficiency of sedimentation tanks
- Recommended 300-1,200 gpd/ft² (12,160-48,645 Lpd/m²)

- $$\text{Surface Loading Rate} = \frac{\text{Flow Rate}}{\text{Surface Area}} = \frac{Q}{A}$$

- **Use “*surface*” as indicator that surface area is involved**

Surface Loading Rate Example

What is the surface loading rate of a circular clarifier with a depth of 8.0 ft, a diameter of 9.0 ft and an effluent flow of 42,000 gpd?

$$\text{Surface Loading Rate} = \frac{Q}{SA}$$

$$SA = \text{Area of a Circle} = \pi r^2 = \pi(4.5 \text{ ft})^2 = 63.6 \text{ ft}^2 \text{ or } 20.25\pi \text{ ft}^2$$

$$\frac{Q}{SA} = \frac{42,000 \text{ gpd}}{20.25\pi \text{ ft}^2} \text{ or } \frac{42,000 \text{ gpd}}{63.6 \text{ ft}^2} = 660 \text{ gpd/ft}^2$$

Surface Loading Rate Practice

- Known design parameters for a rectangular clarifier are listed below. What is the surface loading rate in gal/ft²*day? What is the depth required to maintain a maximum detention time of 3.0 hours?

- Knowns:

$$\frac{Q}{SA} = \frac{2.2 \text{ MGD}}{72 \text{ ft} \times 28 \text{ ft}} = \frac{2,200,000 \text{ gpd}}{72 \text{ ft} \times 28 \text{ ft}} = \sim 1,100 \text{ gal/ft}^2 \cdot \text{day}$$

- Q= 2.2 MGD

- L= 72 ft

$$DT = \frac{V}{Q} = \frac{L \times W \times H}{Q} \rightarrow H = \frac{DT \times Q}{L \times W}$$

- W= 28 ft

$$H = \frac{3.0 \text{ hrs}}{72 \text{ ft} \times 28 \text{ ft}} \times \frac{2,200,000 \text{ gal}}{\text{day}} \times \frac{\text{ft}^3}{7.48 \text{ gal}} \times \frac{\text{day}}{24 \text{ hrs}} = 18 \text{ ft}$$

A collection of diverse human hands raised against a white background. The hands vary in skin tone, from light to dark, and are positioned at different heights and angles, creating a sense of movement and participation. A semi-transparent dark blue rectangular box is centered over the image, containing the word "Questions?" in white, sans-serif font.

Questions?

CONTACT INFORMATION



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