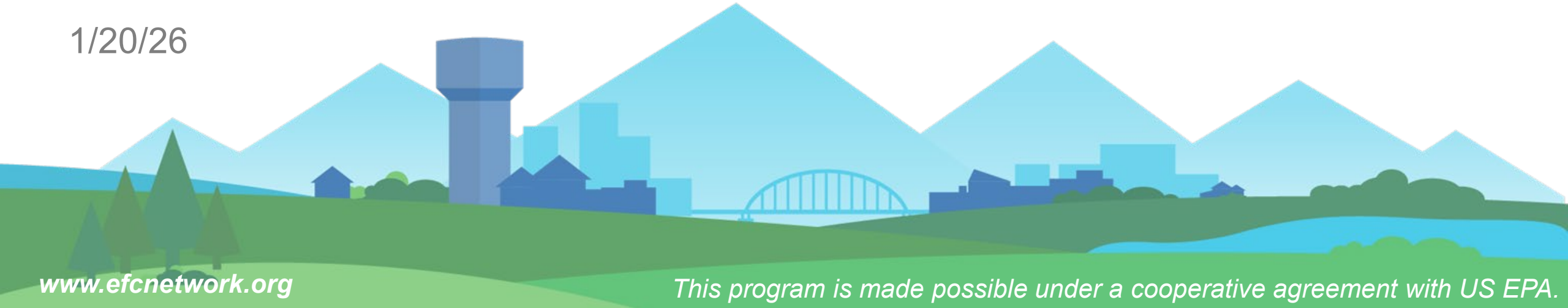
US Territories Wastewater Operator Training Series

Session 14: Mid-Point Review Session

1/20/26



This program is made possible under a cooperative agreement with US EPA.

Your trainers for today:



Dawn Nall
Research Engineer



Valeria Cortes-Mora
Professional Intern



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This training series is funded by the EPA

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

SOUTHWEST ENVIRONMENTAL FINANCE CENTER

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"

The Training Program

Review

WPI/ABC Operator Certification

Get the latest water industry news, insights, and resources from our new blog IMMERSE. Check it out!

WATER PROFESSIONALS INTERNATIONAL
The Associated Boards of Certification

Superior Water Starts Here℠ | Ask WooPI! | Make A Payment

TESTING SERVICES | CERTIFICATION | MEMBERSHIP | ABOUT US | EVENTS | Search ...

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.

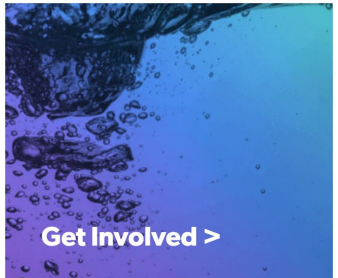
- Wastewater Treatment Operator Class I
- Wastewater Treatment Operator Class II
- Wastewater Treatment Operator Class III
- Wastewater Treatment Operator Class IV

Wastewater Treatment Operator Formula/Conversion Table

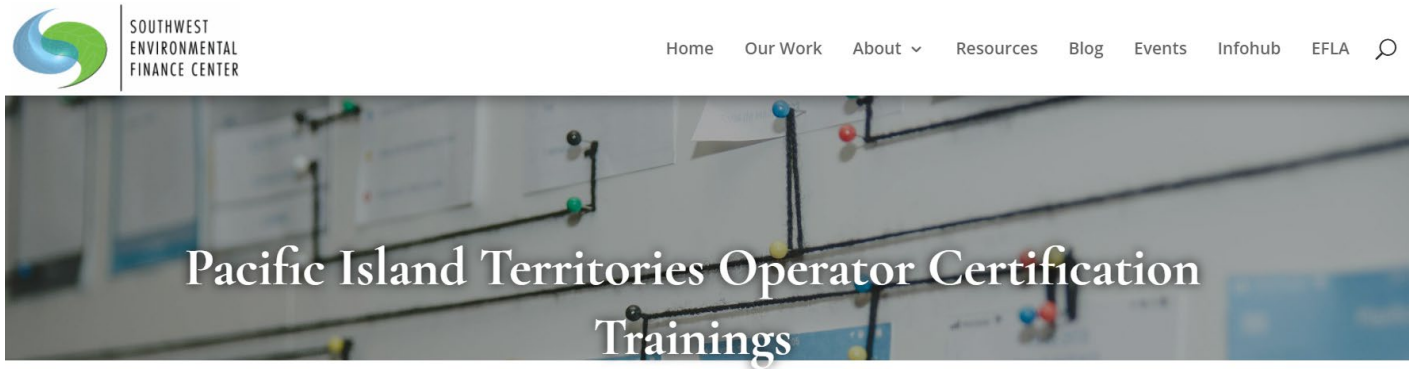
WPI standardized exams are administered with a Formula/Conversion Table containing mathematical formulas and common abbreviations that may be present on the exam.

- Wastewater Treatment Operator Formula/Conversion Table





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	
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	
5	8/20/2025	Collection Systems – Gravity systems	
6	9/3/2025	Collection Systems – Pumping & Force Mains	
7	9/17/2025	Collection System Maintenance	
8	10/1/2025	Operator Safety/OSHA/Chemical Safety & Inventory	

Schedule for 2026:

Date	Topic
1/20/2026	Review Session
2/3/2026	Disinfection Part 1
2/17/2026	Disinfection Part 2
3/3/2026	WW Math Part 3
3/17/2026	WW Math Part 4
3/31/2026	Solids Handling Part 1
4/14/2026	Solids Handling Part 2
4/28/2026	Sampling
5/12/2026	Regulations
5/26/2026	Treatment System Maintenance
6/9/2026	Lab Procedures & Analysis
6/23/2026	Using Technology in Daily Operations
7/7/2026	Course Review Session

Today's Agenda – Collection Systems

- Study Tips
- Treatment Overview
- Wastewater Math
- Collection Systems
- Operator Safety
- Preliminary Treatment
- Primary Treatment
- Activated Sludge

Studying Tips

Session 1 – 06/24/2025

https://www.youtube.com/watch?v=IZJK25_D-ic&t=1361s

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Study Tips

Start early and manage time.

Make a **study plan** and focus on weak areas.

Use **practice tests**, flashcards, and partner study.

Leverage **on-the-job experience** and ask questions.

Read training manuals and "Need-to-Know" guides.

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Test Preparation

Exams have 100 questions (Levels 1 & 2), including math.

Understand question formats: recall, application, analysis.

Learn formulas and conversion tables.

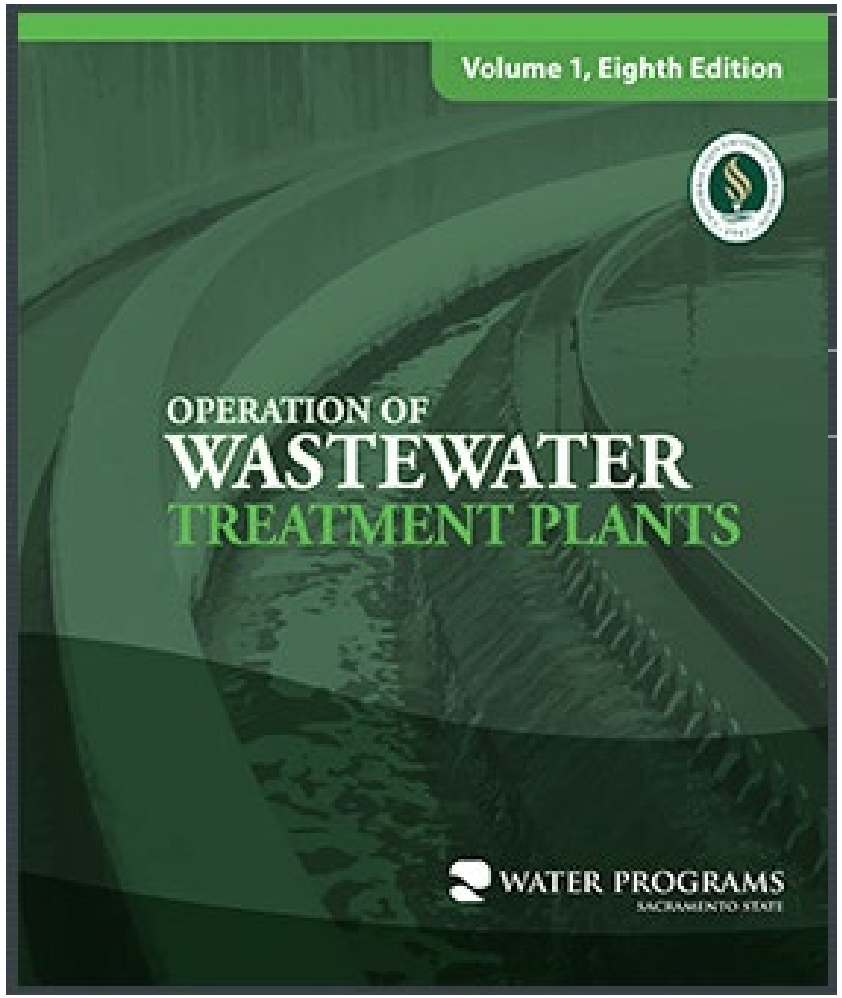
Monitor time during the test; skip and return to tough questions.

Use elimination and common sense for multiple-choice questions.

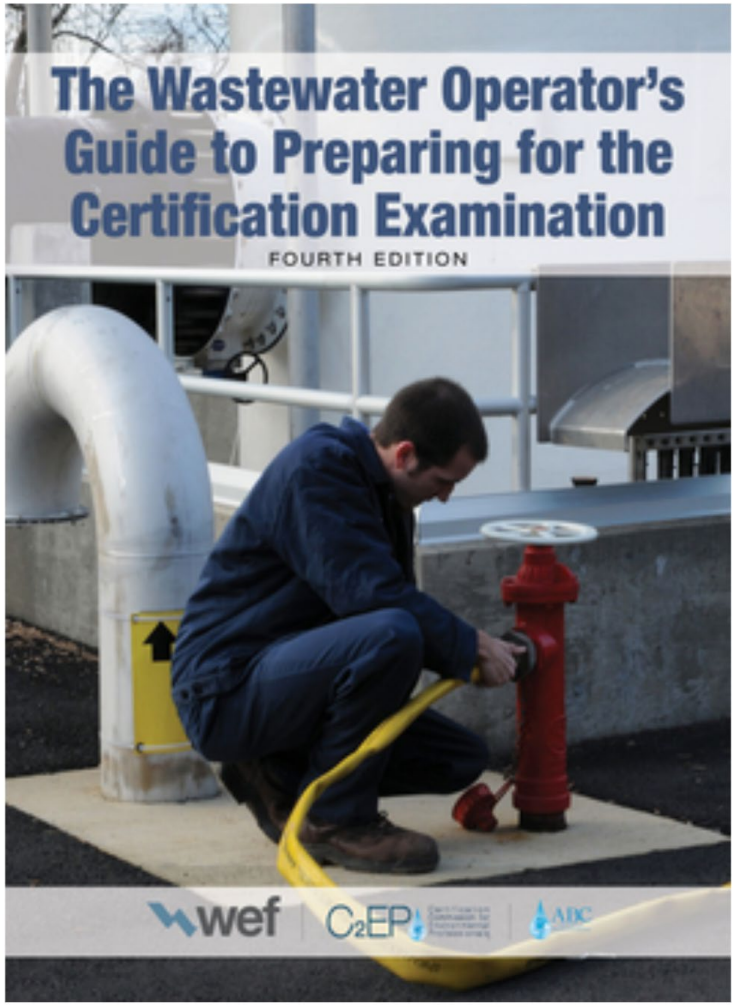
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Study Guides

https://www.owp.csus.edu/



https://connect.wef.org/



Other Study Guides and State Websites can be useful

- California State University, Sacramento
- Association of Boards of Certification (ABC)
  - Examination Study Resources
  - Need to Know Criteria
  - Formula Conversion Table
  - Treatment Plant Operator (TPO) magazine
- Water Environment Federation (WEF)
  - Technical Resources
- American Water Works Association (AWWA)
  - Math
  - WW operator certification

Treatment Overview

Session 2 – 07/08/2025

https://www.youtube.com/watch?v=ucwA-LPNMkE

Why do we treat wastewater?

Protect fresh water supplies

Public health

Environmental health

Required by EPA regulations



What do we treat wastewater for?

- Excess nutrients (BOD, nitrogen and phosphorus)
- Pathogens
- Solids/ debris
- Others (pH, metals, emerging contaminants)



NPDES Permit Program

Required for facilities discharging to surface waters.

- Specifies the effluent limits of the wastewater treatment plant (WWTP)
- Regulates sewer overflows, stormwater, the National Pretreatment Program and biosolids

Sets effluent limits and regulates pretreatment, stormwater, and biosolids.

- Specifies parameters, schedule, frequency, methods, etc.
- Determined by available technology and ability of receiving water to withstand contaminant loading

Enforcement can include:

- Notice of Violation
- Administrative Orders
- Fines,
- Criminal prosecution.

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General treatment processes

Collection

Conveys wastewater from homes and businesses to the WWTP

Consists of pipes and pumps

Preliminary treatment

- Screening
- Grit removal
- Flow measurement
- Flow equalization

Primary treatment

- Slows the flow, allows solids to settle to the bottom
- Liquid can be further treated
- Solids typically sent to digestor

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General treatment processes

Secondary treatment

Designed to remove BOD, NH3 and NO3

Examples include trickling filters, RBCs, activated sludge, ponds

Tertiary treatment

Required for plants that have a higher effluent quality requirement

- Includes polishing ponds, constructed wetlands, advanced filtration, etc.

Disinfection

Through chlorination, ozone or UV

- Prevents spread of water borne diseases

Sludge handling

Sludge disposal is regulated due to the presence of pathogens, heavy metals, etc.

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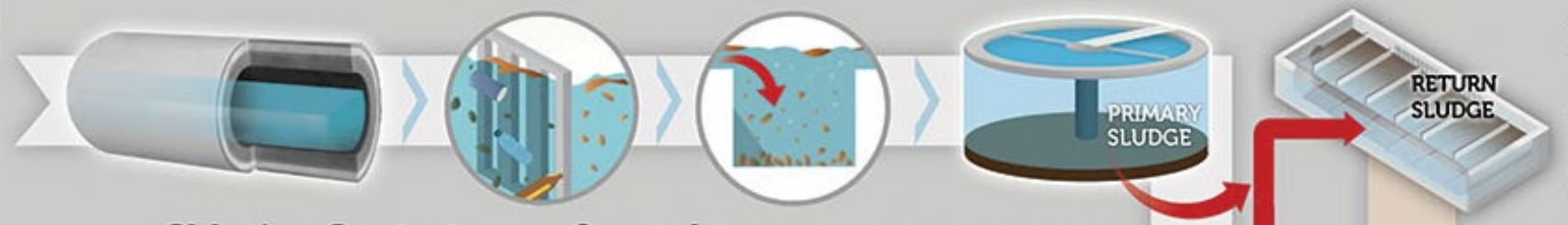
LIQUID TRAIN

Wastewater
From residences and industry enters treatment facility

Fine Screens
Screens remove floating debris from incoming wastewater

Grit Removal
Grit particles sink and are removed

Primary Clarifiers
Grease floats
Heavy sludge sinks
Other wastewater passes through



Chlorine Contact Basin for Disinfection
Sodium Hypochlorite (bleach) kills germs

Secondary Clarifiers
Sludge sinks
Treated water passes through for disinfection

Aeration Basin
Air bubbles are added
Microorganisms eat food particles



Dechlorination
Sodium biosulfite removes leftover bleach

Outfall to Congaree River
Clean, disinfected water is discharged to the river

Waste Sludge



SOLIDS TRAIN

Dissolved Air Flotation Thickeners
Air bubbles are added
Skimmers remove thickened sludge from surface and bottom

Anaerobic Digesters
Sludge is processed and methane gas is captured under a dome cover

Centrifuges
Water is separated. from digested sludge ("dewatered")



Biosolids Disposal
Dewatered sludge is trucked to landfill

Wastewater Math

Session 3 – 07/22/25 https://www.youtube.com/watch?v=S-LFZqs00IQ

Session 4 – 08/05/25 https://www.youtube.com/watch?v=xSOS_Z3Nsgo

Math Concepts to Understand

- Equations:
  - Order of Operations
  - Rearranging Equations
  - Solving For The Unknown
- Percentages
- Units
- Conversions

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Order of Operations

Please (Parentheses)

Excuse (Exponents)

My Dear (Multiply and/or Divide)

Aunt Sally (Add and/or Subtract)

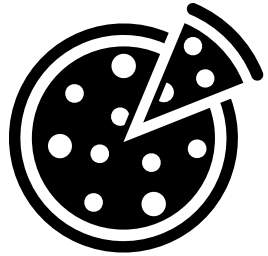
"PEMDAS"

Solving for the Unknown and Rearranging Equations, aka Algebra

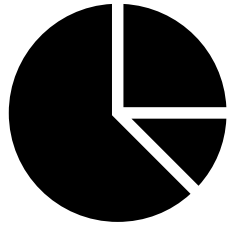
- The unknown is the part of the equation that we are trying to find or solve for
- Sometimes represented by a letter such as d, t, or x (variable)
- When solving for an unknown, the variable/unknown must be by itself on one side of the equation

$$\boxed{46 + x = 98}$$

Fractions and Decimals



Used to represent parts of a whole



Converting…

Fraction to decimals: divide the numerator by the denominator

Ex. $\frac{1}{2} = 1 \div 2 = 0.5$

Decimals to Fraction: write the decimal as a fraction, multiply the numerator and denominator by 100, simplify using the lowest common denominator.

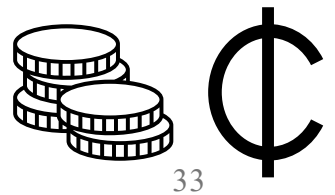
Ex. $2.75 = \frac{2.75 \times 100}{1 \times 100} = \frac{275 \div 25}{100 \div 25} = \frac{11}{4}$

% Percentage: just another fraction

Percent; parts per hundred

- Fractions with 100 in the denominator
- Can be converted to a fraction or a decimal

$$30\ \text{percent} = 30\% = \frac{\mathbf{30}}{\mathbf{100}} = 0.3$$



Units

- Temperature
  - °F, °C, K
- Distance/length
  - Inches, feet, meters, miles, kilometers
- Area
  - $inches^2$, $feet^2$, $meters^2$, $miles^2$
- Volume
  - ft^3, m^3, gallons, liters, acre-feet
- Mass
  - lbs; grams, kilograms, tons
- Rate
  - CFS, GPM



Rate measurements are a unit (e.g., volume, distance) divided by what variable/dimension?

A. Height
B. Weight
C. Time
D. Volume

ABC Formula Sheet Abbreviations and Conversion factors

Abbreviations

C ..... Celsius
cfs ..... cubic feet per second
cm ..... centimeters
DO ..... dissolved oxygen
EMF ..... electromotive force
F ..... Fahrenheit
ft ..... feet
ft lb ..... foot-pound
g ..... grams
gal ..... US gallons
gfd ..... US gallons flux per day
gpcd ..... US gallons per capita per day
gpd ..... US gallons per day
gpg ..... grains per US gallon
gpm ..... US gallons per minute
hp ..... horsepower
hr ..... hours
in ..... inches
kg ..... kilograms
km ..... kilometers
kPa ..... kilopascals
kW ..... kilowatts
kWh ..... kilowatt-hours
L ..... liters
lb ..... pounds
Lpcd ..... liters per capita per day
Lpd ..... liters per day
Lpm ..... liters per minute
LSI ..... Langelier Saturation Index
m ..... meters
MG ..... million gallons
MGD ..... million US gallons per day
mg/L ..... milligrams per liter
min ..... minutes
mL ..... milliliters
ML ..... million liters
MLD ..... million liters per day
ORP ..... oxidation reduction potential
ppb ..... parts per billion
ppm ..... parts per million
psi ..... pounds per square inch
Q ..... flow
RPM ..... revolutions per minute
SDI ..... sludge density index
sec ..... second
SS ..... settleable solids
TOC ..... total organic carbon
TSS ..... total suspended solids
TTHM ..... total trihalomethanes
VS ..... volatile solids
W ..... watts
yd ..... yards
yr ..... years

Conversion Factors

1 acre ..... = 43,560 ft^2
= 4,046.9 m^2
1 acre foot of water ..... = 326,000 gal
1 cubic foot of water ..... = 7.48 gal
= 62.4 lb
1 cubic foot per second ..... = 0.646 MGD
= 448.8 gpm
1 cubic meter of water ..... = 1,000 kg
= 1,000 L
= 264 gal
1 foot ..... = 0.305 m
1 foot of water ..... = 0.433 psi
1 gallon (US) ..... = 3.785 L
= 8.34 lb of water
1 grain per US gallon ..... = 17.1 mg/L
1 hectare ..... = 10,000 m^2
1 horsepower ..... = 0.746 kW
= 746 W
= 33,000 ft lb/min
1 inch ..... = 2.54 cm
1 liter per second ..... = 0.0864 MLD
1 meter of water ..... = 9.8 kPa
1 metric ton ..... = 2,205 lb
= 1,000 kg
1 mile ..... = 5,280 ft
= 1.61 km
1 million US gallons per day ..... = 694 gpm
= 1.55 ft^3/sec
1 pound ..... = 0.454 kg
1 pound per square inch ..... = 2.31 ft of water
= 6.89 kPa
1 square meter ..... = 1.19 yd^2
1 ton ..... = 2,000 lb
1% ..... = 10,000 mg/L
π or pi ..... = 3.14

Alkalinity Relationships

All Alkalinity expressed as mg/L as $CaCO_3$ • P – phenolphthalein alkalinity • T – total alkalinity

Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Concentration
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

*Pie Wheel Format for this equation is available at the end of this document

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How do we use conversion factors?

Multiply or divide your measurement by the conversion factor

What you're really doing:

1. Turning the conversion factor into a fraction
2. Multiplying by one

1 gal = 3.79 Liters $\left(\frac{1gal}{3.79L}\right) = 1$ $\left(\frac{3.79L}{1gal}\right) = 1$

You can multiple anything by 1 and not change its quantity, only change the units.

Surface Area Basics



- A 2-dimensional space
- Area Units
  - inches^2
  - feet^2
  - miles^2
  - meters^2
  - acre

Where in water systems are surface areas important?

You can use conversion factors to convert between these different units.

1 acre ..... = 43,560 ft^2
= 4,046.9 m^2

1 square meter ..... = 1.19 yd^2

Surface Area & Water System Operations

- Wastewater Pond Liner
- Weed Fabric
- Paint
- Building Material

Now let's dive deep into some 3D water math!!!



Volume

Volume of a box (rectangular tank, trench) = (Length)(Width)(Height)

What is the volume in gallons of a rectangular tank with the dimensions of 30 feet long, 10 feel wide, and 15 feet high?

V = (Length)(Width)(Height)
V = (30ft)(10ft)(15ft)
V = 4500 ft^3

1 cubic foot of water = 7.48 gal

$$4500\ \text{ft}^3 * \left(\frac{7.48 gal}{1 ft^3}\right) =$$

$$\frac{4500\ \text{ft3}}{1} \Big| \frac{7.48\ \text{gal}}{1\ \text{ft3}} = 33{,}660\ \text{gal}$$

Hold on! Do we actually know our volume that accurately?

How precise is our input data?



How many **significant figures** did we start with?

Two significant figures in our initial data, three in our conversion factor

What is the volume in gallons of a rectangular tank with the dimensions of 30 feet long, 10 feel wide, and 15 feet high?

V = (Length)(Width)(Height)
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$$\frac{4500\ \text{ft3}}{1} \left| \frac{7.48\ \text{gal}}{1\ \text{ft3}} \right. = 33{,}660\ \text{gal}$$

34,000 gal

Volume of a cylinder (tank, pipe, well)

Area of Circle* = (0.785)(Diameter^2)

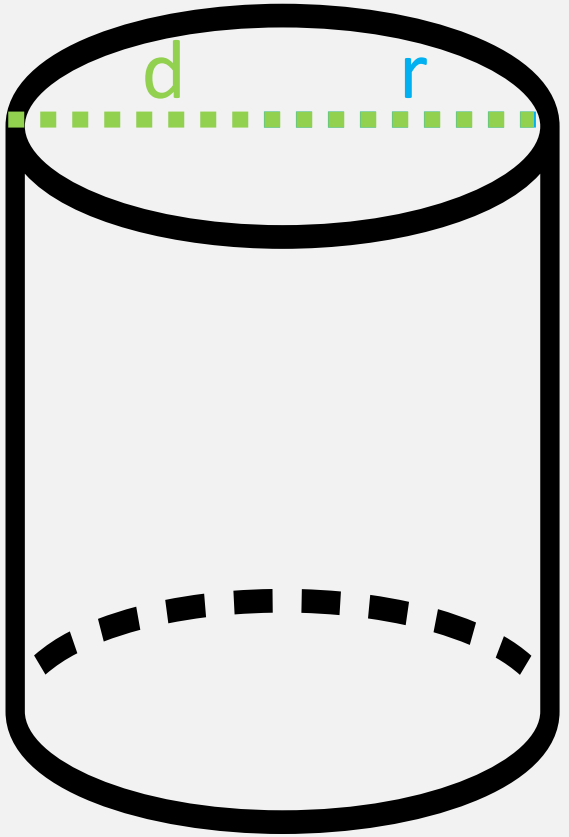
Volume of a cylinder = (0.785)(Diameter^2)(Height)

OR

Area of Circle = (3.14)(Radius^2)

Volume of a cylinder = (3.14)(Radius^2)(Height)

Diameter(d) = Radius(r) x 2

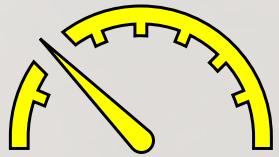


Water Pressure

Pressure Units

- Feet of head (feet)
- Pounds per square inch (psi)
- Torr
- Pascal
- bar
- mm of mercury

Minimum required in distribution = 20 psi



Maximum recommended in distribution = 100 psi

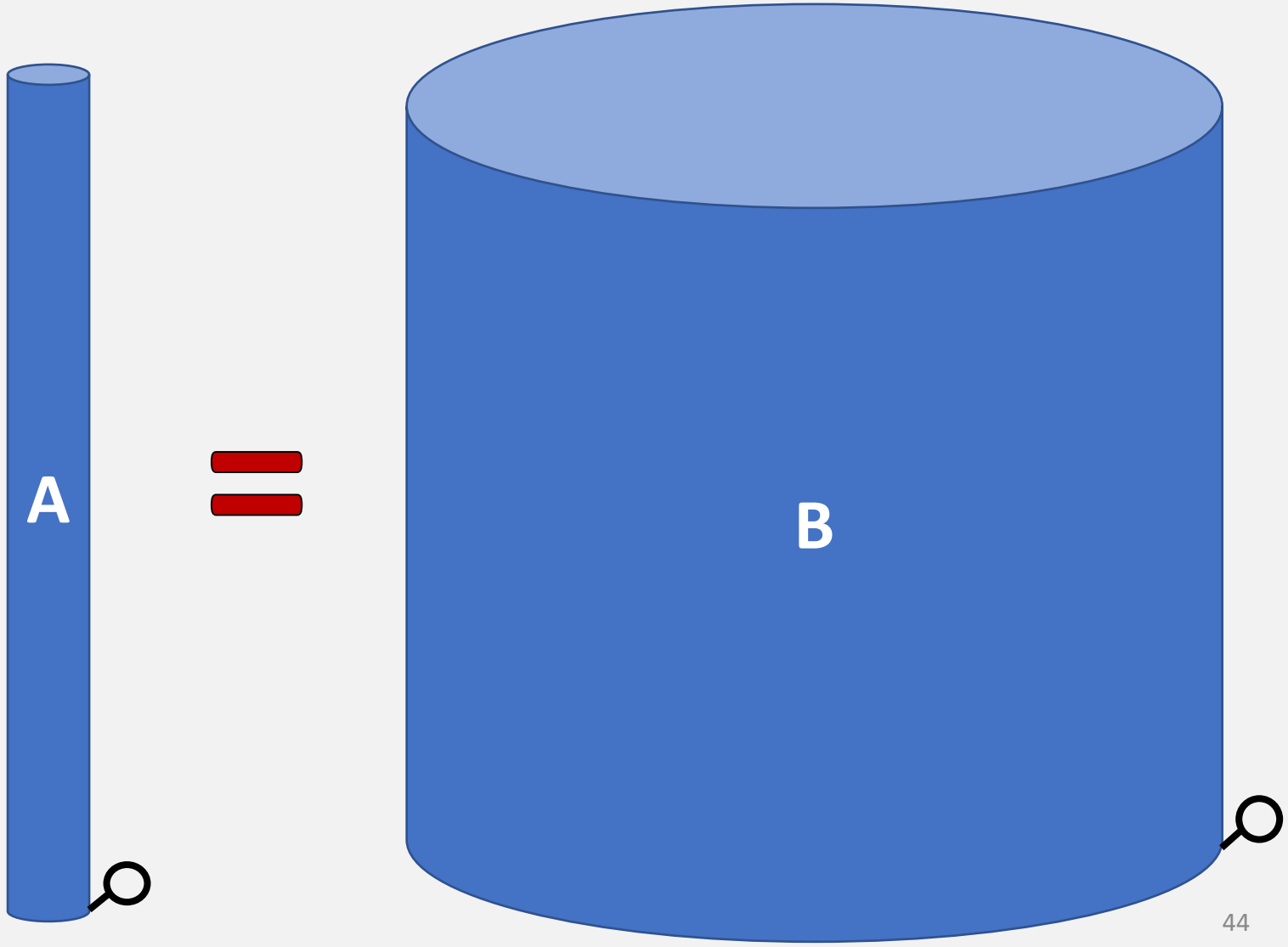


Pressure and Feet of Head

Tank A is 5’ in diameter and 75’ tall and holds ~11,000 gallons of water.

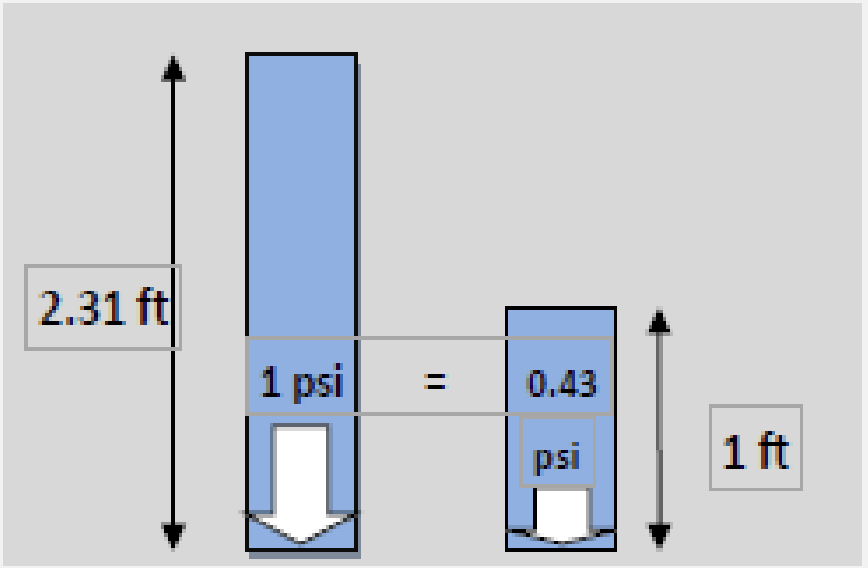
Tank B is 50’ in diameter and 75’ tall and holds ~1.1 million gallons of water.

If each tank has a pressure gauge at its base, which tank has the highest pressure?



Pressure and Feet of Head

- The volume of the water is not important, it's the height of the water (feet of head) that matters.
- There's a direct relationship between feet of head (ft) and pressure (psi).



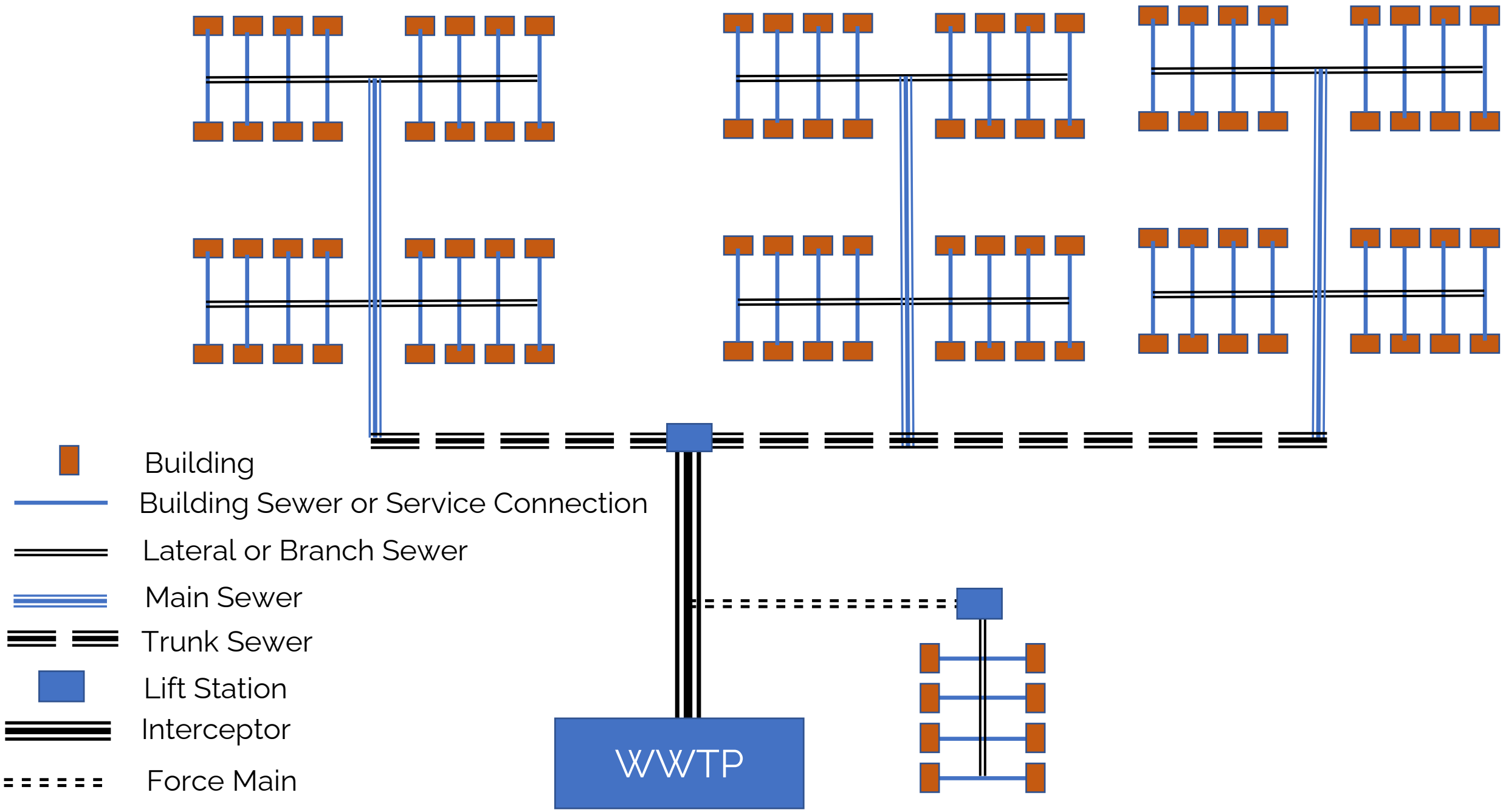
1 foot of water..... = 0.433 psi

1 pound per square inch..... = 2.31 ft of water

Collection Systems

Gravity Systems

8/19/25 - https://www.youtube.com/watch?v=9p0iZImEB9Y



Typical Gravity Wastewater Collection System

Gravity Collection Systems

- Design Principles
  - Designed for 2 to 8 ft/sec flow, 2.5 ft/sec is considered ideal
  - Slope should maintain a minimum velocity of 2 ft/sec at average or peak flows (flow that prevents buildup in the pipe is called "scouring velocity")
  - Collection systems are designed for maximum expected flow (peak flow) when maximum population density has been developed
  - **Sewer should flow half full during average daily flows** (to maintain aerobic conditions and to have room for error)
  - Peaking factors are used to size the WWTPs – typically 2.5 to 3.5 times total daily flow
  - Sewers typically must be at least **2 ft vertically below and 4 ft horizontally from water distribution pipes** to avoid contamination

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Pipe Materials



- AC – Asbestos Cement
- RC & C – Reinforced and Non-reinforced Concrete
- CI & DI – Cast Iron and Ductile Iron
- VC- Vitrified Clay
- FR – Fiberglass Reinforced Pipe
- ABS – Acrylonitrile Butadiene Styrene
- HDPE – High Density Polyethylene
- PVC – Polyvinylchloride

Pipe Joints

Joint #	Joint Description	Joint used with:								
		AC	CI/DI	RC	C	VC	FR	ABS	HDPE	PVC
1	Caulked Bell and Spigot		X							
2	Band Seal Coupling		X			X				X
3	Mortar or Bituminous Filled Bell and Spigot			X	X	X				
4	PVC/PU Preformed Gaskets					X				
5	Rubber Gasket Bell and Spigot		X	X		X	X			X
6	Rubber Gasketed Coupling	X								X
7	Sovent Cemented Coupling or Solvent Bell & Spigot							X		X
8	Butt Welded								X	

Gravity Collection Systems

- Installation Basics:
  - Excavation safety (OSHA trench rules).
  - Bedding & backfill critical for pipe integrity.
  - Bells face upstream; deflection testing via mandrel or CCTV.
- Service Connections:
  - Saddle tees, insertion wyes, epoxy bonded saddles
  - Must prevent infiltration & root intrusion
- Manholes:
  - Installed for maintenance access
  - Spaced 300–500 ft apart; confined space safety (OSHA)

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Collection Systems

Pumping and Force Mains

9/2/25 - https://www.youtube.com/watch?v=UnEY1JOEIHE

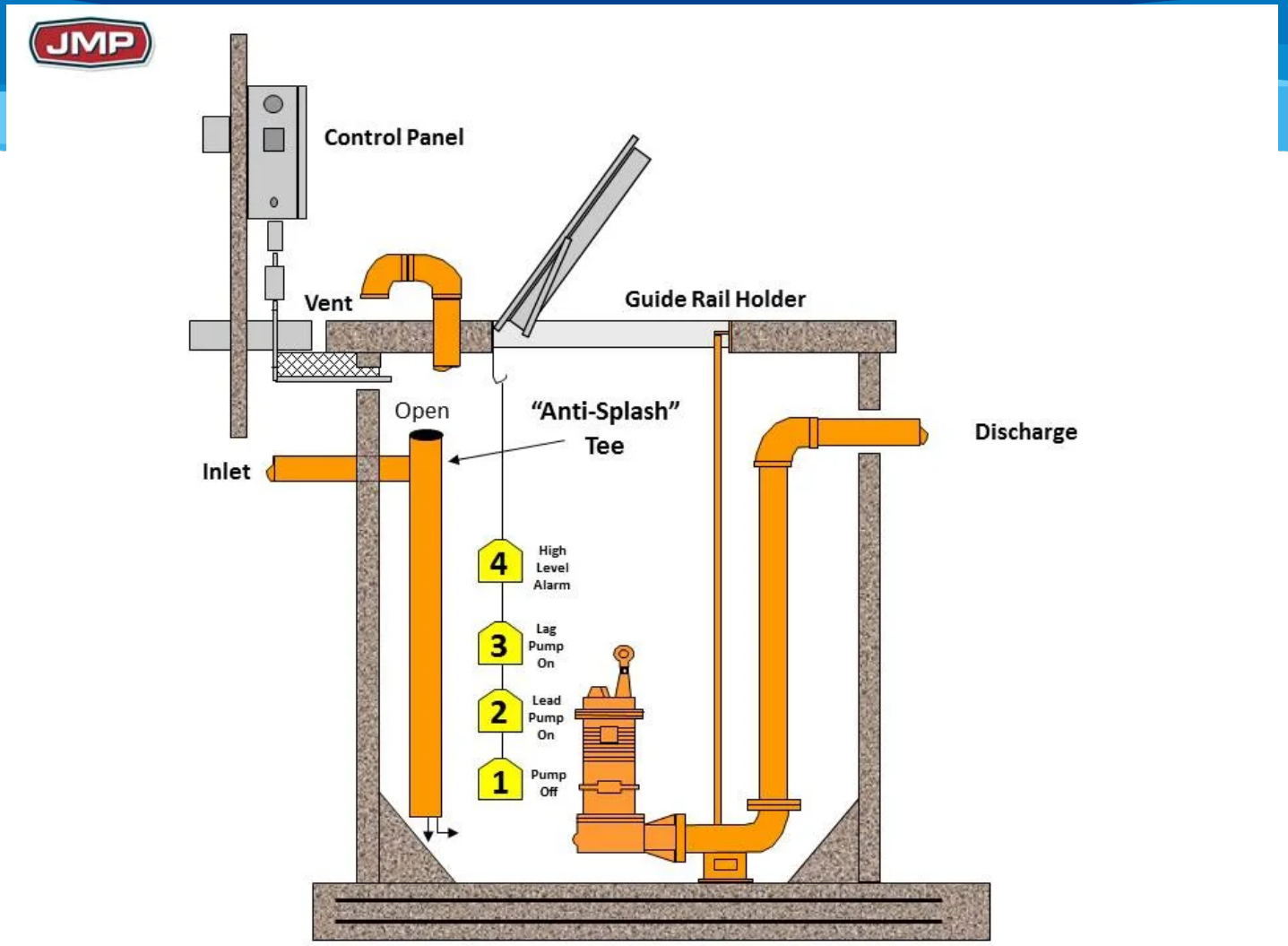
Lift Stations



- Purpose
  - Raising wastewater from lower to higher elevation
  - Use pumps to move water into force mains
  - After the force main gravity takes over
- Types
  - Wet Well (single chamber)
  - Dry Well (two chambers)

Lift Station Components

- Pumps
- Wet/Dry Well/Basin
- Hardware
- Bar Racks/Screens
- Valves
- Electrical Systems
- Alarms
- Motor Control Center
- Pump Controls/Level Controls
- Force Mains



https://jmpcoblog.com/hvac-blog/commercial-sewage-lift-stations-part-5-system-components

Lift Station

Operation

- Water flows into wet well, the water level rises
- Water reaches the first set point the first pump turns on and the water level should start to decrease.
  - If the water level continues to increase, a second set point will be reached and a second pump will come on (if equipped with lead/lag pumps)
- The water is being pumped out faster than it enters. The level decreases and a low level set point is reached, turning the pump(s) off

Maintenance

- Grit
  - Grit accumulation leads to reduced flow to pumps and loss of wet well capacity
- Grease & Scum
  - Causes odors & impairs functioning of equipment
  - Removal:
    - Manual
    - Chemical/biological treatment of FOG
- Odor Control
  - Minimize wet-well turbulence
  - Treatment with scrubbers or biofilters
  - Chemical addition: Chlorine, Hydrogen peroxide, Oxygen
    - Chemicals should be closely monitored

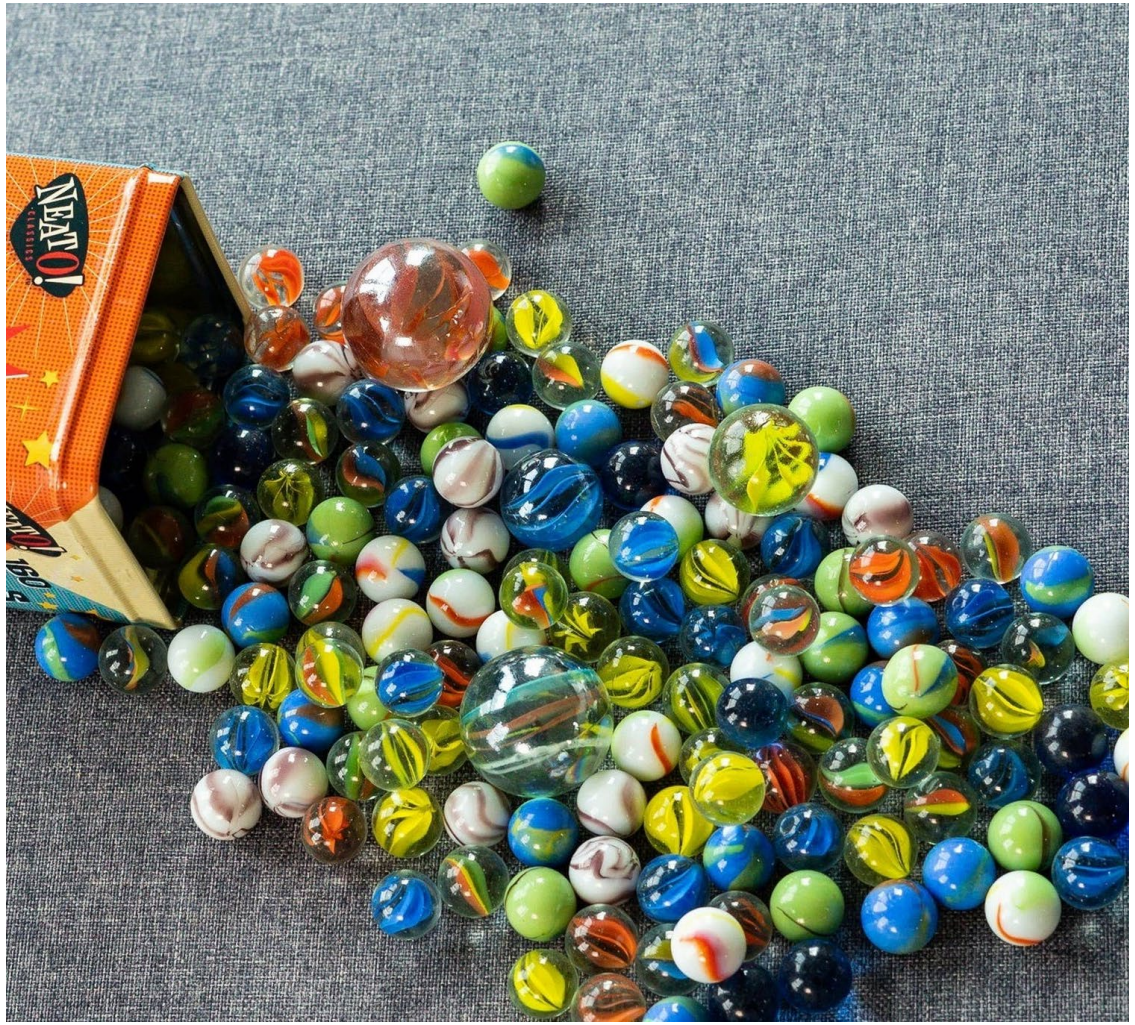
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Lift Station Pumps - Types

- Positive Displacement
  - Low flow/high pressure
  - Water Jet Pumps, Sludge Pumps, Chemical Feed Pumps
  - Piston pumps, diaphragm pumps, progressive cavity screw pumps are the most common types of positive displacement pumps
  - Constant flow rate regardless of discharge pressure
  - May be used in very small lift stations
- Centrifugal
  - High flow/low pressure (head)
  - Booster Pumps, Primary Service Pumps
  - Flow changes when pressure changes
  - Most common in lift stations

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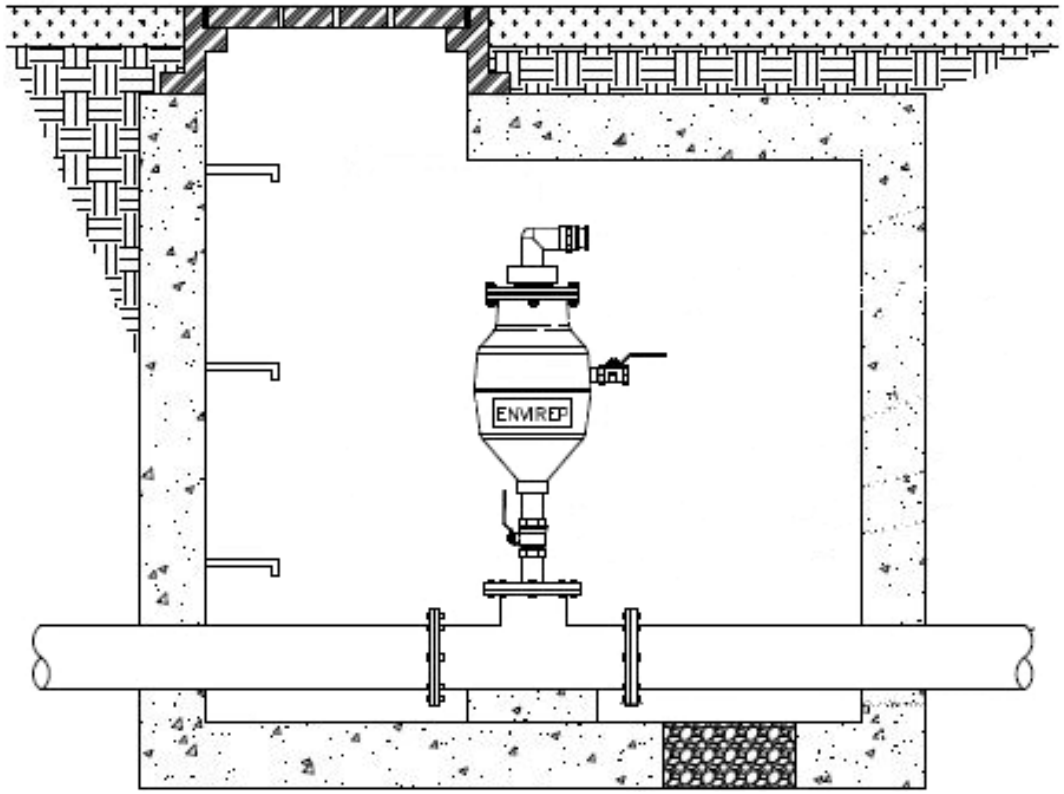
Lift Station Pumps – Centrifugal Pumps



- Operations
  - Pump should not be started or run dry – water used as lubrication
  - Cavitation – pump not running at designed flow/pressure
    - Creates a vacuum that vaporizes the liquid, when the vapor returns to liquid it reacts very quickly causing small amounts of damage to the pump, over time this leads to significant pump vibration and damage
    - A cavitating pump can sound like a can of marbles being shaken. Other indications that can be observed from a remote operating station are fluctuating discharge pressure, flow rate, and pump motor current

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Lift Stations – Force Mains



- Discharge pipe of the lift station
- Under pressure until the next manhole or similar opening (where the system returns to gravity or the flow enters the treatment plant)
- Trapped air can lead to water hammer – high pressure shock wave that moves in the pipe damaging the pipe and other equipment such as check valves that will slam repeatedly
- Trapped air can also decrease flow rates/increase pressure and increase energy use
- Air release valves can be installed at the pipe's high point to allow air to escape automatically

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Collection Systems

Maintenance

9/16/25 - https://www.youtube.com/watch?v=9p0iZImEB9Y&t=2s

Common Collection System Issues

- Obstructions: Debris (trash, grease, sand), root intrusions.
- Structural Problems: Cracked pipes, collapsed lines, misaligned joints, pipe sags.
- Environmental Concerns: Corrosion, odors, sanitary sewer overflows (SSOs).
- Infiltration & Inflow (I/I): Groundwater and stormwater entering the system.



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Collection System Monitoring & Inspection

- Visual inspections: visual observations to assess the condition of sewer pipes and manholes
- CCTV - Use of specialized video cameras to observe and record the interior of sewer systems
- Flow Monitoring - Measuring flow rates to identify flow patterns that determine problems
- Smoke Testing - Introduces visible, non-toxic smoke into sewers to detect defects, illegal connections or leaks
- Dye Testing - Traces flow paths and confirms suspected cross-connections or infiltration sources
- Acoustic/Sonar Inspections - sensors detect blockages by analyzing sound waves in the pipe.

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Maintenance Strategies

- Preventative vs Emergency Maintenance
  - Preventative - Scheduled proactive work
  - Emergency - Unplanned, reactive work
- Cleaning Methods:
  - Hydraulic jetting - remove blockages using high-pressure water
  - Mechanical rodding - physically scraping, cutting, or out pulling debris using specialized mechanical tools
  - Chemical treatments - Use of chemicals designed to target grease, roots, scale, or organic buildup to remove them from the sewers
- Repairs:
  - Open-cut excavation,
  - trenchless methods (CIPP lining, pipe bursting, slip lining),
  - manhole rehabilitation.

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Maintenance Planning and Scheduling

Used to organize routine, preventative, corrective, and emergency maintenance

- Prioritize high-risk areas to prevent blockages
- Should be based on condition, age, material and historical data

Calendar-based or condition-based scheduling

Determine communication procedures and data requirements



Operator Safety/OSHA/Chemical Safety

9/30/25 - https://www.youtube.com/watch?v=NjdxOVMqM4k&t=9s

Safety Hazards



Chemical Hazards
- Toxic chemicals
- Acids
- Bases



Physical Hazards
- Machinery
- Lifting/slipping
- Fire
- Explosions
- Falls
- Noise



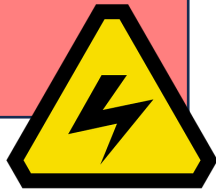
Biological Hazards
- Pathogens
- Infectious disease
- Infections



Environmental Hazards
- Confined spaces
- Drowning
- Engulfment/ entrapment
- Traffic
- Weather



Other Hazards
- UV exposure
- Radiological waste
- Electrical shock
- ???



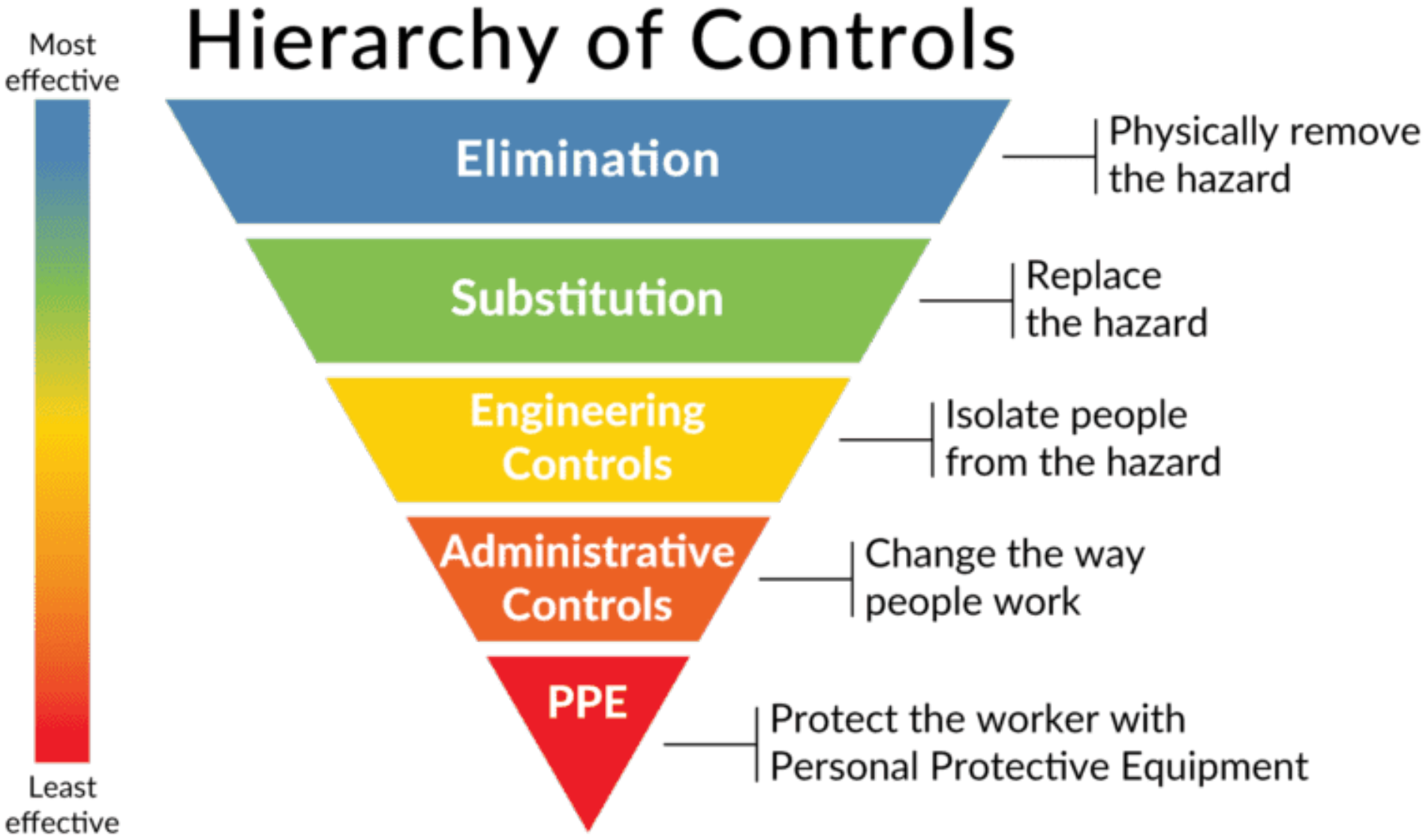
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Safety Programs

- **Identify** the **causes** of accidents, illness, and injuries
- **Provide** safety **training**
- **Implement** an accident **reporting system**
- **Hold supervisors responsible** for **implementing** the safety program

- Operator duties: follow protocols, use PPE, report hazards.
- Management duties: written safety statements, appoint safety officers, set goals, evaluate results.

Actions to Control Workplace Hazards



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Hazard Control

- Infectious Materials
  - Use PPE like gloves
- Water Hazards
  - Reduce slip hazards
  - Use caution
  - Learn to swim
  - Use personal flotation devices
- Electrical Hazards
  - Use Lockout/Tagout
  - Understand the risks
- Excavation Safety
  - Use shoring, shielding or sloping to prevent trench cave in
  - Ladders required
- Chemical Hazards
  - Understand safety data sheets
  - Understand safety squares
  - Use PPE
- Confined Space
  - Require permits
  - Require monitoring

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Safety Equipment

- Respirators
- SCBA - **S**elf **C**ontained **B**reathing **A**pparatus
- Emergency Gear
- Gloves
- Eye Protection
- Toe Protection
- Inoculations

Preliminary Treatment

10/14/25 - https://www.youtube.com/watch?v=39j3UBpYbiM

WWTP Headworks

Location where wastewater system influent is received

- Trunk Lines/ Interceptors Merge
- Flow measurement
- Pretreatment
- Influent sampling and assessment
- Odor control
- Flow equalization
- Pre-aeration



Flow Measurement

Flow is measured through a variety of methods

- Magnetic flow meters
- Parshall flume
- V-notch weirs
- Rotameters
- Ultrasonic level sensors

Flow meters should be placed in easily accessible areas for maintenance and in long straight sections of pipe or channel

Flow meters should be calibrated in place

Pretreatment Screening

Bar Screens: Remove large debris; spacing 3/8–2 inches.

Bar Racks: Remove coarse debris; spacing >2 inches.

Cleaning: Manual raking vs. mechanical/automatic systems.

Hazards: Slips, toxic gases, electrical risks, physical strain.

Disposal: Screenings are hazardous; typically landfilled or incinerated.



Grit Removal

Methods: Grit channels, aerated grit chambers, cyclone separators.

Ideal settling velocity: ~1 ft/s.

Disposal: Landfill with proper covering and regulatory compliance.



Other Pretreatment Information

Influent Sampling

- Composite or grab samples for monitoring quality, detecting pollution, and ensuring compliance.

Odor Control Techniques:

- Chemical dosing, aeration, biofilters, activated carbon, air scrubbers.

Flow Equalization & Pre-aeration

- Equalization tanks manage peak flows.
- Pre-aeration improves treatment efficiency and reduces odors.

Sedimentation, Flocculation and Floatation

10/28/25 - https://www.youtube.com/watch?v=bE4JSyK6pcs

Sedimentation, Flocculation and Floatation

Sedimentation

Sedimentation is the settling of heavier particles in wastewater by gravity.

Particles with specific gravity > 1 sink when flow velocity is slow enough.

Factors affecting settling: particle size, shape, water temperature, and flow velocity.

Flocculation

Process of gathering fine particles into larger clumps after coagulation.

Promotes faster settling by increasing particle mass.

Influenced by basin depth, velocity gradients, overflow rates, and particle concentration.

Floatation

Opposite of sedimentation: lighter materials (fats, oils, grease) float to the surface.

Achieved through aeration, chemicals, electrolysis, heat, or natural buoyancy.

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The Sedimentation Principle is used throughout the treatment train.

Preliminary Treatment: Grit removal using discrete particle settling.

Primary Treatment: Removal of suspended solids in clarifiers.

Secondary Treatment: Biological floc removal in activated sludge processes.



Horizontal Flow Design Criteria for Sedimentation

Item	Typical Horizontal Grit Channel	Typical Primary Settling Tank
Detention Time	1 to 3 min	2 to 3 hours
Horizontal Flow Velocity	0.7 to 1.4 ft/s	1 to 2 ft/min
Specific Gravity of Particles	~ 2.5 to 2.6	<1 to 1.25

Operational Calculations

- Settling time

$$settling\ time = \frac{depth}{settling\ rate}$$

- Removal Efficiency

$$R = \frac{t}{a + bt}$$

- Weir Loading Rate

$$LR_{Weir} = \frac{Q}{L}$$

- Surface Loading Rate

$$LR_{Surface} = \frac{Q_{GPD}}{A_{Surface}}$$

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Checking Facility Performance

You can use SLR, WLR, Removal Efficiency and detention time formulas to compare facilities to common design values

Used in combination with lab tests, process control tests they can help to verify operational goals are being achieved

If lab tests show poor performance these math tests can help identify operational problems

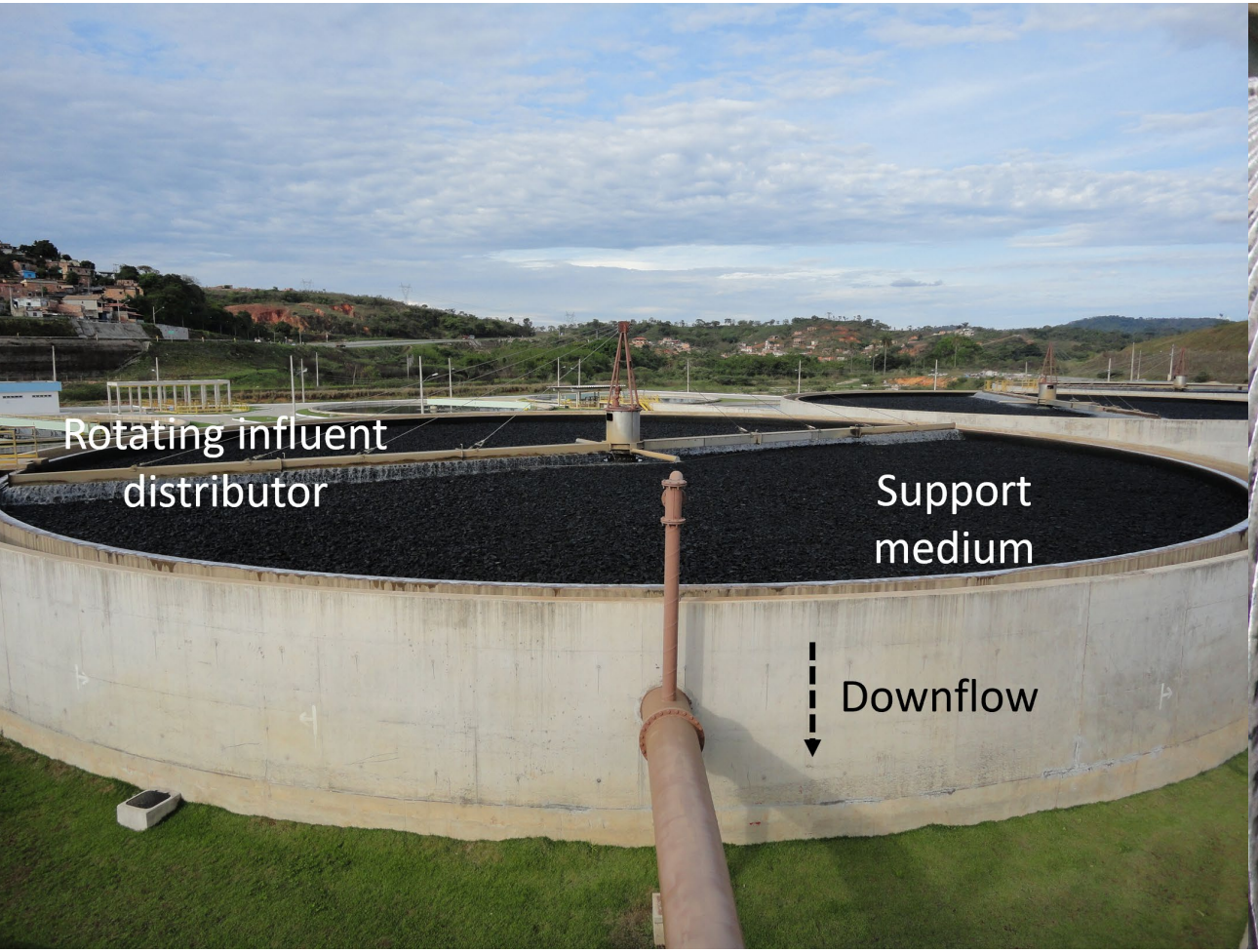
Fixed Film Processes

11/11/25 - https://www.youtube.com/watch?v=iWp24mAUdH8

“Fixed Film”

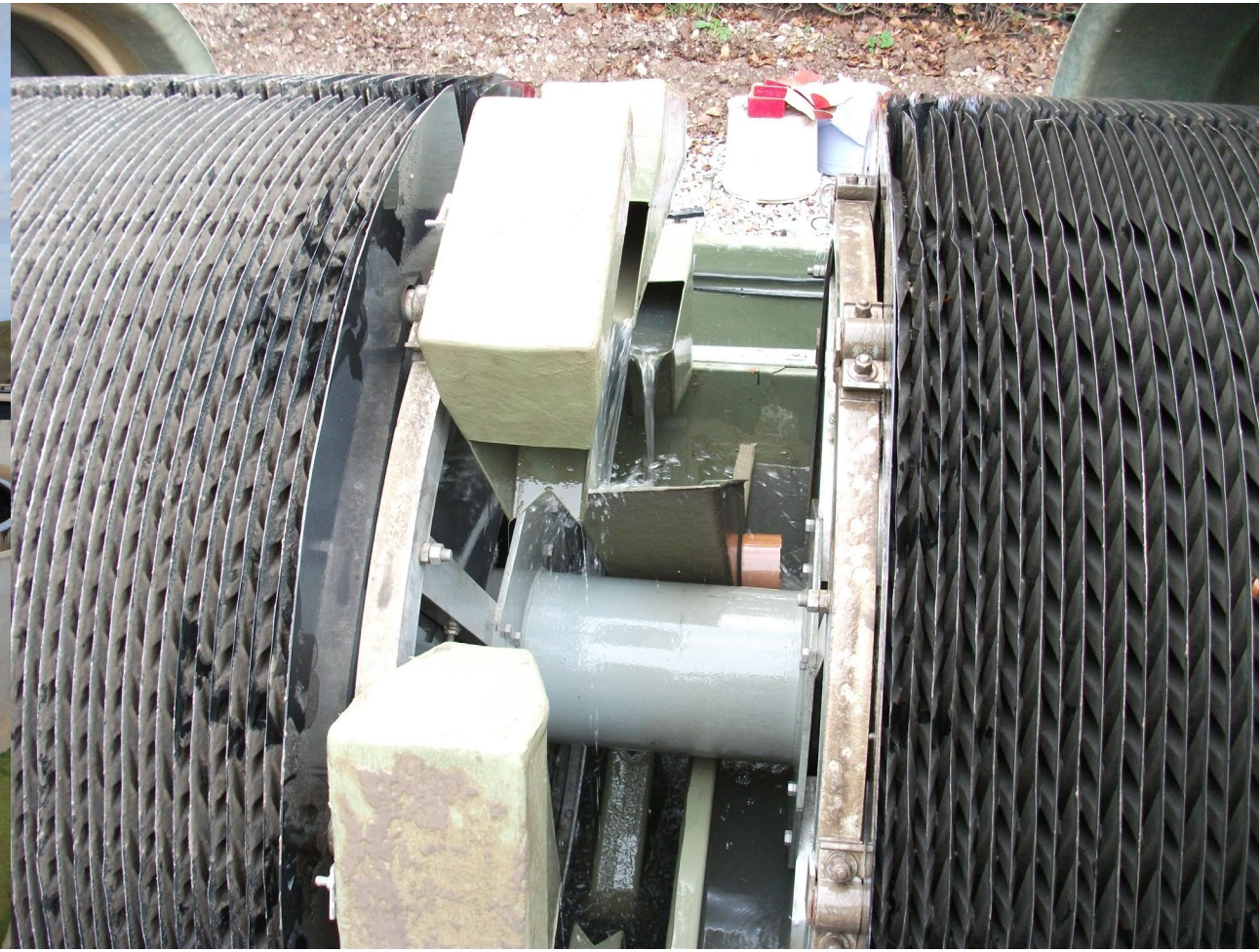
Microorganisms treating waste and living in solids, slimes or films attached (or “fixed”) to media in the treatment process

Trickling Filter



Trickling Filters: Wastewater trickles over stationary media; air flows through voids.

Rotating Biological Contactor (RBC)



Rotating Biological Contactors (RBCs): Media rotates through wastewater, alternately exposing biofilm to air and water.

Design and Operation Highlights

Trickling Filter

- Media Stationary
- Media Types
  - Organic – rock (heavy, limited open or void space)
  - Synthetic – plastic (light, uniform shape, more void space)
- Structure
  - Concrete and short for rock media
  - Metal or Fiberglass for plastic media, can be quite tall
- Underdrain – collects treated water

Rotating Biological Contactor

- Media Rotates in and out of water
- Media Types
  - Standard Density – BOD Removal
    - Biofilm Thickness 0.04 – 0.06 in
  - High Density – Nitrification
    - Biofilm Thickness 0.015 - .03 in

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Performance Parameters

Organic Loading Rate

- amount of organic matter (BOD) fed into system
  - lbs BOD per 1,000 ft^3 of media per day.

$$OLR = \frac{Q_{in}\left[\frac{Mgal}{day}\right] \times \frac{8.34\ L \cdot lb}{mg\ \cdot Mgal} \times BOD\ concentration\left[\frac{mg}{L}\right]}{\frac{V\ [ft^3]}{1000}}$$

Hydraulic Loading Rate

- amount of water fed into the system per day in relation to the media surface area
  - GPD per ft^2 of media surface.

$$HLR\ [\frac{gal\ of\ influent}{ft^2\ of\ media\ \cdot day}] = \frac{Q_{in}\left[\frac{gal}{day}\right] + Qr\left[\frac{gal}{day}\right]}{A_{surface}[ft^2]}$$

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Performance Parameters

Recirculation

- Allows you to control volume of water entering without impacting BOD
- Recirculation Ratio

Dosing Rate

- Used to control the biofilm thickness by adjusting speed.

$$TF\ recirculation\ ratio = \frac{Q_r\ [\frac{gal}{day}]}{Q_{in}\ [\frac{gal}{day}]}$$

$$DR\ [\frac{in}{pass}] = \frac{HLR\ \left[\frac{gal}{ft^2\ of\ media \cdot day}\right] \times \frac{12\ in}{ft}}{\frac{7.48\ gal}{ft^3} \times N \times w\ \left[\frac{rev}{min}\right] \times \frac{1{,}440\ min}{day}}$$

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Sampling Requirements

Parameter	Sampling Frequency	Location(s)	Typical Ranges
TSS	Daily or Weekly	Influent Primary effluent Final Effluent	150 – 400 mg/L 60 – 150 mg/L 15 - 40 mg/L
BOD5	Weekly	Influent Primary effluent Final Effluent	150 – 400 mg/L 100 – 380 mg/L 15 - 40 mg/L
COD	Daily or Weekly	Influent Primary effluent Final Effluent	300 – 800 mg/L 200 – 380 mg/L 60 - 120 mg/L
DO	Daily or Continuously	Filter underflow Filter effluent	3.0 – 8.0 mg/L 1.5 – 2.0 mg/L
pH	Daily or Continuously	Influent Effluent	6.8 – 8.0 7.0 – 8.5
Temperature	Daily or Continuously	Influent	Seasonal
Chlorine residual before de-chlorination	Daily	Secondary Effluent	0.5 – 2.0 mg/L
Coliform bacteria or *E. coli* after de-chlorination	Weekly	Final Effluent	50-700 MPN/100mL

Considerations

Trickling Filter

- Low energy requirements
- Low maintenance requirements
- Ability to treat variable organic loads & toxic substances
- Can generate odors
- Can have issues with macrofauna (insects, flies, snails)
- Temperature sensitivity
- Icing in cold weather
- Low flows can immobilize distributor arms in unmotorized systems

RBC

- Suitable for small facilities (50–5,000 people).
- Operates at lower organic loading rates than trickling filters.
- Requires careful control of biofilm thickness and shaft weight.
- Often staged in series or parallel for flexibility.

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Activated Sludge

Part 1 - 12/2/25 - https://www.youtube.com/watch?v=tU8o9tx6EXA

Part 2 – 12/16/25 - https://www.youtube.com/watch?v=a4ok1sMeGNA

What is the Activated Sludge Process?

Secondary Treatment Process

Biological Process

Microorganisms convert dissolved and suspended organics into settleable solids

- Replicates natural process
- Uses microorganisms already present in wastewater

Primary goal is to remove biochemical oxygen demand (BOD)



Goals of Activated Sludge

Activated Sludge Can Remove:

- BOD
- Suspended Solids
- Ammonia
- Nitrates
- Pathogens

And can aid in other pollutant removal!



Activated Sludge

Process Overview

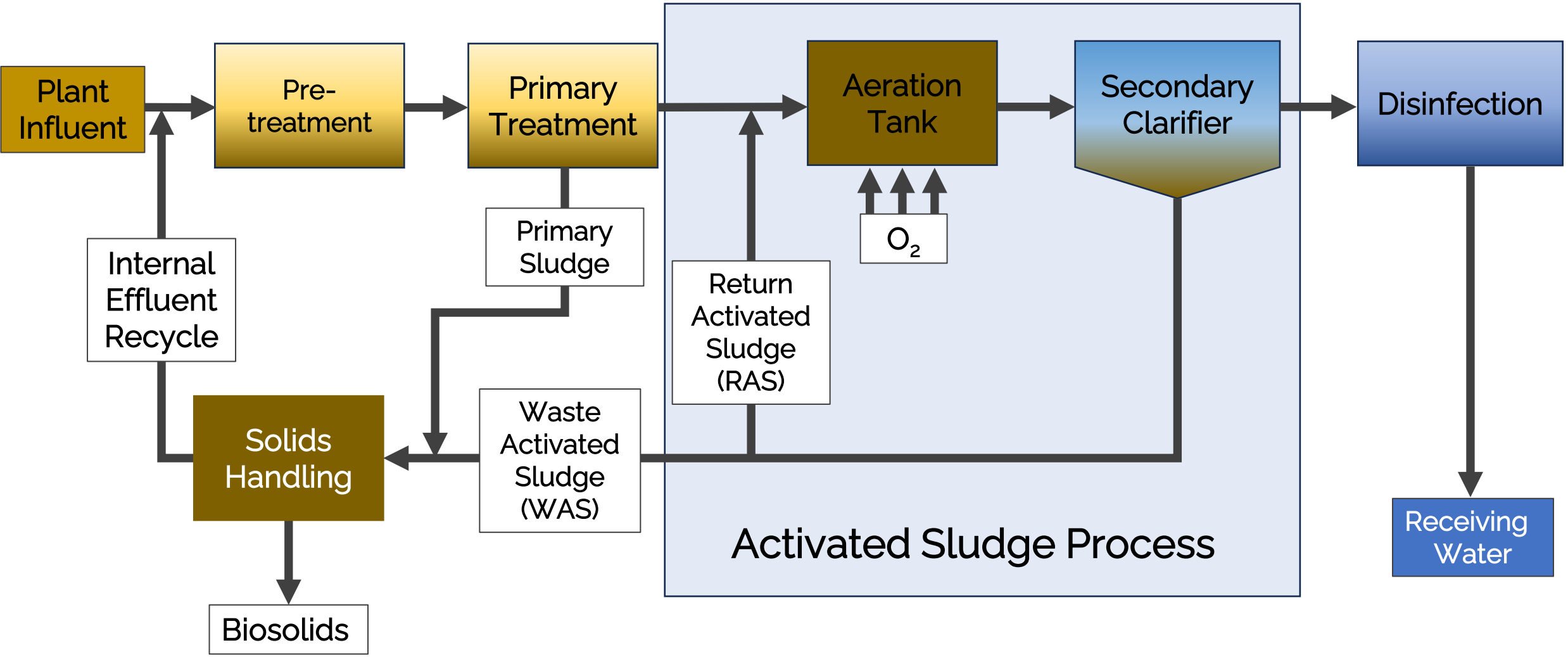
- Influent enters an aeration tank, mixes with cultivated biomass (mixed liquor), and uses oxygen to break down organics.
- Sludge settles in a secondary clarifier, where it is either recycled (RAS) or wasted (WAS).

Components

- Aeration systems (diffused, mechanical, jet aerators) and blowers.
- Mixers to maintain suspension and prevent dead zones.
- Secondary clarifiers for settling and sludge management.
- Monitoring equipment for DO, MLSS, ammonia, and nitrates.

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Wastewater Flow Schematic



Activated Sludge

Biology

- Microorganisms involved: aerobic bacteria (main BOD removers), facultative anaerobes (denitrification), filamentous bacteria (floc structure), protozoa, and rotifers.
- Nitrogen removal through nitrification and denitrification.

Operational Variables

- Key parameters: DO (1–2 mg/L), MLSS (1,000–3,000 mg/L), sludge age, pH (6.5–8.5), alkalinity, and nutrient balance.
- Lab tests: BOD, COD, MLSS, and microscopic analysis for system health.

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Why are activated sludge process (ASP) characteristics and control important?

Biological process with more variables than physical and chemical processes

Operational data must be used to make process control adjustments

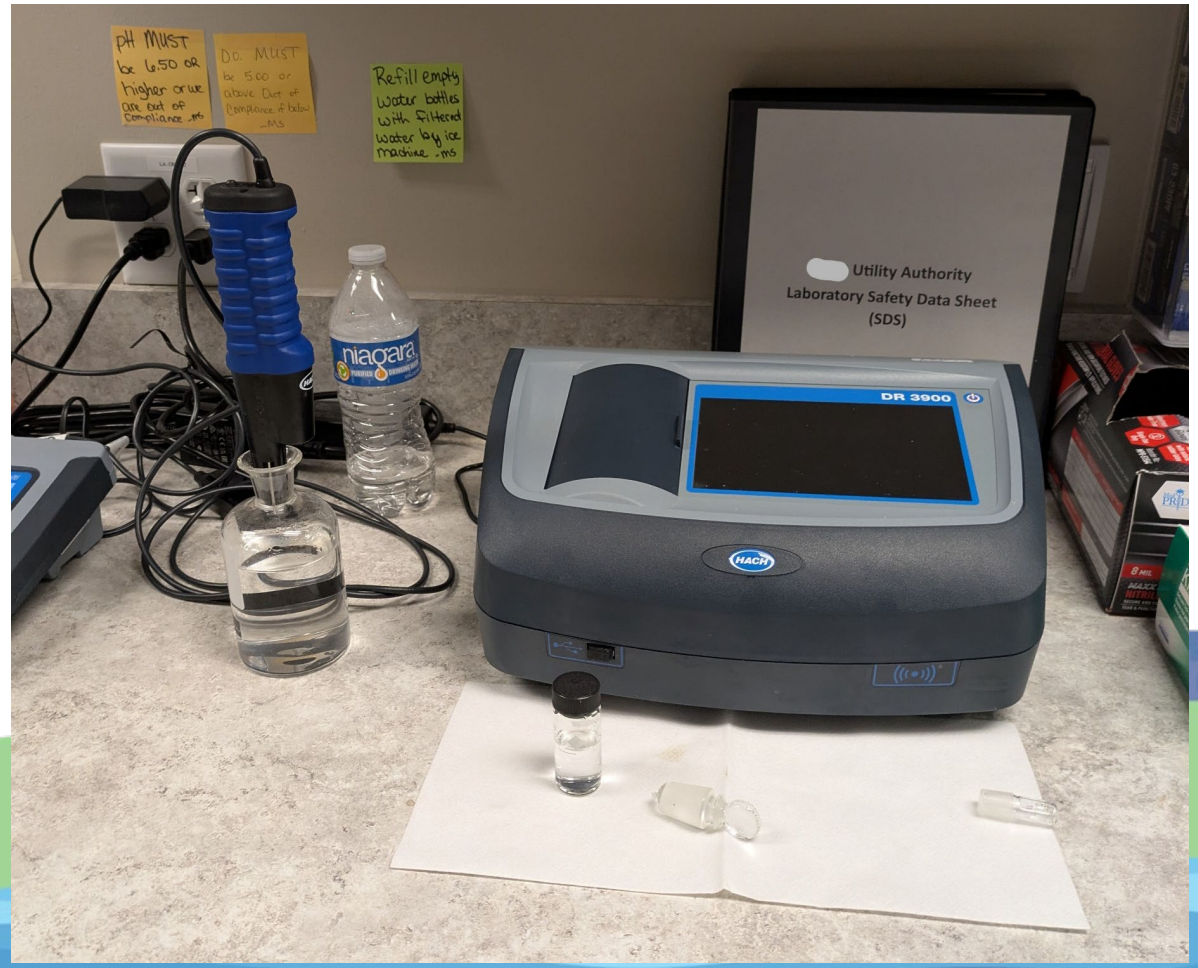
Characteristics change daily and the ASP process must be maintained in a balance state

Objectives of ASP:

- Maintain the aeration tank to produce floc-forming bacteria
- Flocculate and settle the flocs inside the secondary clarifier
- Manage the activated sludge to maintain a healthy proportion of microorganisms in the system



Influent Parameters



- Flow Rate
- Total Suspended Solids (TSS)
- Volatile Suspended Solids (VSS)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Kjeldahl Nitrogen (TKN)
- Ammonia (NH_3)
- Nitrate (NO_3)
- Temperature
- pH
- Alkalinity

Activated Sludge Process Variables



- Dissolved Oxygen (DO)
- Food-to-Microbe ratio (F/M)
- Mixed Liquor Suspended solids (MLSS)
- Mixed Liquor Volatile Suspended solids (MLVSS)
- Solids Retention Time (SRT)
- Mean Cell Residence Time (MCRT)
- Sludge Volume Index (SVI)

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Questions?

CONTACT INFORMATION



SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

swefc@unm.edu

Department of Civil Engineering MSC01 1070
1 University of New Mexico
Albuquerque, NM 87131
505-277-0644
swefc@unm.edu
http://swefc.unm.edu