

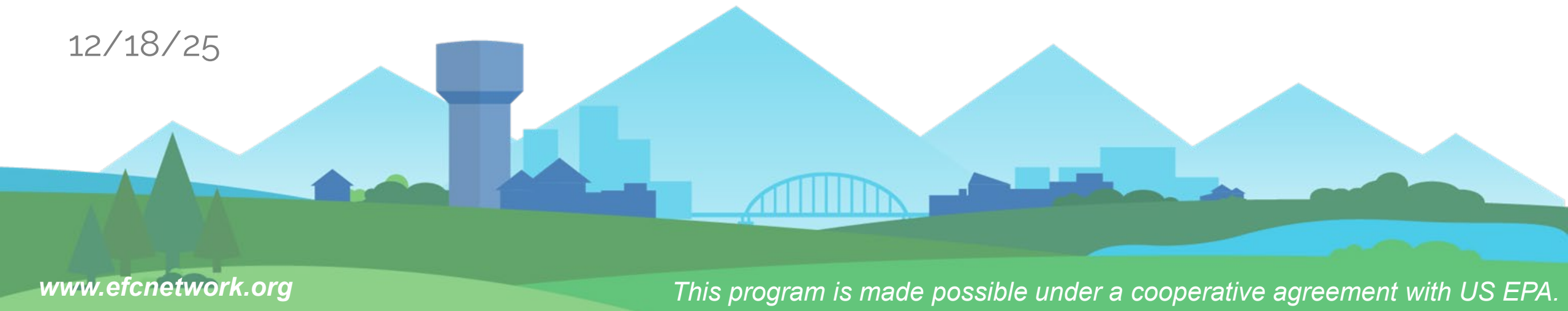


SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Water Operator Training Series

Session 13: Surface Water Treatment 2: Filtration

12/18/25



Your trainer for today

Matt Ziegler
Program Director



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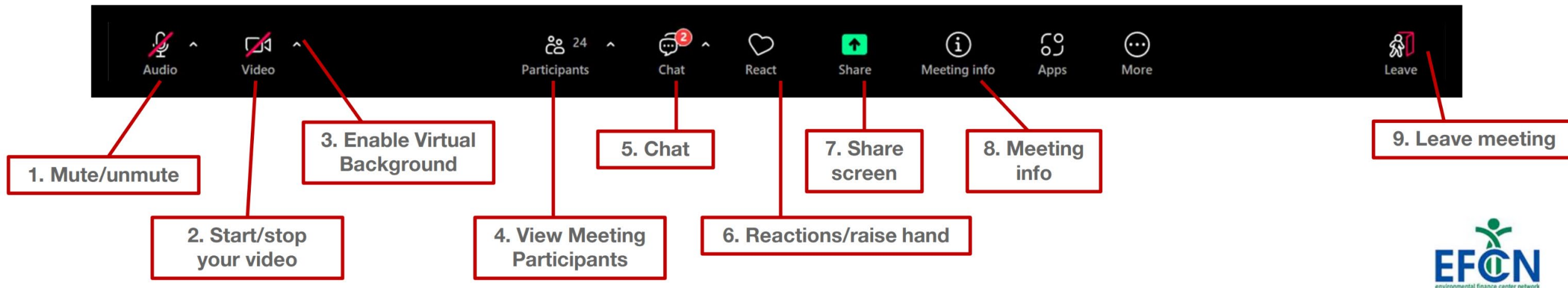
SCHOOL OF
ENGINEERING



This training series is funded by the US 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
 - Move your cursor to the screen's bottom (or top) to reveal this control bar.



Schedule for 2025:

Date	Topic
6/26/25	Program Overview, Test Format, Study & Test Tips
7/10/25	Drinking Water System Overview - (Source, Treatment, & Distribution)
7/24/25	Basic Operator Math (+, -, /, x, Exponents and basic algebra)
8/7/25	Applied Operator Math (e.g. Areas, Volume, Flow Rates, Detention Time, Pressure/Hydraulic Head)
8/21/25	Drinking Water Regulations
9/4/25	Source Water Characteristics
9/18/25	Surface Water Intake Components, Well Components, and O&M
10/2/25	Disinfection 1: Chloramines, UV, Chlorine Dioxide, Chlorine
10/16/25	Disinfection 2: Chlorine Disinfection Application for Sodium Hypochlorite and Gas Chlorine (including storage and safety)
10/30/25	Disinfection 3: Distribution System Application, Residual Measurement, Evaluation & Adjustment,
11/13/25	Disinfection 4: Chlorine Disinfection Math
12/4/25	Surface Water Treatment 1: Coagulation, Flocculation, Sedimentation (including chemistry, process controls, operations)
12/18/25	Surface Water Treatment 2: Filtration

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

Schedule for 2026:

Date	Topic
1/22/26	Alternative Treatment Processes (e.g. flouridation, ion exchange, RO...)
2/5/26	Drinking Water Treatment Math & Concept Review
2/19/26	Safety Program Basics (including personal safety, equipment safety, facility safety)
3/5/26	Lead & Copper Rule, Corrosion Control
3/19/26	Distribution Systems 1: Hydraulics, Pipe Types, Selection, Installation, and Water Quality
4/2/26	Distribution Systems 2: Valves, Hydrants, Meters, and Service Connections
4/16/26	Distribution Systems 3: Storage and Booster Pumping
4/30/26	O&M: Pumps, Main, and Appurtenance Maintenance (including pressure monitoring, valve exercising, and flushing)
5/14/26	O&M: Cross Connection Control
5/28/26	O&M: Distribution System Math and Concept Review
6/11/26	Sampling & Lab Procedures/Analysis/Interpretation
6/25/26	Management Overview (including organization, communication, PR & record keeping)
7/9/26	Drinking Water Practice Exam and Review

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

Pacific Island Territories Operator Certification 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

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: _____

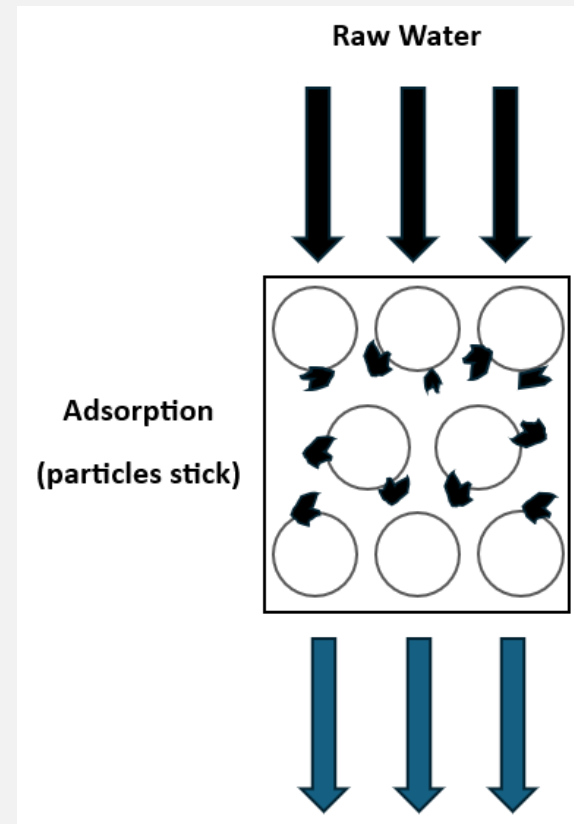
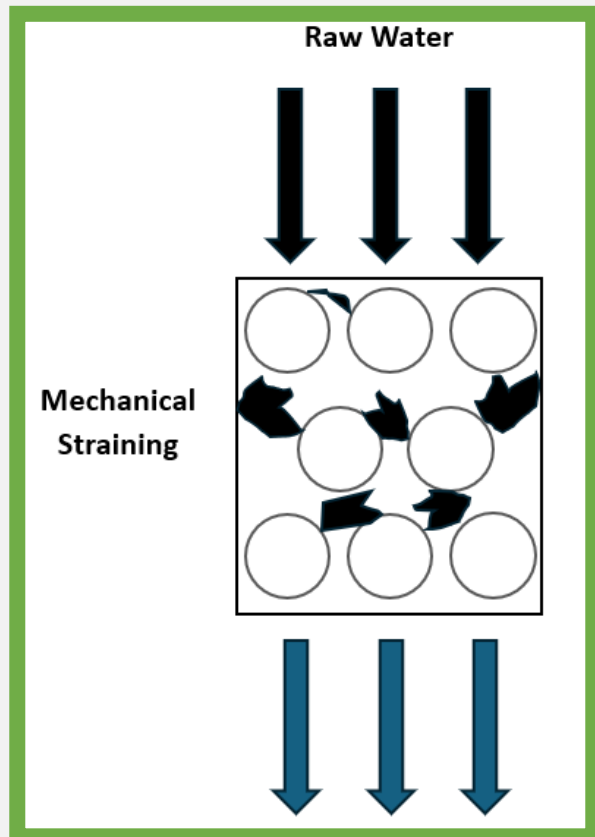
Attendee Name	Attendee Signature	Arrival Time	Departure Time

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

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

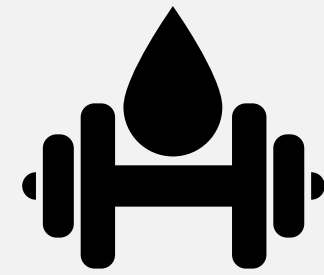
Filtration Definition

The physical process of separating suspended and colloidal particles from water by passing it through a filter media.



**Will cover
adsorption under
Part 4 – Other
Treatment
Methods**

Gravity vs. Pressure Filtration



8.34 pounds/gallon

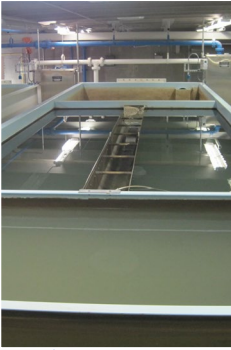
Gravity

- Weight of water pushes water through filter
- Most common

Pressure

- Applied water pressure pushes water through filter
- Requires energy

Filtration/Treatment Approaches



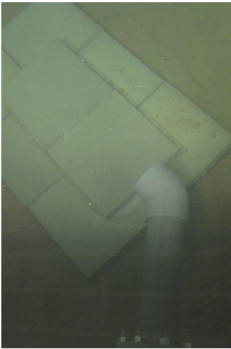
Conventional (Rapid Sand)

- Chemical Pretreatment → Coagulation → Flocculation → Sedimentation → Gravity Filtration → Disinfection



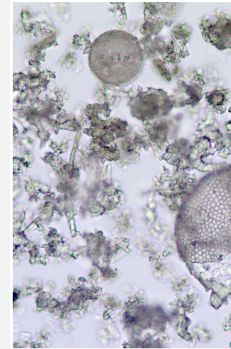
Direct

- Chemical Pretreatment → Coagulation → Gravity or Pressure Filtration → Disinfection



Slow Sand

- Sedimentation → Gravity Filtration → Disinfection



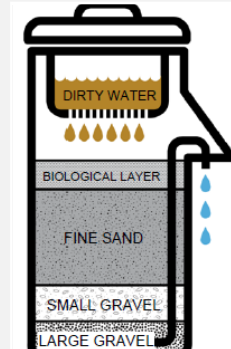
Diatomaceous Earth

- Pressure Filtration → Disinfection



Package

- Chemical Pretreatment → Gravity or Pressure Filtration → Disinfection
- Conventional, Cartridge, Membrane, or Synthetic Media Filtration



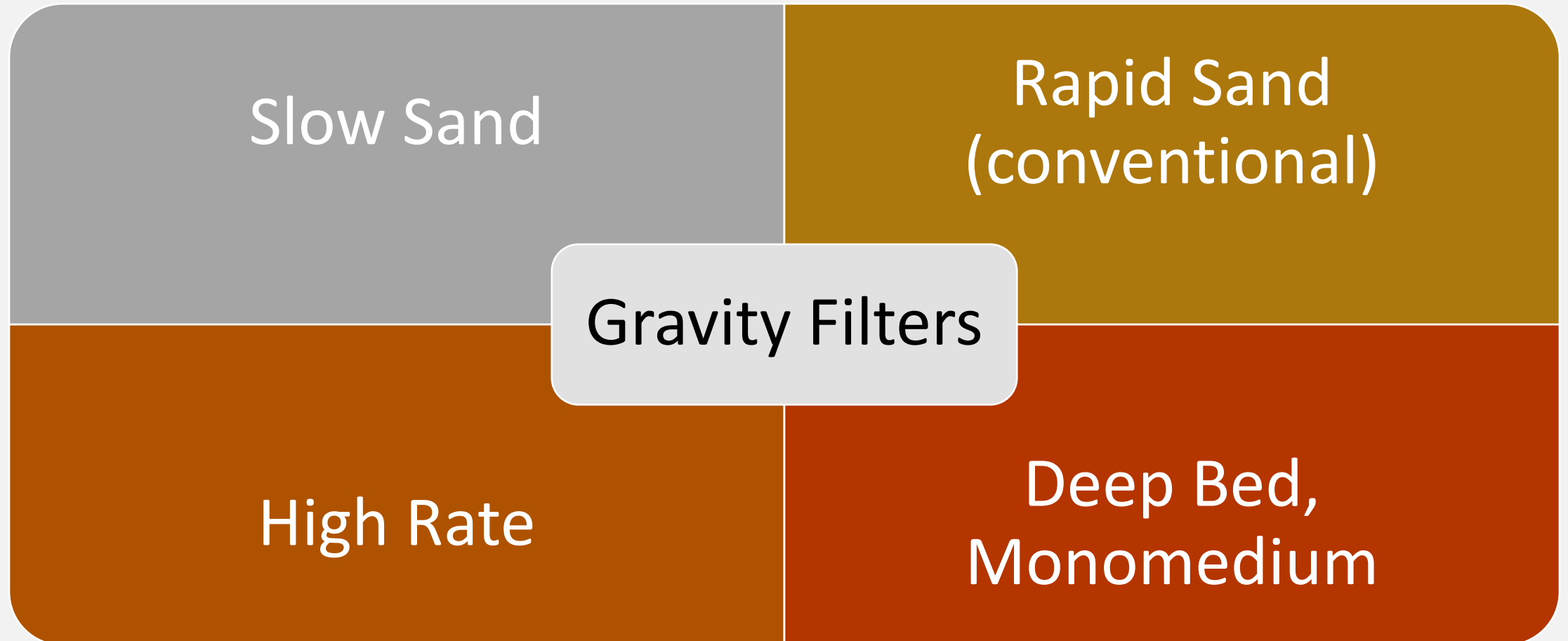
Biological

- Biological Pretreatment → Gravity or Pressure Filtration → Disinfection

Strainers / Prefiltration



Types of Gravity Filters



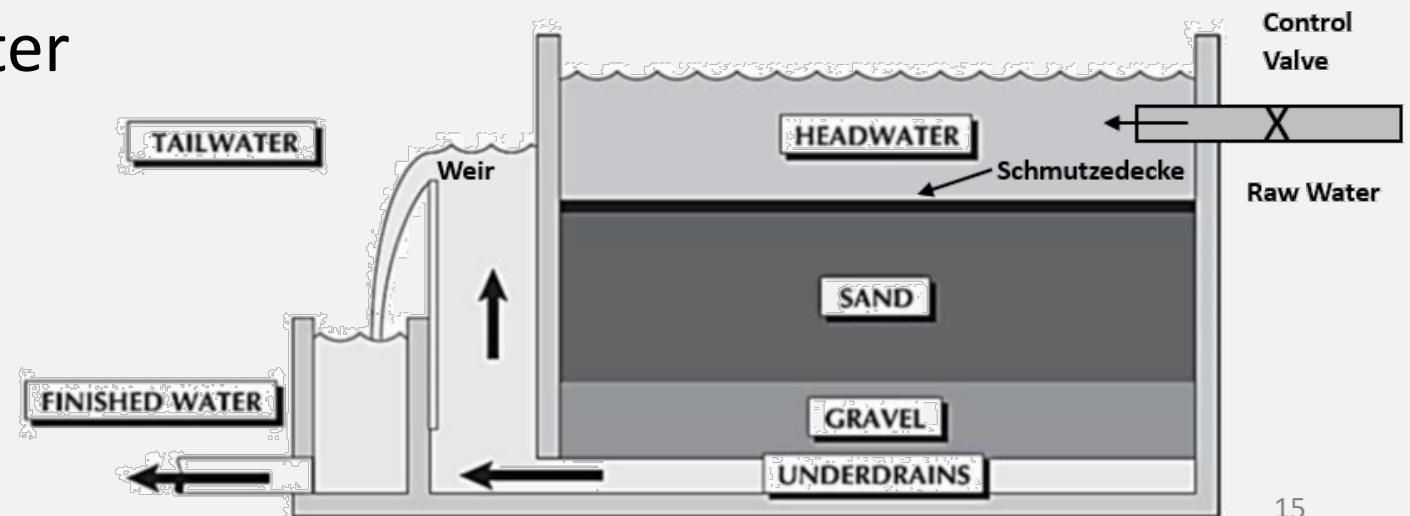
Gravity Filter Comparison

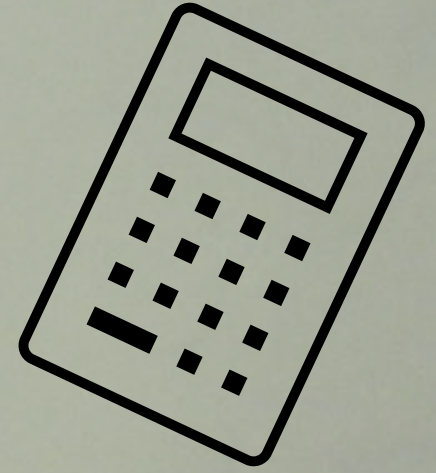
	Slow Sand Filters	Conventional Rapid Sand Filters	High-Rate Filters
Filtration Rate	0.05 gpm/ft ²	2 gpm/ft ²	3-8 gpm/ft ²
Media	Sand	Sand	Sand & coal or Sand, coal, & garnet
Media Distribution	Unstratified	Stratified (fine to coarse)	Stratified (coarse to fine)
Filter run times	20-60 days	12-36 hours	12-36 hours
Loss of head	0.2 ft initial 4 ft final	1 ft initial 8-9 ft final	1 ft initial 8-9 ft final
Amount backwash water used	Not backwashed	2-4% of filtered water	6% of filtered water

Slow Sand Filters

A 1 MGD treatment plant needs a 0.5 to 1-acre filter

- First type of gravity filter used for water treatment
- Large, covered filter beds
- Box and underdrain filled with 3.5 ft of sand
- Needs high quality raw water (<10 NTU)
- No chemical addition
- Filtration rate is ~0.05-0.15 gpm/sq.ft.





Filter Loading Rate

Filter Loading Rate

- Also known as the Filtration Rate.
- Measured in gpm/ft².
- Allows comparison of actual conditions with design specifications.

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

A slow sand filter has a surface area of 2,827 sq ft. What is the filtration rate in gallons per minute per square foot, if it receives a flow of 300 gpm?

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

▪ Filter surface area = 2,827 ft²

▪ Flow = 300 gpm

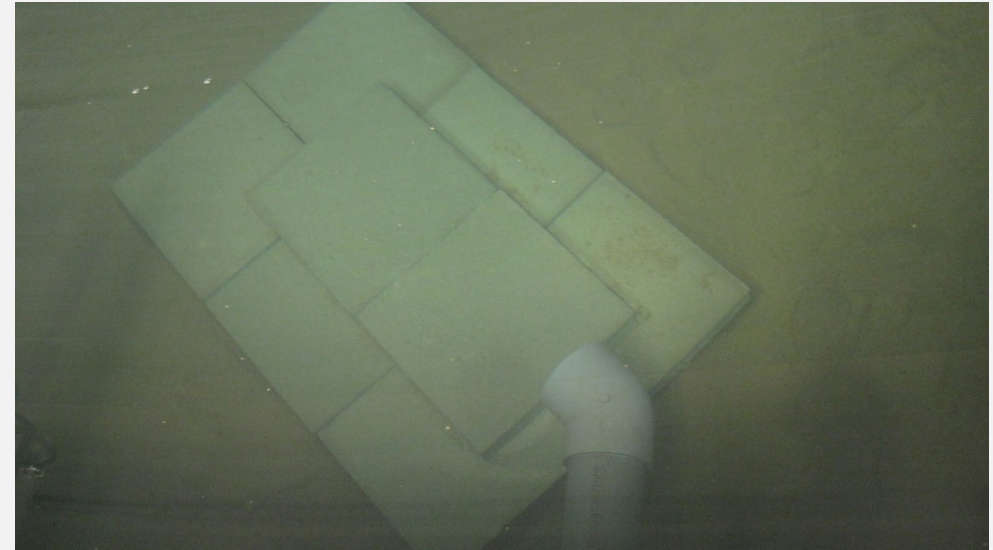
$$\text{Filtration Rate, } \frac{\text{gpm}}{\text{ft}^2} = \frac{300 \text{ gpm}}{2,827 \text{ ft}^2} = 0.106 \text{ gpm/ft}^2$$

Slow sand
design filtration
rate is ~0.05-
0.15 gpm/sq.ft.

0.106 gpm/ft² is the filtration rate for this slow sand filter at a flow rate of 300 gpm.

Slow Sand Filters

- Suspended material collects on surface of filter bed and forms a schmutzdecke = sticky mat of suspended material
- No backwash, when clogged, take out of service and scrape the top inch of sand off the filter bed (why need at least 2 filters)
- After cleaning, must filter to waste for several days before putting back in service
- Eventually add more sand



Slow Sand Filters

Advantages

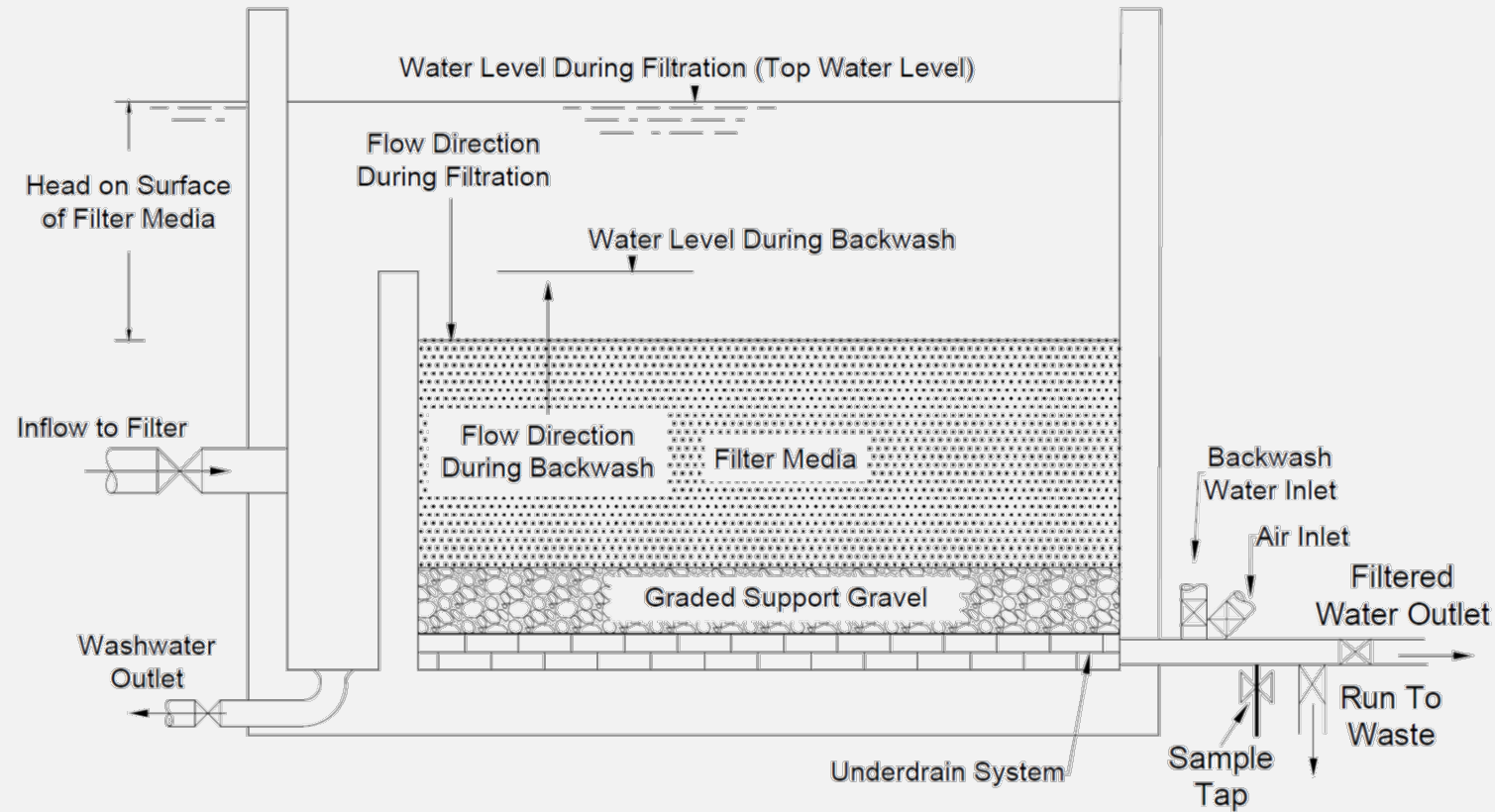
- Low Cost
 - Construction
 - Operating
 - Maintenance

Disadvantages

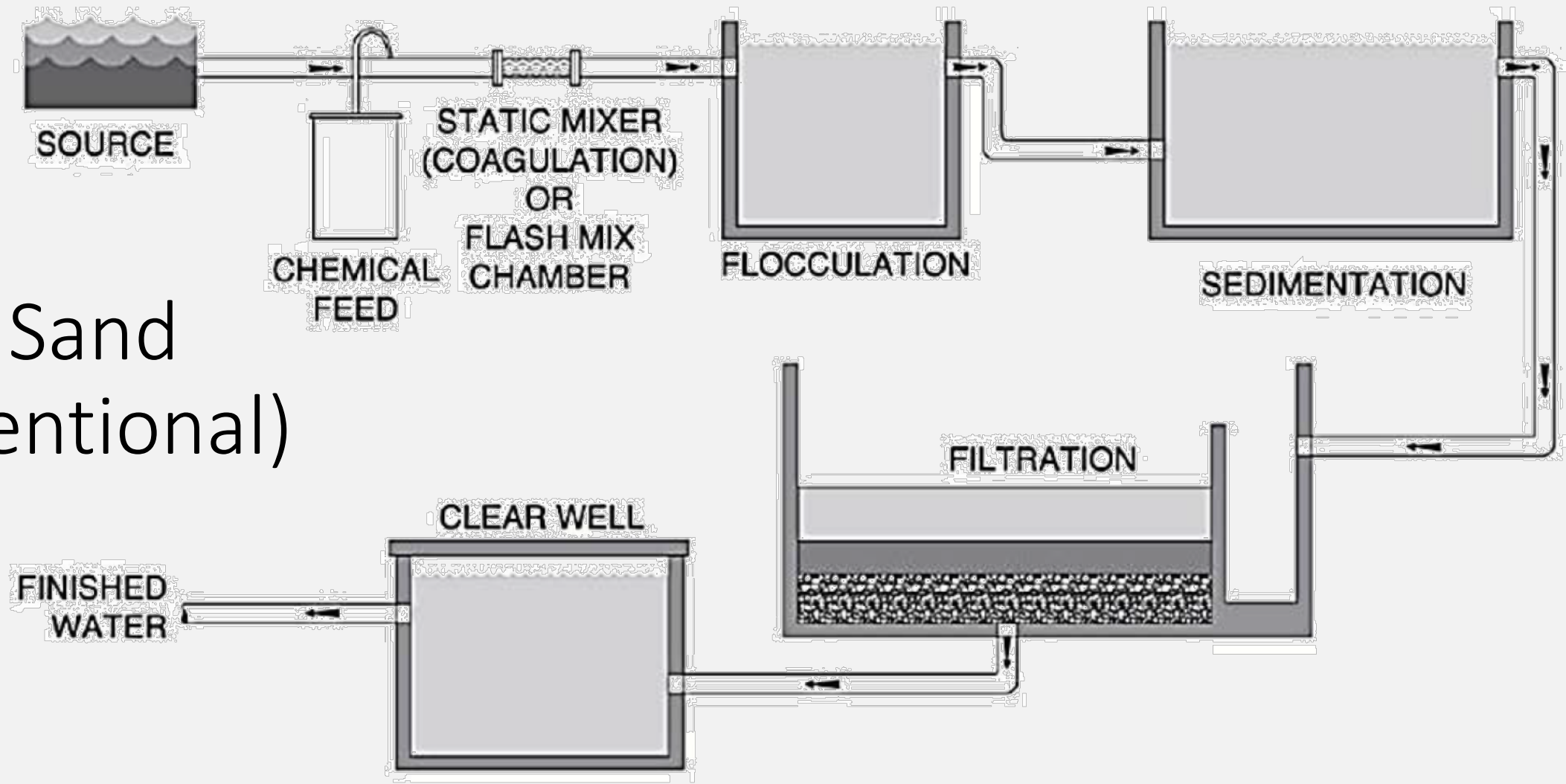
- Need lots of land
- Freezing concerns unless covered or warm climate

Operation of Gravity Filters

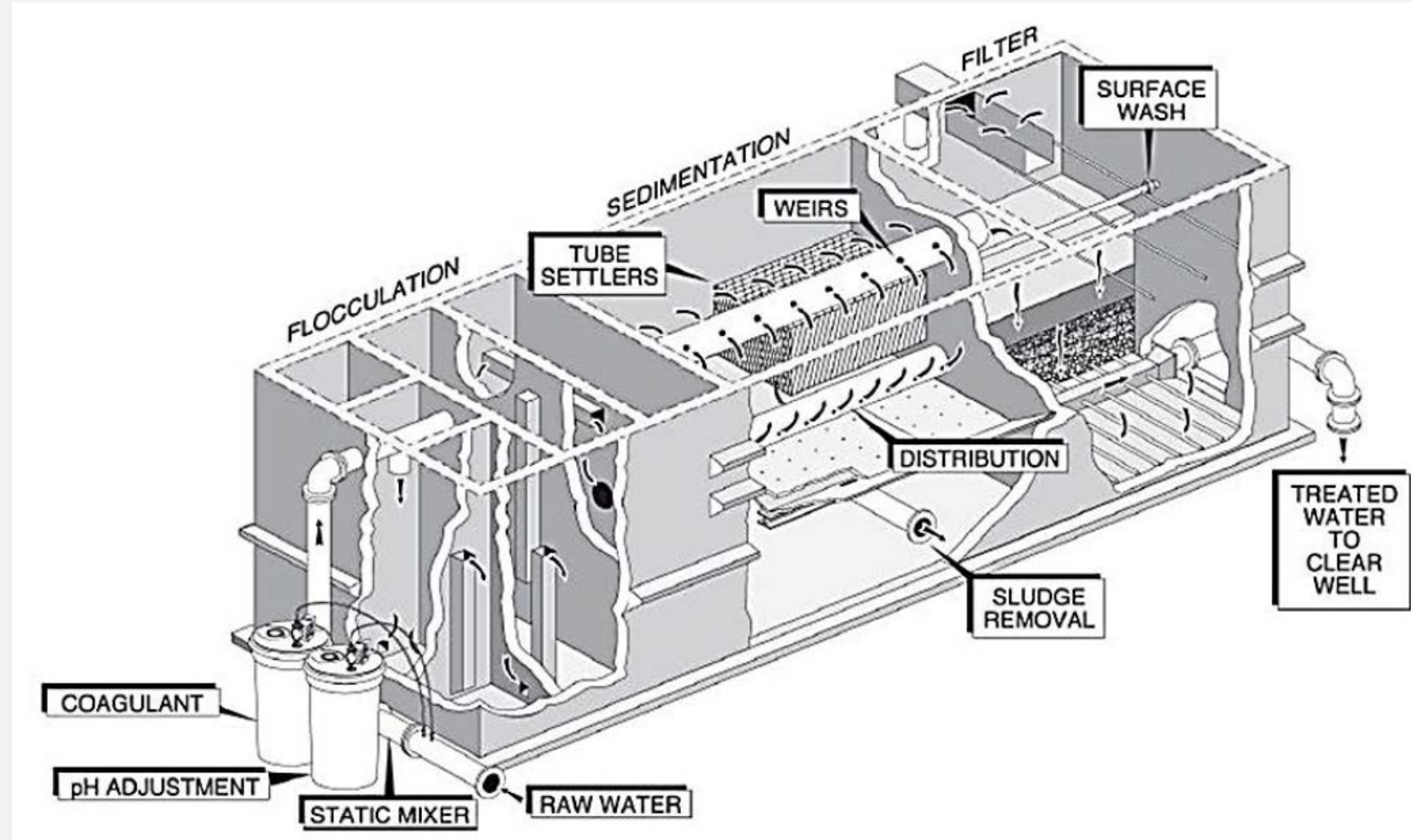
- Operation involves **filtering, backwashing, and filtering to waste** with a goal of producing low turbidity water during an acceptable Unit Filter Run Volume (UFRV)
- UFRV = gallons/ft² of filter surface area
- Good design = 5,000 gallons/ft²



Rapid Sand (conventional)

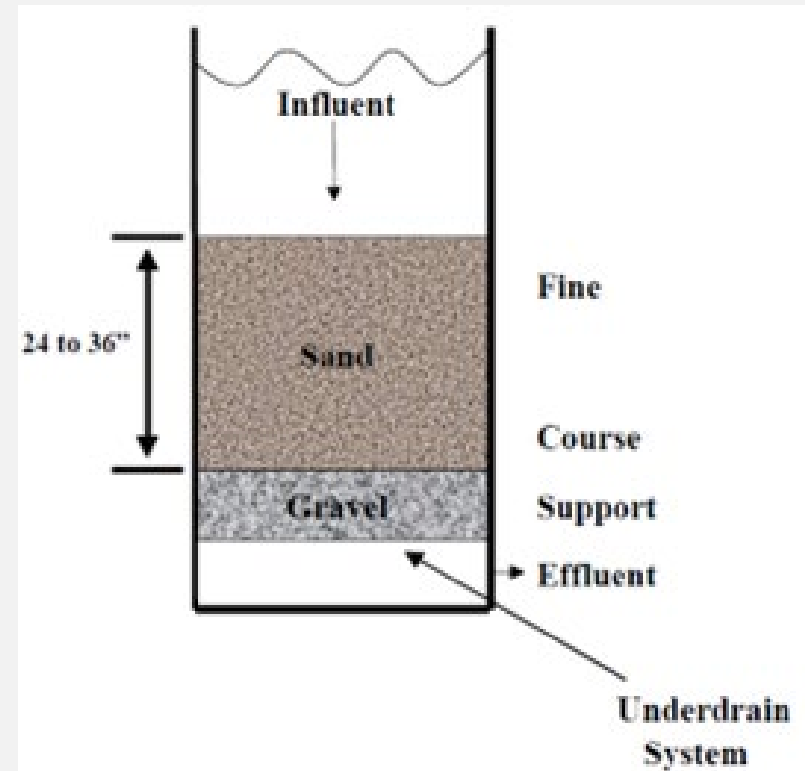


Package Filtration



Rapid Sand Filters (conventional)

- Use coarser sand to trap particles
- Backwash to clean
- Need a minimum of 2 filters that can each meet the design capacity of the plant

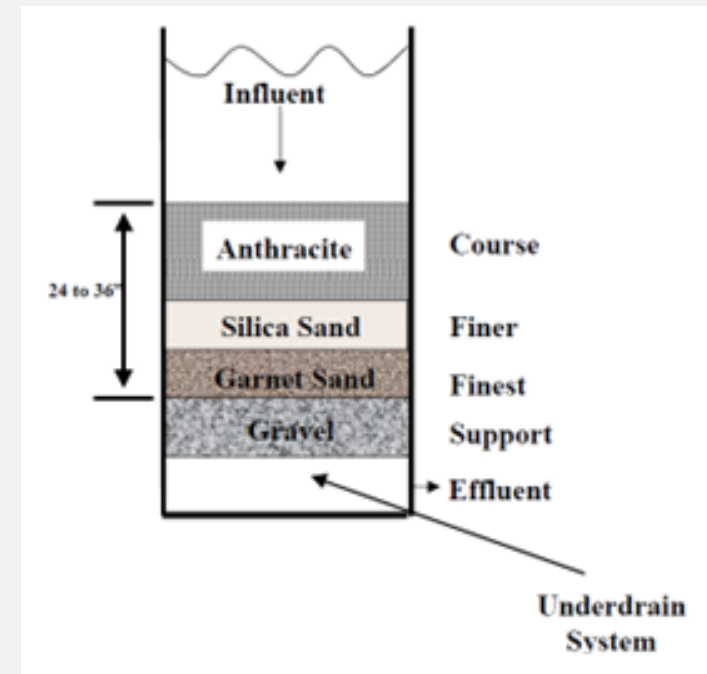
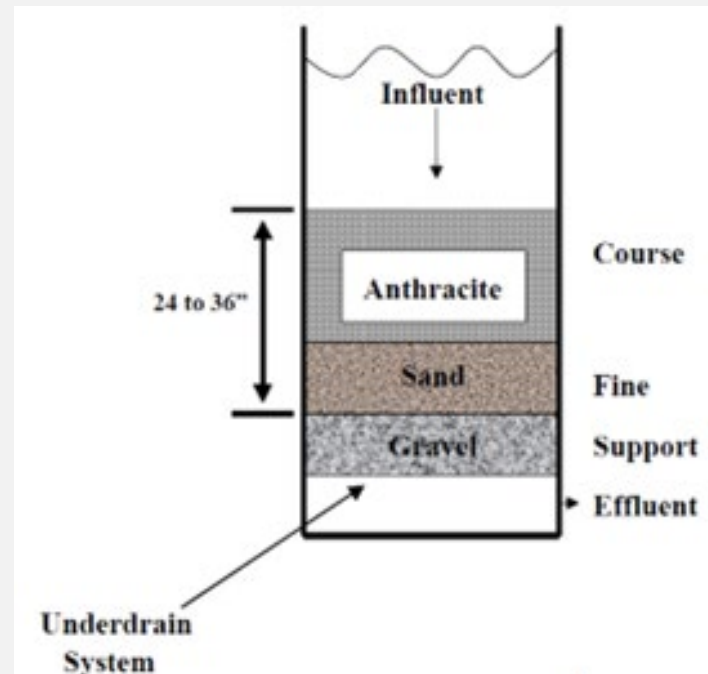


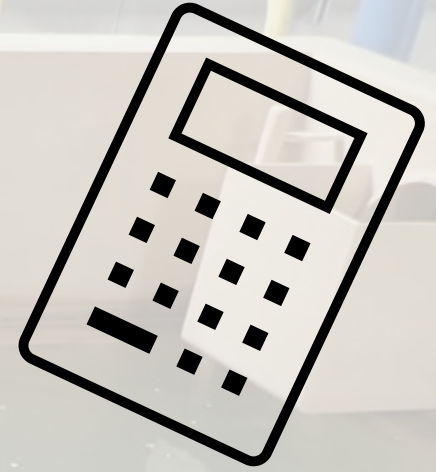
Filtration rate = 2 gpm/ft²

High-Rate Filters

- Use two or more types of media with different particle sizes allows filterable solids to penetrate deeper into the filter bed allowing for higher flows
- Filtration Rates = 3-8 gpm/ft²

Pilot testing done to determine which type of media combo works best for the water source





Filter Loading Rate

A high-rate filter has a surface area of 920 sq ft. What is the filtration rate in gallons per minute per square foot, if it receives a flow of 4,875 gpm?

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

▪ Filter surface area = 920 ft²

▪ Flow = 4,875 gpm

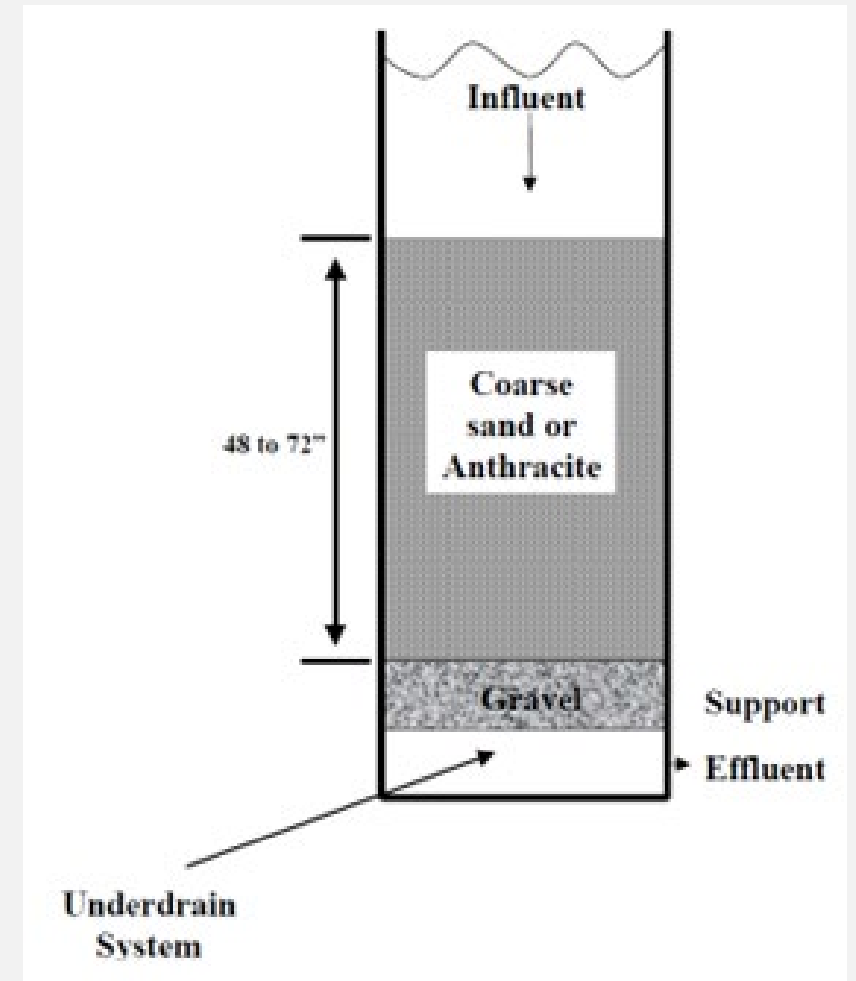
$$\text{Filtration Rate, gpm/ft}^2 = \frac{4,875 \text{ gpm}}{920 \text{ ft}^2} = 5.3 \text{ gpm/ft}^2$$

5.3 gpm/ft² is the filtration rate for this filter at a flow rate of 4,875 gpm.

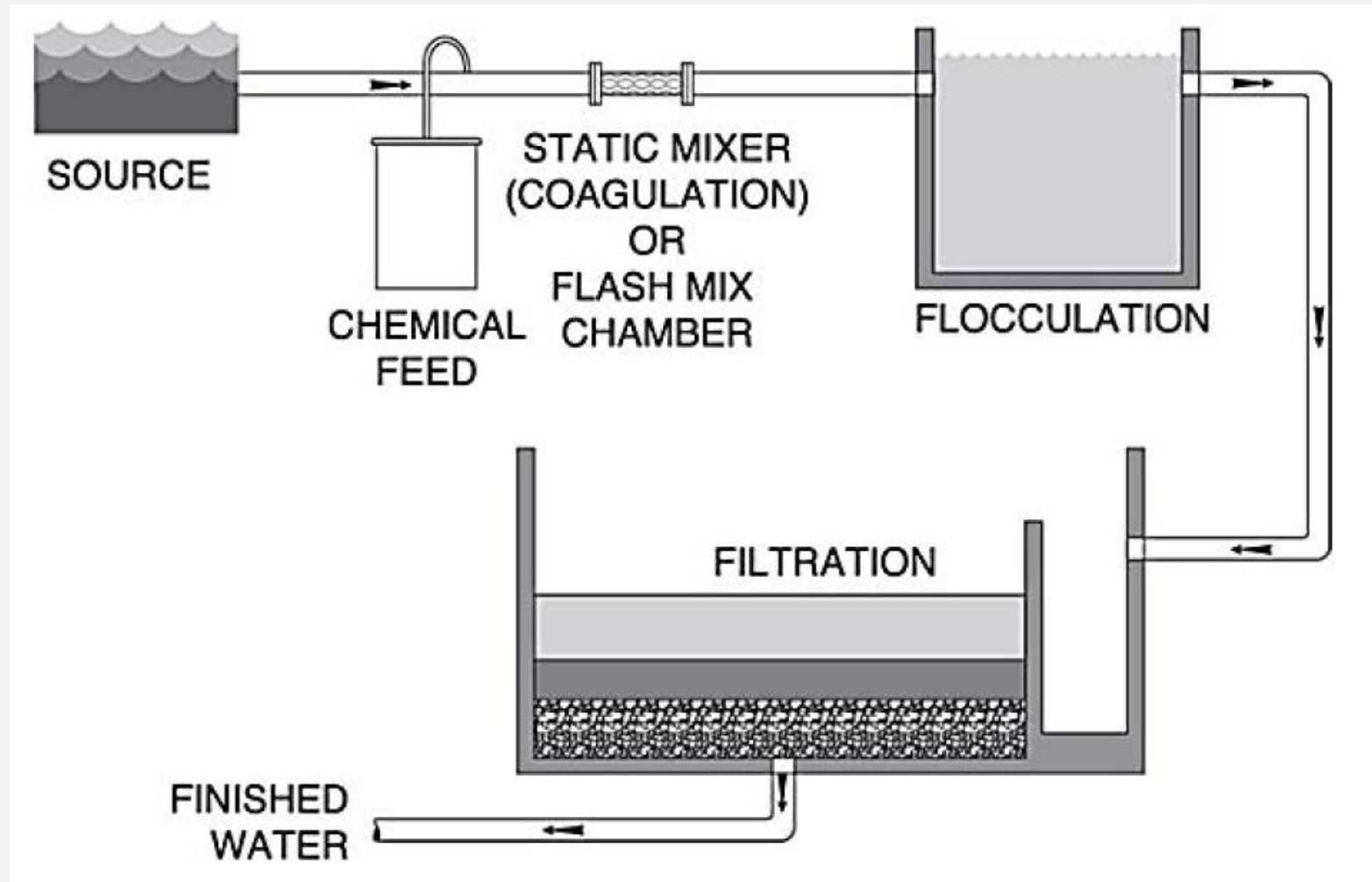
High-rate
design filtration
rate is ~3-8
gpm/ft²

Deep Bed, Monomedium Filters

- Deep bed because coarser filter media
- Gentle backwash combined with air causes media mixing with little stratification
- Thorough backwash can be difficult due to deeply embedded particles having to travel far
- Can be operated at higher rates than dual media filters = well suited for direct filtration



Direct Filtration



Gravity Filter Components

Filter Control
Equipment

Filter Tanks

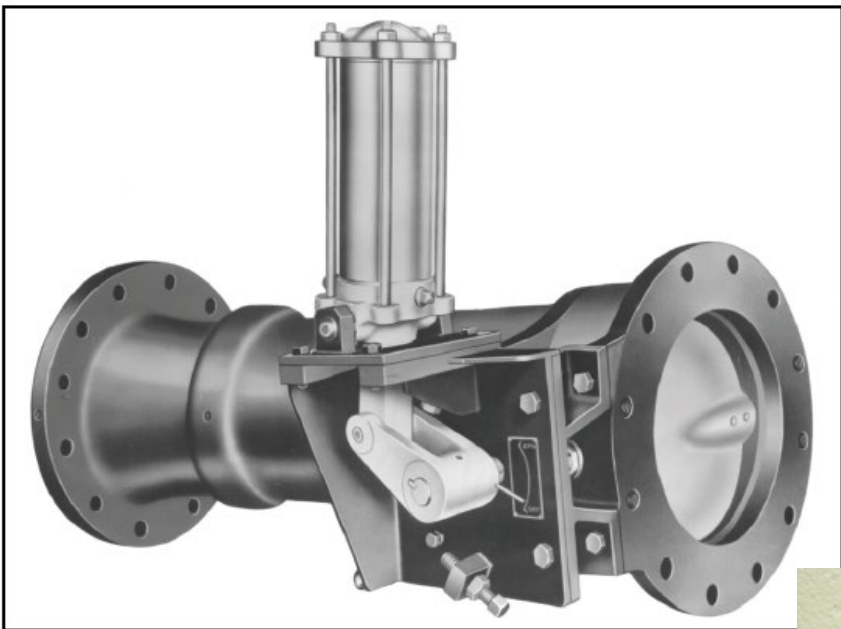
Filter Media

Underdrain

Wash Water
Troughs

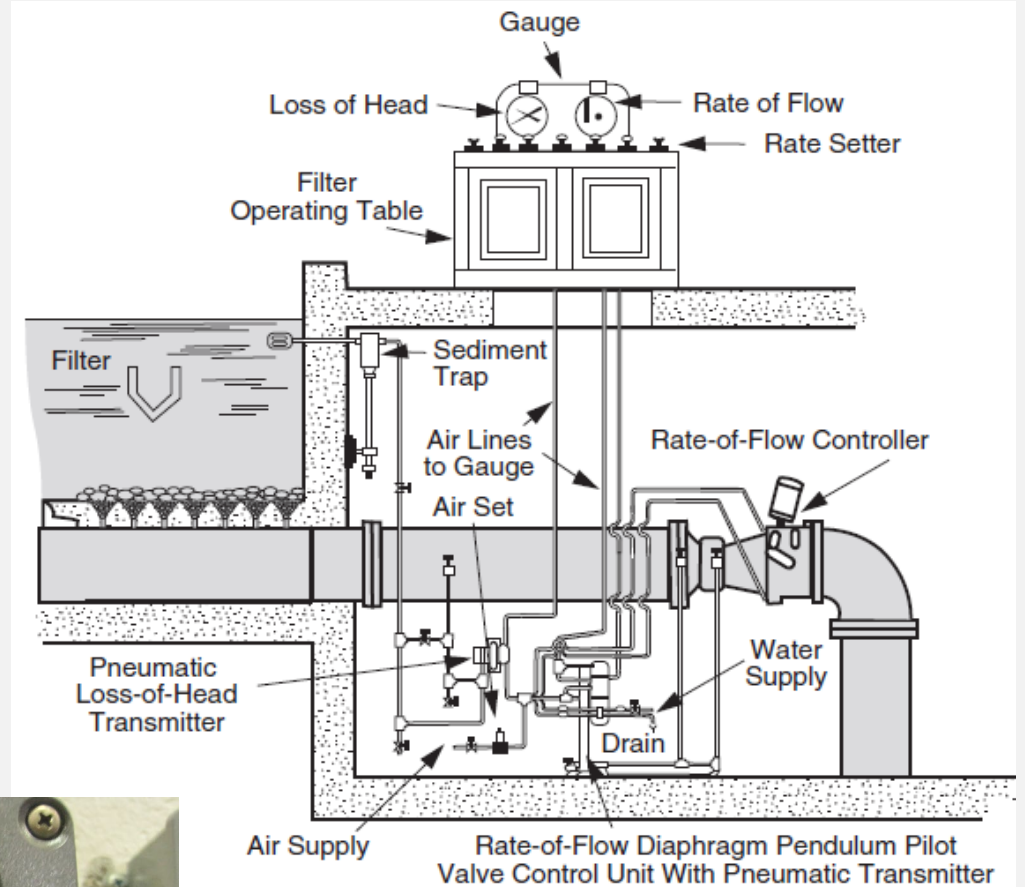
Filter Bed
Agitators

Filter Control Equipment



Rate of Flow
Controller

Loss of Head
Indicator



Online
Turbidimeter

Filter Tanks

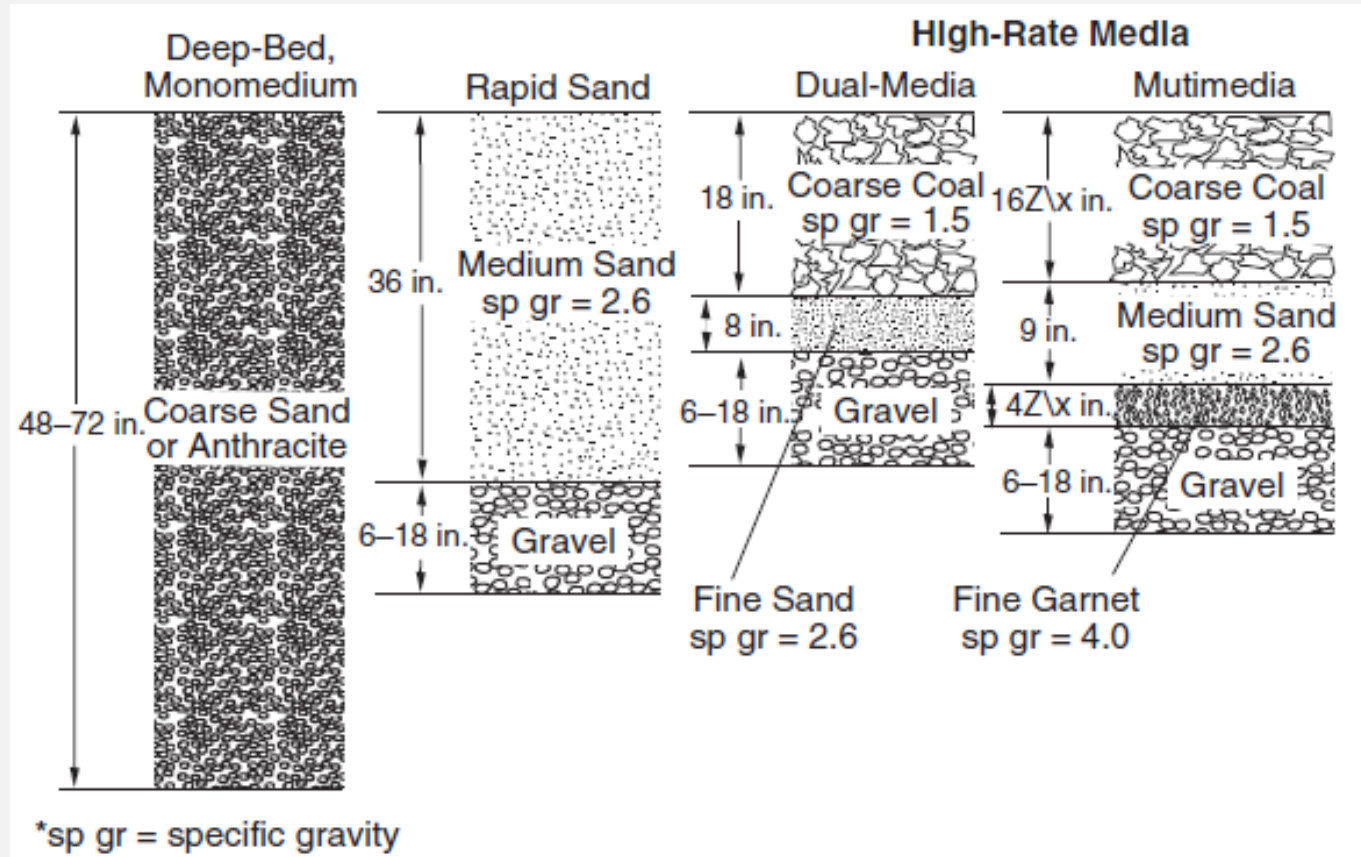
- Rectangular
- Concrete or Steel Construction
- Side by Side Construction



Gravity Filter Media Comparison

What is specific gravity?

It is the weight of the material relative to the weight of water.



Underdrain System Purpose & Types

- Collect filtered water uniformly across filter bottom so filtration rate across filter surface is uniform
- Distribute backwash water evenly

Pipe Lateral
Collectors

Perforated
Tile Bottoms

Wheeler Filter
Bottoms

Porous Plate
Bottoms

False Floor

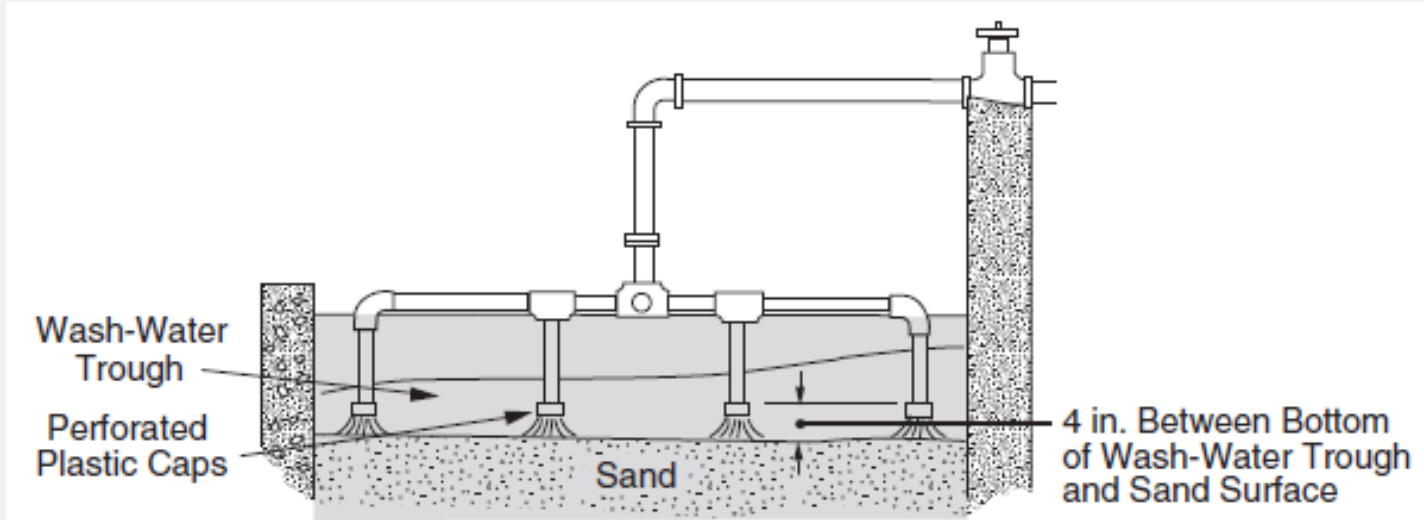
Wash-Water Troughs

- Collects backwash water and carries to waste
- Made of concrete, steel, or fiberglass
- Placement is important to allow for:
 - Proper expansion of media bed during backwash without carrying away media
 - Equal flow is maintained across all part of media bed to allow for uniform wash

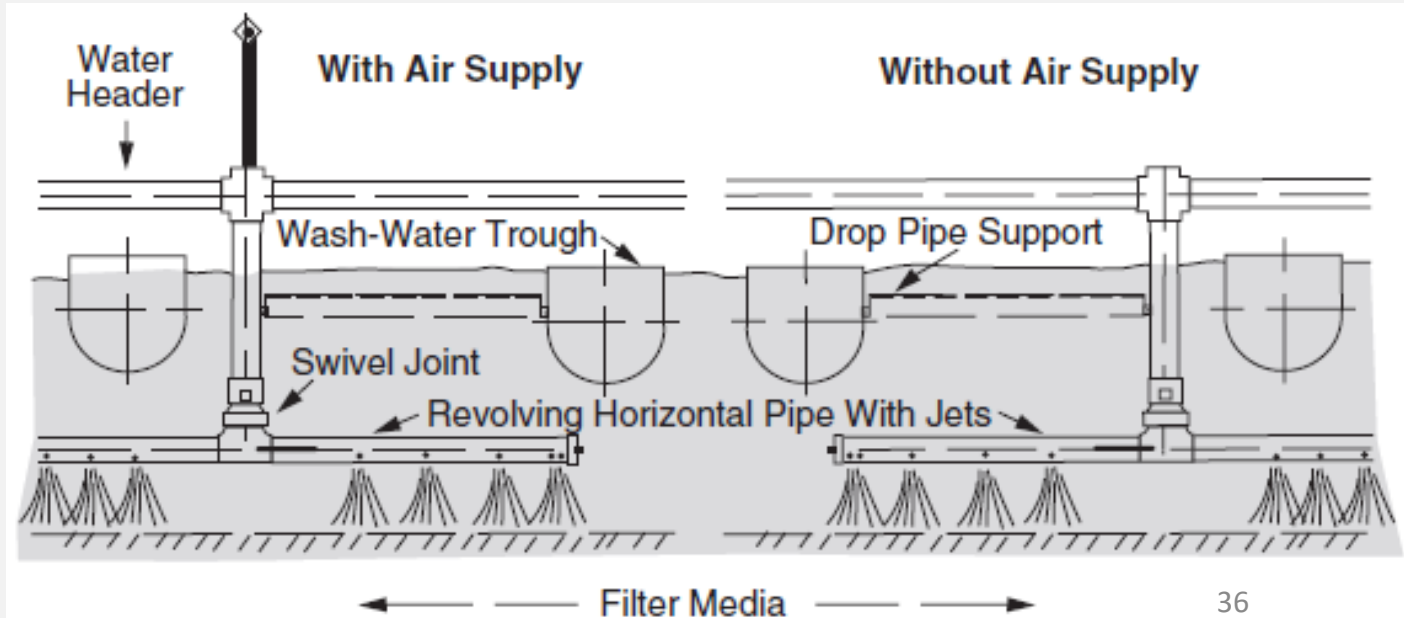


Filter Bed Agitation

- Help release trapped suspended matter that is not removed by backwashing alone
- Fixed nozzle
- Air scouring followed by a fluidization wash without air

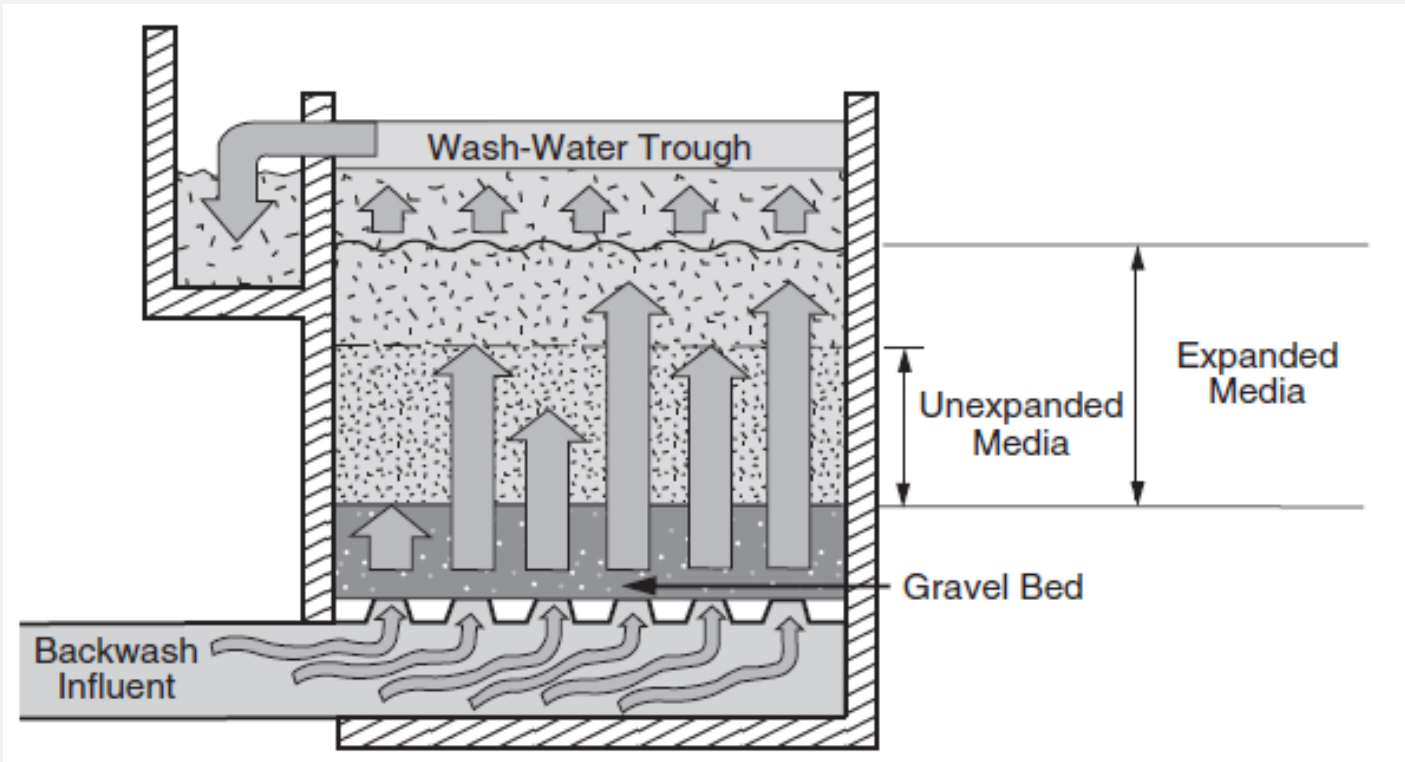


Fixed-nozzle

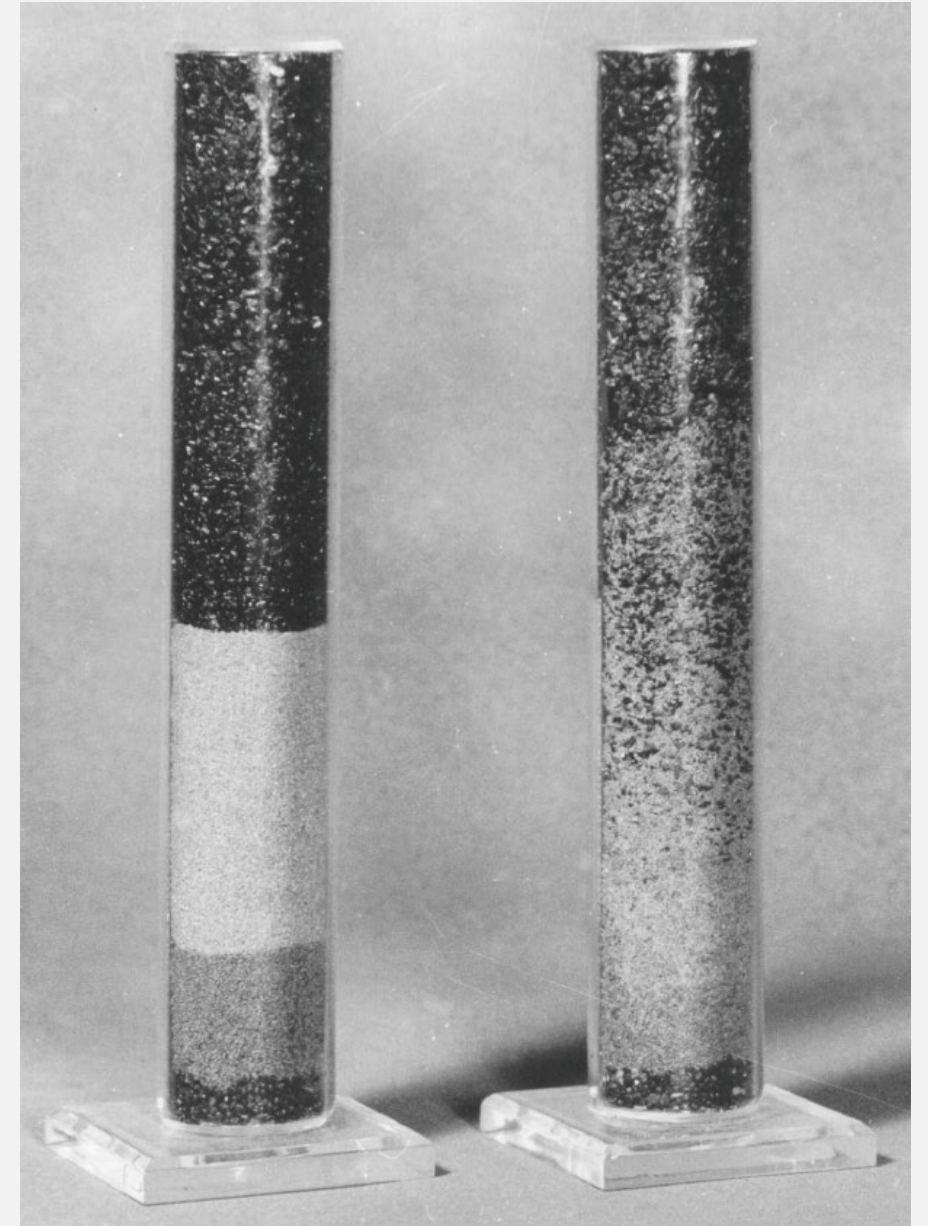


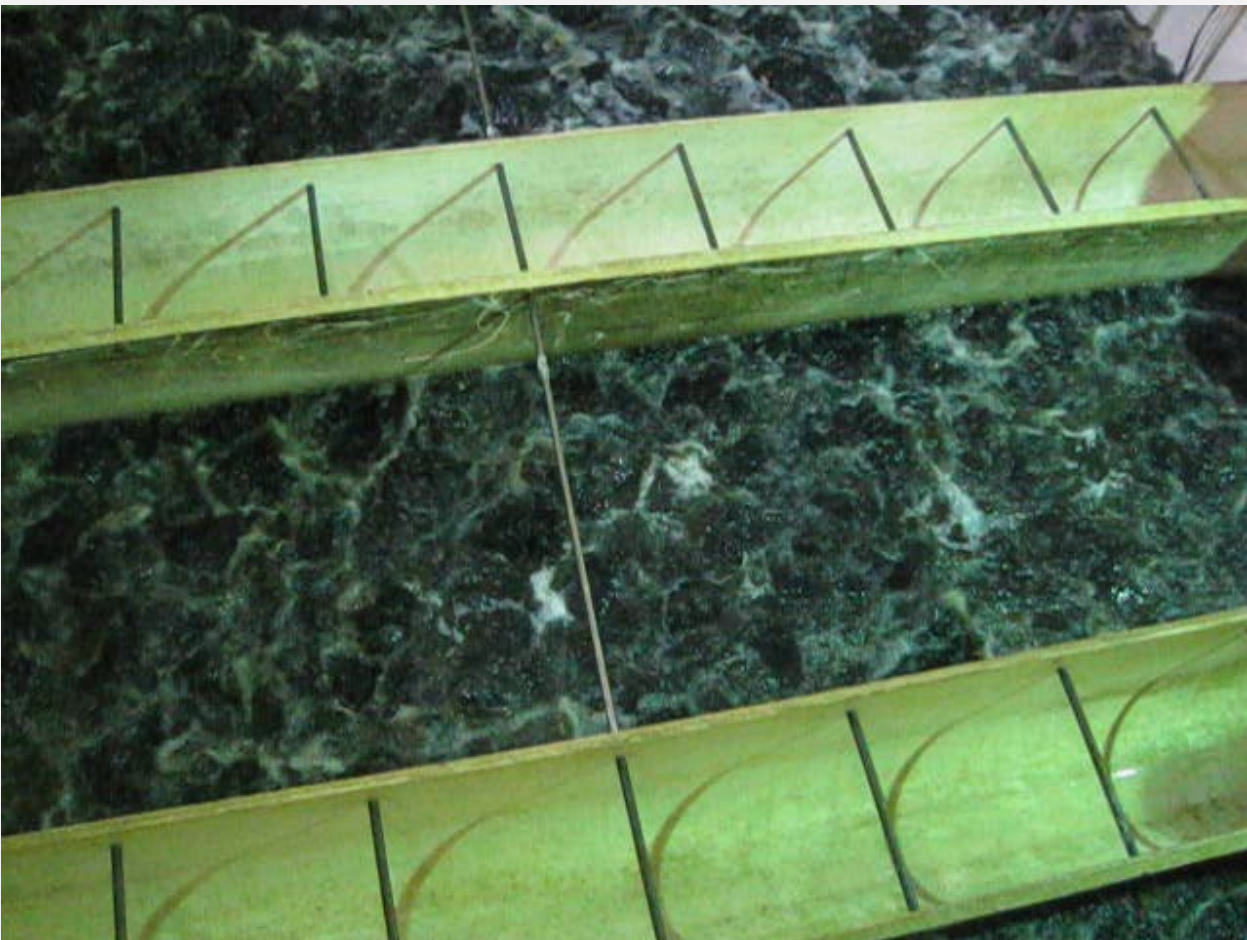
B. Rotary

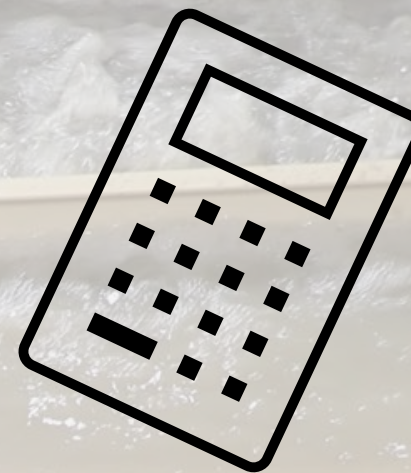
Backwashing



Always use treated water







Backwash Rate

Backwash Rate

- Backwash rate is the movement of water in the opposite direction of filtration to clean and remove filtered solids.
- Measured in gpm/ft².
- Allows comparison of actual conditions with design specifications.
- No direct formula on the ABC formula sheet.

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

$$\text{Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$



**Can Adapt
Formula**

A filter has an area of 840 sq ft with a backwash pumping rate of 20 cfs. What is the backwash rate in gallons per minute per square foot?

$$\text{Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

▪ Filter area = 840 ft²

▪ Flow rate = 20 cfs

Need flow in gpm

$$\begin{aligned} 1 \text{ cubic foot per second} &= 0.646 \text{ MGD} \\ &= 448.8 \text{ gpm} \end{aligned}$$

$$\text{Flow Rate, gpm} = 20 \cancel{\text{ cfs}} \times \frac{448.8 \cancel{\text{ gpm}}}{1 \cancel{\text{ cfs}}} = 8,976 \text{ gpm}$$

A filter has an area of 840 sq ft with a backwash pumping rate of 20 cfs. What is the backwash rate in gallons per minute per square foot?

$$\text{Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

▪ Filter area = 840 ft²

▪ Flow rate = 8,976 gpm

$$\text{Backwash Rate, gpm/ft}^2 = \frac{8,976 \text{ gpm}}{840 \text{ ft}^2} = 10.7 \text{ gpm/ft}^2$$

11 gpm/ft² is the backwash rate for this filter at a flow of 20 cfs.

Optimizing Filter Effluent Quality

- Filter to waste or rest filter after backwash
- Filter aids (polymers) help keep floc together (strengthen bond) especially important for high-rate filters

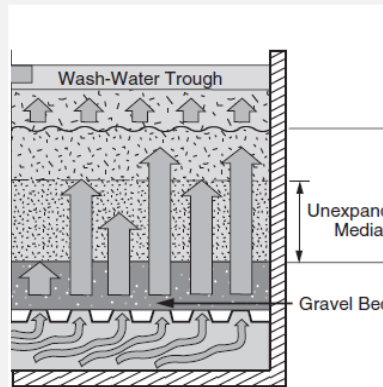
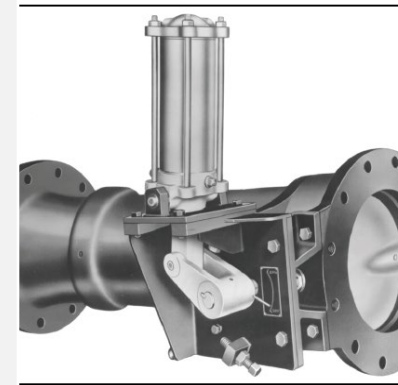


Minimizing Filter Operating Problems



Optimizing
chemical treatment
before filtration

Controlling filter
flow rate



Following proper
backwashing
procedures

Flow Rate Troubleshooting

Filter Breakthrough

- Identified by sudden increase in effluent turbidity
- Running filter at too high a filtration rate
- Run times are too long

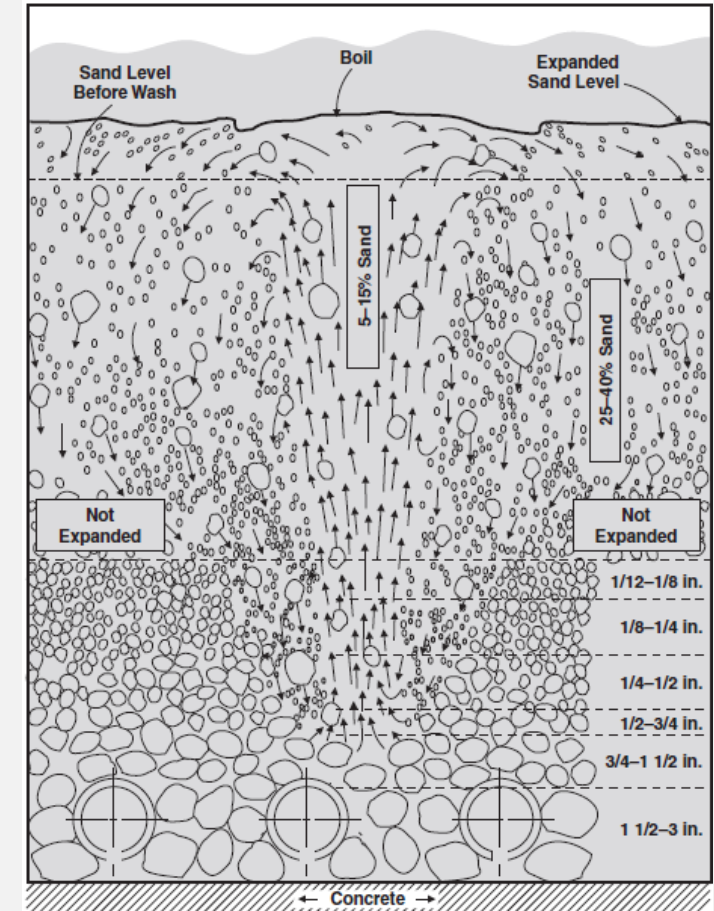
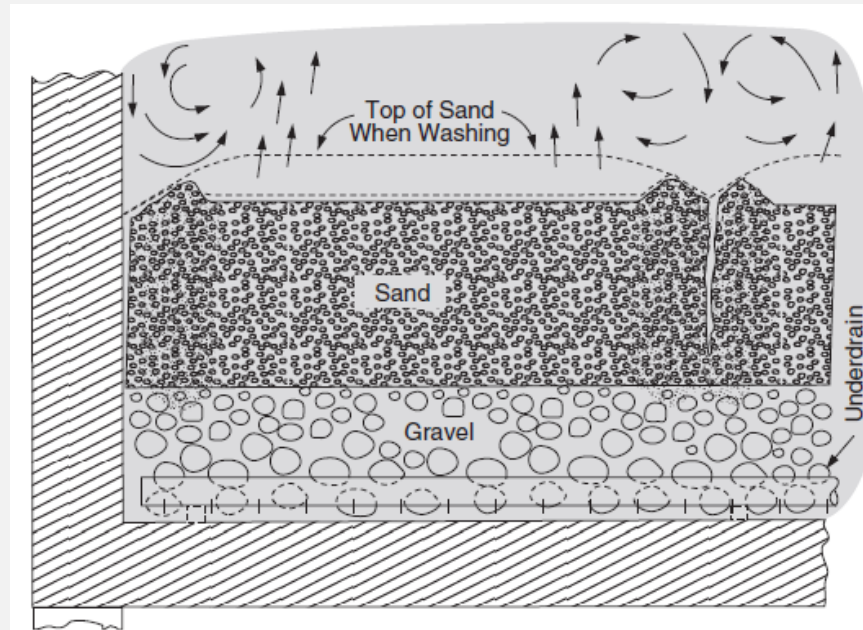
Air Binding

- Identified by abnormally high head loss of recently backwashed filters
- Filter is operated so that the pressure in the bed is less than atmospheric (*negative head*) causing the release of dissolved gasses that become trapped in filter bed

Backwash Troubleshooting

- Mudball formation leads to clogged filter bed with shortened filter run times and loss of filter capacity (flow rate too low or backwash to short)
- Filter Bed Shrinkage
- Gravel Displacement
- Media Loss

Clogged
Filter Bed

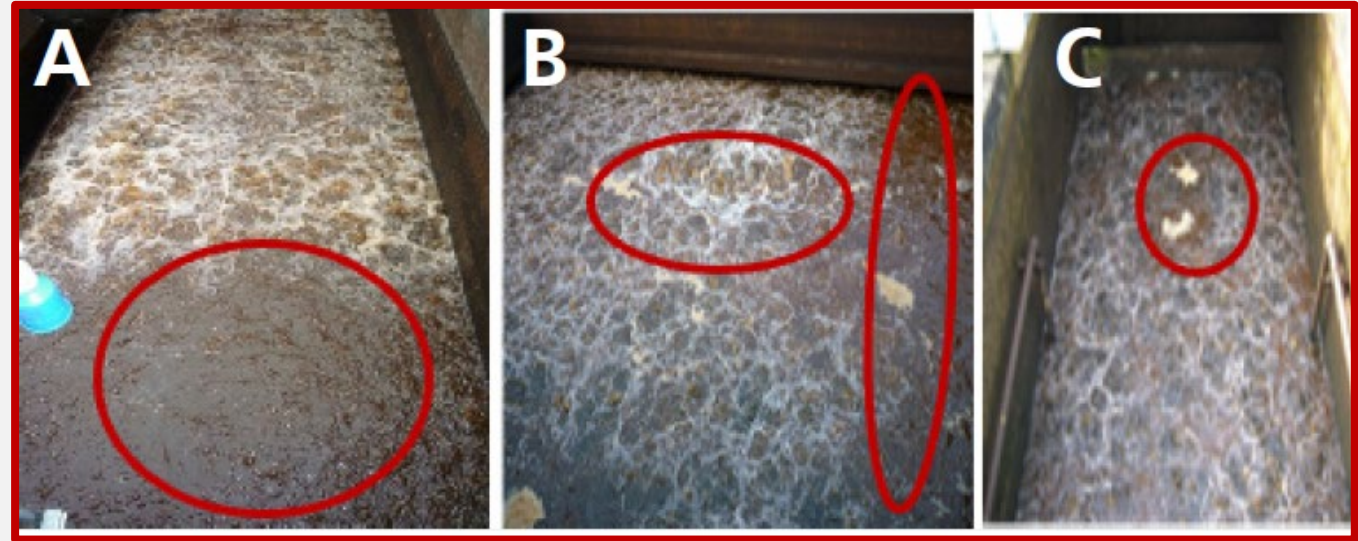


Sand Boil

Backwash Troubleshooting



The Good



The Bad and the Ugly

Filter Assessment



Cleaning Filter Beds

- Scale build up from chemical treatment
 - Use sodium hydroxide (NaOH) to dissolve alum deposits
 - Use hydrochloric/muriatic acid (HCl) to dissolve lime deposits
- Algae build up on outdoor filters
 - Use chlorine or another oxidizing agent to kill algae growth

Pressure Filtration

- Instead of using gravity, influent is forced through the filter under pressure.
- Steel cylinders that use sand or other media to filter water.
- Backwash when media gets clogged with solids.
- Filtration rate is approximately the same as gravity filters.

Types of Pressure Filters

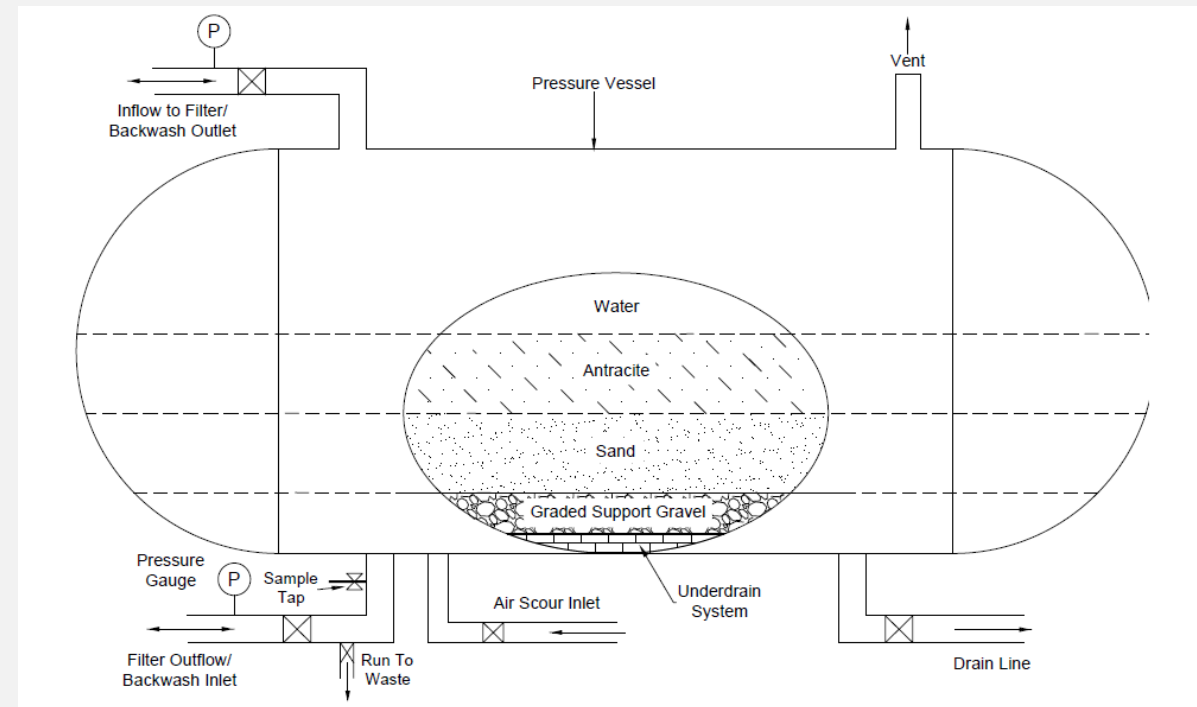
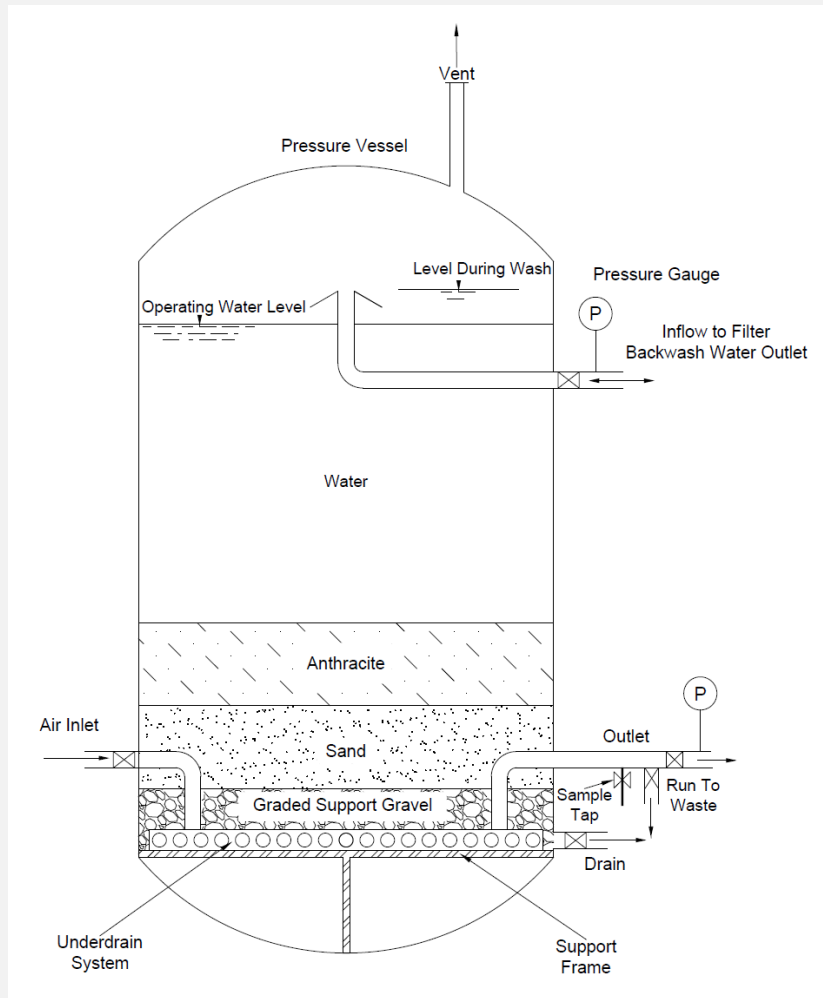
Sand or
Mixed Media

Diatomaceous
Earth (DE)

Bag &
Cartidge

Membrane

Vertical & Horizontal Pressure Filters



Diatomaceous Earth

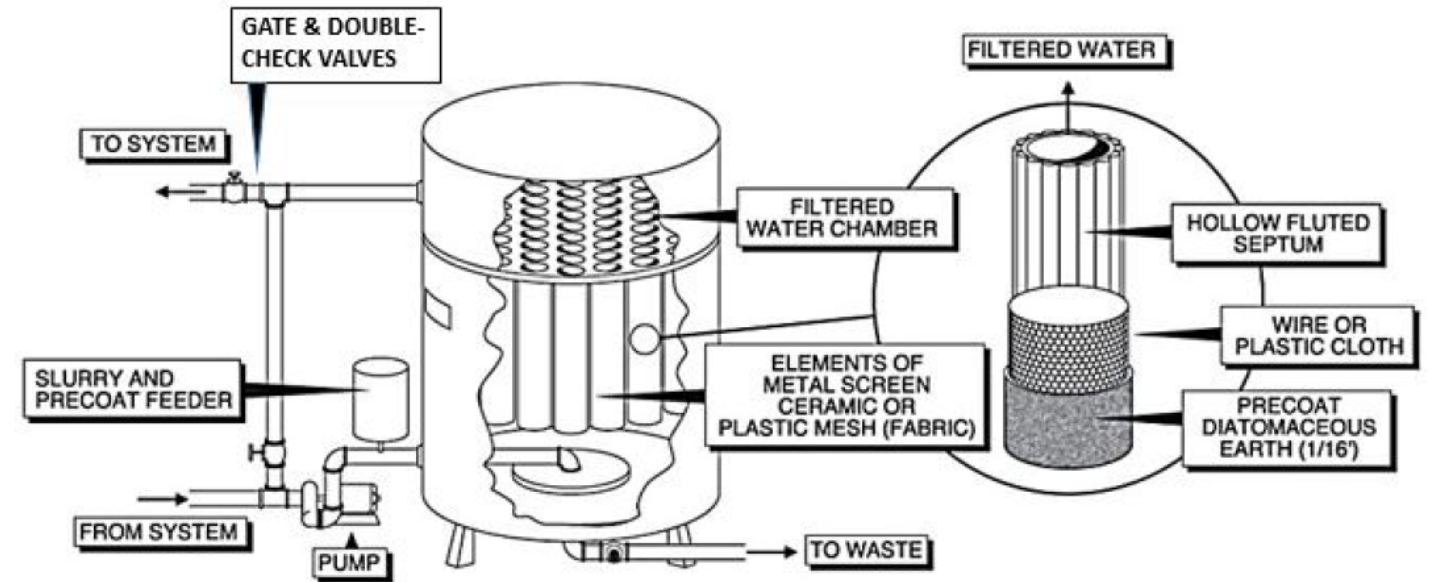
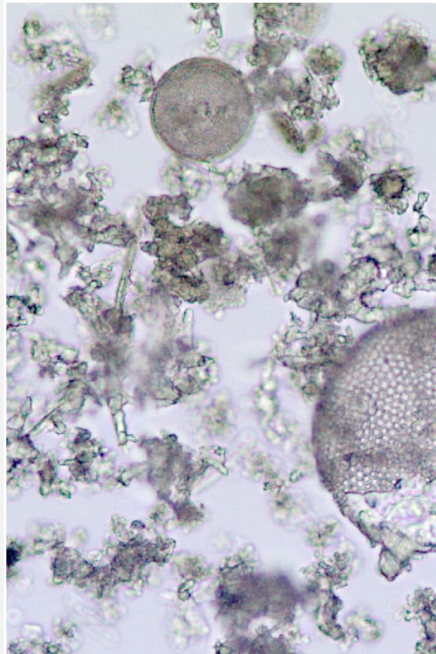
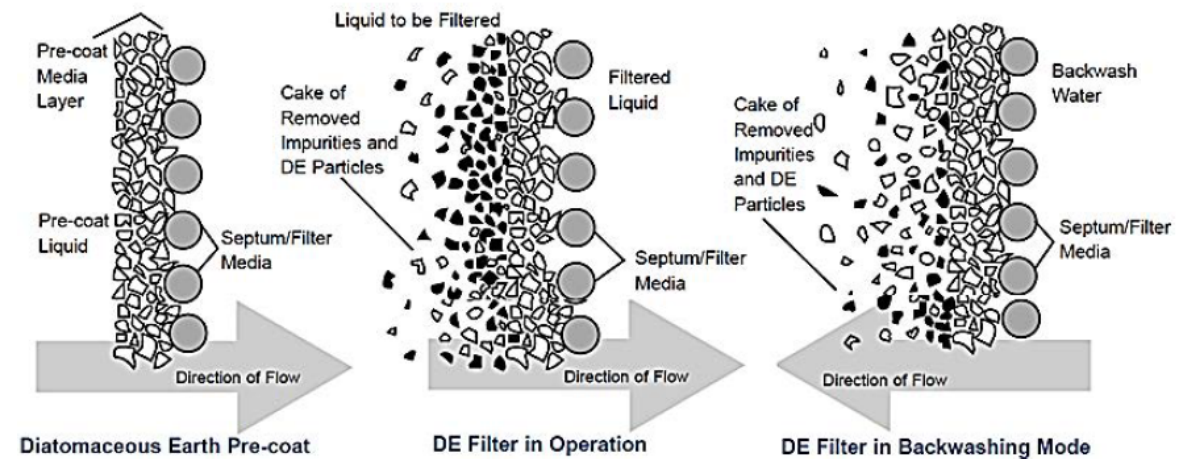
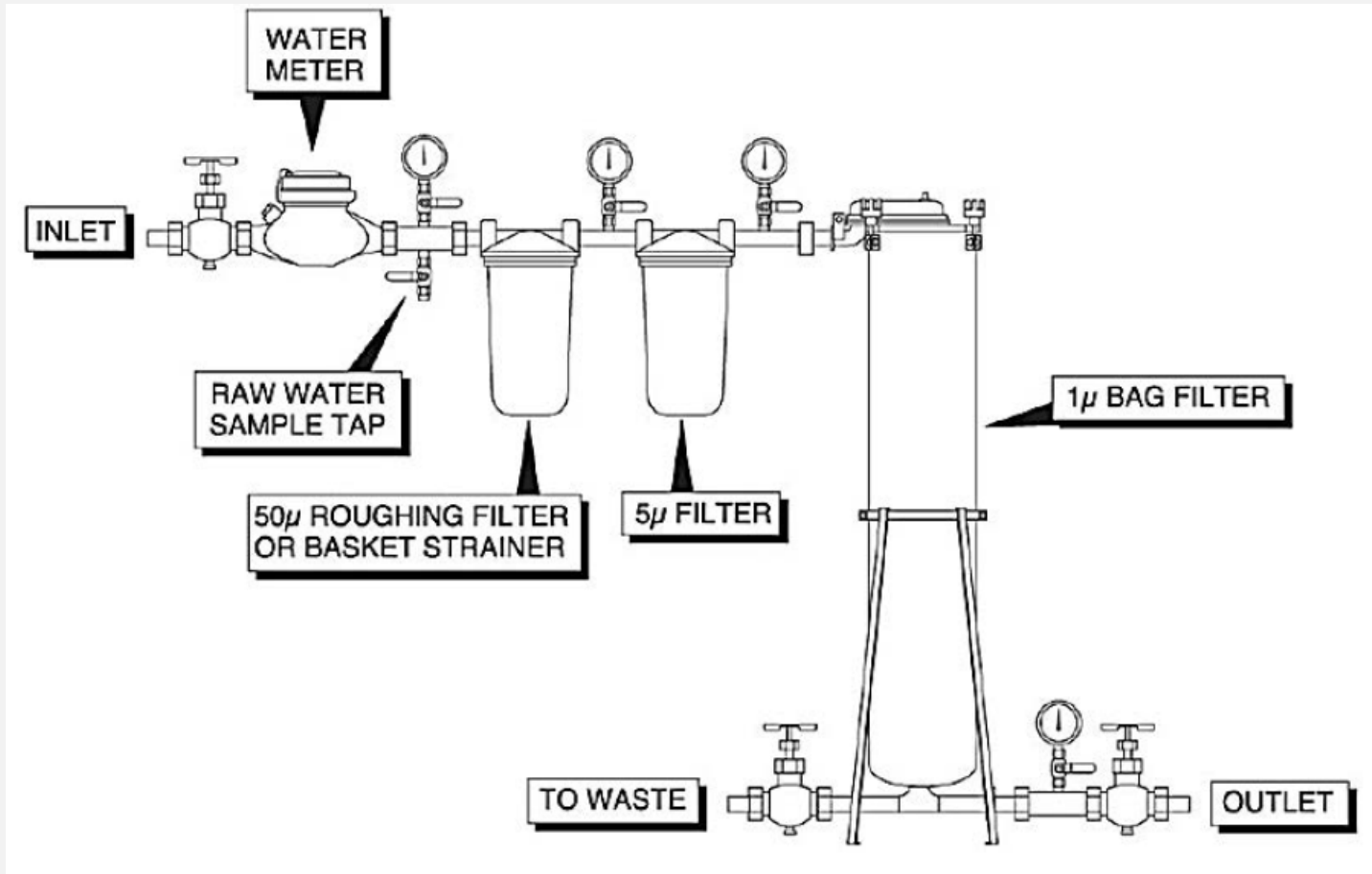


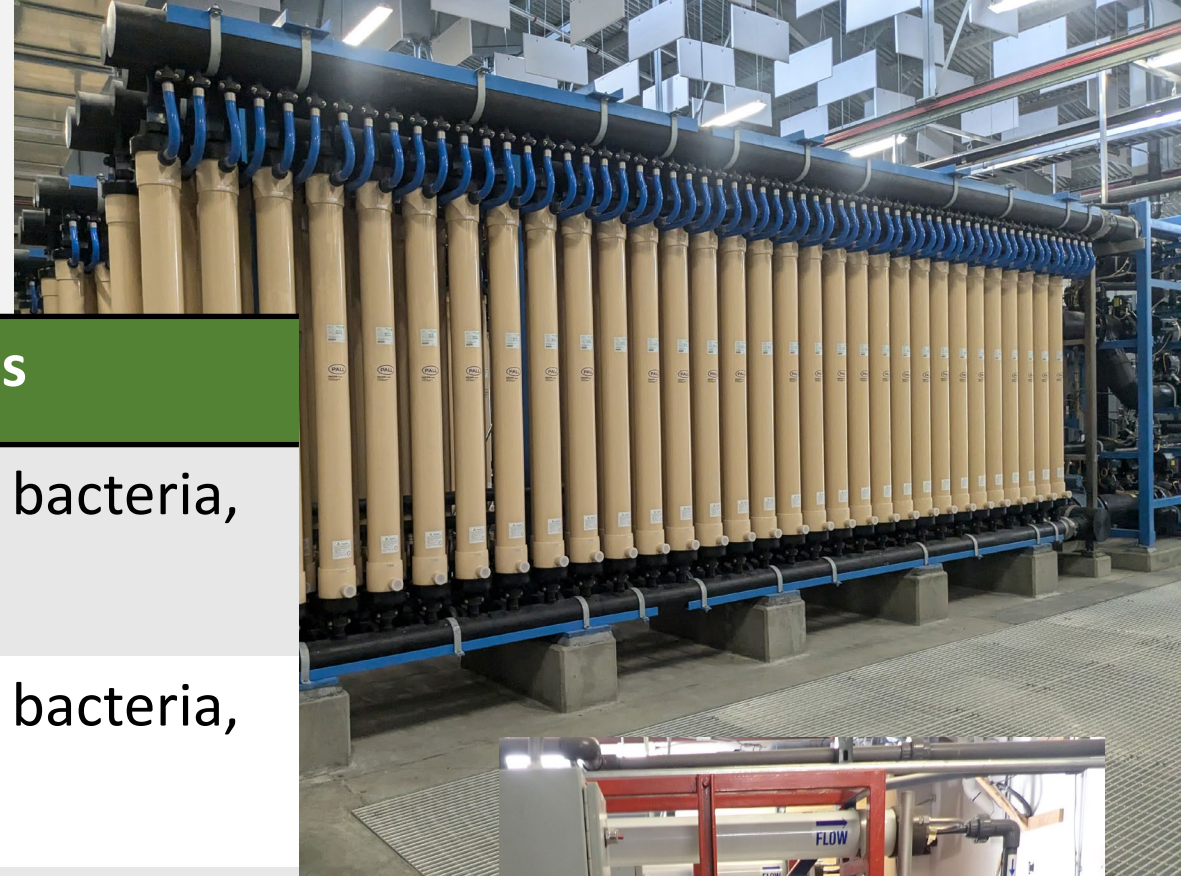
Figure 9-5: Diatomaceous earth filtration



Bag & Cartridge



Membrane



Process	Pore size	Removes
Microfiltration	0.03 – 1.2 μm	Suspended solids, bacteria,
Ultrafiltration	0.02 – 0.05 μm	Suspended solids, bacteria, viruses
Nanofiltration	$\sim 0.001 \mu\text{m}$	Some dissolved solids, viruses, some dissolved OM, hardness
Reverse Osmosis	$\sim 0.0001 \mu\text{m}$	Dissolved solids, viruses, OM, hardness



Reverse Osmosis

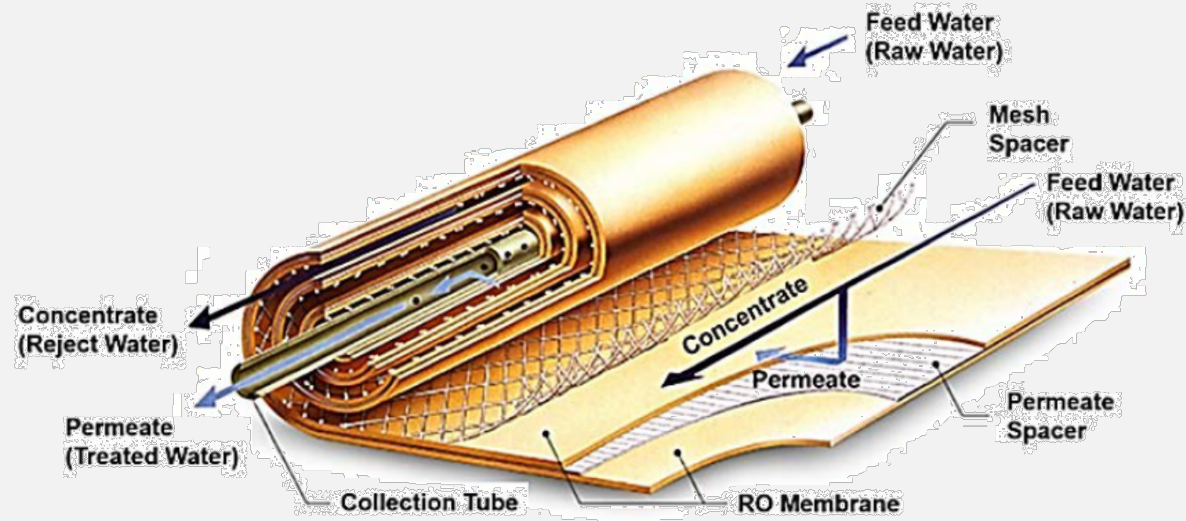


Figure 9-8: Spiral wound RO filter core⁹

⁹ Source: <http://www.aquanext-inc.com/en/product/desalination02.html>



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5/28/26	O&M: Distribution System Math and Concept Review
6/11/26	Sampling & Lab Procedures/Analysis/Interpretation
6/25/26	Management Overview (including organization, communication, PR & record keeping)
7/9/26	Drinking Water Practice Exam and Review

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

CONTACT INFORMATION



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