Recommended Operations and Optimization Goals

Slow Sand Filtration

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A slow sand filtration system—properly designed, operated and maintained—will successfully remove disease-causing organisms like *Giardia, Cryptosporidium*, bacteria, and viruses. Here, we provide simple guidelines and achievable performance goals that will help you keep your system running effectively and efficiently.

Keep the filter flow rate steady. For best performance, the filter effluent flow rate must not vary by more than 50 percent in any 24-hour period. During normal production, operate slow sand filters continuously, without stopping or interrupting the filter effluent flow. If you need to change the filter flow rate, make the change gradually so that previously captured particles remain trapped in the sand.

Set the filter flow controls to accommodate anticipated changes in system demand. Try to set the filtration rate high enough to meet expected daily demand and then divert excess water to waste or recycle during lower demand periods. Don't use intermittent, or on-off, filter operation to control the production rate.

Do not exceed 0.10 gpm/ft^2 maximum filtration rate (hydraulic loading rate). Be prepared to further *reduce* loading rates when filtering cold water (5°C or less), because microbial activity within the schmutzdecke decreases in the cold, hampering performance. You should also reduce filtration rates when raw-water quality deteriorates (for example, during high source turbidity).

During periods of elevated applied water temperature, you may need to check that there is adequate dissolved oxygen to support microbial activity within the schmutzdecke. Insufficient dissolved oxygen may harm the beneficial organisms needed for effective filtration. Also, when dissolved oxygen is low, oxidized metals can re-solubilize and release from the filter. Operators of optimized slow sand filters will periodically monitor filter effluents for dissolved oxygen. The level should be at least 3 mg/L.

Avoid adding groundwater to a slow sand filter. Blending groundwater with a surface water source can harm the beneficial microorganisms in the filter by decreasing the nutrients and oxygen they need to thrive.

Maintain the filter effluent weir at a level above the top of the sand bed. This prevents air binding within the filter. You may adjust the weir level downward after filter scraping, but it should always be at a higher elevation than the sand.

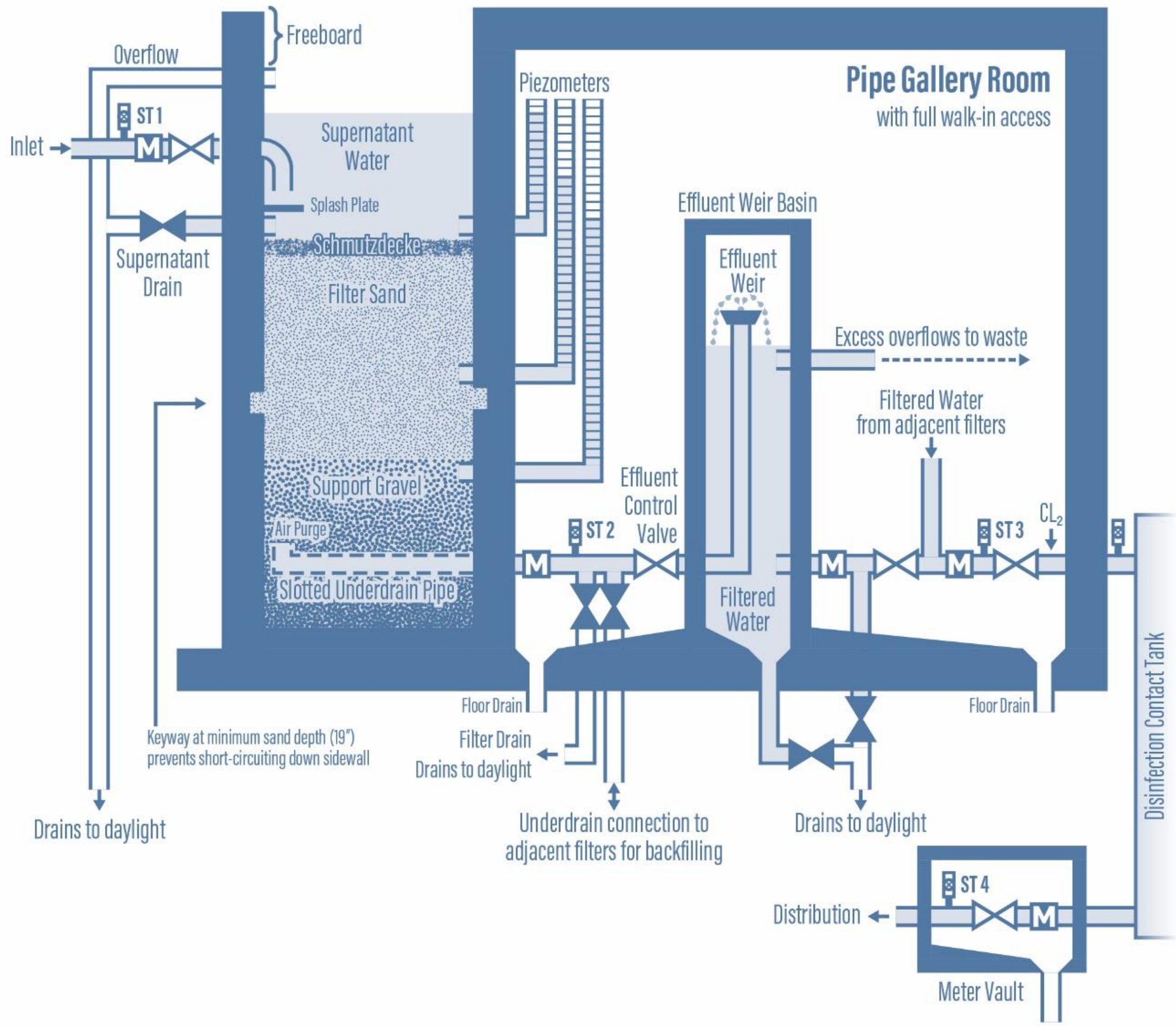
Optimization Goals for Slow Sand Filtration

Turbidity IFE & CFE ≤ 1.0 NTU in 95% of highest daily readings, and IFE & CFE < 5.0 NTU in 100% of all readings.	**Measure *continuously***
Total Coliform IFE TC ≤ 5/100 ml, when Raw water TC < 100/100 ml IFE TC < 10/100 ml, when Raw water TC ≥ 100/100 ml	**Measure *at least monthly***; better weekly, especially during seasonal raw water quality changes. (Analyze by CFU or MPN methods)
Distribution entry point sample = Total Coliform Absent	**Measure *weekly whenever IFE or CFE turbidity > 1 NTU***

IFE = Individual filter effluent
CFE = Combined filter effluent
NTU = Nephelometric turbidity units
TC = Total coliform
CFU = Colony forming units per Standard Methods **MPN** = Most probable number

Recommended Slow Sand Filter General Plant Layout

(Not To Scale)



Legend

- M — Meter
- Sample Tap
  - ST 1—Raw water monitoring point; turbidity, coliform
  - ST 2—Individual Filter Effluent (IFE) monitoring; turbidity, coliform, DO
  - ST 3—Combined Filter Effluent (CFE) turbidity monitoring point
  - ST 4—Distribution entry point monitoring; chlorine, temperature, pH
- Valve: normally closed (NC)
- Valve: normally open (NO)

Cleaning by Scraping

Scrape the filter media when either of the following occurs:

- Depth of the applied water reaches the overflow level.
- Production rate of the filter decreases to a point approaching daily demand and you anticipate not meeting demand.

When removing a filter from service for cleaning, schedule the event during a period of lower demand to avoid overloading the remaining filter(s) trying to meet system demand.

- Work efficiently to minimize the amount of time a de-watered filter is offline. (Remember you will need to filter to waste one hour for every hour the filter is offline, but for not less than 24 hours.)
- Lower the water below the surface of the sand until it is firm enough to stand on. Generally, between two and twelve inches below the sand surface (but not more than twelve inches).
- Avoid walking or driving directly on the schmutzdecke during cleaning.
- Remove the schmutzdecke and no more than ¼- to ½-inch depth of sand with each cleaning. Depending on applied water quality, you may occasionally need to scrape more sand (½- to 1-inch) to remove the plugged portion of the filter and recover clean bed head loss. You can determine the minimum sand depth you need to remove to get optimal filter head-loss recovery by monitoring head loss before and after each scraping.

Record and plot daily head-loss readings for each filter to schedule filter cleanings when demand is low and applied water temperatures are higher (above 5^{0} C). By cleaning filters when demand is lower, you can better meet system needs without overloading adjacent filters. In addition, cleaning when water temperature is warmer will ensure quicker filter recovery (ripening).

The minimum permissible depth of sand is 19 inches.

- After you clean the filter, slowly refill it **from the bottom** with unchlorinated, filtered water from another filter. Backfill slowly, using a rise rate of 0.3–0.6 ft. of bed depth per hour (0.0374–0.0748 gpm/ft^2). This will help assure any trapped air is adequately purged from the filter. Continue refilling until the water is one foot above the sand. This creates a cushion to help minimize scouring of the sand bed when applying the raw water on top. Finish filling from the top. Go slow at first, being careful to not disturb the sand bed.
- *Tip: To convert ft/hr to gpm/ft^2, multiply (ft/hr) by (1 hr/60 min) and then multiply by (7.48 gal/ft3). Example: (0.3 ft/hr) x (1 hr/60 min) x (7.48 gallons/ft3) = 0.0374 gpm/ft^2.*
- Begin filtering to waste at the same rate being used in that filter prior to cleaning. If you anticipate needing to use a different rate when bringing the filter back on line, limit the flow variation to 50 percent or less in any 24-hour period. Do not exceed the design flow rate, or < 0.1 gpm/ft^2, whichever is lower.
- Filter to waste one hour for every hour the filter is offline, but for not less than 24 hours. Then continue filtering to waste until you meet the criteria for returning a filter to service after cleaning on page five.

Cleaning by Harrowing

Note: Cleaning by harrowing only works effectively in filters that are specifically designed for the procedure. It requires the ability to introduce sufficient cross-flow above the filter to carry the suspended harrowing waste, and at the same time, to collect and drain that waste flow at exit velocities that do not mobilize the filter sand.

Harrow the filter media when either of the following occurs:

- Depth of the applied water reaches the overflow level.
- Production rate of the filter decreases to a point approaching daily demand and you anticipate not meeting demand.

When removing a filter from service for cleaning, schedule the event during a period of lower demand to avoid overloading the remaining filter(s) trying to meet system demand.

- Lower the water level to the harrowing waste valve (about six inches (15 cm) above the sand bed). This keeps the head pressure low and helps keep debris from going into the filter during the raking process.
- Open the harrowing waste valve. Then introduce filtered, unchlorinated water from the bottom of the filter at a rate of 0.16 ft/hr (0.02 gpm/ft^2). This rate should be low enough to keep the sand from fluidizing, but high enough to suspend debris and prevent it settling back onto the filter bed during the raking process.
- Introduce water to the top of the filter at a rate high enough to flush debris to waste during raking, but not so high it causes filter sand migration. For rectangular filters, a typical flow rate is 20 gpm, multiplied by the width of the filter measured perpendicular to the incoming flow, in feet; times the depth of water above the sand during harrowing, in feet. For example, 1,000 gpm is good for a 100-ft wide filter with 0.5 feet of water depth, assuming the flow path is perpendicular to the width of the filter.
- For other filters, you'll need to adjust the influent flow to maintain a steady water level above the sand during raking. It is important to maintain a constant water level above the sand throughout the harrowing process by balancing flows in and out of the filter.

Using a stiff-tined rake or appropriate harrowing equipment, gently agitate the top two to three inches (5–8 cm) of sand until the headwater begins to clarify, as indicated by the ability to see the sand bed when the raking stops.

- After you clean the filter, slowly refill it from the bottom at a rate of 0.3–0.6 foot of rise per hour (0.1–0.18 m/hr or 0.0374–0.0748 gpm/ft^2) to purge trapped air. Refill with unchlorinated filtered water from one of the other filters until the headwater is one foot above the sand to minimize scouring of the sand bed when filling from the top begins. Then fill from the top at a rate that minimizes disturbing the sand bed.
- *Tip: To convert ft/hr to gpm/ft^2, multiply (ft/hr) by (1 hr/60 min) and then multiply by (7.48 gal/ft^3). Example: (0.3 ft/hr) x (1 hr/60 min) x (7.48 gallons/ft^3) = 0.0374 gpm/ft^2.*
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- Filter to waste one hour for every hour the filter is offline, but for not less than 24 hours. Then continue filtering to waste until you meet the criteria for returning a filter to service after cleaning on page five.

Returning a filter to service after cleaning

Time: Filter to waste for at least 24 hours, or one hour for each hour the filter is offline, whichever is longer. After filtering to waste, only bring the filter on-line when sampling shows it meets all three of the following tests.

1. **Biological Maturity**: Sample IFE no earlier than 24 hours after starting filter-to-waste. The filter may be considered "matured" and ready to go on-line if the total coliforms in the sample are:
   a. TC $\leq$ 5/100 ml whenever raw water TC $<$ 100/100 mL, or
   b. TC $<$ 10/100 ml whenever raw water TC $\geq$ 100/100 mL.
2. **Turbidity**:
   a. IFE Turbidity $\leq$ 1.0 NTU.
3. **Consistent performance**: You should compare the performance of the newly cleaned filter (turbidity effluent and/or filter effluent coliform counts if available) to the other filters that remained in service, or to the performance of the same filter prior to cleaning. If the performance of the newly cleaned filter is considerably different, consider extending the filter-to-waste period.

   You may need to lower filtration rates for colder raw-water or deteriorated water quality. At lowest flow rates, you may need to monitor filter effluent to ensure adequate dissolved oxygen. If possible, schedule filter cleanings during months when water temperatures are expected to remain above 5°C.

IFE = Individual filter effluent
NTU = Nephelometric turbidity units
MPN = Most probable number
CFE = Combined filter effluent
TC = Total coliform
CFU = Colony forming units per standard methods

For more information

Our publications are online at doh.wa.gov/drinkingwater.

Contact our nearest regional office from 8 AM to 5 PM, Monday through Friday. If you have an after-hours emergency, call 877-481-4901.

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