Optimizing Water Treatment Plants
After a Wildfire
OHA Drinking Water Services
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The purpose of this document is to alert operators of things to consider following a wildfire and provide options to surface water treatment plants to optimize existing treatment to address potential impacts to water quality. Impacts to water quality can include changes in:

- The amount and timing of snowmelt and runoff from storms. Storm events can lead to flash flooding, higher floodwaters, and shorter times to peak flows,
- Raw water quality from build-up of ash, soil erosion, and fire debris, taste, color and smell of drinking water;
- Phosphate, nitrate, and nitrite runoff (firefighting agents may lead to short-lived run-off of phosphates, ammonia,)
- Naturally occurring metals (iron, manganese, arsenic, asbestos, etc.)
- Algal blooms, some of which may produce algal toxins;
- pH and alkalinity. Deposition of ash after a fire can increase pH and alkalinity in soil and water
- Sediment and debris buildup around intake impoundments;
- Coagulation and disinfection required to address higher turbidity and TOC, which also often requires more frequent backwashing and solids/waste handling capabilities and alkalinity if using alum; Organic carbon resulting from fire is more humic and aromatic than pre-fire organic carbon and, therefore, more likely to produce DBPs.
- Risks to water bodies from landslides as well as risks to intakes, treatment plants, and other structures;
- Although the worst effects of fire occur in the first 1-2 years, watersheds may take from 4-8 years and streams can take 4-5 years to recover from a wildfire (Clark, 2010). Recovery varies based on underlying soils & bedrock, vegetation, slopes, stream chemistry, and severity of fire
- Operability of valves and other control systems that may have been damaged or affected by debris and sediment.

General strategies applicable to all surface water filtration systems:

The following strategies will help to prepare for and mitigate the impacts to source water and treatability from wildfires.

1. ***Employ a multiple barrier approach:***

   Water treatment plants employ the multiple barrier approach when they consider each unit process as providing a distinct barrier to contaminants. Water treatment plant optimization is the process of improving the performance of each process to achieve its maximum performance, often performing well beyond that required by regulation.

2. ***Practice:***

   Update operation and maintenance manuals and emergency response plans. Use table-top drills and exercises to practice optimization strategies so they can be implemented when needed – don't wait until the storms come!

3. ***Overall optimization strategies – source, treatment & distribution:***

   <u>Source:</u>

   a. Pay attention to storm events, flood warnings, and source water levels, flows, and/or turbidity levels as this can be an early warning of sudden rises in turbidity due to rain or landslides which can cause turbidity to increase to 1,000 – 10,000 NTU or more. Lowering raw water high turbidity alarms may also give you an earlier warning sign of rapid spikes in turbidity. Like a wave, plan to ride out these peak events by shutting off intake flows if you are able until raw water turbidity drops to more manageable levels and be ready to jar test frequently to ensure proper treatment.
   b. Ensure surface water intake impoundments are dredged or prepare to dredge at a higher frequency as these may be quickly silted in. Plan for emergency cleanout operations in preparation for landslides and debris flows. One storm after the Buffalo Creek Fire in Colorado produced 15 acres of debris, deposited 10 years' worth of sediment, and clogged the Denver Water delivery system (Kennedy, 2011).

c. For water systems with intakes within multiple water layers, utilize the intake from the layer that may be least impacted by ash, sediment, algal blooms or cyanotoxins.
d. Be mindful of the increased risk of falling trees and landslides following a wildfire and if possible, travel in pairs to the intake. Identify hazardous trees for removal if they are within 100-ft of critical facilities, routes, or where staff may congregate. Further distances may be needed if trees are over 100-ft tall.
e. Monitor and clean culverts and other drainage mechanisms that may fail to protect access roads from washing out should they become clogged. Consider upsizing culverts to handle higher runoff flows.
f. Identify alternate routes to access critical facilities, improve evacuation capability, or ensure emergency vehicles can reach staff in an emergency.
g. Identify who to call for assistance with:
    - Tree hazard assessment and removal
    - Culvert cleaning/repair
    - Assessing landslide potential
    - Hazard mitigation funds
    - 24/7 emergency services
h. Keep the City or County Office of Emergency Management informed of the condition and threats to the source or other critical facilities.

<u>Treatment:</u>

a. Evaluate/Increase ability to handle periods of high turbidity. Ash and clay-sized particles contribute to increases in total suspended solids. Anticipate operating at lower flows, shorter filter runs, increased backwashing, and having to override automation in order to meet demands.
b. If chemical contaminants or cyanotoxins are of concern, cease any recycling of process water, for example filter backwash water.
c. Do not apply algaecides during a cyanobacteria bloom as this risks cell lysis, or stressing the cells, potentially causing cyanotoxin release.
d. Treatment objectives may have to shift at times from turbidity removal to TOC removal which can be 5 times higher than normal levels, requiring higher coagulant doses or the use of activated carbon and more frequent jar testing.
e. Increase capability to add more coagulant (if applicable). Alkalinity may need to be increased if using Alum.

f. Ensure sedimentation basins, sludge detention basins and backwash handling facilities have been cleaned and are able to hand the excess wastewater and sludge. Discharge permits may need to be modified/approved to address higher wastewater and sludge disposal needs.
g. Leaching of ash washed into surface waters can release positively charged ions like calcium and magnesium, changing the electric potential of source waters, which may impact coagulation controlled by streaming current meters or zeta meters.
h. Anticipate the need to feed more chlorine due to oxidant demands. Additional oxidation may be needed to address TOC, taste, and odor concerns, however, be mindful of the potential impact to disinfection by-products. Organic carbon resulting from fire is more humic and aromatic than pre-fire organic carbon and, therefore, more likely to produce DBPs.

Distribution:

a. Anticipate/evaluate the ability to meet demands using available storage in case the plant needs to be taken off-line for extended periods of time. Also prepare for issuing notices for water conservation/curtailment.
b. Ensure distribution valves are operational as the frequency of line breaks may increase.
c. Replenish emergency supplies, fuel for back-up generators, treatment chemicals, waterline repair bands, valves, etc.
d. Evaluate operations staffing levels should treatment need to extend run times from having to backwash more often or slow production to handled high turbidity. Also consider higher demands placed upon distribution system operators.
e. Identify/exercise alternate sources or interties with other nearby water systems.

The following information and strategies are specific to filtration type.

4. *Membrane Filtration:*

a. Membranes can generally handle very high feed turbidity provided trans-membrane pressures (TMP) are kept within an acceptable range by lowering flows and increasing backwashing and cleaning frequency. Manual backwashing may be needed to increase backwash frequency to as much as once every 15 minutes in order minimize TMP and fouling.
b. Plan for increased cleanings and clean-in-place frequency and monitor changes permeability or resistance as an indicator of irreversible fouling.
c. Conduct direct integrity testing daily at the test pressures approved by DWS. Think of the direct integrity test as if you were to test a tire for a leak by pumping it up - the less air you pump into the tire, the more likely small leaks will go undetected. Ensure that any filter units that fail a direct integrity test are removed from service, repaired, and re-tested prior to being put back into use. Keeping membranes intact is key to contaminant removal
d. Establish a conservative individual filter unit effluent turbidity goal of 0.05 NTU to alert you to sudden integrity breaches between direct integrity tests. The direct integrity test is the only way to directly test the integrity of the membranes, while the turbidity can indicate a problem between integrity tests.
e. The addition of coagulants can keep membranes from fouling and can assist with particulate and cyanobacterial cell removal. The membrane manufacturer should be consulted prior to adding any type of coagulant as some coagulants can quickly foul membranes. Polymers should never be applied to membranes without checking with the manufacturer due to material compatibility issues and irreversible fouling.
f. MF and UF systems are not generally capable of removing dissolved organics like TOC or extracellular toxins, however, the addition of a coagulant can greatly improve this capability.

5. Conventional and Direct Filtration:

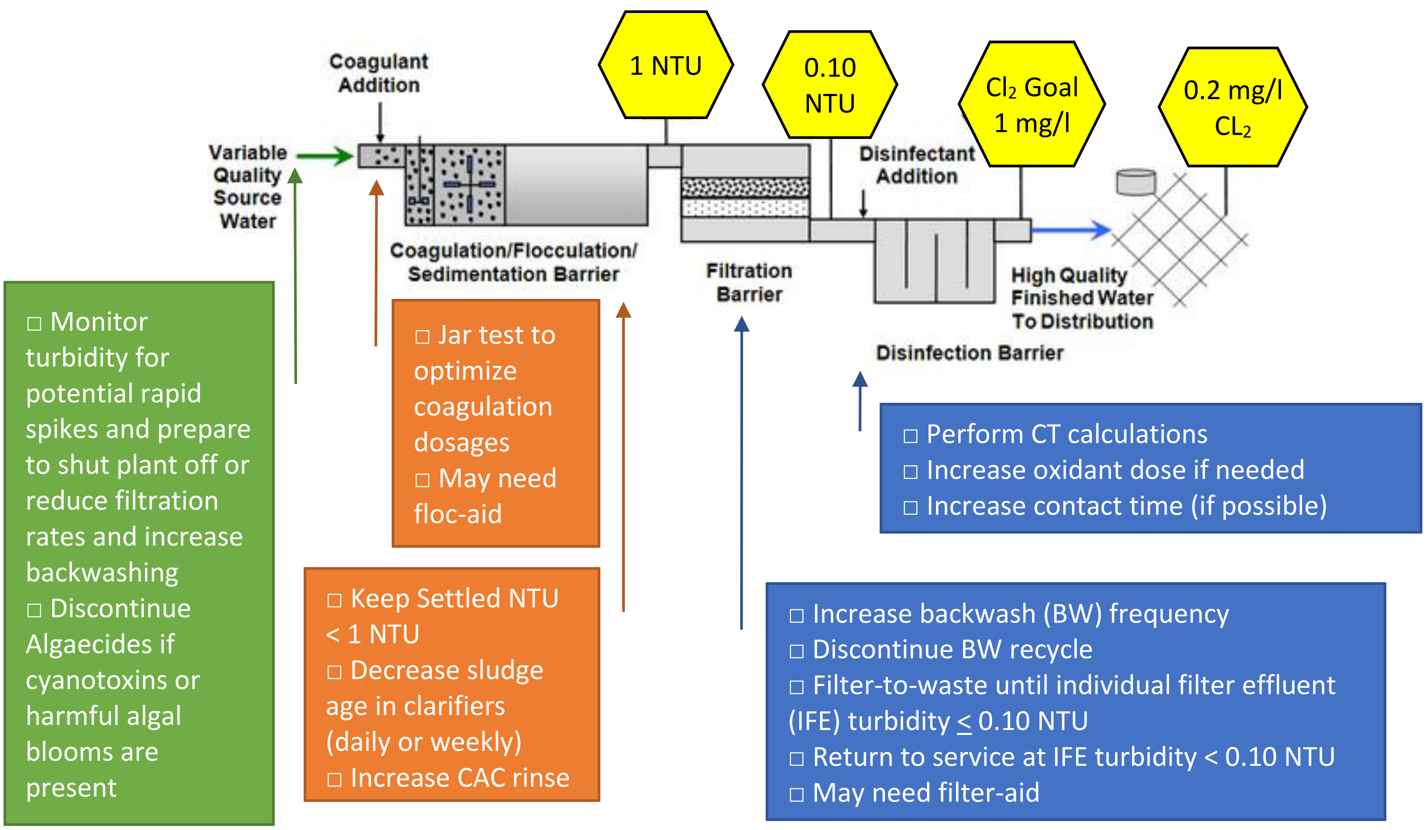
Conventional and direct filtration plants are encouraged to optimize their treatment processes and adopt water quality goals more stringent than the regulatory drinking water standards to allow a buffer should raw water conditions make treatment more challenging. Improved turbidity removal results in increased pathogen removal.

a. Coagulation and flocculation:
   i. Use jar tests to simulate varying coagulant dosages and plant mixing hydraulics to obtain desired floc formation and increased turbidity removal.
   ii. Compare coagulation feed rates or dosages to periods of historical high turbidity events to optimize the delivery of coagulants to increase the removal of turbidity.
   iii. Ensure coagulant storage and feed pump capacity is adequate for any increased coagulant demand caused by the greater turbidity and organic matter associated with wildfire and subsequent storms.
   iv. Develop practices around streaming current monitors or zeta potential analyzers to help determine optimum coagulant dose based on raw water quality charge fluctuations.
   v. Prepare to modify pH adjustment chemical feed settings if pH or alkalinity change as a result of the wildfire, from normal raw water quality conditions.
   vi. If powdered activated carbon (PAC) is plumbed to the front of the plant, turn on the feed to aid in taste, odor, or cyanotoxin removal.
   vii. Develop means of removing any silty solids that may accumulate in flocculation tanks or basins due to increased turbidity.

b. Sedimentation:
   i. Measure and record settled water turbidity daily and meet settled water turbidity optimization goals (settled water below 1 NTU when raw is less than 10 NTU and settled water below 2 NTU when raw is greater or equal to 10 NTU).
   ii. Conduct more frequent clarifier or sedimentation basin sludge removal, such as on a daily or weekly basis.
   iii. Conduct more frequent contact adsorption clarifier (CAC) rinses.

c. Filtration:
    i. When able, produce filtered water that meets the optimization goal of less than or equal to 0.10 NTU.
    ii. Establish your individual filter run and filter-to-waste durations based on meeting 0.10 NTU and quarterly post-backwash filter turbidity profiles.
    iii. Increase backwash frequency.
    iv. Reduce filter loading rates and filter run times.
    v. Ensure that the backwash sufficiently expands the filter bed media (sand and anthracite layers) to at least 20% to remove remnant particles.
    vi. Ensure adequate water and pumping capacity to backwash more frequently as required by increased turbidity in influent water. Ensure remaining filters can meet demand by filters being off-line more for any increased backwashing.

The following graphic summarizes post-wildfire optimization goals and strategies for conventional and direct filtration plants.



6. Slow sand filtration:

a. If turbidity in source water rapidly increases and if there is enough finished water storage available or an alternate source to meet demands, shut off intakes to filters and let the bulk of the high turbidity water pass by the intake to avoid plugging the filters. As turbidity drops, steadily increase flows into the filter and overflow to waste. Not introducing fresh water above the filter bed for days at a time can starve the filter biota of nutrients and dissolved oxygen. Begin filtering when raw water turbidity drops to 10 NTU or less.
b. If cyanotoxins are a concern, lower the filtration rate to improve contaminant removal and allow cyanotoxins to be metabolized. Lowering filtration rates to less than 0.02 gpm/ft^2 should be avoided to keep biota viable.
c. Consider controls that allow a constant higher water level (supernatant or "headwater") above the filter at all times, (i.e., throttle the intake valve to maintain a constant headwater throughout the filter run). This requires the use of piezometers or other pressure sensor to determine head loss. Maintaining deeper headwater keeps increases available storage while minimizing algal blooms in the filter.
d. Monitor head loss so that the filter can be cleaned during the time of year less likely to have algal blooms and high run-off. Graphing head loss development versus time can reveal how fast the filter plugs as the filter approaches the time when cleaning is needed.
e. Staggering cleanings may allow longer filter-to-waste times without the risk of the other filters plugging in the interim.
f. Filter-to-waste for a minimum of 24 hours to ensure filters are ripe after each cleaning.
g. Just prior to cleaning, sample influent and effluent coliform counts in units of MPN/100 ml and determine the percent removal. Clean the filter and repeat the sampling after the first 24 hours of filtering to waste to determine the post-cleaning percent removal. Use the pre- and post-cleaning coliform removals as an indicator of the filter recovery following a cleaning. Avoid returning a filter to service when filter effluent coliform counts are more than 5 MPN/100 ml, turbidity is above 1 NTU, or % coliform removal is less than 90% (2-log).
h. Blending with a source that has lower turbidity and/or cyanobacteria cells may help, however, use caution when blending with groundwater as this can "starve" the slow sand filter of nutrients. Keep blended groundwater

to a minimum and monitor coliform removal twice a week to watch for elevated coliforms in the effluent or declining coliform removals. If possible, investigate this option prior to needing it for an emergency and consider nutrient amendments such as acetic acid to provide a food source for filter biota.

7. Cartridge and Bag filtration:

a. Expect to change the filters more frequently and at a lower pressure differential (difference between filter inlet and outlet pressure) than under standard operating conditions as filters may quickly clog
b. Lower flows may be needed to keep differential pressures in check.
c. Ensure gaskets and seals used in cartridge cannisters are in good working order and replace according to manufacturer's recommendation and if they appear worn or damaged.
d. Ensure a sizable supply of spare filters are on-site.
e. Closely monitor raw water turbidity as this can allow you to shut the plant off to avoid turbidity from extreme rain/runoff events.
f. Investigate adding backwashable sand filters, re-usable bag filters, or other type of roughing pre-filter to reduce the turbidity load on the finish filter.

8. Diatomaceous earth (DE) filtration:

a. Anticipate more frequent cleaning by having more diatomaceous earth media on hand.
b. Closely monitor raw water turbidity as this can allow you to shut the plant off to avoid turbidity from extreme rain/runoff events.
c. Investigate adding backwashable sand filters, re-usable bag filters, or other type of roughing pre-filter to reduce the turbidity load on the DE filters.

9. Adding treatment:

If optimizing existing water treatment facilities is not enough to handle higher turbidity, TOC, and other contaminants, adding new treatment, such as a roughing filter, granular or powdered activated carbon, or ozone, may be useful. DWS plan review approval is required prior to adding new water treatment facilities. See www.healthoregon.org/pwsplanreview for further information or contact DWS. Caution should be exercised, and manufacturer consulted when considering PAC as it may damage polymeric membranes and plug slow sand and cartridge/bag filters.

Additional Resources:

- State of Oregon wildfire recovery information: https://wildfire.oregon.gov/
- Wildfire Information for Water Systems - OHA – Drinking Water Services
- Refer for the Oregon Post-Wildfire Flood Playbook for more information on identify and mitigating flood risks and other fire-related information.
- Oregon Department of Environmental Quality - Wildfire response Information, debris removal, and fact sheets. This site also contains links to funding and additional state and federal FEMA resources.
- After the Fire fact sheet for homeowners includes resources and advice on how to proceed with recovery in both English and Spanish.
- For more detailed information on potential source water changes, see USGS' Wildfires and Water or US EPA's Wildfires: How Do they Affect our Water Supplies

On-site technical assistance and resources for water systems:

- State Revolving Loan Fund - Technical Assistance Circuit Riders
- Oregon Association of Water Utilities (OAWU)
- Oregon Water/Wastewater Agency Response Network (ORWARN)
- Rural Community Assistance Corporation (RCAC) - non-profit
- Oregon Department of Environmental Quality (DEQ) Wildfire Response

The following general optimization resources may be found on DWS' surface water treatment web page at www.healthoregon.org/swt:

  - Optimization goals for conventional and direct filtration plants
  - Optimization goals for slow sand filter plants
  - Filter turbidity profile example
  - Filter bed expansion measurement

Since wildfires may contribute to algal blooms, learn how to prepare/mitigate harmful algal blooms and optimize treatment of cyanotoxins on-line at:

  - https://www.oregon.gov/oha/PH/HealthyEnvironments/DrinkingWater/Operations/Treatment/Pages/algae.aspx

  - US EPA's Water Treatment Optimization for Cyanotoxins

References

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