



Script 1 — Surface Water, Ground Water, and the Microbial Rules

Recording script. Target ~15–20 minutes at a normal reading pace. Headers, bracketed notes, and timing estimates are for your reference and are not read aloud.

The Surface Water Treatment Rules

1. Multi-barrier framing [~1 min]

The rules covered in this script all share one idea: the multi-barrier treatment approach. The concept is that a plant uses several different treatment processes in series, so that if any one process fails or underperforms, the others pick up the slack and keep the finished water safe. A system that relies on only one or two processes has no backup when something goes wrong. Every surface water rule that follows is built to reinforce that principle: multiple independent barriers against pathogens, with monitoring at each barrier so a problem shows up before it reaches the customer.

The pathogens these rules target are *Cryptosporidium*, *Giardia*, and viruses. The two core barriers are filtration, which physically removes organisms, and disinfection, which inactivates what gets through.

2. The Surface Water Treatment Rules [~10 min]

The Surface Water Treatment Rules consist of five rules built up over several decades. They apply to any system using surface water, or groundwater under the direct influence of surface water.

The original Surface Water Treatment Rule set the foundation. It required 3-log (99.9%) inactivation of *Giardia* and 4-log (99.99%) inactivation of viruses, through filtration and disinfection. The SWTR set the first turbidity limits for the combined filter effluent, or CFE: a 95th percentile at or below 0.5 NTU, and never above 5.0 NTU. It also set the disinfectant residual requirements: at least 0.2 mg/L entering the distribution system, and a detectable residual in at least 95 percent of distribution system samples across any two consecutive months.

Turbidity is the real-time indicator of how well filtration is working. Low turbidity means the filter is capturing particles, including *Giardia*. When turbidity rises, that is the signal that the physical barrier is weakening.

The next two rules were the Interim Enhanced Surface Water Treatment Rule and the Long Term 1 Enhanced Surface Water Treatment Rule. They carried effectively the same requirements, but the Interim Enhanced rule came first and applied to larger systems, while LT1 applied to smaller systems.

These rules added 2-log (99%) removal of *Cryptosporidium* through filtration and tightened turbidity requirements to the limits in force today: a CFE 95th percentile at or below 0.3 NTU, and never above 1.0 NTU. *Crypto* is the pathogen that drove much of this tightening because it has a hard outer shell that resists chlorine at normal doses. The defense against it leans heavily on physical removal by filtration.

To minimize the potential for breakthrough of the filtration barrier, these rules added individual filter effluent, or IFE, monitoring which is continuous turbidity monitoring on each filter, recorded every 15 minutes. The CFE can hide one or more bad filters. Monitoring the output of each filter allows an operator to see when one or more may be underperforming and threatening the barrier. How an operator responds depends on whether the filter is returning to service or operating routinely.

California treats a filter returning to service, either after a backwash or any other service disruption, as the highest-risk window. Operators first bring the filter back online gradually rather than at full rate. Then, if a filter reads greater than 2.0 NTU at any time during the first four hours, or is still greater than 0.5 NTU once it has been running for four hours, the filter must be taken out of service, inspected, and not returned to service until the problem is corrected. Additionally, if the turbidity is greater than 0.3 NTU after the filter has been continuously running for at least an hour, a filter profile must be produced if the cause is unknown.

A filter in normal operation has different triggers. If the IFE turbidity is greater than 1.0 NTU at any time, a filter profile must be produced within seven days if the cause is unknown. If the IFE is greater than 1.0 NTU at the same filter three months in a row, a filter self-assessment must be performed within 14 days. Lastly if the IFE is greater than 2.0 NTU at the same filter two months in a row, a comprehensive performance evaluation must be performed.

The out-of-service triggers act on a single high reading. The profile and escalation triggers use two consecutive readings taken 15 minutes apart.

A filter profile is a graph of the filter's turbidity across an entire run, backwash to backwash, including how it behaves while another filter is backwashed.

A filter self-assessment is an evaluation of the filter where a profile is made, and steps are taken to identify and rank the factors limiting performance and assess what corrections could apply.

A comprehensive performance evaluation is a thorough review of the entire treatment plant's performance and its operation & maintenance practices. The goal is to establish what is limiting compliance and fix it without major capital investment if possible.

These rules also required sanitary surveys by the state, introduced disinfection profiling and benchmarking, and required new finished-water storage reservoirs to be covered.

The Filter Backwash Recycling Rule addresses plants that recycle their backwash water, or any liquids derived from a solids separation process, such as filtrate from a belt press or supernatant from a settling pond. These liquids are full of particles and pathogens in concentrated form. Sending them back into the plant carelessly can introduce a slug of *Crypto* ahead of treatment.

In California, Title 22 requires recycle flows to be treated via solids removal and returned to the headworks of the plant. It also requires monitoring the turbidity and flow of the recycle stream. Through the rule's Technical Guidance Manual and California's *Cryptosporidium* Action Plan, goals of a recycle flow rate under 10 percent of the plant's influent flow, and under 2 NTU are heavily encouraged, often winding up in a plant's operating permit. The goal is to avoid overwhelming the main treatment train with a heavy *Crypto* load.

The last rule in the family is the Long Term 2 Enhanced Surface Water Treatment Rule. LT2 targets *Crypto* specifically. It required systems to monitor their source water for *Crypto*, and based on the average level found, placed each system into one of four bins. Bin 1 is the lowest contamination and requires no additional *Crypto* treatment. Bins 2 through 4 require progressively more treatment on top of the 2-log baseline requirement.

- Bin 2 requires an additional 1.0-log for conventional filtration and 1.5-log for direct filtration.
- Bin 3 requires an additional 2.0-log for conventional filtration and 2.5-log for direct filtration.
- Bin 4 requires an additional 2.5-log for conventional filtration and 3.0-log for direct filtration.

Water systems use the Microbial Toolbox, which is an EPA technical guidance manual that details the options a system can use to earn a set amount of log-removal or log-inactivation credit. The tools fall into categories: source protection and management, additional pretreatment, improved existing filtration performance, additional filtration, and additional inactivation through disinfection. A system can combine tools to reach its required credit. LT2 also required existing uncovered finished-water reservoirs to be covered, or the water re-treated before entering the distribution system.

Disinfection credit under these rules is measured by CT, which is disinfectant concentration multiplied by contact time. A required CT value must be met to claim a given level of *Giardia* or virus inactivation. The two levers an operator controls are the residual concentration and the contact time the water spends before the first customer. Two water conditions also affect it: colder water and higher pH both require more CT to achieve the same inactivation. Systems using chlorine dioxide, ozone, or ultraviolet light can also earn additional *Crypto* inactivation credits under LT2, since those disinfectants are effective against *Crypto* where free chlorine is not.

3. The Ground Water Rule [~3 min]

The Ground Water Rule takes a different approach from the surface water rules. Ground water is generally better protected than surface water, so the rule does not impose blanket filtration or disinfection on every system. Instead, it is risk-targeted: it identifies the ground water systems that are vulnerable to fecal contamination and directs treatment there.

The GWR works through four parts:

- First, sanitary surveys: the state looks for significant deficiencies that make a system vulnerable to contamination. After the initial survey, these run every 3 years, or every 5 years for systems that provide 4-log virus inactivation treatment or have strong performance records.

- Second, triggered source water monitoring: when a routine distribution coliform sample comes back total-coliform-positive, a system that is not already providing 4-log virus inactivation treatment must sample any source in use for *E. coli*. Samples must be collected within 24 hours and taken prior to treatment. A triggered sample that is *E. coli*-positive results in a Tier 1 public notification. Failure to conduct triggered monitoring when required results in a Tier 3 public notification.
- Third, treatment techniques: if the source sample shows *E. coli* contamination, or a sanitary survey finds a significant deficiency, the system must fix it. The options are to correct the deficiency, eliminate the source of contamination, provide an alternate source, or install treatment that reliably achieves 4-log virus inactivation before the first customer.
- Fourth, compliance monitoring: a system that provides 4-log virus inactivation treatment monitors that treatment to confirm it is working, and in exchange avoids the triggered source sampling. Large systems serving a population greater than 3,300 must monitor via online continuous-read analyzers. If the analyzer fails, grab samples every four hours may be substituted until the equipment is back in service, with continuous monitoring resumed within 14 days. A failure to maintain 4-log virus inactivation treatment occurs when treatment is lost and not restored within four hours. That failure requires a Tier 2 public notification. Failure to conduct required compliance monitoring results in a Tier 3 public notification.

4. The Total Coliform and Revised Total Coliform Rules [~4 min]

The Total Coliform Rules consist of the original Total Coliform Rule and the Revised Total Coliform Rule. The revised rule did not throw out the original. It kept most of the original rule's sampling framework but changed how a system responds when coliforms show up.

The original Total Coliform Rule established distribution system monitoring for coliforms by requiring systems to collect routine samples. If a routine sample comes back total-coliform-positive, the system must collect a repeat sample set within 24 hours: a repeat at the original location, and samples within five service connections upstream and downstream of the original. The TCR also established a total coliform MCL, with two kinds of violations. A monthly violation occurred when a system taking 40 or more samples had more than 5 percent of its samples test positive for coliforms, and an acute violation occurred when any repeat sample was *E. coli*-positive, or when an *E. coli*-positive routine sample was followed by a total-coliform-positive repeat.

The Revised Total Coliform Rule built on the TCR framework. Routine sampling still follows a written Bacteriological Sample Siting Plan, and every total-coliform-positive sample is tested for *E. coli*. In California, the number of routine samples a water system collects each month is based on the population served or the number of service connections, whichever yields the greater number of required samples.

The RTCR's biggest change was to eliminate the acute and monthly coliform MCL altogether. Total coliforms are common in the environment and are not by themselves proof of fecal contamination, so under the RTCR a positive total coliform result is no longer a violation and instead becomes a trigger to investigate by means of a find-and-fix treatment technique.

A Level 1 assessment is conducted by the system's own staff and is triggered when a system taking 40 or more samples per month has more than 5 percent of its samples test positive for coliforms, or when a system fails to take all its required repeat samples.

A Level 2 assessment is more serious and is conducted by the state or a state-approved third party. It is triggered by an *E. coli* MCL violation, or by a second Level 1 trigger within a rolling 12-month period. An *E. coli* MCL violation is triggered by any one of the following conditions:

- A TC-positive routine and a TC-positive repeat, where the repeat was not analyzed for EC,
- A TC-positive routine and an EC-positive repeat,
- An EC-positive routine and any missing repeat,
- An EC-positive routine and a TC-positive repeat, or
- An EC-positive routine and an EC-positive repeat

An *E. coli* MCL violation signals an acute health risk and requires Tier 1 public notification.

The purpose of both assessments is to find the sanitary defect and correct it. The assessment form goes to the state within 30 days of the trigger, with corrective action completed within that same 30 days or on a state-approved schedule.

5. Close [~1 min]

Everything in this script comes back to the multi-barrier approach. Filtration and disinfection are the two core barriers against pathogens in surface water. Turbidity monitoring watches the filtration barrier in real time. CT confirms the disinfection barrier. The enhanced rules added *Crypto* protection because it resists chlorine. The Filter Backwash Recycling Rule keeps a plant from undermining its own barriers. The Ground Water Rule extends risk-based protection to vulnerable groundwater. And the Total Coliform Rules monitor the distribution system for signs that a barrier has failed somewhere between the plant and the customer.