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TCEQ Water Supply Division

Direct Potable Reuse for Public Water Systems

Introduction

Senate Bill 905 from the 87th Legislative Regular Session required the Texas Commission on Environmental Quality (TCEQ) to develop a regulatory guidance manual outlining agency rules that apply to direct potable reuse. This guidance manual explains how direct potable reuse (DPR) is regulated in Texas and what is required for a public water system to receive approval of a DPR project.

The State of Texas Health and Safety Code 341.0391 defines DPR as "the introduction of treated reclaimed municipal wastewater either: directly into a public water system; or into a raw water supply immediately before the water enters a drinking water treatment plant"

TCEQ must ensure that public water supply projects comply with applicable federal and state laws, regulations, rules, guidelines, and design criteria to produce safe drinking water. Public health protection requires that microbiological and chemical constituents be removed to the extent practicable before a source water may be used for potable purposes. Complete removal of all microorganisms and chemicals is impossible; therefore, goals are established to limit human exposure of specific identified constituents to concentrations that are not harmful to human health. The maximum allowable concentrations of these constituents are established as drinking water standards.

The Safe Drinking Water Act (SDWA) requires the US Environmental Protection Agency (EPA) to establish and enforce standards that public water systems must follow including maximum contaminant levels (MCLs) for chemicals and log reductions for pathogens and fecal indicator bacteria. Currently, there are no federal regulations or guidelines pertaining to DPR.

TCEQ's current DPR approval process results in issuing authorizations that are tailored for a specific plant design and unique source water quality. Since minimum treatment requirements are based on the wastewater effluent characterization, each DPR plant can be designed to meet the specific quality of the source water. If federal and state finished drinking water standards can be met, TCEQ can approve the proposed plant design. This process ensures public health is protected and avoids unnecessary "over-design" of the plant.

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EPA Guidelines for DPR

EPA's 2017 Potable Reuse Compendium[1] states, "Although EPA encourages an integrated approach to water resources management, it does not require or restrict practices such as water reuse. EPA acknowledges the primacy of states in the allocation and development of water resources. EPA, State, and local governments implement programs under the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) to protect the quality of source waters to ensure that source water is treated so that water provided to the tap is safe for people to drink (e.g., contaminant specific drinking water standards). The SDWA and the CWA provide a foundation from which states can further develop and support potable water reuse as they deem appropriate."

TCEQ Exception Process for DPR

TCEQ reviews engineering plans and specifications for all drinking water treatment facilities to ensure that each design meets the minimum design standards in TCEQ's Rules and Regulations for Public Water Systems (in Title 30, Texas Administrative Code (30 TAC), Chapter 290, Subchapter D) and will produce water that meets the standards found in the Standards and Reporting Requirements for Public Water Systems (in 30 TAC Chapter 290, Subchapter F). Because the use of wastewater effluent as a source for public water systems is an uncommon practice and can vary, neither TCEQ nor EPA rules define specific design standards for DPR facilities. To be responsive to ongoing research and the latest full-scale plants, TCEQ regulates DPR through the rule exception process.

For treatment technologies without design standards, TCEQ can grant exceptions to requirements in Subchapter D if the public water system can demonstrate that the exception will not compromise public health or result in a degradation of service or water quality. The use of wastewater effluent as a source for drinking water is reviewed on a case-by-case basis as an exception. TCEQ reviews the results of studies performed by the public water system to see if the proposed treatment scheme will produce water quality that meets federal and state water quality regulations.

Overview of Treatment Requirements

In Texas, a DPR plant's source is treated wastewater effluent. This is wastewater that has been successfully treated by a wastewater treatment plant (WWTP) with a current Texas Pollutant Discharge Elimination System (TPDES) permit or Texas Land Application (TLAP) permit and has TCEQ approval to provide reclaimed water. The use of permitted WWTP effluent as the source of the DPR plant allows a clear delineation between regulatory oversight by the wastewater programs under the CWA and regulatory oversight by the drinking water programs under the SDWA.

Because a DPR plant produces drinking water, the drinking water program which implements the SDWA at TCEQ reviews and approves DPR projects. Therefore, TCEQ uses the EPA and State rules that implement the SDWA as the basis to review exception requests for DPR projects. Each DPR exception sets site-specific design, operation,

[1] www.epa.gov/ground-water-and-drinking-water/2017-potable-reuse-compendium

maintenance, and reporting requirements for the demonstrated treatment as specified in 30 TAC 290.39(l)(4). Although DPR treatment schemes are site-specific, the following subsections provide general information about treatment for DPR plants in Texas.

Pathogen Treatment

A pathogen is a microorganism capable of injuring its host, such as causing gastrointestinal illness. The primary source of pathogens in municipal wastewater is feces. Pathogens that can live outside of a host are primarily transmitted via ingestion of contaminated water or food, or by inhalation of aerosolized water containing suspended pathogens. In DPR, pathogens, if not treated, pose an acute risk because disease presents quickly (hours or days) after exposure. TCEQ uses the requirements and standards in the federal Surface Water Treatment Rules (SWTRs) to determine the concentration of pathogens allowed in drinking water, and in turn the treatment needed at each DPR plant. Additionally, TCEQ uses the SWTRs to determine how much pathogen removal or inactivation each proposed treatment unit for the DPR plant can provide.

For DPR projects, the highest concentration found for each pathogen determines the acceptable level of treatment to be provided at the DPR facility. The public water system proposing a DPR project collects samples of the WWTP effluent to be used as the DPR source. The maximum pathogen levels are used to determine if the proposed pathogen treatment levels for the DPR facility are adequate. The amount of treatment needed for each DPR project is based on the difference between the incoming WWTP effluent and the allowed EPA maximum finished water levels of 2.2×10^{-7} MPN/L viruses, 7.0×10^{-7} cysts/L *Giardia*, and 3.0×10^{-5} oocysts/L *Cryptosporidium*. These values correspond to the concentrations needed to remain below a 1-in-10,000 per capita risk of infection (EPA, 2006) (Regli, Rose, Haas, & Gerba, 1991), which is the governing paradigm underlying existing surface water treatment regulations under the SWTRs and its amendments (EPA, 2006; 1989; 1998). These finished water pathogen concentrations are too small to measure, so the log removal value (LRV) concept is applied to DPR the same way it is applied under existing surface water treatment regulations. LRVs are determined by taking the logarithm of the ratio of pathogen concentration in the influent and effluent water of a treatment process.

TCEQ has set minimum LRV treatment levels for DPR of 5.5-log *Cryptosporidium*, 6-log *Giardia*, and 8-log virus. The basis for these minimum LRV treatment levels is provided below. If the WWTP effluent sample results demonstrate the need for treatment levels higher than the stated minimum levels, we only approve proposed DPR projects with pathogen treatment levels that are at or above the levels calculated from the WWTP effluent sampling results. To ensure protection of public health, the above minimum treatment levels are needed even if sampling results from the wastewater characterization suggest lower levels of treatment may be adequate.

The 5.5-log *Cryptosporidium* minimum treatment level was based on the highest *Cryptosporidium* treatment level required by the Long Term 2 Enhanced Surface Water Treatment Rule (LT2, (EPA, 2006)). Since wastewater effluent has a higher risk of being contaminated with pathogens than surface water, the minimum limit for C*ryptosporidium* treatment was set at the highest level required for surface water sources. To establish the minimum *Giardia* LRV level, TCEQ used the Texas source water *Cryptosporidium* and *Giardia* concentrations from the Information Collection

Rule and the Texas LT2 Schedule 1 Round 1 *Cryptosporidium* results to better understand the occurrence patterns of these pathogens in source water. Though the *Giardia* data was limited compared to the *Cryptosporidium* data, the percentages of results at increasing levels appeared be consistent. Based on these data, the reviewers determined 6.0-log *Giardia* LRV to be the minimum allowable treatment level for proposed DPR plants. Lastly, the minimum LRV level for virus treatment was scaled to match those levels established for the other two pathogens. To ensure protection of public health, we use the largest concentration of each pathogen found in the WWTP effluent sample results to determine minimum levels of adequate treatment for each individual project.

Chemical Treatment

EPA sets legal limits, known as maximum contaminant levels (MCL), for chemical contaminants in drinking water. The MCL reflects the level that protects human health and that water systems can achieve using the best available technology. EPA rules also set water-testing schedules and methods that public water systems must follow.

DPR plants must produce water that meets finished water MCLs because it is used for human consumption and must meet EPA rules. Most chemical contaminants are regulated by EPA to provide public health protection through the reduction of chronic, or long-term, risks from: cancer, organ damage, circulatory system disorders, nervous system disorders, and reproductive system disorders. The exceptions are nitrate and nitrite, which pose an acute health risk. The EPA regulation of nitrate and nitrite reduces the risk of Methemoglobinemia or "blue baby syndrome" which can harm infants.

The SDWA requires EPA to regulate contaminants that meet each of three criteria[2]: "The contaminant may have an adverse effect on the health of persons; The contaminant is known to occur or there is substantial likelihood the contaminant will occur in public water systems with a frequency and at levels of public health concern; and regulation of the contaminant presents a meaningful opportunity for health risk reductions for persons served by public water systems."

The chemical makeup of domestic wastewater can vary depending on the activities taking place at the wastewater source. In domestic wastewater, pharmaceutically active substances enter the wastewater stream through human excretion and improper disposal of medications via toilet flushing. Trace chemical constituents may include pharmaceuticals, non-prescription drugs, personal care products, household chemicals, food additives, flame retardants, plasticizers, biocides, as well as degradation and disinfection by-products deriving from these original parent compounds. Wastewater treatment does not eliminate all potable reuse constituents of concern.

Due to the rarity of using wastewater effluent directly as a source for drinking water, some of the chemical contaminants that might be associated with the source water have not been evaluated by EPA. Since wastewater effluent is returned to rivers and streams and these rivers and streams are the source for many drinking water plants (de facto reuse), there are MCLs for many contaminants in wastewater. (e.g., nitrate). To

[2] https://www.epa.gov/ccl/basic-information-ccl-and-regulatory-determination#what-crieria-reg-det

ensure protection of public health, TCEQ will only approve exceptions for proposed DPR plants which include treatment units that remove or degrade a wide range of chemical contaminants, such as reverse osmosis (RO) membranes and ultraviolet light with advanced oxidation.

To understand the specific chemical compounds in a potential DPR plant's source water, TCEQ reviews at least one year of chemical monitoring of the selected WWTP effluent (see Appendix A). The effluent must be monitored for regulated drinking water contaminants so the DPR plant can be designed to remove the identified contaminants. TCEQ strongly recommends also monitoring for unregulated contaminants such as personal care products that may be present. The WWTP effluent monitoring informs the type of treatment needed at the proposed DPR plant and the years-worth of data captures seasonal fluctuations.

Effectiveness of Treatment

To ensure safe water, each unit process at the DPR plant must include a method to regularly test the effectiveness of the unit. If the test shows that the unit process is not able to function properly, the unit must be shut down, repaired, and retested before it can produce water again.

Because there is no reliable method that is economically and technically feasible to measure pathogen concentrations to indicate there is not a health concern, EPA's SWTRs rules set "treatment technique" requirements rather than an MCL. A treatment technique[3] is an enforceable procedure or level of technological performance which public water systems must follow to ensure control of a contaminant. Because pathogen results for treated drinking water would be received days, weeks, or even months after the water is treated, the SWTRs include treatment technique requirements. These requirements include treatment, testing, and results criteria to determine if the treatment is working properly. This testing scheme is an integral part of EPA's SWTRs, and when the treatments are used, the testing and shut down requirements in the SWTRs are implemented at DPR plants.

Unlike pathogens, many chemical contaminants have test methods that allow for continuously monitoring concentrations in the treated water directly from the unit's effluent piping. If the WWTP effluent source water has high levels of a chemical contaminant with an acute health risk, that public water system will monitor the contaminant in the effluent of the treatment units at the DPR plant, to ensure the chemical is adequately removed.

The frequency and type of monitoring to be performed at the DPR plant is based on levels of the contaminants found in the source water, if the health risk from the contaminants is acute or non-acute (chronic), the amount and type of treatment provided for the contaminants, and the robustness of controls at the DPR plant. TCEQ conceptualizes monitoring, treatment, and operations as three sides of a triangle that bounds safety (or risk reduction) in the middle. Each DPR project may have differing levels of proposed monitoring, treatment, and operations, but they are balanced so that the amount of safety in the triangle remains the same. For example, a DPR plant which proposes to provide the minimum amount of *Cryptosporidium* treatment needed

[3] www.epa.gov/dwsixyearreview/reviewing-treatment-methods-six-year-review-drinking-water-standards

based on the source water quality would benefit from regular source water *Cryptosporidium* monitoring to ensure the levels do not exceed those of the treatment provided. Another DPR plant may choose to install twice the calculated amount of *Cryptosporidium* treatment and thus could forgo the regular source water monitoring for that pathogen.

An on-line monitoring system with alarms and shut-down statements is needed for TCEQ exception approval. Many public water systems use a Supervisory Control and Data Acquisition (SCADA) System to control processes, monitor data, perform shut down and alarm actions, directly interact with unit processes, and record historical data. Due to the amount and data to be recorded it is not practical for manual collection of data. Additionally automatic shutdowns cannot work without a control system. If the public water system does not currently use a SCADA system, or if the SCADA system use is limited, a system will need to be installed or upgraded. All DPR plants will need to have the SCADA system customized for the DPR plant's equipment and requirements.

Operator Requirements

TCEQ requires each DPR plant to be manned any time that water is produced. Additionally, TCEQ requires that at least one operator for the DPR facility hold a Class B Surface Water Operator License, or higher, and that a least one full time operator at the associated wastewater treatment plant hold a Class B Wastewater Operator License (or, if required by 30 TAC Chapter 30, a Class A Wastewater Operator License). The technologies used in DPR plants (membranes, UV light disinfection with advanced oxidation, etc.) are newer technologies and are not used at most Texas surface water treatment plants (SWTPs). The public water system will need to locate operators with experience using these technologies or plan to train existing or new staff to not only operate the equipment but also trouble shoot issues at the DPR plant.

Additional Permitting Requirements

Additional permitting programs within TCEQ may review documents or set requirements for DPR plants.

Wastewater

The Water Quality Division (WQD) reviews and issues wastewater permits and reclaimed water authorizations and reviews the treatment system design plans and specifications to ensure compliance with the appropriate rules and requirements. To be considered for use as a source of drinking water, the WWTP must be compliant with the TPDES or TLAP permit and reuse authorization.

Another program in the WQD that may review or set additional requirements is the Pretreatment Program. Commercial and industrial facilities utilize pretreatment to remove harmful pollutants before they are discharged to a sewer collection system to the WWTP. Wastewater from homes, commercial buildings, and industrial facilities is collected and transported through a series of pipes, called a wastewater collection system, to WWTPs. WWTPs are designed to treat wastes from households but may not efficiently treat pollutants from industrial or commercial facilities. These pollutants

may cause problems at WWTPs. Such problems may be prevented by recycling, waste minimization, chemical substitution, pretreatment, or other best management practices at the industrial or commercial facilities.

By placing effluent limits on certain pollutants in the wastewater discharged to the sewer system from industrial facilities, the WWTP can prevent interference with the operation of the plant, prevent the introduction of pollutants that could pass through the WWTP untreated, improve opportunities for reuse or recycling of wastewater, and prevent the introduction of pollutants and protect health or safety.

The Contributing Industries and Pretreatment Requirements section of the TPDES permit includes pretreatment requirements for all WWTPs. If the WWTP has a TCEQ approved pretreatment program, the permit includes specific prohibitions as well as monitoring and notification requirements. If the WWTP does not have an approved program, the pretreatment requirements in the TPDES permit are based on whether the WWTP has significant industrial users that are discharging wastewater to the WWTP. TCEQ's Pretreatment Program participates in the review of DPR plants. The extent of the review is based on the type and amount of commercial and industrial facilities that contribute to the sewer system and the current pretreatment program.

Additionally, in past DPR plant reviews, TCEQ has required the WWTP to divert all hauled waste to WWTPs that do not contribute to the DPR plant. Hauled waste is received at the WWTP by truck or rail, not via the wastewater collection system (EPA, 1999). Such waste may include domestic septage, chemical toilet waste, grease and grit trap waste, nonhazardous commercial and industrial waste, hazardous waste, groundwater remediation site waste, and landfill leachate. TCEQ does not allow WWTPs that provide source water for DPR facilities to receive hauled waste because the pollutants are usually more concentrated, which may adversely impact the WWTP facility, and therefore the quality of the DPR source water.

Lastly, depending on the treatment provided, the DPR plant may produce a concentrated waste stream. Reverse Osmosis (RO) is one such process that creates concentrated liquid waste (water treatment wastes) that must be handled appropriately. If a PWS intends to discharge water treatment wastes into or adjacent to waters in the state, a TPDES permit from TCEQ's Water Quality Division (MC-148) will be needed.

Water Rights

The Water Availability Division (WAD) reviews and approves applications for surface water rights permits and processes water supply contracts. Water rights permits include specific types of use, locations where the water may be used, and may also include special conditions related to the use of the water. More information on surface water rights permitting is available on TCEQ's Water Rights website[4].

If a public water system uses surface water, it either has a water right permit or a contract for surface water with another entity, such as a river authority. Each permit or contract is different and the public water system would need to ensure that the water right or contract water can be used for the required purposes and at the locations served by the public water system and that there are no special conditions in the water

[4] www.tceq.texas.gov/permitting/water_rights/wr-permitting/wr_amiregulated.html

right that would need to be addressed. TCEQ suggests that the public water system review its documents, and if there are concerns, discuss the issue with WAD staff or the water rights permit holder of the contract water.

Other Considerations

Community Involvement

Ensuring that the public is aware of the planned DPR project is essential to its success. As with most successful water projects, a public water system that intends to pursue a DPR project should begin discussing the reason for it, the cost, and the type of project with the community from the very beginning. The dialogue should continue throughout the planning, construction, testing, and operation of the plant.

DPR Plant Costs

Due to the amount of treatment necessary to clean the source water, the cost of the engineering, construction, and operations can be significant at DPR plants. Some public water systems underestimate the cost for DPR. Once the public water system estimates the full cost of engineering, construction, testing, and operation, the public water system may determine that other sources of water are more economical. Additionally, if a public water system decides to pursue DPR, the public water system may need to secure an additional funding source (WateReuse, 2015).

Supplemental Water Source

As stated above, if the DPR plant does not meet the granted exception's conditions, it cannot produce water for human consumption. Each DPR plant will need a contingency plan for providing water to the community if the DPR plant is taken offline.

Treatment Plant Design

Below is a list of design principles that TCEQ recommends each public water system consider while planning for DPR.

Multi-Barrier Approach

EPA and TCEQ rules promote a multi-barrier approach for treating drinking water. A multi-barrier treatment process provides several protective "layers" against contamination by using more than one method of prevention and treatment to remove or inactivate microorganisms and chemical contaminants. For example, all SWTPs are required by the SWTRs to provide both filtration to removal pathogens and chemical disinfection to inactivate pathogens. Due to the potentially higher levels of pathogens and chemical contaminants in the WWTP effluent source water, TCEQ looks for at least two physical/removal treatment processes and two inactivation or oxidation treatment processes at each proposed DPR plant. The SWTRs regulate which treatments can provide removal or inactivation of pathogens.

Redundancy

If monitoring indicates that the treatment unit or the entire facility is failing to meet treatment standards or finished water quality goals, the unit process or the entire facility may need to be shut down. The public water system must still be able to meet customer demand even if the DPR plant is shut down. The drinking water may be supplied from existing SWTPs, wells, or from neighboring public water systems though purchase water contracts. If the public water system has limited sources of water, TCEQ suggests including redundant treatment units at the DPR plant. If a single unit is taken offline due to failure or maintenance, then additional units can continue to provide treatment.

Pathogen Treatment

Pathogens in drinking water can cause acute health impacts if the water is improperly treated, thus pathogen treatment is an important focus for DPR plants. TCEQ only approves DPR plants that propose treatment to remove or inactivate the site-specific percentage, or log, of each pathogen. Because DPR plants produce drinking water, TCEQ applies the EPA SWTRs which regulate the type of treatment and level of pathogen removal or inactivation for each treatment proposed for use at a DPR plant.

Pathogen Inactivation

Chemical disinfectants are used to inactivate *Cryptosporidium*, *Giardia*, and viruses in drinking water. Because there is no reliable method that is economically and technically feasible to measure pathogen concentrations, the EPA provides concentration contact time (CT) tables. These tables prescribe the CT (the disinfectant residual concentration in the water multiplied by the time the disinfectant is in contact with the water) needed to provide specific levels of inactivation. EPA's June 2020 Disinfection Profiling and Benchmarking Technical Guidance, Appendix B, provides CT tables for *Giardia* and virus inactivation for free chlorine, chloramines, ozone, and chlorine dioxide. Additionally, ultraviolet light (UV) dose tables are provided for *Cryptosporidium*, *Giardia*, and virus inactivation in the same document (EPA, 2020). The CT tables for *Cryptosporidium* inactivation with chlorine dioxide and ozone are provided in the Long Term 2 Enhance Surface Water Treatment Rule (LT2 (EPA, 2006)) and the EPA's LT2 Toolbox Guidance Manual[5]. Depending on the pathogen and disinfectant, the temperature and pH of the water may change the CT needed for inactivation. The EPA provides specific CT tables for these conditions.

For DPR facilities, TCEQ allows up to 6.0-log inactivation of *Cryptosporidium*, *Giardia* or virus for a single UV reactor based on achieving the UV dose in the tables provided in the April 2020 Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems (Wright, 2020) and based on the research shown in the EPA June 2003 Draft Ultraviolet Disinfection Guidance Manual (EPA, 2003). For DPR facilities, TCEQ will also allow a total of up to 6.0-log inactivation of *Cryptosporidium*, *Giardia,* or virus with chemical disinfectants in the entire facility. The maximum log inactivation by chemical disinfection in a single disinfection zone for *Giardia* is 3.0-log and for virus is 4.0-log. Inactivation of *Cryptosporidium* by chlorine

[5] www.nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1009JLI.txt

dioxide or ozone is limited to a maximum of 3.0-log per disinfection zone. A disinfection zone is a section of the system beginning at one disinfectant injection or monitoring point and ending at the next disinfectant injection or monitoring point.

EPA's LT2 requires public water systems to use UV reactors that have undergone validation testing. This validation testing must determine the operating conditions under which the reactor delivers the required UV dose for treatment credit [40 Code of Federal Regulations (CFR) 141.720(d)(2)]. These operating conditions must include flow rate, UV intensity as measured by a UV sensor, and UV lamp status. Validated operating conditions must account for UV absorbance of the water, lamp fouling and aging, measurement uncertainty of online sensors, UV dose distributions arising from the velocity profiles through the reactor, failure of UV lamps or other critical system components, and inlet and outlet piping or channel configurations of the UV reactor [40 CFR 141.720(d)(2)(i)]. Validation studies are performed by third party entities and submitted to TCEQ by the UV manufacturers for TCEQ approval. TCEQ reviews validation reports and approves those that comply with LT2 requirements. When a public water system determines which UV reactor it intends to install, the reactor chosen, the flow rate, ultraviolet light transmission of the water, requested pathogen inactivation, and other design specifications are provided to TCEQ. If the chosen reactor design and operating conditions match those in the validation study approved by the TCEQ, site-specific requirements for the UV system are included in the DPR exception. More information about the approval of UV for pathogen inactivation see TCEQ Regulatory Guidance (RG)-570 UV Disinfection for Pathogen Inactivation Credit[6].

Pathogen Removal

Under the SWTRs, every public water system must reliably and consistently provide the necessary treatment to achieve adequate *Cryptosporidium*, *Giardia,* and virus log removal or inactivation. TCEQ only approves DPR plants that propose treatment to remove or inactive a site-specific percentage, or log, of each pathogen. Removal can be achieved through coagulation, settling, or different types of filtration. The table below lists the removal credits of several media filtration methods and was adapted from EPA's Disinfection Profiling and Benchmarking: Technical Guidance (EPA, 2020) and EPA's LT2 Toolbox Guidance documents.

Table 1. Typical Removal Credits for Media Filtration

Process	*Giardia*	*Cryptosporidium*	*virus*
Conventional Treatment: Coagulation, flocculation, sedimentation, and media filtration	2.5	3.0	2.0
Direct Filtration: Coagulation, flocculation, and media filtration	2.0	2.5	1.0
Slow Sand Filtration	2.0	3.0	2.0

[6] www.tceq.texas.gov/downloads/drinking-water/plan-technical-review/guidance/rg-570.pdf

Process	*Giardia*	*Cryptosporidium*	*virus*
Diatomaceous Earth Filtration	2.0	3.0	1.0

The EPA's LT2 provided several additional filtration technologies for the removal of *Cryptosporidium*. Table 2 below lists the removal credits of several additional filtration methods listed in the LT2.

Table 2. Pathogen Removal Credits for Other Filtration

Process	*Giardia*	*Cryptosporidium*	virus
Bag Filters: up to 1 log removal credit with demonstration of at least 2 log removal efficiency in challenge test	0 to 1.0	0 to 1.0	0.0
Cartridge Filters: up to 2 log removal credit with demonstration of at least 3 log removal efficiency in challenge test	0 to 2.0	0 to 2.0	0.0
Membrane Filtration (Ultrafiltration and Microfiltration): Log removal credit is the lower of the removal efficiency demonstrated during challenge testing and the removal efficiency that can be verified through direct integrity testing.	0 to 5.5	0 to 5.5	0.0

The LT2 requires bag, cartridge, and membrane filters to be challenge tested—a process in which a known quantity of pathogens (or an acceptable surrogate) is added to the filter influent, and the effluent concentration is measured to determine the removal capabilities of the filter. This testing is product-specific, not site-specific, meaning it does not have to be tested at every water system seeking removal credit. Instead, a manufacturer (with an independent third party) would challenge test each of its products to obtain a challenge test log removal value.

Membrane filters have additional LT2 requirements beyond challenge testing to determine and verify their log removal efficiency. While challenge testing demonstrates the ability of an integral membrane filter to remove pathogens, breaches can develop in the membrane during routine operation that could allow the passage of microorganisms. To verify the removal efficiency of a membrane process during operation, direct integrity testing is required by the LT2. A direct integrity test (DIT) is a physical test for a membrane unit to identify integrity breaches. Each DIT must meet criteria for resolution, sensitivity, and frequency. The direct integrity method must have a resolution of 3 micrometers (µm) or less, which is based on the size of *Cryptosporidium*. The DIT sensitivity must be capable of verifying the proposed log removal. The DIT must be performed at a frequency of at least once per day. The DIT resolution and sensitivity must be approved by TCEQ. See the EPA Membrane Filtration Guidance Document (EPA, 2005) for more information about membrane challenge studies and DIT information. The EPA and TCEQ operational membrane requirements for SWTPs also apply to DPR plants and include the prohibition of producing water after a unit fails a DIT, and standards for continuous indirect integrity monitoring and calibration, amongst others.

Corrosion Control

EPA's Lead and Copper Rule (LCR) regulates the amount of lead in drinking water due to the potentially harmful long-term effects of elevated lead levels. Lead, copper, iron, asbestos, and other materials can enter drinking water when plumbing materials containing these compounds corrode. This corrosion occurs when the water has low pH, low mineral content, or other factors. The most common sources of lead in drinking water are lead pipes, faucets, and fixtures mostly found in older cities with homes built before 1986.

Corrosion is the dissolving or wearing-away of metal caused by a chemical reaction between water and plumbing. Some factors that impact how much metal enters the water include the water's chemistry (acidity, alkalinity, mineral content and concentration), the concentration of metals in the plumbing, the water's temperature, the wear on the pipes, how long water stays in the pipes, and protective scales or coatings inside the plumbing. One requirement of the EPA's LCR is corrosion control treatment to prevent lead and copper from contaminating drinking water. Corrosion control treatment makes drinking water less corrosive to the materials it comes into contact with while traveling to consumers' taps.

Various treatments at DPR plants that remove or oxidize chemical contaminants also remove or oxidize other minerals that can be needed to stabilize water. For example, reverse osmosis (RO) and nanofiltration (NF) membranes remove minerals such as calcium and magnesium and can produce a permeate water with a pH below 6. The resulting product water can be extremely corrosive.

Water produced by a DPR treatment plant may need to be stabilized so that it does not cause corrosion and has water quality similar to that distributed to the customers from the public water system's other sources. The water can be stabilized through a combination of treatments. Decarbonation, the removal of carbon dioxide, can increase pH but does not increase alkalinity. The addition of sodium hydroxide, also called caustic soda, can increase total alkalinity and pH, but not hardness. The addition of calcium oxide, also called lime, can increase alkalinity, hardness, and pH, but has operational challenges. Blending with treated water from traditional sources can stabilize water depending on the amount of water available to blend and the quality of that water. Finally, the chloride to sulfate ratio may need to be optimized or the public water system may need to add orthophosphate, especially if orthophosphate is added to the treated water from traditional sources (EPA, 2016).

Process for DPR Approval

As stated above, TCEQ can grant exceptions to requirements in Subchapter D based on 30 TAC 290.39(l), if the public water system can demonstrate that the exception will not compromise public health or result in a degradation of service or water quality. The use of wastewater effluent as a source for drinking water is reviewed on a case-by-case basis as an exception. An exception for the alternate treatments used in a DPR plant can only be granted based on pilot-scale test data as required by 30 TAC 290.42(g). Under no circumstances can water created during the pilot-scale study enter the drinking water distribution system.

The pilot-scale study is used to show that the chosen treatments and operating conditions will produce safe water. In the absence of this evidence, the water produced cannot be documented to be safe to drink. The sections below describe the steps for DPR plant approval which include: the pilot-scale study, plans and specifications reviews, and other steps. For TCEQ to fully understand the project and review it for exception approval all of these steps must be followed in order and all information requested must be provided.

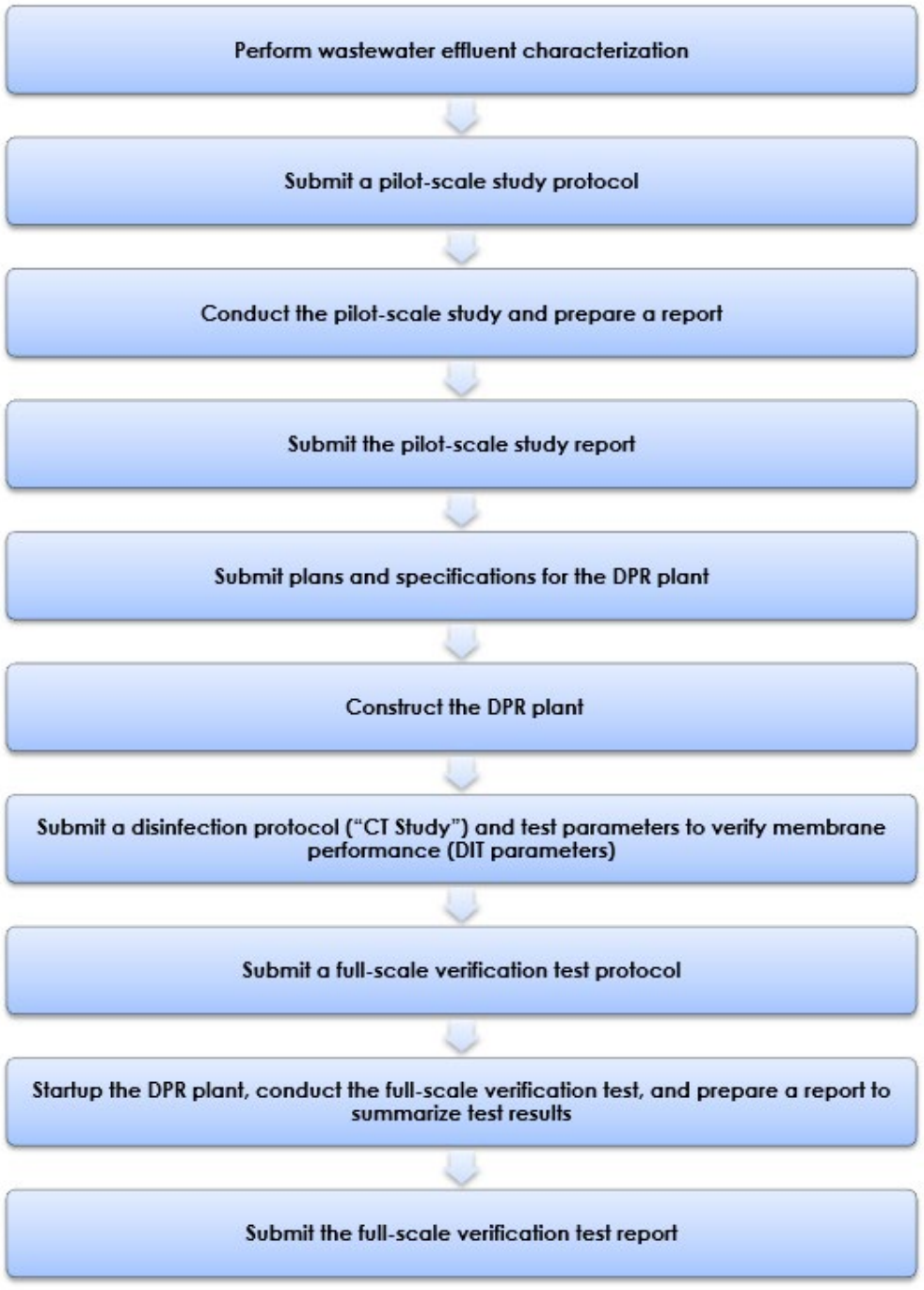

Figure 1. Sequence of Steps for DPR Plant Approval

Wastewater Effluent Characterization

Step one: The first step for the public water system is to perform sampling of the WWTP effluent to find the levels of chemicals and pathogens present. The sample results are used in conjunction with the pilot-scale study to obtain the exception. As shown in 290.42(g), the sampling must be conducted for at least 12 months to assess the WWTP effluent quality over the course of a year. This ensures any seasonal variations are captured. The maximum levels found are used to determine the amount of pathogen treatment that is needed. See Appendix A: Characterizing Wastewater Effluent Water Quality for Use as a Source of Drinking Water for the specific compounds to sample and the sample frequencies. Public water systems can submit a sampling plan for TCEQ to review before they begin sampling, but it is not necessary if the compounds, frequencies, analytical methods, and other items listed in Appendix A are followed.

TCEQ will review the sampling results. We recommend that the public water system submit them with the pilot-scale study protocol. When submitting the sample results, include the full lab reports complete with QA and QC. Additionally, include summary tables which contain: the compound name; analytical method; number of samples collected; range of dates; average, minimum and maximum sample results; and date the maximum result was collected.

Submitting a Pilot-Scale Study Protocol

Step two: TCEQ requires that the public water system submit a pilot-scale study protocol for review before beginning that study (30 TAC 290.42(g)). A pilot-scale study is a method of studying different ways of treating water on a small scale, in the field, and using the proposed source water.

The protocol must: state what the study will do and why it is being done. It should contain:

- A detailed plan of the DPR pilot-scale study.
- The source water quality.
- The goals for the finished water.
- The study's duration.
- Information about the proposed treatment units and proposed flows.
- The sampling plan.
- Any other pertinent information.

A professional engineer licensed in the state of Texas must submit the protocol, (30 TAC 290.42(g)). It should also include basic information such as the public water system's name and ID number, the location of the study, and proposed location of the full-scale plant. The protocol must also include detailed information about the proposed full-scale treatment train(s).

TCEQ reviews protocols and provides corrections and additions if needed. Review and approval of the protocol ensures all the necessary samples are included since it is extremely difficult, if not impossible, to collect the missing samples after the study has been completed.

Source Water and Drinking Water Quality Objectives

The wastewater effluent characterization sample results and drinking water quality goals determine the type and amount of treatment needed. The protocol must contain the following information:

- A summary of the wastewater effluent samples including:
    - Number of samples collected.
    - Frequency of collection.
    - Unit of the results.
    - Average, maximum, and minimum results of each sample type.
    - Sampling locations.
    - WWTP treatments in use when the samples were collected.
- The lab reports for the wastewater effluent samples.
- Detailed information about the WWTP including:
    - Location.
    - Full treatment train.
    - Outfall location.
    - WWTP permit.
    - Compliance history.
    - Any current reuse authorizations if used.
- The public water system's drinking water quality goals, including the characteristics needed to match the existing drinking water quality from other drinking water sources.

Duration of the Study

The protocol must include the schedule for the study, including a description of the goal of each phase. TCEQ approves exceptions when each treatment unit is operated for at least 30 days at the maximum flow rate using the cleaning and other operational parameters that will be used at the full-scale DPR plant. If the treatment will have an intensive cleaning (e.g., the clean-in-place process used for low pressure membrane filters), a cleaning must be performed as part of the study, along with an additional 10 days of operation. The operating data collected after the cleaning demonstrates the effectiveness of the cleaning.

Most pilot studies last longer than 30 days. DPR pilot-studies may last 6 months or more, to test the equipment during different seasons as WWTP effluent quality can change. Additionally, pilot studies are used to test different treatment units to see which one or which combination of treatment units have the best performance. Additional time is used to optimize the flow rate, backwashes, and other operation parameters. Finally, additional time has been used to familiarize and educate operators and the public on the DPR project.

Treatment Train(s)

The protocol must include the following information:

- A detailed diagram of the pilot-scale treatment trains from the raw source to the finished water including:
    - Sample collection locations.
    - Monitoring points.
    - Chemical injection points.
    - Any pretreatment or post-treatment.
    - Flow measuring devices.
    - Flow control valves.
    - Pump(s).
    - Media vessels.
    - Membrane units.
    - Waste streams.
    - Backwash or regeneration sources.
    - Any other equipment needed to operate the treatment process.
- The configuration of the treatment trains that will be tested during each phase of the study if the treatment types or sequences will change.
- The disposal methods for all of the wastes and permeate.
- The treatment processes proposed for the full-scale DPR plant, except for UV or chemical inactivation solely for pathogen inactivation, since adequate data about pathogen inactivation is available in the CT-Tables provided by the EPA.
- Some chemical disinfectants should be included in the study because their oxidation effects can potentially impact water quality and down-stream treatment performance. If the disinfectant may have an impact provide:
    - the injection location
    - downstream treatments
    - potential impacts.

If the study will test different types of treatments for the same compound in parallel, samples must be collected from the effluent of each treatment type. For example, if the study will compare nitrate removal using biological denitrification and RO, samples for nitrate must be collected from the effluent from the biological process unit and from the effluent of the RO unit. A single sample collected after the point where the two effluents combine would not allow a public water system to understand which process performs better. Additionally, the impact of any differences in the effluents' water qualities will be obscured if they are blended before entering the next stage of treatment. To avoid this problem, a public water system can test these types of treatment units in different phases of the study.

Treatment Units

For each treatment unit, the protocol must include the following information: the purpose, vendor, make and model number, the proposed design parameters, and proposed operating parameters. The parameters include: feed water quality needs and associated pre-treatment needs; flows; cleaning procedures; monitoring; and stabilization. See below for typical design and operating parameters for specific treatment technologies proposed for use at DPR plants.

Low-Pressure Membrane Units

Drinking water treatment units have manufacturer requirements for feed water quality. Depending on the process, specific compounds need to be limited in the feed water for the treatment to function properly or function optimally. For some treatments, parameters such as pH and total solids need to be in a specific range. These compounds or parameters are monitored in the feed water and pre-treatment is installed if necessary to adjust the feed water quality.

Constituents in the feed water of low-pressure membrane units (ultrafiltration and microfiltration) can cause fouling on the membrane surface and limit flow. Each membrane model can be impacted differently by the different levels and combinations of compounds, so the protocol must be customized to monitor the membrane model specific compounds. The EPA Membrane Filtration Guidance Manual (MFGM) identifies the following feed water constituents and parameters to monitor: turbidity, total organic carbon (TOC), temperature, pH, total suspended solids (TSS), alkalinity, calcium, iron, magnesium, manganese, silica, and sulfate. Depending on the levels detected, pretreatment may be proposed, and different customized backwash and cleaning types and durations can be analyzed and optimized (EPA, 2005).

The protocol must include:

- Monitoring all of the following:
    - feed flow rate
    - feed water temperature
    - feed pressure
    - filtrate pressure
    - hydraulic configuration of the unit
- The calculations for flux, transmembrane pressure, temperature-corrected flux at 20˚ C, and temperature corrected specific flux.
- The information needed to calculate the capacity of the membrane units including recording the total time a unit is not producing water and the amount of filtrate used per unit for each of the following:
    - Backwash.
    - Any maintenance cleanings.
    - Direct integrity testing.

      Any other event that occurs more frequently than once per 30 days when a membrane unit is not able to produce water.

- To receive credit for pathogen removal, the public water system can choose membrane units that have already received TCEQ approval of their challenge studies. Alternatively, the public water system can include a challenge study for review in the protocol.
- The equipment for continuous monitoring each low-pressure membrane unit's effluent turbidity with the readings recorded every 5-minutes.
- To show that the membrane units do not contain breaches, include the performance of a daily DIT, and the calculations used to determine the DIT parameters for the study unit(s).
- The collection of the following information for each DIT performed:
    - The date and time all DITs are initiated,
    - The starting and ending pressure,
    - The duration of the test.
    - Corrective actions performed due to the DIT results.

High-Pressure Membrane Units

Similar to the low-pressure membrane units, constituents in the feed water of high-pressure membrane units (reverse osmosis (RO) and nanofiltration (NF)) can cause fouling. Due to the smaller pores of RO and NF modules, the same feed levels can cause more fouling in high-pressure units than in low-pressure membrane units. Additionally, many RO and NF membrane modules can be harmed by chlorine, so the feed may need to be dechlorinated. The EPA MFGM provides the following as feed water constituents and parameters to monitor: turbidity, TOC, temperature, pH, silt density index (SDI), total dissolved solids (TDS), alkalinity, aluminum, ammonia, barium, calcium, iron, magnesium, manganese, potassium, sodium, strontium, chloride, fluoride, nitrate, silica, and sulfate. Depending on the levels detected, pretreatment (e.g., antifoulant addition) may be needed.

The protocol must include:

- Monitoring of all the following:
    - Feed flow rate.
    - Feed water temperature.
    - Permeate flow rate.
    - Concentrate flow rate.
    - System pressures.
    - Hydraulic configuration of the unit.
- The calculations for flux, net driving pressure, and temperature-corrected flux at 25° C.
- Effluent monitoring for TDS.
- Effluent monitoring for the constituents of concern that the unit is proposed to remove.
- Concentrate monitoring to assist with concentrate disposal.
- At least one parameter that can indicate the membrane unit has a breach and can be used to trigger a shutdown of the unit.

Biological Filter Units

Biological filters are media filters with microbial growth (biofilm) that can consume organic matter. In biofilters used for biological denitrification, nitrate is converted to nitrogen. Granular activated carbon (GAC) is often used to provide the necessary surface to promote the development of biofilm. Biological filters remove contaminants by three main mechanisms: biodegradation, adsorption of micropollutants, and filtration of suspended solids. Biofiltration is normally preceded by the addition of ozone or other strong oxidant, as the oxidant converts some of the total organic carbon (TOC) to biodegradable dissolved organic carbon (BDOC). Key feed water quality parameters are temperature, pH, calcium carbonate, iron, manganese, alkalinity, turbidity, dissolved oxygen, and BDOC. Pretreatment to prevent fouling of the GAC, or the addition or changing of other feed water quality parameters, may be needed to optimize the treatment.

The protocol must include:

- Monitoring of the following:
    - Feed flow rate
    - Feed water temperature
    - Dimensions of the unit
    - Filter loading rate
- Recording of information about each backwash, including:
    - The length of each filter run.
    - The length of each backwash.
    - The flow rate for each backwash.
    - Any other information about the backwash or about filter-to-waste, if used.
- If the public water system wants the filter unit to receive credit for pathogen removal, the continuous monitoring of turbidity with the readings recorded every 15-minutes.
- Recording of TOC and other constituents of concern the unit is proposed to remove.

Ozone and Chlorine Dioxide

Ozone and chlorine dioxide are strong oxidants. Use of these chemicals can change water quality. Therefore, if the DPR plant will use these chemicals, it is recommended that they be included in the study so the impact on down-stream treatment is understood. Please note that the EPA provides CT tables to be used for calculating the amount of inactivation that can be achieved based on the concentration of the oxidant and the time it is in contact with water. The protocol must include:

- The proposed equipment manufacturer.
- The dimensions of the contact chamber.
- The flow rate.
- If ozone is applied, monitoring for:
    - The feed water bromide and TOC levels.

The ozone feed rate.
    - pH.
    - Temperature.
    - Ozone residual.
    - Effluent bromate concentration.
- If chlorine dioxide is applied, monitoring for:
    - The chlorine dioxide feed rate.
    - pH.
    - Temperature.
    - Effluent chlorine dioxide residual.
    - Chlorite concentration.

Ultraviolet Light with and without Advanced Oxidation

If the public water system wants to include a UV reactor in the DPR plant and for it to receive credit for pathogen inactivation, the protocol can include a reactor that has already received TCEQ approval of its validation study or can include the validation study for review. Though UV has EPA-approved doses for pathogen inactivation, the public water system may want to pilot test UV or UV with advanced oxidation. The advanced oxidation process (AOP) is the use of UV with hydrogen peroxide (H_2O_2) to generate hydroxyl radicals (-OH). AOP can destroy many micropollutants through direct chemical oxidation. The protocol must include:

- Feed water monitoring for UV transmittance (UVT).
- Flow rate.
- All the parameters needed to calculate the UV dose based on the formulas in the validation study.
- Effluent chemical monitoring for the constituents of concern proposed to be inactivated by the process.

Ion Exchange Units

Ion exchange[7] (IX) processes are reversible chemical reactions for removing dissolved ions from solution and replacing them with other similarly charged ions typically in a pressure vessel filled with a specific IX resin. Contaminants such as hardness, nitrate, fluoride, sulfate, arsenic, and others can all be removed by IX, which is typically used for targeted removal of specific compounds. When the capacity of the resin is exhausted, it is necessary to regenerate and return the resin to its initial condition. Competition for ion exchange sites on a resin can greatly impact a system's efficiency in removing the target compounds, and at worst case can cause a slug of the target compound to release into the effluent. The choice of resin used must take into account the feed water quality to avoid competition or release issues. Relative affinities of common ions listed from highest to lowest include: silver, cesium, potassium, sodium, and lithium; barium, strontium, calcium, and magnesium; and iodine, nitrate, cyanide,

[7] www.tdb.epa.gov/tdb/treatmentprocess?treatmentProcessId=263654386

hydrogen sulfate, nitrite, chlorine, and bicarbonate. Scaling of minerals, chemical precipitants, and surface clogging all lead to resin fouling. Pretreatment measures such as filtration of suspended solids, or addition of chemicals to reduce scaling, may be needed.

The protocol must include:

- The contaminant to be removed by the IX process.
- The monitoring upstream and downstream of the unit to document effectiveness of the treatment.
- Monitoring of the feed flow rate for competing ions.
- Dimensions of the unit.
- The empty bed contact time,
- The recording of information about each backwash or regeneration including:
    - The time or flow between cleanings.
    - The length of each backwash or regeneration.
    - The backwash or regeneration procedure
    - Any other information about the backwash.

Stabilization

As stated above, treatments at DPR plants to remove or oxidize harmful chemicals can also remove or oxidize other minerals that may be needed to stabilize water. To reduce the risk of metal corrosion and to match the water quality of the public water system's other sources, the plant will most likely have to stabilize the water. The methods to stabilize water are discussed in the EPA Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems[8] in detail.

The protocol must include:

- Finished water sampling for the corrosion screening water quality parameters of: conductivity, TDS, pH, temperature, alkalinity, chloride, sulfate, calcium and sodium.
- If including plans for coupon or pipe loop testing of different stabilization methods for comparison include:
    - The different treatments.
    - The method for running the study.
    - The dosage of different chemicals injected.
    - The samples to be the collected in the feed and effluent to compare the different treatments effectiveness.

[8] www.epa.gov/dwreginfo/optimal-corrosion-control-treatment-evaluation-technical-recommendations

Calibration and Certification

All flow-measuring devices, turbidimeters, pressure sensors, and other on-line monitoring equipment must be calibrated prior to the study per the manufacturer's recommendations. Calibration assures accurate measurements with reduced uncertainty. All verifications required by TCEQ rules must occur during the study and be documented in the pilot-study report.

All treatment chemicals and media used in the study must conform to American National Standards Institute/NSF International (ANSI/NSF) Standard 60 for Drinking Water Treatment Chemicals and ANSI/NSF Standard 61 for Drinking Water System Components and must be certified by an organization accredited by ANSI as specified by several citations in 30 TAC 290: Subchapter D. Documentation demonstrating compliance with these requirements must be included in the pilot-study report.

Sampling Plan

The protocol must include a sampling plan that comprises:

- A summary of all the samples to be collected during the study. The summary is typically displayed as a table that lists:
    - The samples to be collected.
    - The sampling locations.
    - The frequency of sample collection.
    - The analytical method proposed.
    - Whether the sample will be analyzed in a laboratory or on-site.
- The samples to be collected in the WWTP effluent and the samples to be collected in the study plant's finished water which must include the regulated compounds found in 30 TAC 290.104 and 290.105 at least three times during the study.
- The sampling based on the treatment specific monitoring requirements listed in the treatment unit section.
- The sampling for *Cryptosporidium*, *Giardia,* and viruses in the raw water and finished water, and also after each treatment unit proposed for pathogen treatment.
- The regulatory requirements listed in TCEQ rules. Many treatment units have regulatory monitoring requirements that test if the unit is performing adequately. For example, UF/MF membrane units have a combination of turbidity and DIT test requirements as specified in 30 TAC 290.101(f).
- The sample collection for proposed shut-down trigger monitoring in the raw water, finished water, and after any proposed treatment without regulatory requirements.

The off-site laboratories must be accredited by the State of Texas under the National Environmental Laboratory Accreditation Program (NELAP) and use methods approved by EPA[9] to analyze drinking water samples, where available as specified by 30 TAC 25.1.

[9] www.epa.gov/dwanalyticalmethods/approved-drinking-water-analytical-methods

Conducting the Pilot-Scale Study

Step three: After TCEQ has reviewed and approved the protocol, the public water system should proceed with the pilot-scale study. TCEQ staff are available to assist with any questions that might arise during the course of the study. Following the study, the results should be compiled, analyzed, and packaged into a pilot-study report.

Submitting the Pilot-Scale Study Report

Step four: When TCEQ reviews a DPR pilot-study report, if all the information is present, TCEQ can grant all of the project's necessary exceptions. If not all the decisions about which treatment units will be used or the order of the treatment units have been made, additional submittals can be provided until all the needed exceptions have been granted.

The report must include:

- All the information, documents, and sample results proposed in the protocol.
- A summary of the study.
- The treatment train chosen for the full-scale facility.
- An analysis of the data in the form of tables and graphs.
- The raw data in Microsoft Excel format on a compact disc, universal serial bus (USB) flash drive, or electronic transfer.
- A discussion of each treatment included in the study, the performance of each treatment unit, and the basis for how the final treatment train was chosen.

Submitting DPR Plant Plans and Specifications

Step five: TCEQ's review of plans and specifications is based on the requirements in the Rules and Regulations for Public Water Systems in 30 TAC, 290, Subchapter D and the conditions included in the granted exceptions as specified in 30 TAC 290.39(d). Plans, specifications, and related documents must be prepared under the direction of a licensed professional engineer. All engineering documents must have engineering seals, signatures, and dates affixed in accordance with the rules of the Texas Board of Professional Engineers. Upon completion of the review of plans and specifications for the DPR plant, TCEQ will approve the public water system to construct the plant.

DPR Plant Construction

Step six: After TCEQ has reviewed and approved the plans and specifications, the public water system can construct the DPR plant. TCEQ staff are available to assist with any questions that might arise during construction. During the construction the public water system can begin compiling the information needed for the CT study, the DIT parameters (if UF or MF membranes are used), and the verification study protocol.

CT Study and DIT parameters

Step seven: The performance of a water treatment plant's disinfection process is evaluated in a CT study based on analyses of the concentration (C) of a disinfectant and the theoretical contact time (T) of a disinfectant used in each stage of treatment. The purposes of the CT study are to: identify the number of disinfection zones at the DPR plant; determine the effective contact time for each disinfection zone; calculate crucial CT parameters to track the plant's daily disinfection performance; and determine the plant's total disinfection ability. When the DPR plant is approximately 90 percent complete or at least 6 months from startup, the public water system can submit a CT study. You can find the electronic template to assist the public water system at the webpage Concentration-Time Study for Water Treatment Plants[10]. TCEQ reviews and approves CT studies after construction is substantially complete because the CT is based on contact time. Contact time is calculated from the accurate measurements of treatment units and length of pipes, which may change during construction.

If the public water system is proposing microfiltration or ultrafiltration membrane units for pathogen treatment, DIT parameters must also be submitted for review and approval as specified in 30 TAC 290.101(f). DIT parameters should be submitted after the membrane units and associated systems have been installed or at least 6 months from startup.

Full-Scale Verification Test Protocol

Step eight: The exception will contain a condition requiring a full-scale verification test (FSVT) once construction of the DPR plant is complete. The FSVT is a trial of the plant's treatment units, data recording, and alarms systems to ensure the plant can meet all regulatory requirements. Before beginning a DPR FSVT, submit a full-scale verification test protocol for review. The FSVT protocol must include:

- A detailed plan of the DPR FSVT.
- The FSVT duration of at least 14 days.
- Operation of at least one unit of each treatment process.
- A sampling plan that includes all the regulatory sampling requirements listed in TCEQ Drinking water rules and the granted exception,
- The sampling required in the Plan Review Step 2 for Surface Water Plants[11] and Step 2 for RO and NF membranes checklists[12],
- A test for all regulatory alarms and shutdowns,
- Completion of all required operating reports.

[10] www.tceq.texas.gov/drinkingwater/swmor/swmor/
[11] www.tceq.texas.gov/downloads/drinking-water/plan-technical-review/forms/checklist-surface-water-plant-step2.pdf
[12] www.tceq.texas.gov/downloads/drinking-water/plan-technical-review/forms/checklist-membrane-use-step2.pdf

Conducting the Full-Scale Verification Test

Step nine: After TCEQ has reviewed and approved the FSVT protocol, the public water system can conduct the test. TCEQ may conduct a site visit during the FSVT. The visit would witness the FSVT, assess the data system and reporting practices, and assist with any trouble shooting or questions. Any corrections requested by TCEQ staff during the site visit should be included in the FSVT Report.

Submitting the Full-Scale Verification Test Report

Step ten: The FSVT report must include:

- All the information, documents, and sample results proposed in the TCEQ-approved FSVT protocol,
- A summary of the FSVT and an analysis of the data in the form of tables and graphs,
- The raw data in Microsoft Excel format on a compact disc, universal serial bus (USB) flash drive, or electronic transfer,
- The standard operating procedures pertaining to regulatory requirements,
- The on-going alarm and shut-down testing plans and schedules.

If the FSVT report is acceptable, TCEQ will respond with approval to use the DPR plant. This approval will explicitly state that the finished water from the DPR plant may be delivered to customers.

Conclusion

All drinking water professionals strive to protect public health. Whether the water source is groundwater, surface water, or wastewater effluent, the drinking water produced must be of a quality that is suitable for human consumption. Because wastewater effluent may have a higher pathogen and chemical load than any other type of source water, every aspect of treatment, monitoring, and responses to triggers must be more robust, frequent, and rapid to ensure safe DPR operations.

References

EPA. (1989). Surface Water Treatment Rule. *Federal Register, 54*(124), 27544.
EPA. (1998). Interim Enhanced Surface Water Treatment Rule. *Federal Register, 63*(241), 69477.
EPA. (1999). *Guidance Manual for the Control of Wastes Hauled to Publicly Owned Treatment Works.* Washington DC: US Environmental Protection Agency.
EPA. (2003). *Ultraviolet Disinfection Guidance Manual.* Washington DC: US Environmental Protection Agency.
EPA. (2005). *Membrane Filtration Guidance Manual.* Washington DC: US Environmental Protection Agency.
EPA. (2006). Long Term 2 Enhanced Surface Water Treatment Rule. *Federal Register, 71*(3), 654.

EPA. (2020). *Disinfection Profiling and Benchmarking Technical Guidance Manual.* Washington DC: US Environmental Protection Agency.

Regli, S., Rose, J., Haas, C., & Gerba, C. (1991). Modeling the Risk From Giardia and Viruses in Drinking Water. *Journal AWWA, 83*(11), 76-84.

WateReuse. (2015). *Framework for Direct Potable Reuse.* Alexandria: WateReuse Research Foundation.

Wright, H. M. (2020). *Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems.* Washington, DC: U.S. Environmental Protection Agency. Retrieved from https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=349759&Lab=CESER

Appendix A:

Characterizing Wastewater Effluent Water Quality for Use as a Source of Drinking Water

Purpose of Wastewater Effluent Characterization

Texas rules require that any entity proposing to use a new source of water for a public water system must identify the quality of that source water (Title 30, Texas Administration Code (30 TAC), 290.41(a), 290.41(c)(3)(G), 290.41(e)(1)(F)-(G)). Wastewater effluent is, by definition, impacted by fecal microbes and chemicals of human origin. Therefore, the quality of wastewater effluent is characterized to document the level of such pollutants.

Texas adopts specific rules under 30 TAC Chapter 210 – Use of Reclaimed Water for reclaimed water quality. However, the 30 TAC Chapter 210 standards only address the chemical and microbial constituents of concern for non-potable uses. Drinking water rules in 30 TAC Chapter 290 are based on the removal of constituents at levels typically found in ambient water, which can be different than concentrations of the same constituents in wastewater effluent.

This document provides guidance for site-specific monitoring of currently regulated contaminants (Table 1) and contaminants which the EPA is taking action to address in drinking water (Table 2) for public water systems that are considering the use of wastewater effluent as a source for drinking water.

Locations

Collect the water samples at a location such that the water collected will be representative of feed water for the DPR plant. For example, if wastewater effluent will be blended with a groundwater source, then the samples should be collected where the two sources blend together. Alternatively, the two sources' samples should be collected and analyzed separately, and the final results should be calculated based on the proposed percentage of each water source. *Additionally,* a map showing the sampling locations, and a list describing the sample location(s) should be provided to the TCEQ when the effluent characterization report is submitted.

Frequency

A single 'snapshot' view of water quality is not sufficient for characterization. Instead, periodic sampling is needed to provide sample results representative of water during all seasons. To characterize seasonal variation, wastewater effluent sampling should include:

- The microbes shown in Table 1, nitrate, and nitrite at least 24 times at approximately equal intervals over a period of at least one year.

- Ammonia, trihalomethanes, hardness, total dissolved solids, and alkalinity on a monthly basis. Temperature and pH results should be provided for all collected samples.
- The remaining constituents on Table 1 and Table 2 at least four times over the same one-year period: once in the summer at the hottest temperature, once in the winter at the lowest temperature, and once in spring and fall at the midpoints.
- Any sample results for compliance with a current wastewater permit.

Analytes and Analytical Methods

There are two tables shown below. Table 1 provides a list of the regulated compounds while Table 2 includes contaminants which the EPA is taking action to address in drinking water. **Methods listed in these tables are recommendations; other approved EPA methods exist and may be proposed for use.**

The laboratories used must be accredited by the State of Texas under the National Environmental Laboratory Accreditation Program (NELAP) and use methods approved by EPA[13] to analyze drinking water samples, where available as specified by 30 TAC 25.1. If the public water system wishes to sample for compounds or parameters without EPA approved methods, include complete documentation of the proposed analytical method's step-by-step process.

Table 1. Regulated Analytes

Microbes	**Method**	**Frequency**
Bacteria		
Total coliform - enumeration [1]	Standard Methods (SM)[2] 9223B	Twice a month
Escherichia coli – enumeration (E. coli) [1]		
Heterotrophic plate count (HPC)	SM 9215B	
Viruses		
Total culturable viruses	EPA Method 1615	Twice a month
Enterovirus		
Norovirus		
Protozoans:		
Cryptosporidium	EPA Method 1623	Twice a month
Giardia		
Chemicals	**Method**	**Frequency**
Disinfection byproducts		
Total trihalomethanes	EPA Method 524	Monthly
Haloacetic acids [3]	EPA Method 552	
Inorganic chemicals		
Nitrate and nitrite (as nitrogen)	EPA Method 353	Twice a month
Metals [4]	EPA Method 200.5[5]	Monthly
Minerals [6]	EPA Method 300.0[5]	
Cyanide	EPA Method 335.4	

[13] www.epa.gov/dwanalyticalmethods/approved-drinking-water-analytical-methods

Free available ammonia (as nitrogen)	Meets the requirements of 30 TAC 290.110(d)(3)[7]	Monthly
Asbestos [8]	EPA Method 100.2	
Disinfectant residual (if wastewater is disinfected)	Applicable method	Daily
Organic chemicals		
Volatile organic chemicals (VOCs) [9]	EPA Method 524.4	Twice
Synthetic organic chemical (SOC) Semivolatiles Group [10]	EPA Method 525.3 EPA Method 508[11]	Twice during probable application periods [12]
SOC Chlorinated Acid Group [13]	EPA Method 515.4[14]	
SOC N-Methylcarbamoyloximes and N-Methylcarbamates Group [15]	EPA Method 531.2	
EDB/DBCP (ethylene dibromide and dibromochloropropane)	EPA Method 504.1	
Glyphosate	EPA Method 547	
2,3,7,8-TCDD (Dioxin)	EPA Method 1613	
Diquat and paraquat	EPA Method 549.2	
Endothall	EPA Method 548.1	
Water Quality Parameters	**Method**	**Frequency**
Alkalinity, hardness, magnesium, calcium, and orthophosphate or silica if applied to the drinking water.	30 TAC 290 40 CFR 141.23 EPA Approved Methods[16]	Monthly
pH and temperature (field measurements using an EPA approved method)		With every sample

1. All EPA-approved methods for Total Coliform and E.coli are listed on EPA's Approved Drinking Water Analytical Methods website[14].
2. Standard Methods for the Examination of Water and Wastewater, 21st, 22nd, 23rd and Online Editions, American Public Health Association (APHA, 2005; 2012; 2017).
3. Haloacetic acids including the group of five regulated species plus bromodichloramethane.
4. Regulated primary metals include antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, selenium, sodium, and thallium. Regulated secondary metals include aluminum, copper, iron, manganese, silver, zinc.
5. Either the method shown or any of the appropriate methods approved[15] in Title 40 Code of Federal Regulations (40 CFR) Section 141.23 may be used for analysis.
6. The regulated primary mineral is fluoride. Regulated secondary minerals are fluoride, chloride, sulfate, and total dissolved solids. Total dissolved solids cannot be analyzed using EPA Method 300.0.
7. The free ammonia level must be measured to a minimum accuracy of plus or minus 0.1 mg/L.
8. If asbestos/cement pipe is used in drinking water distribution, wastewater collection, or associated piping. Best Practice is to sample for this analyte.
9. VOCs include 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-Dichloroethylene, 1,2-dichloroethane, 1,2-dichloropropane, 1,2,4-trichlorobenzene, benzene, carbon tetrachloride, cis-1,2-dichloroethylene, dichloromethane, ethylbenzene, monochlorobenzene, o-dichlorobenzene (1,2-dichlorobenzene), para-dichlorobenzene (1,4-dichlorobenzene), styrene, tetrachloroethylene, toluene, trans-1,2-dichloroethylene, trichloroethylene, vinyl chloride, and xylenes.
10. Semivolatile SOCs include: alachlor, atrazine, benzo(a)pyrene, chlordane, di(2-ethylhexyl)adipate, di(2-ethylhexyl)phthalate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene (HCB), hexachlorocyclopentadiene, lindane, methoxychlor, pentachlorophenol (PCP), polychlorinated biphenyls (PCB), simazine, and toxaphene.
11. The extraction conditions of this method are comparable to EPA Method 608, which does measure the multicomponent constituents: commercial polychlorinated biphenyl (PCB) mixtures (Aroclors), toxaphene, and chlordane. The extract derived from this procedure may be analyzed for these constituents by using the gas chromatography (GC) conditions prescribed in either EPA Method 608 (packed column) or EPA Methods 505, 508.1, or 525.2 (capillary column).

[14] www.epa.gov/dwanalyticalmethods/approved-drinking-water-analytical-methods
[15] www.epa.gov/dwanalyticalmethods/approved-drinking-water-analytical-methods

12. SOC groups representing herbicides should be collected during the periods of time when they are most likely to be applied in the local area of the public water system.
13. Chlorinated acid SOCs include: 2,4-D, 2,4,5-TP (Silvex), Dalapon, Dinoseb, picloram, and dicamba.
14. Please note that this method will provide analytical results for chlorinated acid SOCs; however, analysis of additional unregulated SOCs may be provided with this method. We recommend the public water system contact their laboratory to determine if these additional unregulated SOCs may be included with the analysis.
15. Methylcarbamoyloximes and N-Methylcarbamates include Aldicarb, Aldicarb sulfone, Aldicarb sulfoxide, Carbaryl, Carbofuran, 3-Hydroxycarbofuran, Methiocarb, Methomyl, 1-Naphthol, oxamyl (Vydate), and Propoxur.
16. The methods approved in the system's TCEQ-approved Monitoring Plan (30 TAC 290.121) should be utilized. Instruments used for 'approved-laboratory' analyte testing must be maintained in accordance with the minimum operating conditions and calibration frequency (30 TAC 290.46).

Table 2. Contaminants Which the EPA is Taking Action to Address

Analyte	Method	Frequency
Per- and polyfluoroalkyl substances (PFAS)[1]	EPA Method 533/537.1[2]	Monthly

1. Per- and polyfluoroalkyl substances (PFAS)
2. EPA Method 533 can analyze up to 26 PFAS analytes (including short-chain PFAS). EPA Method 537.1 can analyze up to 18 PFAS analytes. Since these two methods may capture both long- and short-chain PFAS, the TCEQ recommends that the public water system analyze and provide results for as many PFAS analytes as possible. At a minimum, the following PFAS analytes should be provided: perfluorooctanesulfonic sulfonate (PFOS), perfluorooctanoic acid (PFOA) perfluorononanoic acid (PFNA) perfluorohexanesulfonic acid (PFHxS) perfluoroheptanoic acid (PFHpA) perfluorobutanesulfonic acid (PFBS).Including Perfluorooctanesulfonic sulfonate (PFOS), perfluorooctanoic acid (PFOA) perfluorononanoic acid (PFNA) perfluorohexanesulfonic acid (PFHxS) perfluoroheptanoic acid (PFHpA) perfluorobutanesulfonic acid (PFBS).

In February 2021, the EPA announced their commitment to address and regulate per- and polyfluoroalkyl substances (PFAS) by repurposing the Fifth Unregulated Contaminant Monitoring Rule (UCMR 5) to include 29 PFAS and reissuing final regulatory determinations for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). (EPA, 2021)

EPA method 537.1 was released in 2018 and updated in 2020 to version 2.0. Currently, this updated method can be used to test for 18 PFAS in drinking water. In late 2019, EPA Method 533 was announced to complement EPA Method 537.1 by testing for 11 additional PFAS compounds, focusing on "short chain" PFAS. Using both methods, a total of 29 unique PFAS can be effectively measured in drinking water. (EPA, 2022)

Bibliography

APHA. (2005). *Standard Methods of the Examination of Water and Wastewater* (21st ed.). Washington, DC: American Public Health Association.

APHA. (2012). *Standard Methods for the Examination of Water and Wastewater* (22nd ed.). Washington, DC: American Public Health Association.

APHA. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). Washington, DC: American Public Health Association.

EPA. (2021). *EPA Takes Action to Address PFAS in Drinking Water*. Retrieved from https://www.epa.gov/newsreleases/epa-takes-action-address-pfas-drinking-water

EPA. (2022). *PFAS Analytical Methods Development and Sampling Research*. Retrieved from https://www.epa.gov/water-research/pfas-analytical-methods-development-and-sampling-research