Connecticut
Department of Energy &
Environmental Protection

Connecticut Reuse Design Manual

Prepared for:
Design Engineers & Treatment Operators

Prepared by:
Connecticut Department of Energy & Environmental Protection

Bureau of Materials Management & Compliance Assurance

Water Permitting & Enforcement Division

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Disclaimer: On July 1, 2014, Public Act 14-163, "An Act Concerning the Responsibilities of the Water Planning Council," became effective in the State of Connecticut. The Act directs the Water Planning Council (WPC) to develop a State Water Plan in accordance with 17 specific requirements: "Not later than July 1, 2017, the Water Planning Council, established pursuant to section 25-33o, as amended by this act, shall, within available appropriations, prepare a state water plan for the management of the water resources of the state." Action No. 10, requires the WPC to "Develop a water reuse policy with incentives for matching the quality of the water to the use." This document is not the state's reuse policy rather DEEP's technical guidance manual for permitting and engineering as reclaimed projects are presented to the Department.

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1.0 National Outlook for Non-Potable Water Reuse

Non-potable water reuse is a growing national priority as states seek resilient, cost-effective ways to manage water demands amid population growth, climate variability, and aging infrastructure. Across the U.S., utilities, regulators, and industry are turning to non-potable reuse to supplement existing water supplies and reduce the demand on potable systems. In this context, non-potable reuse is not just a sustainability strategy, it is a fundamental tool for long-term water security.

1.1 National Trends Driving Adoption

1.1.1 Drought and Water Scarcity

The Western U.S. has historically led the way in water reuse due to persistent drought. However, water-stressed regions in the Midwest and East Coast are also adopting reuse as part of broader diversification strategies.

1.1.2 Decentralized Infrastructure Opportunities

Building-scale and district-scale non-potable reuse systems are becoming common in new developments and urban retrofits, offering flexibility and resilience.

1.1.3 Federal and Interagency Coordination

The U.S. Environmental Protection Agency's Water Reuse Action Plan (EPA, 2020) and updates to Clean Water Act permitting guidance have paved the way for integrating reuse into national water policy initiatives and infrastructure funding opportunities.

1.1.4 Regulatory Innovation

A majority of States have established comprehensive non-potable reuse frameworks, regulations, or guidelines providing regulatory models for others — including Connecticut — to adapt.

1.2 Connecticut's Strategic Perspective and Alignment with the State Water Plan

Connecticut views non-potable reuse as a tool for sustaining its water resources amid population growth, urban expansion, climate change, and water quality challenges. The 2018 Connecticut State Water Plan and Nonpoint Source Management Plan identify reclaimed water as a tool for resilience, protecting drinking water supplies, and reducing pollutant loads to sensitive waters such as Long Island Sound.

1.2.1 Preserving Drinking Water for Essential Uses

Non-potable reuse protects Connecticut's drinking water sources by substituting reclaimed water for uses such as cooling tower makeup, restrooms, or data centers.

1.2.2 Advancing "One Water" Thinking

A "One Water" approach treats all water — wastewater, stormwater, and potable — as a single managed resource. Non-potable reuse enables this approach by:

- Creating closed-loop systems.
- Reducing reliance on inter-basin transfers or emergency potable supplies.
- Facilitating watershed-scale infrastructure planning that aligns with stormwater BMPs, development goals, and ecological streamflow needs.

1.2.3 Building Climate Resilience into Water Infrastructure

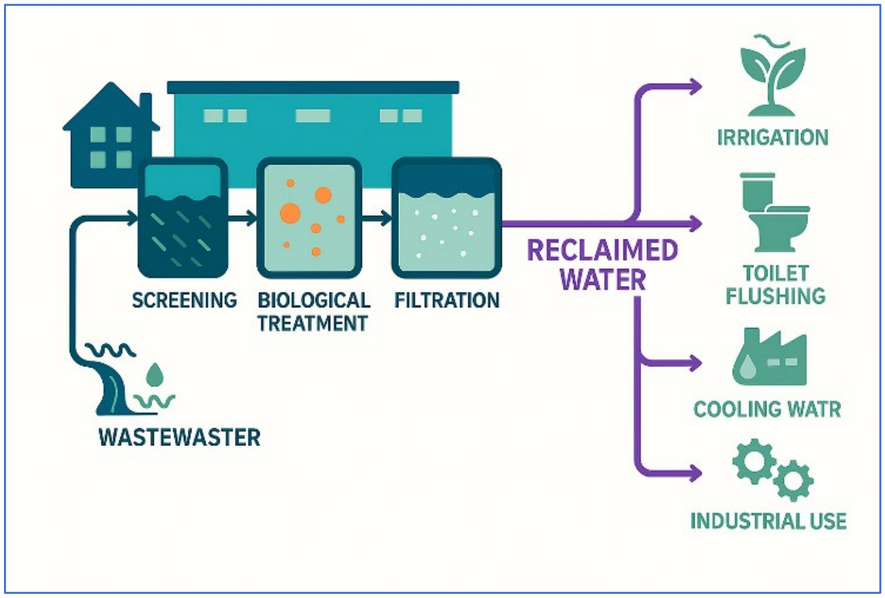
Connecticut is planning for climate changes—and water infrastructure must adapt. State and regional climate model's project:

- Heavier rainfall events may increase urban flooding.
- Longer, more frequent droughts that stress reservoirs, wells, and surface supplies.
- Rising sea levels that threaten low-lying infrastructure in coastal areas such as Bridgeport, Stamford, New Haven, and Norwalk by increasing groundwater intrusion and increased inflow and infiltration in the sewer systems.

1.2.4 Role of Non-Potable Reuse in Adaptation

Non-potable reuse can reduce vulnerability by providing alternative local water sources, enhancing redundancy during emergencies, and supporting decentralized, location-specific solutions.

1.3 Building Climate Resilience into Water Infrastructure



Connecticut's climate models project several environmental changes that will significantly impact the state's water infrastructure and resource planning. These changes are expected to occur over the next several decades and include more frequent and intense precipitation events, longer and more severe drought periods, and sea level rise that will affect coastal and low-lying communities.

From an engineering and planning perspective, these anticipated conditions require proactive adaptation strategies that can increase the flexibility, redundancy, and resilience of water systems. Non-potable water reuse is a tool in this adaptation portfolio, offering multiple benefits for managing both water supply and water quality.

1.3.1 Reducing Reliance on Vulnerable Potable Water Systems

Decentralized non-potable reuse systems provide alternative water sources on-site or within a localized distribution network. This reduces dependency on inter-basin transfers or groundwater withdrawals from stressed aquifers. In regions such as eastern Connecticut, where small systems are highly dependent on groundwater, integrating reuse systems for applications such as irrigation or industrial processes can reduce peak demand on potable sources and maintain system stability during shortages.

1.3.2 Enhancing Emergency Redundancy and Operational Continuity

Non-potable reuse can play a vital role in maintaining essential operations during emergencies such as flooding, drought, or contamination events that compromise potable supplies. Having a dedicated reclaimed water source enables continued operation of critical services including toilet flushing, cooling systems, process water needs, and even fire suppression (where permitted by code). This redundancy is particularly valuable for facilities such as hospitals, emergency response centers, state campuses, correctional institutions, and corporate headquarters.

1.3.3 Supporting Green Infrastructure and Flood Mitigation

When paired with Connecticut's Stormwater Quality Manual, stormwater best management practices (BMPs), non-potable reuse systems can provide both water supply and flood mitigation benefits. For example, systems that capture roof runoff or treated stormwater for reuse in landscape irrigation can offset potable demand while simultaneously reducing peak runoff volumes during heavy rain events. Such dual-purpose designs can be implemented in public schools, transportation hubs, and municipal facilities, integrating with bioswales, permeable pavements, or subsurface infiltration systems to manage stormwater effectively.

1.3.4 Coastal Protection and Infrastructure Longevity

Sea level rise poses a significant threat to wastewater collection and treatment infrastructure in coastal cities including Bridgeport, Stamford, New Haven, and Norwalk. By decentralizing water supply infrastructure and reducing hydraulic loading at vulnerable treatment plants, non-potable reuse systems can help extend the functional life of these facilities. Additionally, inland siting of decentralized systems can safeguard critical infrastructure from saltwater intrusion, inflow and infiltration (I&I), and other coastal climate risks.

1.3.5 Policy Alignment with Resilience Frameworks

The expansion of non-potable reuse aligns with multiple state-level resilience and climate adaptation frameworks. For instance, the Connecticut Governor's Council on Climate Change (GC3) promotes diversification of water resources, infrastructure resilience, and the use of decentralized solutions to reduce system vulnerabilities. Similarly, the Drinking Water Vulnerability Assessment and Resilience Plan (DWVAR Plan) identifies distributed systems and redundant supply as key strategies to mitigate climate-related risks.

Integration of non-potable reuse within these frameworks ensures that water infrastructure planning supports long-term sustainability goals. This includes siting reuse systems in resilience hub locations such as municipal buildings, community centers, and shelters where local water access during emergencies is essential.

1.4 State of Connecticut Outlook

Connecticut's approach to non-potable water reuse is grounded in its commitment to sustainable water management, as outlined in the 2018 Connecticut State Water Plan and related policy documents. Water conservation plays a central role in ensuring that potable water sources remain available for essential uses while meeting the needs of a growing population, aging infrastructure, and adapting to the impacts of climate change.

State agencies, including the Connecticut Department of Energy and Environmental Protection (CT DEEP) and the Connecticut Department of Public Health (CT DPH), coordinate efforts to regulate, promote, and oversee water reuse initiatives. This includes setting treatment standards, approving system designs, and ensuring ongoing compliance through inspections and monitoring.

1.4.1 Policy Drivers

Connecticut's water reuse policies are influenced by several key factors:

- Protection of limited high-quality drinking water supplies.
- Compliance with state and federal water quality regulations.
- Protection of public health.
- Integration of water reuse into municipal planning and development codes.
- Alignment with climate adaptation and resilience strategies.
- Economic incentives for reducing potable water demand in industrial, institutional, and municipal sectors.

1.4.2 Opportunities for Connecticut

Table 1. Strategic Opportunities for Reclaimed Water Implementation

This table outlines the key areas where policy, engineering, and planning can intersect to accelerate the adoption of water reuse.

Opportunity Area	Potential Strategic Actions
Land Use and Planning	Integrate "purple pipe" requirements into municipal Master Plans; mandate dual-plumbing for toilets and irrigation in new commercial or high-density residential developments.
Industrial and Institutional Use	Identify high-demand users (data centers, hospitals, universities) for cooling tower make-up, HVAC condenser water, and equipment washdown to reduce potable water stress.
Public Facilities Leadership	Use state-owned assets—such as state-owned maintenance facilities, state parks, and administrative campuses—as "Demonstration Projects" to prove technical and social viability.
Education and Outreach	Develop public-facing dashboards showing real-time water savings and quality metrics; install educational signage at reuse sites to normalize reclaimed water in the public eye.

1.4.3 Connecticut's Evolving Landscape

Both built and natural landscapes demand a shift toward resilient, adaptive water infrastructure. Non-potable reuse is:

- Technically feasible
- Economically smart
- Environmentally essential
- With proper permitting, public health oversight, and statewide coordination, Connecticut can scale non-potable reuse to meet 21st-century challenges while preserving the natural resources and communities that make the state thrive.

1.5 Regional Outlook

Water reuse policies and regulations vary significantly across the New England region, reflecting differences in water supply availability, demand pressures, and regulatory frameworks. While some states have implemented formal water reuse regulations, others rely on case-by-case approvals or non-binding guidelines. Understanding these regional differences is essential for Connecticut as it seeks to align its own reuse strategies with best practices and regional cooperation opportunities.

1.5.1 Massachusetts

Promulgated water reuse regulations in March 2009, covering multiple reuse categories and establishing water quality criteria, signage requirements, and setback distances. The Massachusetts Department of Environmental Protection (MassDEP) oversees compliance.

1.5.2 New Hampshire

No formal regulations, but guidance exists to encourage water reuse and reduce groundwater stress. Projects are approved on a case-by-case basis with input from the Department of Environmental Services.

1.5.3 Maine

No formal reuse regulations. Installations approved individually, with decisions typically made by the Department of Environmental Protection.

1.5.4 Rhode Island

Developed water reuse guidelines in 2007 for restricted irrigation, unrestricted irrigation, non-contact cooling water, and agricultural reuse for non-food crops. Established water quality criteria and setback distances.

1.5.5 Vermont

TBD

1.5.6 New York

No formal guidelines: initial work on reuse guidelines was suspended due to budget constraints. In urban areas like Manhattan, the cost of dual-piping systems from central facilities is a significant barrier.

1.5.7 New Jersey

Issued a draft 'Technical Manual for Reclaimed Water for Beneficial Reuse' in 2005 and codified regulations in 2009, defining public access and restricted access categories.

2.0 Introduction

Water scarcity, changing climate conditions, and increasing demand for sustainable water management practices have led many states to explore non-potable water reuse as a viable alternative to traditional water supply and discharge strategies. Non-potable reuse refers to the treatment and beneficial use of reclaimed domestic wastewater for applications not intended for human consumption, such as landscape irrigation, industrial processes, toilet flushing, and agricultural use.

This guidance document provides Connecticut-specific technical, regulatory, and design recommendations for engineers, treatment operators, municipal planners, and decision-makers. It draws upon state and federal regulatory frameworks, including the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Connecticut General Statutes (Conn. Gen. Stat.), and the Regulations of Connecticut State Agencies (Regs. Conn. State Agencies), as well as guidance from the Connecticut Department of Energy and Environmental Protection (CT DEEP) and the Connecticut Department of Public Health (CT DPH).

2.1 Document Structure

The document is organized to reflect both regulatory requirements and best engineering practices, offering a framework that is generally consistent with national standards and aligned with Connecticut's water management goals. It includes effluent quality limits for various reuse applications, design and operational standards, monitoring and reporting protocols, and public safety measures. Where possible, it incorporates Connecticut-specific considerations such as climate patterns, topography, and seasonal demand variations.

This is a living document, intended to be updated periodically to reflect advancements in science, technology, and policy. Users of this publication assume responsibility for the application of its information and must ensure compliance with all applicable local, state and federal regulation, codes, and standards.

Note: The Department recognizes that reclaimed water systems were designed and brought online prior to the publication of this document. As permits are reissued, the Department will coordinate with the permittees to determine if the current treatment system and permit conditions need to be updated to align with current engineering practices, science, policies, or regulations.

2.2 Considerations for a Reclaimed Water System.

When considering if a reclaimed water system should be part of your project, consider the following major elements:

- Supply and demand to ensure year-round supply and disposal (e.g. water balance).
- Effluent characterization.
- Wastewater technology and design.
- Treatment system reliability and redundancy.

- User agreements and use limitations.
- Manpower requirements and permit reporting can make a reuse facility expensive for a small operation.
- Education programs.
- Labeling and signage.

3.0 Regulatory Framework

3.1 Federal Regulations

3.1.1 Clean Water Act (CWA)

The Clean Water Act (33 U.S.C. §1251 et seq.) is the foundational federal law governing surface water quality. It regulates discharges of pollutants into U.S. waters through the National Pollutant Discharge Elimination System (NPDES) program, which is administered in Connecticut by the Department of Energy and Environmental Protection (CT DEEP) under delegated authority.

Though most reuse applications do not involve direct surface water discharge, the CWA informs treatment and monitoring standards to ensure protection of water bodies when discharges do occur (e.g., via reject water or excess irrigation runoff).

3.1.2 Safe Drinking Water Act (SDWA)

The SDWA (42 U.S.C. §300f et seq.) protects the quality of drinking water in the United States. In the context of reclaimed water use, the SDWA influences how systems are designed to prevent cross-connections with potable systems and to ensure that distribution infrastructure does not compromise the integrity of public drinking water systems. The Underground Injection Control (UIC) Program is a federal program designed to protect underground sources of drinking water from pollution. The US Environmental Protection Agency (EPA) pursuant to the Federal Safe Drinking Water Act, 42 U.S.C.A §§300f to 300j-26, administers this program. The EPA divides injection practices into five classes. EPA has delegated the UIC Program to CT DEEP.

3.2 State of Connecticut Regulations

3.2.1 Connecticut General Statutes (Conn. Gen. Stat.)

The Con. Gen. Stat. contains the legal framework for environmental protection in the state, including statutory authority for regulating water pollution. Con. Gen. Stat. § 22a-430 establishes the requirement for discharge permits.

3.2.2 Regulations of Connecticut State Agencies (Regs. Conn. State Agencies)

The Regs. Conn. State Agencies contains detailed regulations adopted by DEEP and DPH relevant to non-potable reuse. Key applicable regulations include:

- Regs. Conn. State Agencies § 22a-430-3: Application procedures and permit requirements for wastewater discharges.
- Regs. Conn. State Agencies § 22a-430-4: Effluent limits and treatment standards.
- Regs. Conn. State Agencies § 22a-430-6: Definitions and standard permit conditions.
- Regs. Conn. State Agencies § 22a-430-7 & 8: Monitoring, reporting, and compliance requirements.
- Regs. Conn. State Agencies § 19-13-B102 & B103 (DPH): Cross-connection control and protection of drinking water systems.

3.2.3 CT DEEP

The Connecticut Department of Energy and Environmental Protection:

- Performs the permitting, compliance, and enforcement.
- Provides technical assistance.
- Reviews and approves treatment systems.

3.2.4 CT DPH Requirements

The Department of Public Health regulates infrastructure that may affect public health, including:

- Cross-connection control between potable and non-potable systems.
- Irrigation design criteria to prevent contact with spray, mist, or runoff.
- Use prohibitions for hose bibs accessible to the public.
- DPH-approved plumbing codes (including International Plumbing Code amendments) apply to reclaimed water reuse within buildings (e.g., toilet flushing, cooling systems).

4.0 Climate, Topography, and State-Specific Challenges

4.1 Connecticut Climate and Implications for Reuse

Connecticut has a humid continental climate characterized by cold winters, warm summers, and generally evenly distributed precipitation throughout the year. Key climate considerations affecting water reuse include:

- Freezing Temperatures: Freeze-thaw cycles can damage irrigation components and require seasonal shutoff and drainage of distribution lines.
- High Summer Demand: Peak reuse demand often coincides with dry summer months, especially for irrigation, landscaping, and cooling tower applications.
- Rainfall Distribution: Approximately 45–50 inches of annual precipitation, with runoff and groundwater recharge implications for soil absorption and stormwater infiltration.
- Snow Accumulation: Snowmelt may contribute to system inflows in spring, potentially impacting storage or balance in reuse ponds.

Source: National Weather Service – Northeast Regional Climate Center (NOAA, 2024)

4.1.1 Topography and Hydrogeology

- Topography: Connecticut's terrain ranges from hilly inland areas with shallow bedrock to flatter coastal and riverine floodplains. This variation affects infiltration rates, subsurface absorption system design, and surface runoff management.
- Soils: Many areas have glacial till soils with low permeability, affecting leach field sizing, stormwater percolation, and reject water disposal.
- Groundwater Sensitivity: Shallow aquifers and high-water tables exist in several areas, especially in the Connecticut River Valley and coastal plain, making cross-contamination prevention and leachate control critical. Groundwater depth and vulnerability are highly site-specific, do not always flow with the topography of the land, and can differ significantly within short distances (i.e. within the same parcel).

Table 2. Regional and State-Specific Implementation Challenges

Challenge	Implication for Reclaimed Water Systems
Aging Infrastructure	Many legacy Water Pollution Control Facilities (WPCF) lack the hydraulic profile or footprint for tertiary upgrades; "add-on" modules like Cloth Media Filters or UV channels may require innovative retrofitting.
Dense Urban Topography	High land costs and limited setbacks restrict large-scale irrigation; engineering focus shifts toward indoor non-potable reuse (toilet flushing) and industrial cooling towers.
Seasonal Flow Variability	Shoreline and tourism-based communities face significant fluctuations in influent loading; treatment systems must be designed for wide turndown ratios to maintain effluent quality during off-peak seasons.
Public Perception & Social License	"Toilet-to-tap" stigma remains a hurdle; robust public outreach, transparent water quality data, and standardized purple pipe signage are mandatory for project viability.
Inter-Agency Governance	Permitting complexity involves navigating CT DEEP (environmental discharge), CT DPH (public health/plumbing), and local land-use authorities.
MS4 & Stormwater Nexus	Reclaimed water irrigation must be managed to prevent "dry-weather runoff" into storm drains, ensuring compliance with MS4 (Municipal Separate Storm Sewer System) permits.

5.0 Reclaimed Water Classification/Categorization

The following classifications are based on the EPA Guidelines for Water Reuse and regional standards for the protection of public health. It is important to note that while the following classifications (Classes A, B, and C) are standard industry benchmarks used for engineering design and international best practices, these specific letter-grade classifications are used solely for the purposes of categorization and are not currently defined by specific CT DEEP regulations. In Connecticut, reclaimed water projects are evaluated on a case-by-case basis under existing discharge permit frameworks, with water quality requirements dictated by the specific end-use and potential for human or environmental exposure.

5.1 Urban Non-Potable Water

This is the most common classification for municipal reuse systems. It is characterized by high-level disinfection to ensure safety for use in areas with potential human contact.

- Unrestricted Urban Reuse: Reclaimed water used for applications where public access is frequent and uncontrolled.
- Examples: Irrigation of public parks, playgrounds, schoolyards, and residential landscaping.
- Treatment Requirement: Requires tertiary filtration and high-level disinfection.
- Restricted Urban Reuse: Water used in areas where public access can be controlled or limited.
- Examples: Golf courses (with nighttime irrigation), highway medians, and industrial park buffer zones.
- Treatment Requirement: May allow for slightly higher microbial thresholds if combined with strict setback distances and timing restrictions.

5.2 Agricultural Reclaimed Water

Agricultural reuse is divided based on the risk of the water coming into direct contact with the edible portion of the crop.

- Food Crops (Direct Contact): Crops that are consumed raw (e.g., lettuce, strawberries).
    - Requirement: Although Connecticut does not currently permit water reuse for direct human food crop contact, this application would necessitate the highest level of treatment to ensure the prevention of pathogen transmission.
- Processed Food/Non-Food Crops: Crops that are either thermally processed before consumption or used for non-food purposes (e.g., fodder for livestock, fiber crops like cotton, or sod farms).
    - Requirement: Secondary treatment with disinfection, provided there is no risk of aerosolization to neighboring areas.

5.3 Industrial Reclaimed Water

Industrial applications are highly diverse, and the "type" of water is often dictated by the specific chemistry of the industrial process.

- Cooling Water: Used as "make-up" water for cooling towers. This is the largest volume industrial use. It requires specific management for scale inhibition, corrosion control, and legionella prevention.
- Process Water: Water used directly in manufacturing (e.g., aggregate washing, textile dyeing, or paper pulping). Each industry has unique water quality tolerances for hardness, silica, and dissolved solids that need to be considered.

5.4 Environmental and Augmentation Water

This water is used to restore or enhance natural hydrologic systems.

- Streamflow Augmentation: Discharging reclaimed water into rivers or streams to maintain minimum "7Q10" flows during drought conditions.
- Wetland Restoration: Providing a steady water supply to constructed or degraded wetlands to support biodiversity.
- Groundwater Recharge: The intentional infiltration or injection of water into an aquifer to replenish the water table or create a barrier against saltwater intrusion.

Table 3: Reclaimed Water Classifications at a Glance

Treatment Level	Typical Use Case	Potential for Human Contact
Tertiary + Advanced Disinfection	Food crops	Highest
Tertiary + Advanced Disinfection	Indoor flushing, Parks	High
Secondary + Filtration + Disinfection	Golf courses, Cooling towers	Moderate
Secondary + Disinfection	Fodder crops, Dust control	Low

6.0 Pollutants of Concern

6.1 Biochemical Oxygen Demand (BOD_5-day)

Biochemical Oxygen Demand quantifies the amount of dissolved oxygen consumed by microorganisms while decomposing organic matter under aerobic conditions at 20°C over a five-day period. It serves as the primary metric for evaluating the stability and organic loading of reclaimed water.

Impact on Reuse Systems. In water reclamation and distribution, reducing BOD_5-day to low levels (typically <10 -30 mg/L depending on the application) is critical for the following reasons:

- Biological Stability: High BOD_5-day provides a food source for microbial regrowth within the distribution network, leading to biofilm formation and localized odors.
- Disinfection Interference: Residual organic matter exerts a high oxidant demand, reducing the efficacy of chlorine or UV disinfection and potentially forming harmful disinfection byproducts (DBPs).
- Operational Integrity: Excessive organics can lead to "sloughing" in pipelines, resulting in clogged irrigation nozzles or fouled cooling tower packing.
- Aesthetic Quality: Organic stabilization prevents the water from becoming putrescible (septic) and helps eliminate color and unpleasant odors.

Treatment Methods. BOD_5-day reduction is achieved through secondary or tertiary biological processes where bacteria oxidize dissolved organics.

- Suspended Growth: Conventional Activated Sludge (CAS) or Sequencing Batch Reactors (SBR).
- Advanced Processes: Membrane Bioreactors (MBR) are highly effective at achieving near-zero BOD_5-day levels by decoupling hydraulic and solids retention times and providing a physical barrier to suspended organics.

6.2 Turbidity and Total Suspended Solids (TSS)

Turbidity and Total Suspended Solids (TSS) are the primary metrics used to quantify particulate matter in reclaimed water. While TSS measures the mass concentration of solids (mg/L), Turbidity measures water clarity via light-scattering (NTU). In water reuse design, these parameters are the most critical predictors of disinfection success.

The Relationship Between Particles and Pathogens. The removal of suspended matter is directly correlated with the inactivation of bacteria, viruses, and protozoa. Particulate matter compromises the "log reduction" of pathogens in two distinct ways:

- Pathogen Shielding: Many pathogens are "particulate-associated," meaning they are embedded within or attached to suspended solids. These particles act as a physical shield, protecting bacteria and viruses from UV radiation and chemical disinfectants (e.g., Chlorine).

- Oxidant Demand: Organic particulates consume chlorine and other oxidants, exerting a "demand" that reduces the concentration of disinfectant available to neutralize free-floating pathogens.

Engineering Standards for Disinfection Readiness. To ensure reliable inactivation of pathogenic microorganisms, the engineering industry consensus—supported by the EPA Guidelines for Water Reuse (2012) is that water must be polished to the following levels prior to disinfection:

- Turbidity: 2 NTU (Daily Maximum).
- TSS: 5 mg/L (Daily Average).

Operational Monitoring: Real-Time vs. Composite. A robust design manual must distinguish between these two parameters for process control:

- TSS (Process Performance): Typically measured daily via 24-hour composite samples. This provides an accurate measure of the total organic and inorganic load but is reactive; it cannot trigger an immediate system shutdown.
- Turbidity (Safety Interlock): Monitored continuously in real-time. Continuous turbidity meters (turbidimeters) are the "gatekeepers" of the reuse system. They must be programmed to automatically divert water to waste or shut down the system if turbidity spikes above the permitted limit (e.g., 2 NTU), preventing inadequately disinfected water from reaching end-users.

6.3 Salinity and Heavy Metals

While secondary and tertiary treatments are effective for organic and pathogen removal, they do not significantly reduce dissolved salts or trace metals. Long-term monitoring of these constituents is critical for protecting soil health and infrastructure integrity.

Salinity and Total Dissolved Solids (TDS). Salinity is typically quantified as Total Dissolved Solids (TDS) or measured via Electrical Conductivity (EC). In reclaimed water systems, elevated salinity presents several engineering and agronomic challenges:

- Soil and Crop Health: High TDS can lead to osmotic stress in plants and soil "salinization." Furthermore, the ratio of sodium to calcium and magnesium—known as the Sodium Adsorption Ratio (SAR)must be monitored, as high sodium levels can destroy soil structure and reduce permeability.
- Infrastructure Damage: Dissolved salts increase the corrosivity of the water, accelerating the degradation of metal pipes and fittings. In industrial reuse, salinity contributes to scaling in boilers and cooling towers.
- Aesthetic and Functional Issues: High salinity can leave unsightly mineral residues in car wash operations or irrigation spray.

Heavy Metals and Trace Elements. Trace metals, including lead, mercury, cadmium, chromium, and arsenic, may enter the wastewater stream through industrial discharges or the corrosion of aged distribution infrastructure.

- Bioaccumulation: Unlike organic matter, heavy metals do not biodegrade. They can accumulate in the soil and plant tissues over time, posing long-term environmental risks, particularly in "closed-loop" irrigation systems where water is recycled repeatedly.
- Regulatory Compliance: Reuse projects must ensure that metal concentrations remain below the thresholds established by the EPA (2012) Guidelines and state-specific groundwater protection standards.

Management and Mitigation. Salinity removal generally requires advanced membrane processes such as Reverse Osmosis (RO) or Electrodialysis Reversal (EDR). These options are energy-intensive and produce a concentrated brine waste stream, which requires specialized disposal permits (e.g., NPDES). Site-specific monitoring plans are essential for projects involving sensitive vegetation or long-term land application.

6.4 Bacteria & Pathogens

Pathogens are microorganisms capable of causing disease in humans and animals. In reclaimed water systems, engineering design must account for four primary classes of pathogens found in untreated wastewater:

- Bacteria: (e.g., *Escherichia coli, Salmonella spp., Legionella spp*.).
- Viruses: (e.g., Norovirus, Enterovirus, Hepatitis A).
- Protozoa: (e.g., *Cryptosporidium parvum, Giardia lamblia)*.
- Helminths: (Parasitic worms, eg. roundworms, tapeworms).

Exposure Pathways and Risk. Public health risk is determined by the concentration of pathogens and the specific human exposure pathways associated with the reuse application:

- Ingestion: Accidental swallowing (e.g., during irrigation or via cross-connection).
- Inhalation: Breathing aerosols/mists from spray irrigation, cooling towers, or decorative fountains.
- Dermal Contact: Skin exposure during landscape maintenance or recreational activities.

Resistance and Treatment Challenges. Standard secondary treatment alone is insufficient for pathogen removal. Engineering designs must address specific resistance profiles:

- Chlorine Resistance: Protozoan parasites (*Cryptosporidium and Giardia*) are highly resistant to free chlorine. Inactivation requires physical removal via filtration or advanced disinfection using Ultraviolet (UV) Irradiation or Ozone.
- Viral Persistence: Viruses are extremely small and may pass through conventional media filters. Effective control requires a combination of coagulation, membrane filtration, and chemical or UV disinfection.

The Multi-Barrier Approach and LRVs. To ensure safety, systems employ a "Multi-Barrier Approach." This design philosophy ensures that if one process fails, subsequent steps provide redundancy. Each treatment step is assigned a Log Reduction Value (LRV):

- Physical Barriers: Sedimentation and filtration (targets protozoa and helminths).

- Biological Barriers: Secondary treatment (targets bacteria and some viruses).
- Disinfection Barriers: UV, Chlorine, or Ozone (targets viruses and residual bacteria/protozoa).

Prevention of Regrowth and Recontamination. System design does not end at the treatment plant. The distribution network must be engineered to prevent microbial regrowth:

- Disinfectant Residual: Maintaining a measurable chlorine residual prevents the regrowth of bacteria and controls biofilm formation.
- Materials Selection: Utilizing smooth-walled, corrosion-resistant piping (e.g., PVC, HDPE) to minimize niches for biofilm.
- Physical Protection: Ensuring strict separation from potable lines and utilizing dedicated "purple pipe" infrastructure to prevent cross-connections.

6.5 Indicator Organisms and Surrogates

Because monitoring for every potential pathogen is technically and financially impractical, surrogates are used to validate disinfection efficiency. It is critical to distinguish between pathogens (disease-causers) and indicators (safety proxies). Indicators are typically non-pathogenic but signal the potential presence of fecal contamination or a failure in the treatment barrier.

Standard Bacterial Indicators. Bacterial indicators are the regulatory baseline for most reuse permits, though they vary in specificity:

- Total and Fecal Coliforms: Historically the standard for measuring disinfection efficiency. While effective for tracking bacterial pathogens, they are poor predictors of viral or protozoan persistence.
- *Escherichia coli* (*E. coli*): A subset of fecal coliforms and a more specific indicator of fecal contamination from warm-blooded animals. Connecticut regulations have largely shifted to *E. coli* as the primary bacterial metric.
- Enterococci: Highly resilient bacteria used as indicators in saline or brackish environments and for certain recycled water applications due to their tolerance of environmental stress.

Advanced Indicators and Surrogates. To address the limitations of bacteria in predicting viral and parasitic risks, advanced surrogates are utilized in high-exposure reuse projects:

- Coliphages (Bacteriophages): Viruses that infect bacteria. Because their size, morphology, and UV resistance mimic human enteric viruses (like Norovirus), they are the preferred surrogate for validating viral log reduction.
- Clostridium perfringens: A spore-forming bacterium used as a surrogate for hardy protozoan cysts (e.g., Cryptosporidium). Its spores resist environmental degradation and chemical disinfection similarly to parasitic oocysts.
- Turbidity: A physical surrogate for filtration performance. High turbidity can "shield" pathogens from UV or chemical disinfectants, rendering the disinfection stage ineffective.

Regulatory Application and Process Validation. In accordance with EPA Guidelines (2012) and Connecticut standards, microbiological safety is typically verified through daily effluent sampling.

However, traditional cultivation methods (e.g., membrane filtration or Quanti-Tray) require a 24-hour incubation period, creating a "data lag" that is insufficient for real-time safety. To bridge this gap, engineering designs must incorporate on-line surrogates for immediate process validation:

- UV Transmittance (UVT): Real-time measure of water's clarity to UV light.
- Free Chlorine Residual: Real-time measure of secondary disinfection capacity.
- Continuous Turbidity Monitoring: Real-time measure of filtration integrity.

Pathogen Monitoring and State Regulatory Trends. While indicator organisms remain the national standard, several states have implemented direct pathogen monitoring requirements for high-exposure reuse applications.

Specific Pathogen Monitoring Requirements.

- Protozoan Monitoring: States such as California (Title 22), Arizona, and Florida require monitoring for *Giardia lamblia* and *Cryptosporidium* for specific reclaimed water classes.
- Viral Monitoring: North Carolina requires enteric virus monitoring specifically for the reclaimed water irrigation of food crops.

The Role of Indicator Organisms. In most jurisdictions, including Connecticut, the performance of the treatment system is validated through the daily monitoring of indicator organisms rather than the pathogens themselves:

- Bacterial Indicators: Total Coliforms, Fecal Coliforms, *E. coli,* and *Enterococci.*

Viral Indicators: Coliphage (bacteriophages) is increasingly used to validate the performance of UV and ozone systems due to its morphological similarity to human enteric viruses.

6.6 Nutrients (Nitrogen and Phosphorus)

Nitrogen (N) and Phosphorus (P) are essential elements for biological growth; however, in the context of water reclamation, their concentrations must be strictly managed to protect both the distribution infrastructure and the downstream environment.

Environmental Impacts and Eutrophication. Excessive nutrient loading in reclaimed water used for irrigation or discharged to surface waters can trigger eutrophication. This process involves:

- Algal Blooms: Rapid proliferation of algae that blocks sunlight from submerged aquatic vegetation.
- Oxygen Depletion: As algal blooms die and decay, microbial decomposition consumes dissolved oxygen (DO), potentially leading to hypoxic conditions ("dead zones") and fish kills.
- Biodiversity Loss: Shifts in water chemistry and habitat structure that favor invasive species over native aquatic life.

Operational Challenges in Reuse Systems. Beyond environmental concerns, residual nutrients in reclaimed water can cause significant operational issues within the distribution network:

- Biological Regrowth: Nitrogen and phosphorus act as fertilizers for biofilms within purple-pipe networks, leading to pipe fouling, increased friction loss, and potential odor issues.

- Scaling and Fouling: Certain phosphorus species can contribute to mineral scaling in cooling towers and heat exchangers.

Nutrient Removal and Management Strategies. To meet stringent water quality standards, engineering designs must incorporate specific nutrient reduction technologies:

- Biological Nutrient Removal (BNR): Utilizing specialized anaerobic, anoxic, and aerobic zones to promote the uptake of phosphorus and the denitrification of nitrogen.
- Chemical Precipitation: Dosing with metal salts (e.g., alum or ferric chloride) to physically settle out phosphorus.
- Enhanced Filtration: Utilizing tertiary cloth media or membrane filters to capture particulate-bound nutrients.

Integrated Management. In addition to mechanical treatment, effective reuse strategies include Source Control and Best Management Practices (BMPs). This includes optimized fertilizer application rates for irrigation sites receiving reclaimed water—accounting for the existing nutrient content in the water to prevent over-application—and robust erosion control measures.

6.7 Oxyhalides

Oxyhalides—including bromate, chlorate, and perchlorate—are inorganic disinfection byproducts (DBPs) or contaminants that pose human health risks and environmental concerns in water reuse applications.

Formation and Sources. Oxyhalides typically enter the reclaimed water stream through two primary pathways:

- Ozonation Byproducts: Bromate (BrO_3^-) is formed when source water containing bromide is treated with ozone. Because bromate is a suspected carcinogen, ozonation systems must be engineered with specific controls (such as pH adjustment or ammonia addition) to suppress bromate formation.
- Chemical Degradation: Chlorate (ClO_3^-) and perchlorate (ClO_4^-) often originate from the degradation of sodium hypochlorite (liquid bleach). These compounds accumulate in storage tanks as the bleach ages, especially when exposed to high temperatures or sunlight.

Agricultural and Public Health Impacts.

- Bioaccumulation: Perchlorate is highly mobile in soil and can bioaccumulate in certain crops, particularly leafy greens and tobacco.
- Phytotoxicity: At elevated concentrations, certain oxyhalides can be toxic to sensitive plant species, potentially stunting growth or reducing crop yields.

Engineering Control Strategies. To minimize oxyhalide concentrations in reclaimed water, the following design and operational practices should be implemented:

- Hypochlorite Management: Design chemical storage systems to minimize bleach "residence time." Use "first-in, first-out" inventory management, keep storage tanks in temperature-controlled environments, and protect them from UV/sunlight exposure.

- Alternative Disinfection: Utilize Ultraviolet (UV) Irradiation as the primary disinfectant where bromide levels are high, as UV does not promote the formation of bromate.
- Source Tracking: Identify and mitigate industrial inputs of perchlorate or bromide into the wastewater collection system.

6.8 Trace Organic Compounds and Constituents of Emerging Concern (CECs)

Trace organics, often referred to as Constituents of Emerging Concern (CECs) or Micro-constituents, consist of a diverse group of chemicals detected at very low concentrations (nanograms to micrograms per liter).

Composition and Sources. These compounds originate primarily from domestic and industrial wastewater and include:

- Pharmaceuticals and Personal Care Products (PPCPs): Antibiotics, steroids, fragrances, and detergents.
- Endocrine-Disrupting Compounds (EDCs): Chemicals that mimic or interfere with natural hormones.
- Per- and Polyfluoroalkyl Substances (PFAS): Persistent "forever chemicals" used in non-stick coatings, water and stain resistant treatments, and firefighting foams.

Removal Technologies. Conventional secondary treatment is not specifically designed to remove these complex molecules. Where high-purity water is required, advanced treatment "trains" are employed:

- Adsorption: Granular Activated Carbon (GAC) or Powdered Activated Carbon (PAC) physically adsorbs organic molecules onto its surface.
- Advanced Oxidation Processes (AOP): The combination of UV/Hydrogen Peroxide (H2O2) or Ozone (O3) to generate hydroxyl radicals that chemically break down persistent organic structures.
- Reverse Osmosis (RO): A high-pressure membrane barrier that provides the most comprehensive removal of dissolved organics.

7.0 Non-Potable Treatment Systems

Treatment of reclaimed water involves multiple stages designed to progressively remove contaminants and meet the quality standards required for specific non-potable uses. The stages described below represent a typical treatment train, though actual configurations may vary depending on source water quality, project objectives, regulatory requirements, and site constraints.

7.1 Preliminary Treatment

Preliminary treatment removes large solids, grit, and other debris that could damage downstream equipment or interfere with treatment processes. Common components include:

- Screening systems (coarse and fine screens) to remove rags, plastics, and large debris.
- Grit removal chambers to settle out sand, gravel, and other dense particles.
- Flow equalization basins to dampen fluctuations in flow and pollutant load.

These processes are not intended for significant pollutant removal but are critical for protecting downstream treatment units.

7.2 Primary Treatment

Primary treatment focuses on the physical removal of settleable solids and floatable organic material to reduce the organic loading on downstream biological processes.

- Physical Separation: This is typically achieved through Primary Clarifiers or Sedimentation Tanks, where the flow velocity is reduced to allow solids to settle by gravity.
- Surface Scum Removal: Skimming Devices are employed to remove "FOG" (fats, oils, and grease) and other buoyant materials from the water surface.
- Pre-treatment Integration: For modern systems, primary treatment is often preceded by Fine Screening or Grit Removal to protect mechanical equipment from damage or clogging.

Under typical operating conditions, primary treatment can remove:

- 50–70% of Total Suspended Solids (TSS)
- 25–40% of Five-Day Biochemical Oxygen Demand (BOD_5-day)

7.3 Secondary Treatment

Secondary Treatment Secondary treatment employs biological processes to degrade and remove dissolved and suspended organic matter. These systems are generally categorized by their method of microbial growth:

- Suspended Growth Systems: Includes Activated Sludge variants such as conventional plug-flow, extended aeration, and Sequencing Batch Reactors (SBR).
- Attached Growth (Fixed-Film) Systems: Includes Trickling Filters and Rotating Biological Contactors (RBC).

- Membrane Bioreactors (MBR): An advanced process that combines suspended growth biological treatment with membrane filtration, often eliminating the need for secondary clarification.

These processes are typically designed to remove 85–95% of BOD_5-day and Total Suspended Solids (TSS). When configured for Biological Nutrient Removal (BNR), these systems utilize specialized anaerobic, anoxic, and aerobic zones to significantly reduce total nitrogen and phosphorus concentrations.

7.4 Tertiary Treatment

Tertiary treatment, often referred to as "advanced treatment," provides additional polishing to secondary effluent to satisfy stringent water quality requirements for high-exposure reuse. These processes are designed to remove residual suspended solids, nutrients, and pathogens that remain after biological treatment.

- Filtration: Media Filtration: Utilizes sand, anthracite, or multi-media beds to physically strain remaining particulates.
- Membrane Filtration: Employs Microfiltration (MF) or Ultrafiltration (UF) to provide a superior physical barrier against bacteria and protozoa (e.g., Cryptosporidium).
- Advanced Nutrient Removal:
    - Phosphorus Removal: Achieved through chemical precipitation (e.g., alum or ferric chloride dosing) followed by sedimentation or filtration.
    - Nitrogen Removal: Enhanced biological Nitrification-Denitrification or ion exchange processes to reach low total nitrogen (TN) limits.
    - Adsorption: Use of Granular Activated Carbon (GAC) to remove dissolved organic compounds, color, and odor-causing agents.

Tertiary systems are essential for achieving the low Turbidity (typically <2 NTU) and high Log Reduction Targets (LRTs) required for non-potable applications where human contact is possible.

7.5 Disinfection

Disinfection inactivates or destroys pathogenic microorganisms to ensure the reclaimed water is safe for its intended use. Common methods include:

- Chlorination (sodium hypochlorite, chlorine gas) with contact basins.
- Ultraviolet (UV) irradiation.
- Ozonation.

Selection of a disinfection method depends on target pathogens, water quality, operational considerations, and residual requirements in the distribution system.

7.6 Advanced Treatment

Advanced treatment is applied when high-water quality is required, such as for indirect potable reuse or industrial applications with strict quality needs. Processes include:

- Reverse osmosis (RO).
- Advanced oxidation processes (AOPs) combining UV, ozone, and hydrogen peroxide.
- Granular activated carbon (GAC) adsorption.

These technologies target trace organic compounds, salinity, and other constituents that were not effectively removed in earlier stages.

7.7 Residuals Management

Residuals generated from reclaimed water treatment, such as screenings, grit, sludge, and spent filter media, must be properly handled and disposed.

8.0 Numeric Effluent Limits, Monitoring, Sampling, and Analytical Protocols

This section defines the technology-based design standards for non-potable reclaimed water (domestic or commingled) intended for toilet flushing, cooling water, and irrigation. Compliance with chlorine residual and turbidity must be met on a single-sample basis. The Department reserves the right to modify these requirements or sampling frequencies on a case-by-case basis. Reclaimed water must be disinfected using either chemical oxidants or ultraviolet radiation to ensure the inactivation of pathogens.

8.1 Chlorination

- Residual: A minimum Total Chlorine Residual (or Chlorine Produced Oxidant - CPO) of 1.0 mg/L must be maintained.
- Contact Time (CT): A minimum contact time of 15 minutes at peak hourly flow is required.
- Monitoring: Continuous on-line monitoring is mandatory at the compliance point. For spray irrigation, CPO must be monitored to ensure residuals do not cause phytotoxicity (vegetation damage).

8.2 Ultraviolet (UV) Disinfection

- Dose: A design UV dose of 100 mJ/cm2 at maximum daily flow is required.
- Validation: Systems must comply with the NWRI/Water Reuse Ultraviolet Disinfection Guidelines.
- Monitoring: Compliance is based on continuous monitoring of lamp intensity, UV Transmittance (UVT), and flow rate.

8.3 Microbiological Limits (Total Coliform)

To validate disinfection efficacy, the following bacterial limits apply:

- Instantaneous Maximum: Shall not exceed 14 MPN/100 mL (or CFU) at any time.
- 7-Day Median: Shall not exceed 2.2 MPN/100 mL.

8.4 Filtration and Clarity (TSS & Turbidity)

Clarity is the primary indicator of a system's ability to be effectively disinfected.

- Total Suspended Solids (TSS): Shall not exceed 5.0 mg/L before disinfection.
- Turbidity: Turbidity shall not exceed 2 NTU.

A filtration system must follow clarification. If turbidity or TSS limits are exceeded, the system must be engineered to auto-divert effluent away from the reuse distribution header.

8.5 Chemical and Nutrient Limits

- Total Nitrogen ($NO_3 + NH_3$): Concentrations shall not exceed 10 mg/L. A higher limit may be permitted if the applicant demonstrates that the increased load remains protective of the local environment (e.g., specific soil uptake capacities).

- pH: Must be maintained within the range of 6.0–9.0 standard units.
- Metals and Toxics: Reclaimed water must achieve the minimum health and environmental guidelines established in the EPA Guidelines for Water Reuse regarding heavy metals and trace toxic chemicals.

8.6 Industrial Use

Reclaimed Water for Beneficial Reuse (RWBR) in industrial settings typically involves applications such as cooling tower make-up, boiler feed, and industrial washing operations. Because every industrial process has unique water quality tolerances, it is impossible to establish a single universal treatment standard for this category. Consequently, all industrial reuse systems are subject to a case-by-case technical review by the Department prior to implementation.

- Non-Contact Cooling Water: This is one of the most common industrial applications. In some instances, secondary effluent may require minimal additional treatment beyond enhanced disinfection and scale inhibition, provided there is no risk of human exposure or aerosolization.
- Process Water and Washing: Applications involving higher human contact or sensitive chemical processes (e.g., equipment rinsing) will likely trigger requirements for tertiary filtration and high-level disinfection.
- Operational Considerations: Industrial users must evaluate the reclaimed water for Scaling, Corrosion, and Biological Growth potential. Chemical conditioning (e.g., adding anti-scalants or supplemental biocides) is frequently required to protect high-value industrial assets.

Table 5. Reclaimed Water Numeric Effluent Permit Limits

Category	Parameter	Limit / Standard
Organics	BOD[1]	10 - 30 mg/L (Application dependent)
Disinfection (Chlorine)	Total Residual (CPO)	Greater than 1.0 mg/L
	Contact Time (CT)	Greater than 15 Minutes
Disinfection (UV)	Design Dose	100 mJ/cm^2
	Validation Standard	NWRI/WaterReuse 2000
Microbiological	Total Coliform	2.2 MPN/100 mL
	Total Coliform	14 MPN/100 mL
Clarity & Solids	Turbidity[2]	Less than or equal to 2 NTU
	TSS[1]	Less than or equal to 5.0 mg/L
Nutrients	Total Nitrogen[3]	Less than or equal to 10 mg/L
Chemistry	pH	6.0 - 9.0 S.U.
Metals & Toxics	Metals & Toxics	Case-by-Case Review
Industrial Use	Process Specific	Case-by-Case Review

Footnote 1: BOD/TSS Synergy. The recommended BOD and TSS limits are intended to indicate that organic matter has been stabilized and is non-putrescible. These levels are readily achievable at well-operated water reclamation plants using secondary or tertiary biological processes.

Footnote 2: Filtration Requirement. To consistently meet the less than or equal to 2 NTU turbidity limit, a filtration system (e.g., sand, cloth media, or membrane) must follow the clarification stage and be preceded by a coagulant feed if necessary.

Footnote 3: Nitrogen Flexibility. The 10 mg/L limit for Total Nitrogen (NO_3 + NH_3) is the standard for groundwater protection.

8.7 Monitoring, Sampling, and Analytical Protocols

A robust water quality monitoring program is the primary mechanism for ensuring public health protection and environmental stewardship. Monitoring strategies must be designed to validate that treatment barriers are functioning as intended before the water leaves the facility.

8.8 Monitoring Scope

Standard monitoring programs are structured around parameters with established numeric reuse criteria. The scope is typically divided into three tiers:

- Compliance Parameters: Mandatory reporting of BOD_5-day, TSS, Turbidity, and Pathogen Indicators (e.g., *E. coli* or Fecal Coliform).
- Operational Surrogates: Real-time, online monitoring of parameters such as UV Transmittance (UVT), Chlorine Residual, and ORP (Oxidation-Reduction Potential) to provide instantaneous feedback for process control.
- Environmental/Health Protective Parameters: Periodic testing for salts (TDS/EC), nutrients (Nitrogen/Phosphorus), and constituents with Maximum Contaminant Levels (MCLs) to ensure the protection of groundwater and surface water quality at the point of use.

8.9 Sampling Point and Procedures

- Location: Unless otherwise specified in the permit, all compliance sampling and analysis shall occur at the water reclamation facility’s effluent header, prior to distribution to the reuse network.
- Standards: All sampling, preservation, and analytical procedures must strictly comply with 40 CFR Part 136 ("Guidelines Establishing Test Procedures for the Analysis of Pollutants").
- Sample Types: Composite Samples: Required for parameters like BOD_5-day and TSS to represent average daily loading.
- Grab Samples: Required for time-sensitive parameters such as pH, temperature, and bacteria.

8.10 Equipment Maintenance and Calibration

The accuracy of a monitoring program is entirely dependent on the reliability of the instrumentation. The facility’s Operations and Maintenance (O&M) Manual must include:

- Calibration Schedule: A formalized frequency for the inspection and calibration of all online turbidimeters, pH probes, and chlorine analyzers.
- Calibration Logs: Permanent records of all calibration activities, which must be made available for inspection by CT DEEP or DPH officials upon request.
- Fail-Safe Testing: Routine verification of the "auto-divert" or "fail-to-waste" logic triggered by online monitoring exceedances.

Table 6: Summary Table: Monitoring and Compliance Framework

Parameter	Sampling Frequency	Sample Type	Regulatory Driver
Turbidity	Continuous	Continuous	Disinfection Shielding / Filtration Efficiency
Total Chlorine (CPO)	Continuous	Continuous	Pathogen Inactivation
$BOD_{5\text{-day}}$	1x - 3x / Week	24-hr Composite	Organic Stability & Odor Control
TSS	1x - 5x / Week	24-hr Composite	Filtration Performance / Solids Loading
Total Coliform / *E. coli*	Daily	Grab (100 mL)	Microbial Safety (2.2 MPN Median)
UV Dose	Dose is based on continuous monitoring of lamp intensity, UV transmittance, and flow rate.	Continuous	Microbial Safety
Total Nitrogen	1x / Month	Composite	Environmental Protection (10 mg/L limit)
pH	Daily	Grab / Online	Corrosion Control / Biological Health
Other (salinity, metals, etc.)	TBD	TBD	As Needed

8.11 Operational Protocols for Intermittent and Side-Stream Supply

For facilities that do not supply reclaimed water continuously, the transition from "standby" to "active" status requires heightened monitoring to ensure stagnant water does not enter the distribution network.

- Intermittent Sampling Requirements: Bacteria (E. coli or Fecal Coliform) must be sampled every day that reclaimed water is supplied to the distribution system.
- Immediate Diversion Protocol: If any single sample exceeds the instantaneous maximum limit.
- The facility must immediately divert all flow away from the reclaimed water distribution system.
- Supply to the end-user must remain suspended until a subsequent sample proves compliance.
- Root Cause Analysis: A formal investigation must be conducted to identify the cause of the exceedance (e.g., equipment failure, short-circuiting, or biological upset) and corrective actions must be documented to prevent recurrence.
- UV Log Reporting: Facilities utilizing UV disinfection must maintain daily logs recording UV Intensity, Lamp Status, and Transmittance (UVT) to validate that the design dose was achieved during all hours of operation.

8.12 Surface and Groundwater Monitoring

While the quality of reclaimed water is verified at the treatment plant, the impact on the receiving environment may require additional oversight depending on the project's hydrogeology.

- Standard Irrigation Projects: Monitoring of local groundwater or surface water is not generally required for reclaimed water used for irrigation, as the "treatment" provided by soil-aquifer and plant uptake is considered sufficient.
- Case-by-Case Determination: The Department reserves the authority to mandate environmental monitoring if the project is located near sensitive ecosystems, high-yield aquifers, or impaired water bodies.
- Groundwater Recharge and Saltwater Barriers: For projects designed for aquifer recharge or preventing saltwater intrusion, specialized monitoring infrastructure may be required:
    - Lysimeters: To measure water quality in the unsaturated (vadose) soil zone.
    - Monitoring Wells: To track changes in groundwater table elevation and chemical composition.
    - Production Wells: Sampling existing down-gradient wells to ensure no degradation of the regional water supply.

Table 7. Comprehensive Permit Limits and Monitoring Requirements

This table integrates the numeric effluent limits, mandatory monitoring frequencies, and the required analytical methods for Reclaimed Water for Beneficial Reuse (RWBR).

Parameter	Regulatory Limit	Monitoring Frequency	Sample Type	Compliance Logic / Objective
Turbidity	Less than or equal to 2 NTU	Continuous	Online Sensor	Auto-Divert Trigger: Prevents pathogen shielding.
Total Residual Chlorine (CPO)	Greater than or equal to 1.0 mg/L	Continuous	Online Sensor	Auto-Divert Trigger: Ensures viral/bacterial inactivation.
UV Dose	Greater than or equal to 100 mJ/cm^2	Continuous	Online Calculation	Auto-Divert Trigger: Based on Flow, UVT, and Intensity.
Total Coliform	2.2 MPN/100 mL	Weekly	7-Day Median	Long-term disinfection performance validation.
Total Coliform	14 MPN/100 mL	Weekly	Grab (Inst. Max)	Immediate safety verification.
TSS	Less than or equal to 5.0 mg/L	Weekly	24-hr Composite	Verification of filtration efficiency.
$BOD_{5\text{-day}}$	10 - 30 mg/L	Weekly	24-hr Composite	Ensures organic stability and prevents odors.
Total Nitrogen ($NO_3 + NH_3$)	Less than or equal to 10 mg/L	Monthly	Composite	Protects groundwater from nitrate loading.
pH	6.0 - 9.0 S.U.	Continuous	Online Sensor	Protects infrastructure and soil chemistry.
Metals & Toxics	Per EPA 2012	Case-by-Case	Grab or Composite	Prevents bioaccumulation in soil and ground water

8.13 Operational Compliance Requirements

- Analytical Standards: All laboratory analyses must be conducted by a state-certified laboratory using methods approved under 40 CFR Part 136.
- Calibration Protocols: Online sensors (Turbidimeters and Chlorine Analyzers) must be calibrated according to the manufacturer's specifications. Calibration logs must be maintained on-site for regulatory inspection.
- The TSS-Turbidity Correlation: Because TSS is measured weekly and Turbidity is measured continuously, it is recommended the permittee maintain a statistically significant correlation between the two. This correlation must be updated annually to ensure the turbidimeter remains a reliable proxy for solids removal.
- Reporting: Any exceedance of the "Instantaneous Maximum" for bacteria or a failure of the auto-divert system must be reported to the Department immediately as a non-compliance event.

9.0 Treatment Technologies and Performance Requirements

Combining Treatment Systems with Water Quality Limits provides the means for a safe and efficient reuse system for the specific type of reclaimed water usage.

9.1 Design Criteria

Design criteria ensure that reclaimed water treatment and distribution systems are built to consistently meet effluent limits, provide operational reliability, and protect public health and the environment. Connecticut specifies certain mandatory requirements for treatment processes, storage, and distribution systems, while other best practices are drawn from authoritative sources such as the U.S. Environmental Protection Agency (EPA), the Great Lakes–Upper Mississippi River Board's Ten States Standards and the NEIWPCC TR-16: Guidelines for the Design of Wastewater Treatment works.

9.2 General Design Principles

Reclaimed water systems must be designed for reliability, redundancy, and ease of maintenance. EPA recommends incorporating a minimum of two parallel process units for critical treatment steps to ensure uninterrupted service during maintenance (EPA Guidelines for Water Reuse, 2012).

A reclaimed water distribution system must be designed to:

- Prevent cross-connections and contamination of potable water.
- Ensure access control and restrict unauthorized use.
- Support long-term system integrity and safe operation.
- Reliability and redundancy for critical treatment components.
- Ease of maintenance, including safe access for inspection and repair.
- Use of materials resistant to corrosion and ultraviolet degradation.
- Compliance with state and federal safety codes.

Permit holders are responsible for ensuring compliance with permit conditions, applicable local, state, federal regulations, building codes, and all plumbing and public health requirements.

9.3 Physical Design Standards

All materials must be approved for recycled water use and installed per plumbing and building code requirements. All reuse distribution systems in Connecticut must comply with the following:

9.4 Distribution System Design Standards

The physical infrastructure of a reclaimed water system must be clearly distinguishable from potable water and sewer systems to prevent cross-connections and accidental ingestion. The following elements define the engineering requirements for the "Purple Pipe" network.

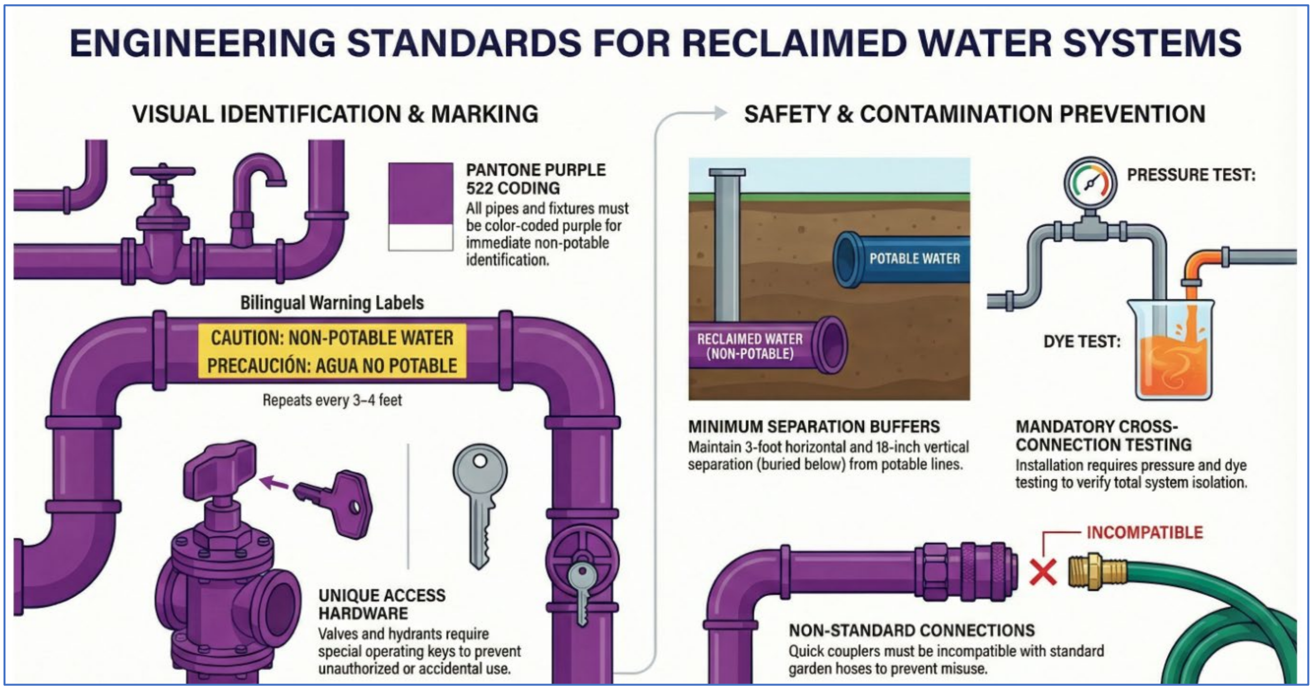


Table 8: Design Elements for Reclaimed Water Distribution

Design Feature	Standard	Engineering Specification
Pipe Color	Pantone Purple 522	Must use UV-resistant pigment for all exposed piping and integral color for buried PVC/HDPE.
Pipe Labeling	Warning Text	"CAUTION: NON-POTABLE WATER – DO NOT DRINK" and "PRECAUCIÓN: AGUA NO POTABLE – NO BEBER" printed every 3–4 feet on the pipe or using identification tape.
Separation (Horizontal)	Greater than 3 feet	Minimum horizontal distance from potable water or sewer lines.
Separation (Vertical)	Greater than18 inches	Reclaimed lines must be buried below potable lines at crossings to prevent contamination during leaks.
Valves & Hydrants	Purple / Unique Key	All fixtures must be color-coded purple and require a special operating nut/key to prevent unauthorized use.
Backflow Prevention	RPZ Assembly	Reduced Pressure Zone (RPZ) backflow preventers required at all service connections to the potable system.

Design Feature	Standard	Engineering Specification
Cross-connection Test	Pressure/Dye Test	Mandatory testing during installation and recurring intervals per DPH/DEEP requirements.
Quick Couplers	Non-Standard	Must be incompatible with standard garden hose threads or potable water quick-connects.
Hose Bibbs	Prohibited	Standard hose bibbs are strictly prohibited in all public or accessible areas.
Service Metering	Separate & Marked	Meters must be distinct from potable meters, painted purple, and clearly tagged.
Dye Injection Point	Permanent Port	All building owners must provide a permanent injection port in an accessible vault/box outside the building.

Reference: CT DPH Cross-Connection Guidelines (2024); International Plumbing Code (2021); EPA Water Reuse Guidelines (2012)

9.5 Detailed Technical Requirements

Identification and Signage. All points of use (irrigation heads, quick couplers, valves) must be identified with signage in both English and Spanish indicating that the water is non-potable.

Valve Boxes. Covers must be triangular or specifically shaped to distinguish them from potable water (round) or sewer (square) boxes and must be cast with the words "RECLAIMED WATER" and “AGUA NO POTABLE”

9.6 Cross-Connection Dye Testing

The requirement for a permanent dye injection point is critical for high-density urban or indoor reuse.

- Procedure: During inspections, a non-toxic dye (e.g., Fluorescein) is injected at the service entrance. All potable fixtures (sinks, water fountains) are then checked to ensure no colored water appears.
- Isolation: Irrigation systems should be designed with isolation valves so that dye testing can be performed on the building interior without staining landscaping or turf.

9.7 Separation and Burial

In areas where 3 feet of horizontal separation is physically impossible (e.g., narrow urban utility corridors), the designer may request a variance, which usually involves encasing the reclaimed line in a secondary sleeve or using higher-pressure-rated pipe material.

9.8 Hydraulic Design for Reclaimed Water Systems

The hydraulic design of a reclaimed water network must balance the unique demand patterns of reuse—such as nocturnal irrigation—with the need to maintain water quality and infrastructure integrity.

In accordance with industry standards for pressurized distribution (e.g., Ten States Standards, 2018), the network must be sized to meet peak demands while ensuring the following pressure gradients:

- Minimum Design Pressure: 35 psi at the hydraulically most remote point of the system under peak demand conditions.
- Maximum Operating Pressure: 80 psi to protect plumbing fixtures and prevent excessive wear on valves and seals.

9.9 Critical Design Parameters

- Peak-to-Average Flow Ratio: Reclaimed water demand is often highly skewed. Irrigation systems typically operate in a concentrated window (e.g., 10 PM to 6 AM), leading to much higher peaking factors than standard potable systems.
- Surge Control (Water Hammer): Reclaimed systems often experience frequent pump cycling and rapid valve actuation. Surge tanks, variable frequency drives (VFDs), or slow-closing valves must be specified to prevent transient pressure spikes.
- Stagnation and Age Management: Unlike potable systems, reclaimed water may have higher biological activity. Pipelines should be designed with adequate slope and strategically placed automatic flushing valves at dead-ends to prevent water age issues and biofilm buildup.
- Future Capacity: Infrastructure should be sized for ultimate service area build-out, as retrofitting buried "purple pipe" in a developed urban corridor is significantly more expensive than initial over-sizing.

Table 9: Hydraulic Design Baseline

Parameter	Design Value	Rationale
Min. Pressure	35 psi	Ensure operation of irrigation heads/flush valves.
Max. Pressure	80 psi	Prevent fixture damage and pipe fatigue.
Velocity	2–5 ft/s	Prevent solids settling (low) and scouring/surge (high).
C-Factor (Hazen-Williams)	140 (PVC/HDPE)	Standard friction coefficient for plastic piping.

10.0 Treatment Process Design

The engineering of a water reclamation facility must prioritize consistency and fail-safe operation. Because reclaimed water is often used in public-access areas, the treatment train must be designed to handle both hydraulic surges and biological upsets without compromising effluent safety. Treatment processes must be designed to meet or exceed effluent limits under all operating conditions. EPA recommends incorporating bypass management systems to prevent untreated or partially treated water from entering the reclaimed water distribution system (EPA Guidelines for Water Reuse, 2012).

Key Design Considerations:

- Detention Time: Sufficient residence time must be provided for sedimentation, biological oxidation, and disinfection kinetics.
- Redundancy: A "Firm Capacity" approach is required—critical components (pumps, blowers, filters) must meet peak demand with the largest unit out of service (N+1 redundancy).
- Emergency Management: The system must be capable of immediate diversion to a reject pond, holding tank, or an alternative permitted discharge point during an upset.

10.1 Unit Operations: From Oxidation to Filtration

- Biological Oxidation: All facilities must employ a secondary biological process (e.g., Activated Sludge, MBR, or SBR) to stabilize organic matter and reduce BOD to non-putrescible levels.
- Clarification: Multiple sedimentation units are required. Design must ensure that solids loading and weir overflow rates remain within acceptable ranges even during unit maintenance. Note: Advanced membrane technologies (MBR) may be substituted for traditional clarification if performance is validated.
- Coagulation: To maximize pathogen and phosphorus removal, chemical coagulant feed systems are mandatory. Operational Requirement: If turbidity limits can be met without chemicals, the system may remain idle but must be exercised twice monthly to ensure mechanical readiness.
- Filtration: Filtration is the primary barrier for removing protozoan pathogens like Cryptosporidium and Giardia.
- Auto-Divert: A turbidimeter must be installed on the combined filter effluent. If turbidity exceedances occur, an automatic diversion valve must activate immediately and remain open until compliance is restored.

10.2 Advanced Disinfection Protocols

Disinfection is the final safety barrier. Reliability is achieved through baffling, monitoring, and redundant hardware.

- Chlorination (CT Compliance): Systems must achieve a minimum contact time of 15 minutes at peak hourly flow.

- Baffling: Contact basins must be designed with a high length-to-width ratio (serpentine flow) to minimize "short-circuiting" and ensure all water receives the required dose.
- Ultraviolet (UV) Validation: UV systems must be validated via Bioassay (using MS-2 bacteriophage) in accordance with NWRI protocols.
- Design must account for UVT (Transmittance) degradation, lamp aging, and quartz sleeve fouling over a 6-month performance window.
- Fail-Safe Requirements: Automatic switchover for chemical feeds.
- Standby power (Generator or UPS) with automatic transfer.
- Redundant reactor trains (in series or parallel).

10.3 Power and Alarms

To ensure uninterrupted protection of public health, the facility must have a resilient power strategy:

- Standby Power: An on-site generator or dual-feed lines from separate substations are required.
- Mandatory Alarms: Remote and local alarms must trigger for loss of power, pump failure, and disinfection system failure (e.g., low chlorine or UV lamp out).

It is recommended that all disinfection systems provide a detectable disinfectant residual at the point of delivery. The design should consider multiple points of disinfection (before and after storage, prior to long transport lines, critical points within the distribution system, etc.). For ultraviolet (UV) disinfection, minimum design and delivered dosage determinations must be supported and validated with the following:

- A bioassay documenting dose-response validated in accordance with National Water Research Institute protocols,
- Transmittance degradation assessment to include sleeve fouling, buildup, debris or any other sources of potential transmittance degradation.
- Lamp output reduction to include end-of-lamp life validation.
- Six months of testing data to determine potential energy absorption losses from the waste stream documenting UV transmittance.

Table 10. Treatment Reliability Summary

Feature	Requirement	Standard / Protocol
BOD Removal	Biological Oxidation	Secondary Treatment Baseline
Clarification	N+1 Redundancy	Ten States Standards
Turbidity Control	Filtration + Coagulation	Continuous Monitoring with Auto-Divert
UV Validation	Bioassay (MS-2)	NWRI / Water Reuse Protocols
Chlorine CT	15 min at Peak Flow	Baffling Factor greater than 0.5 (Typical)
Emergency Power	Automatic Switchover	On-site Generator or UPS

11.0 Monitoring, Reliability, and Environmental Resilience

The operational success of a water reclamation facility depends on its ability to detect failures instantly and withstand the regional climatic extremes of the Northeast.

11.1 Monitoring and Control Systems (SCADA)

A centralized Supervisory Control and Data Acquisition (SCADA) system is the "brain" of the reuse facility. It must provide continuous performance tracking and remote alarm capabilities to ensure that no non-compliant water reaches the distribution header.

- Continuous Online Monitoring: Mandatory for Turbidity, Chlorine Residual, and Flow Rates at key compliance points.
- Automated Shutdown/Diversion: The SCADA must be programmed to automatically actuate the diversion valve if water quality exceedances occur, bypassing the storage facilities entirely.
- Mandatory Alarm Triggers: The system must provide immediate notification (visual, audible, and remote) for:
    - Loss of Normal Power: Instant notification of a switch to standby power.
    - Pumping System Failure: Detection of "no-flow" conditions or motor faults.
    - Disinfection System Failure: Low UV intensity, lamp failure, or low chlorine residual.

11.2 Climate and Seasonal Considerations

Connecticut's climate presents unique challenges that must be addressed during the engineering phase to prevent infrastructure damage and permit violations.

- Freeze Protection: All exposed piping, valves, and monitoring equipment must be heat-traced and insulated or housed in climate-controlled enclosures to withstand deep freeze cycles.
- Inflow and Infiltration (I&I): Design must account for heavy precipitation events that can dilute biological processes or hydraulically overwhelm filtration units.
- Seasonal Demand Shifts: Treatment processes must be flexible enough to handle "winter low-flow" (stagnation risk) and "summer peak-flow" (high irrigation demand).

11.3 Reliability and Redundancy Standards

To satisfy CT DEEP expectations and EPA Reliability Guidance, the following hardware redundancies should be included:

- Firm Capacity (N+1): All critical treatment stages (oxidation, clarification, filtration, disinfection) must be capable of meeting peak design flow with the largest single unit out of service.
- Flow Equalization: For facilities with highly variable inflows, equalization basins are required to provide a steady "constant-rate" feed to the tertiary filters and disinfection reactors.
- Disposal Alternatives: If a facility has no alternative permitted discharge point (e.g., a river outfall), it must have 100% redundancy in all critical units and sufficient emergency storage to hold off-spec water during repairs.

- Spare Parts Inventory: The facility must maintain an on-site stock of critical wear items (UV lamps, ballast, pump seals, sensor probes) sufficient to ensure a 3-day repair turnaround.

Table 11: Reliability and Redundancy Checklist

Reliability Feature	Requirement	Purpose
Critical Units	N+1 Redundancy	Service continuity during maintenance.
Automation	Auto-Divert Logic	Prevents off-spec water distribution.
Power	Auto-Switchover	Maintains disinfection during grid failure.
Equalization	Sizing for Peak Hourly	Stabilizes filter loading rates.
Inventory	3-Day Supply	Minimizes downtime for common failures.

12.0 Storage and Distribution Design

Storage and distribution systems are critical for buffering the difference between constant treatment plant production and fluctuating end-user demand. These systems must be engineered to maintain the high quality of reclaimed water from the point of treatment to the final point of use.

12.1 Overview

The primary functions of storage facilities are to balance supply and demand, provide operational flexibility, and offer emergency capacity. Distribution systems must convey water to end users while maintaining adequate pressure, flow, and safety safeguards.

12.2 Storage Requirements

Storage tanks must be constructed of materials that are non-corrosive and compatible with reclaimed water (e.g., concrete with protective liners, fused-glass-to-steel, or reinforced plastic).

- Diurnal Balancing: If a facility does not have an alternative disposal method (like a river outfall), the storage must be sized to handle the diurnal demand cycle. Even if storage is not strictly required by permit, an engineering evaluation must prove that flow equalization is sufficient to match demand patterns.
- Freeboard and Inspection: Tanks must maintain adequate freeboard to prevent overflows and be equipped with accessible hatches and drainage for routine sediment removal and structural inspection.
- Pond Storage (Golf Courses/Lakes): Existing ponds are acceptable if they do not have a direct connection to a surface water body (to prevent accidental unpermitted discharge).
- Use for reclaimed water must not impair the pond's primary function (e.g., as a critical stormwater retention basin).

12.3 General Design Principles

All storage systems must be designed according to four key protective pillars:

- Contamination Prevention: Tanks must be fully enclosed or protected from bird/animal intrusion and windblown debris.
- System Separation: Reclaimed storage must remain physically distinct from stormwater collection and potable water systems.
- Overflow Management: Systems must include high-level alarms and overflow piping that does not discharge directly to sensitive surface waters.
- Reject Water Management: Every facility must have a dedicated Reject Water Storage unit (tank or pond). This allows water that fails quality sensors (e.g., high turbidity) to be held and returned to the headworks for re-treatment rather than entering the distribution network.

12.4 Safety and Security

Given that reclaimed water is non-potable, physical security is mandatory to prevent accidental misuse or tampering.

- Access Control: Fencing, locked hatches, and secured valve vaults are required for all storage sites.
- Warning Signage: Prominent signs must be posted at all access points and fixtures in English and Spanish (if applicable), stating: "CAUTION: RECLAIMED WATER – DO NOT DRINK" and “PRECAUCIÓN: AGUA NO POTABLE – NO BEBER”

Table 12: Storage Configuration Summary

Storage Type	Primary Purpose	Material Standard	Mandatory Feature
Operational Storage	Diurnal Balancing	AWWA D100/D103	Level Sensors / Mixing System
Reject Storage	Off-spec Holding	Lined / Enclosed	Return Pump to Headworks
Pond Storage	Seasonal / Irrigation	30-mil Synthetic Liner	No Surface Water Connection

12.5 Storage, Reject Management, and Land Application

This section defines the mandatory design and operational standards for holding reclaimed water and safely applying it via spray irrigation. The core objective is to prevent off-spec water from entering the distribution system and to minimize human and environmental exposure to aerosols.

12.6 Reclaimed Water Storage Design

Storage facilities must be engineered to maintain water quality and provide a sufficient buffer for on-demand use.

Table 13: Design Criteria for Reclaimed Water Storage

Design Criteria	Standard Specification
Water Quality Entry	Reclaimed water must meet all turbidity and bacteriological standards prior to storage.
Minimum Capacity	Designed to support on-demand reuse; must hold a minimum of 3 days of average daily flow.
Seepage Control	Constructed ponds must utilize a synthetic liner to prevent groundwater contamination.

Design Criteria	Standard Specification
Freeboard	Minimum of 12 inches above the maximum operating level.
Covered Storage	Strongly recommended to prevent algae growth and evaporation.
Overflow Handling	Overflows are unauthorized discharges unless an active NPDES point-source permit is held.
Automatic Shutoff	Inflow must automatically stop when the control elevation is reached.

12.7 Reject Water Management

Reject water—effluent failing to meet reuse standards—must be isolated immediately to protect the integrity of the distribution network.

- Automatic Diversion: Triggered by turbidity or bacteria alarms.
- Isolation: Stored in lined, isolated reject ponds or holding tanks, physically separated from reclaimed water.
- Reprocessing: Reject water must be returned to the treatment plant headworks for reprocessing or routed to a permitted disposal site.

Table 14: Reject Storage Requirements

Feature	Reject Pond Requirement	Reject Holding Tank
Minimum Storage	3 days of average design flow	3 days of average design flow
Liner / Material	Synthetic Liner	Non-corrosive / Lined
Drainage	No inflow from stormwater/irrigation	No inflow from stormwater/irrigation
Overflow Handling	Return to headworks / Approved discharge	Return to headworks / Approved discharge

12.8 Integrated Reuse/Irrigation Storage Ponds

When ponds serve dual functions (reuse and stormwater), they must be managed to ensure stormwater capacity is not compromised by reclaimed water levels.

- Sizing: Based on 20+ years of historic rainfall and runoff analysis.
- Bleed-down: Must be equipped with devices to restore stormwater capacity within 5 days of an event.
- Note: "Always full" aesthetic ponds receiving reclaimed water may trigger surface water discharge permit requirements.

12.9 Spray Irrigation Protocols & Buffers

Spray irrigation is strictly regulated to prevent aerosol drift and incidental contact.

Operational Practices

- Seasonal Window: Authorized between April 1st and October 31st.
- Timing: Conducted during non-use (nocturnal) hours using low-trajectory sprayers.
- Automatic Cessation: Irrigation must stop if overland flow (runoff) occurs or if surface ponding is observed.
- Nutrient Management: A plan is required to track the combined nutrient load from wastewater and supplemental fertilizers.
- Barrier Credit: The use of natural barriers (hedges, dense tree lines) to reduce aerosol drift may be considered on a case-by-case basis to reduce the 400-foot setback.

Table 15: Buffer and Barrier Setbacks

Feature	Minimum Setback Requirement
Sensitive Structures	400 feet from buildings, wells, and surface water intakes.
General Property Lines	100 feet from any property line, wetland, or surface water body.
Roads & Pavement	Zero spray allowed on paved areas, decks, or driveways.
Public Well Drawdown	No irrigation allowed within the drawdown zone.

13.0 Operations, Maintenance, Training, and Compliance Requirements

This section provides system operation expectations, operator certification, and DEEP reporting protocols required for non-potable reuse systems in Connecticut.

13.1 Operator Requirements

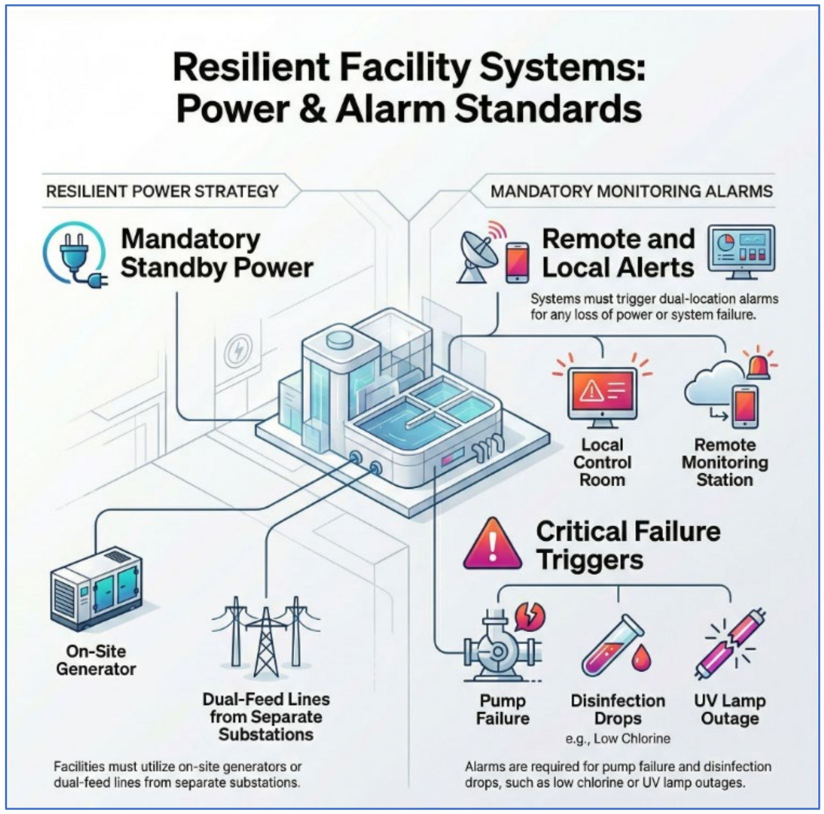
All personnel involved in system oversight must receive specialized training in reclaimed water operations, cross-connection prevention, and emergency response protocols.

- Operator in Responsible Charge (ORC): The facility must be under the direct supervision of an ORC who holds a valid Connecticut Wastewater Treatment Plant Operator certification. The certification class must be equal to or greater than the classification of the treatment facility as determined by CT DEEP under Regs. Conn. State Agencies § 22a-416-4.
- Staffing and Monitoring: Systems producing reclaimed water shall be monitored on-site seven days per week. Reductions in on-site staffing frequency may be granted by CT DEEP on a site-specific basis only if the facility utilizes approved remote, automated fail-safe alarms, and 24-hour call-out capabilities.
- Incident Response and Notification: In the event of a system failure, pipeline rupture, or suspected cross-connection, the ORC shall notify the CT DEEP Bureau of Materials Management Compliance Assistance, Bureau of Water Protection and Land Reuse, and the CT DPH Drinking Water Section within 24 hours. The following emergency actions must be taken:
    - Isolation: Immediately shut down and isolate the affected portions of the treatment or distribution system.
    - Communication: Inform all affected end-users and building management.
    - Remediation: Implement corrective measures and document the duration, volume, and nature of the event in the facility's permanent log.
    - Regulatory Reference: Regs. Conn. State Agencies§ 22a-416-1 through § 22a-416-10.

13.2 Operations Manual

The Operations Plan for the Onsite Non-potable Water System (ONWS) system is critical to project success, documenting all key components for system operation and maintenance. It should be developed by the Design Engineer and/or system integrator with input from equipment manufacturers, Operators, and the System Owner. An electronic copy should be accessible from a workstation and mobile devices (e.g., tablets, smartphones) at the ONWS facility, with a hard copy backup.

Essential elements include:



- Operations and Maintenance (O&M) Manual – Compilation of equipment O&M manuals.
- Process Design and Control Theory – Process control, performance monitoring, alarms/notifications, system design criteria, installation instructions, control narrative, bill of materials, as-built process/mechanical/electrical drawings.
- Standard Operating Procedures – Detailed startup/shutdown procedures, operator log sheets/checklists, troubleshooting procedures.
- Maintenance Plan – Maintenance recommendations/frequencies, spare parts recommendations, component technical cut sheets.
- Compliance Reporting – Sampling and reporting requirements.
- Environment, Health, and Safety Plan – Safety protocols, personal protective equipment, security measures, key contact information.
- Emergency Response Plan – Contingency plan (e.g., supplemental alternative water sources), key contact information.
- O&M Staffing Plan
- Commissioning and Acceptance Test Plan
- Process Optimization- All procedures and plans must be kept up to date, accessible to the operator in charge, and available upon request. Distribution systems must be flushed periodically to prevent sediment buildup. Seasonal systems, such as those serving irrigation, should be winterized to prevent freeze damage. Operational records must be kept in compliance with CT DEEP and DPH requirements.

- Inspection & Maintenance - Routine inspection and maintenance extend the service life of storage and distribution infrastructure while ensuring compliance with water quality standards.

13.3 Inspection and Maintenance Requirements

Effective long-term operation of a reclaimed water system relies on rigorous maintenance schedules and transparent compliance reporting. This section outlines the regulatory expectations for keeping the system safe and accountable to CT DEEP. Preventative maintenance is the primary defense against system failure. The following table establishes the minimum frequencies for infrastructure oversight.

Table 16: Inspection and Maintenance Schedule

Component	Inspection Frequency	Maintenance Frequency	Key Action Items
Storage Tanks	Quarterly	Annually	Check for sediment, algae, and liner integrity.
Pumps	Monthly	Semi-Annually	Inspect seals, motor vibration, and VFD status.
Valves	Semi-Annually	Annually	Exercise all isolation and auto-divert valves.
Distribution Pipelines	Annually	As Needed	Leak detection and "Purple Pipe" signage audits.

13.4 Compliance and Non-Compliance Reporting

All facilities must maintain a formal Sampling and Analysis Plan (SAP). This plan serves as the operational roadmap for meeting permit conditions.

- Reporting Requirements: Daily records and Monthly Discharge Monitoring Reports (DMRs) must be submitted to the Department. Required data includes online process trends (turbidity/chlorine), grab sample results, and meter calibration logs.

13.5 Non-Compliance Notification (The 24-Hour Rule)

In the event of a permit exceedance (e.g., bacteria spike or turbidity failure), the facility must notify CT DEEP via the Online Environmental Report Portal. The notification must detail:

- Nature and Cause: What happened and why (e.g., power failure, equipment malfunction).
- Corrective Action: Immediate steps taken to stop the violation (e.g., auto-diversion activated).

- Timeline: When the system is expected to return to full compliance.

13.6 Record Keeping and System Mapping

To ensure historical accountability and infrastructure safety, facilities must adhere to a strict document retention policy.

- 10-Year Retention: All laboratory results, calibration logs, daily operator logs, and user agreements must be retained for at least 10 years following permit expiration.
- System Mapping: Facilities are required to maintain an accurate, up-to-date map of all reclaimed water service lines. This map must clearly identify isolation valves and customer connection points and be available for immediate Departmental inspection.

13.7 Public Safety Controls

Public safety measures are essential to prevent unintended exposure to non-potable water.

- Physical Controls: Locked valve boxes, unique keys for hydrants, and "Purple Pipe" color-coding.
- Operational Controls: Adherence to spray buffers and nocturnal irrigation schedules.
- Informational Controls: High-visibility signage at all points of use and public education programs for facility staff and end-users.

14.0 Public Safety, Outreach, and Best Management Practices (BMPs)

Public safety is the cornerstone of any water reuse program. In Connecticut, this is achieved through a multi-layered approach involving physical engineering controls, rigorous signage, and comprehensive public education to prevent accidental ingestion or cross-connections.

14.1 Signage and Labeling Requirements

Visual cues are the first line of defense in identifying non-potable water. All public access points and distribution infrastructure must be clearly marked.

Table 17: Required Sign and Label Elements

Element	Requirement	Color / Format	Placement
Language	English and Spanish	Black text on white/yellow	All public access points
Wording	"Reclaimed Water – Do Not Drink" / "Agua Recuperada – No Beber"	Bold, Uppercase	Visible from 25 feet
Symbol	Universal "No Drinking" icon	Black on White circle	Adjacent to text
Pipe Label	"Reclaimed Water" / "Agua Recuperada"	White text on Purple	Every 10 feet of pipe

14.2 Exposure Prevention and Design Setbacks

To eliminate direct human contact with reclaimed water mists or aerosols, the following design and operational constraints are mandatory for above-ground irrigation:

- Aerosol Mitigation: Systems must be designed to limit aerosol formation within 100 feet of public areas.
- Sensitive Buffers: Irrigation is prohibited within 200 feet of a drinking water impoundment.
- Overspray Prevention: No water may reach buildings, patios, athletic fields, pools, splash pads, or drinking fountains.
- Environmental Protection: Irrigation must be managed to avoid pooling or runoff that could reach storm drains.
- Weather Constraints: Operations must cease during high winds or when the public is expected to use the area.

14.3 Best Management Practices (BMPs)

BMPs provide the framework for integrating safety into the entire lifecycle of the project, from initial planning to daily operations.

Table 18: Planning, Design, and Operational BMP Checklist

Category	BMP Item	Description
Planning	Risk Assessment	Evaluate public access and environmental sensitivities.
Design	Freeze Protection	Insulate or bury lines below frost depth for CT winters.
Operation	Pipeline Flushing	Flush distribution lines at least twice per year to maintain quality.
Operation	Signage Audit	Verify all required signs are intact and legible monthly.

14.4 Seasonal BMP Calendar

Table 19. Connecticut's climate requires dynamic operational adjustments throughout the year.

Season	Inspection & Monitoring	Maintenance & Operations
Spring	Inspect for frost damage; full panel water test.	Resume irrigation gradually; repair winter leaks.
Summer	Monthly pump/tank checks; increase monitoring.	Water in early morning/evening; lubricate motors.
Fall	Pre-winter pipe inspection; test residuals.	Blow out and drain lines; reduce frequency.
Winter	Monthly inspection of indoor systems/heaters.	Shut down outdoor lines; maintain indoor storage.

14.5 User Agreements and Restrictions

All end-users must enter into a formal contract with the permittee to ensure accountability.

Mandatory User Restrictions:

- Prohibited Uses: No drinking, food preparation, swimming pools, or splash pads.
- Edible Crops: No irrigation of human consumption crops.
- Cross-Connections: Absolutely no interconnection with potable water supplies.
- Reporting: Users must immediately report line breaks or runoff events.

The Permittee's Responsibility:

The permittee must maintain updated as-built drawings, perform regular compliance inspections, and retain the authority to terminate service for any user found in non-compliance.

14.6 Public Outreach and Multi-Cultural Engagement

Outreach must be inclusive and reach multi-lingual and multi-ethnic communities. Programs should include:

- Educational Seminars: For both users and maintenance personnel.
- Digital Transparency: Public-facing websites with real-time safety data.
- Notification: Clear procedures for notifying the Department of any changes in ownership or use of a reuse-connected property.

15.0 Case Studies

This section provides structured case studies illustrating how reclaimed water systems are implemented and operated in Connecticut. Each brief includes project drivers, system design, compliance measures, operational performance, and lessons learned. Examples cover institutional, recreational, and industrial applications.

15.1 University of Connecticut (UCONN) – Storrs Campus

Project Overview:

- **Purpose**: Offset potable water demand during drought and summer peaks
- **Source**: Tertiary-treated wastewater from the UCONN Water Pollution Control Facility (WPCF)

Reuse Applications:

- Power plant cooling water (closed-loop)
- Irrigation of athletic fields and landscaping
- Toilet flushing in certain academic buildings

System Highlights

- Treatment: Biological oxidation, membrane filtration, UV disinfection
- Storage: Covered tank adjacent to the WPCF
- Piping: Purple pipe distribution system throughout campus
- Monitoring: Continuous turbidity and chlorine residual sensors
- Cross-Connection Control: Physical separation and backflow preventers

Source: UCONN Facilities Operations, CT DEEP, 2020–2023

Figure: Aerial view of the UConn Water Reclamation Facility, Storrs campus. Highlights the sedimentation basins, filtration structures, and reclaimed water tank.

15.2 Lake of Isles Golf Course – Mashantucket Pequot Reservation (North Stonington, CT)

Project Overview:

Reclaimed water from an onsite wastewater treatment plant operated by the Mashantucket Pequot Tribal Nation is used to irrigate the Lake of Isles golf course. The facility consistently delivers an estimated 1 million gallons per day of reuse water during the peak growing season.

Reuse Applications:

- Irrigation of 36 holes of golf course turf
- Use in maintenance ponds and landscaping

System Highlights:

- Biological Treatment: Sequence Batch Reactors (SBR) followed by nitrification/denitrification processes
- Filtration & Disinfection: Turbidity and protozoa barriers, followed by UV disinfection and controlled chlorine dosing
- Storage: Dedicated onsite storage tank (approximately 800,000 gallons)
- Design Controls: Proprietary irrigation timing (typically 9 p.m. to 6 a.m.), low-trajectory nozzles, and runoff safeguards
- System Redundancy: Parallel pumps, UV reactors, and backup power supplies

Regulatory and Design Considerations

- While tribal treatment facilities are sovereign, reclaimed water distributed off-reservation must comply with Connecticut reuse regulations per Con. Gen. Stat./ Regs. Conn. State Agencies standards
- Drainfield and leach systems are used for reject water under controlled conditions
- Buffer zone and spray control measures aligned with CT DPH and 314 CMR 20.13 guidance

Key Outcomes

- High-volume reuse for recreation reduces potable water demand by roughly 1 MGD
- Reduction of infiltration bed usage and nutrient loading
- Maintains high turf quality without expanding potable supply or septic systems

Sources: CT DEEP Case Study PDF; CT DEEP P2View newsletters; EPA Region 1 Draft SP0002408 permit documentation (2024)

Figure. Lake of Isles Golf Course irrigated by reclaimed water supplied from Mashantucket Pequot Treatment Plant (Source: CT DEEP case study).

16.0 Glossary of Terms

Authority: The definitions below are derived from Con. Gen. Stat. § 22a-423, Regs. Conn. State Agencies §§ 22a-430-3(a), 22a-430-6, and language adapted from Connecticut individual discharge permits. Each definition is provided as it appears in state regulations or permits.

General Definitions

Annual: For sampling frequency, means the sample must be taken in the month of March.

Average: The arithmetic average.

Average Daily Concentration: The average concentration of a substance in a daily composite sample.

Average Daily Flow: The average of all total daily flows measured during any calendar month.

Average Monthly Concentration: The average of all composite or grab sample averages taken during a calendar month.

Average Monthly Limit: The highest allowable average of all samples collected in a calendar month.

Continuous: A sampling frequency in which data must be collected at least every one minute for as long as discharge occurs.

Day: A 24-hour period beginning at 12:00 a.m. unless otherwise specified.

Discharge: The emission of any water, substance, or material into the waters of the state, whether or not it causes pollution. (*Con. Gen. Stat. § 22a-423*)

Domestic Sewage: Sewage from residences or buildings, excluding manufacturing wastewater, blowdown, stormwater, or yard drains.

Effluent Limitation: A numerical or qualitative limit imposed by the Commissioner on the discharge of water, substances, or materials. (*Regs. Conn. State Agencies § 22a-430-3(a)*)

Grab Sample: An individual sample collected in less than 15 minutes.

Ground Waters: Waters below the earth's surface including flow through soil or rock.

Injection: Subsurface emplacement of fluids through a well.

Instantaneous: A grab sample collected automatically or measured in-line.

Maximum Concentration: The highest value observed in a grab sample.

Maximum Daily Concentration: Highest observed daily value, from a composite or grab sample.

Maximum Daily Flow: Greatest discharge volume in a single day (not exceeding design flow).

Maximum Daily Quantity: Maximum quantity of waste generated during an operating day.

mg/L: Milligrams per liter, a unit of concentration.

MBBR: Moving Bed Biofilm Reactor.

Non-Point Source: Diffuse pollution sources such as stormwater or atmospheric deposition.

Permittee: Any person or municipality authorized under a CT DEEP discharge permit.

Pollutant: Any substance regulated by effluent limitations.

Quarterly: For sampling frequency, means one sample in each calendar quarter (ending March, June, September, December).

Safe Drinking Water Act (SDWA): 42 U.S.C. § 300f et seq. and implementing federal regulations.

Subsurface Sewage Disposal System: A septic system including tanks, leaching, and pumps.

Sufficiently Sensitive: A method meeting detection criteria in 40 CFR § 122.44(i)(1)(iv).

Three Times Per Year: Maintenance frequency, during the period May to November.

Twice Per Month: Sampling frequency—two samples each calendar month at least 12 days apart.

Twelve-Month Rolling Average: The average monthly concentration averaged over the current and previous eleven months.

Well: A bored, drilled, or driven shaft deeper than its widest dimension or a defined septic system well.

17.0 List of Abbreviations and Acronyms

This section provides a standardized reference for the technical and regulatory terminology used throughout this manual. Consistent use of these terms ensures clarity in engineering reports, permit applications, and daily operational logs.

Abbreviation	Full Term
AWWA	American Water Works Association
BOD	Biochemical Oxygen Demand
CFR	Code of Federal Regulations
CGS	Connecticut General Statutes (Alt: *Con. Gen. Stat.*)
CT DEEP	Connecticut Department of Energy and Environmental Protection
CT DPH	Connecticut Department of Public Health
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
MBBR	Moving Bed Biofilm Reactor
mg/L	Milligrams per Liter
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
ONWS	Onsite Non-potable Water System
POTW	Publicly Owned Treatment Works
RCSA	Regulations of Connecticut State Agencies (Alt: *Regs. Conn. State Agencies*)
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition

Abbreviation	Full Term
SDWA	Safe Drinking Water Act
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UCONN	University of Connecticut
UV	Ultraviolet (Disinfection)
WPCF	Water Pollution Control Facility
WWTP	Wastewater Treatment Plant

18.0 References

American Water Works Association. (2020). *Water reuse: Issues, technologies, and applications*. https://www.awwa.org

Connecticut Department of Energy and Environmental Protection. (2024). *Water permitting and enforcement*. https://portal.ct.gov/deep

Connecticut Department of Public Health. (2024). *Cross connection control manual*. Drinking Water Section. **https://portal.ct.gov/dph/drinking-water/dws/backflow-prevention-and-cross-connection-control**

Connecticut Department of Public Health. (2010). *Guidelines for reclaimed water system design*. [Archived document].

Conn. Gen. Stat. § 22a-423. (2024). https://www.cga.ct.gov/current/pub/chap_446k.htm#sec_22a-423

Environmental Protection Agency. (2012). *2012 guidelines for water reuse* (Report No. EPA/600/R-12/618). https://www.epa.gov/waterreuse/2012-guidelines-water-reuse

Environmental Protection Agency. (2024). *Water reuse and recycling: Community and technical resources*. https://www.epa.gov/waterreuse

Environmental Protection Agency. (1981). *Process design manual: Land treatment of municipal wastewater* (Report No. EPA 625/1-81-013).

Environmental Protection Agency. (1984). Process design manual: Land treatment of municipal wastewater – Supplement on rapid infiltration and overland flow (Report No. EPA 625/1-81-013a).

Georgia Environmental Protection Division. (2023). *Water reuse guidelines*. Watershed Protection Branch. https://epd.georgia.gov

Great Lakes–Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. (2018). Recommended standards for water works: Policies for the review and approval of plans and specifications for public water supplies. Health Research, Inc.

International Code Council. (2020). ***2021 international plumbing code*.** https://codes.iccsafe.org/content/IPC2021P4

Massachusetts Department of Environmental Protection. (2022). *314 CMR 20.00: Reclaimed water use regulations*. https://www.mass.gov/regulations/314-CMR-2000-reclaimed-water-use

National Blue Ribbon Commission for Onsite Non-Potable Water Systems. (2023). *Health risk-based benchmarks for onsite treatment of water*.

National Weather Service. (2024). *Northeast climate data summaries*. National Oceanic and Atmospheric Administration. https://www.weather.gov

NEIWPCC (New England Interstate Water Pollution Control Commission). (2026). *TR-16: Guides for the Design of Wastewater Treatment Works* (2026 ed.). Technical Report #16. Lowell, MA.

New Hampshire Department of Environmental Services. (2020). Land treatment and disposal of reclaimed wastewater: Guidance for groundwater discharge permitting.

New Jersey Department of Environmental Protection. (2005). Reclaimed water for beneficial reuse: A New Jersey technical manual.

New England Interstate Water Pollution Control Commission. (2011). *TR-16: Guides for the design of wastewater treatment works*.

Pecson, B., & Post, B. (2020). *Onsite non-potable water system guidance manual* (Project No. WRF1732/4909). Water Research Foundation. https://watereuse.org/wp-content/uploads/2020/12/DRPT-4909.pdf

Regs. Conn. State Agencies §§ 22a-430-3, 22a-430-6, 22a-430-8. *Discharge permitting regulations*. https://eregulations.ct.gov/eRegsPortal/Browse/RCSA

San Francisco Water Power Sewer. (2022). Onsite water recycling: An innovative approach to solving an old problem.

Schoen, M. E., Ashbolt, N. J., Jahne, M. A., & Garland, J. (2017). Risk-based enteric pathogen reduction targets for non-potable and direct potable use of roof runoff, stormwater, and greywater. *Microbial Risk Analysis, 5*, 32-43.

Schoen, M. E., Garland, J., Soller, J. A., Thimons, S. X., & Jahne, M. A. (2023). Onsite nonpotable water systems pathogen treatment targets: A comparison of infection and disability-adjusted life years (DALYs) risk benchmark approaches. *Environmental Science & Technology*.

Sharvelle, S., Ashbolt, N., Clerico, E., Hultquist, R., Leverenz, H., & Olivieri, A. (2017). *Risk-based framework for the development of public health guidance for decentralized non-potable water systems* (Final Report). Water Research Foundation.

University of Connecticut. (2019). *Water reclamation facility factsheet and case study*. UConn Facilities Operations. https://fo.uconn.edu

U.S. Geological Survey. (2024). *Groundwater data for Connecticut*. https://waterdata.usgs.gov/ct/nwis/gw

Water Research Foundation. (2023). Assessing the microbial risks and impacts from stormwater capture and use to establish appropriate best management practices (Project No. 5111).

19.0 Appendix A. Engineering Report

Type of Information to be Included in an ONWS Engineering Project Plan

Project Element	Type of Information Provided
General Information	1. Identify all entities involved in the design, treatment, distribution, construction, and operation and maintenance of the facilities. 2. Describe legal arrangement with roles and responsibilities between the entities. 3. Identify the treatment system manager, along with manager's qualifications and responsibilities. 4. Provide organizational chart (as needed). 5. Provide additional project information, e.g., building size and type, description of uses, types and number of occupants, visitors, and/or employees.
Rules and Regulations	Identify relevant rules and regulations governing development and use of ONWS system.
Raw Source Water	1. Describe the source water for ONWS (e.g., blackwater, graywater, etc.). 2. Describe the quality (or assumed quality) of source water. 3. Describe industrial inputs and source control (as needed). 4. Estimate total daily and/or annual flow of each source water (may be needed to meet water budget or grant requirements).
Treatment	1. Develop process flow diagram including tanks, unit processes, monitors, waste streams, diversion locations, overflows to sanitary sewers, potable makeup supply location, backflow prevention devices, sample ports, etc. 2. Describe unit processes. 3. Provide design criteria for unit processes. 4. Define proposed pathogen credit for each group and associated crediting framework. 5. Define flow rates entering and leaving each unit process. 6. Describe chemical usage requirements including identification of chemicals used, the point of application, dosing rate, and chemical specifications. 7. Provide overview of operations and maintenance 8. Describe solids and residuals handling.

Monitoring and Reporting	1. Describe monitoring and reporting program including all monitoring required by relevant rules and regulations. 2. Include frequency and location of sampling. 3. Summarize online monitoring capabilities. 4. Summarize grab sample monitoring locations and frequency. 5. Describe calibration methods and frequency.

20.0 Appendix B. Application available on the UIC Program Website