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UNIFIED FACILITIES SUPPLEMENT (UFS)

WATER REUSE

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FOREWORD

Unified Facilities Supplements (UFS) provide non-mandatory, supplemental information in support of Unified Facilities Criteria (UFC). Only UFC establish enforceable criteria. UFS are For Information Only (FIO) and exist to help users understand and apply UFC requirements.

The purpose of UFS is to offer procedural guidance, best practices, lessons learned, examples, and explanatory materials that clarify how to meet UFC criteria. They may include step-by-step procedures, checklists, illustrations, or decision aids, but they do not create new requirements or modify UFC content.

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UNIFIED FACILITIES SUPPLEMENT (UFS)

WATER REUSE

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

This UFS provides requirements for water reuse. Water reuse is the method of recycling treated wastewater for a variety of beneficial uses, including potable and non-potable purposes. In recent years, the term "water reuse" has generally replaced the use of “wastewater reuse” and other interchangeable terms such as "water reclamation" and "water recycling.” This UFS will generally use the terms “water reuse” and “water recycling” interchangeably.

1-2 PURPOSE AND SCOPE.

This UFS provides technical criteria and technical requirements for water reuse in applications of non-potable reuse (NPR), indirect potable reuse (IPR), and direct potable reuse (DPR), for the Department of Defense (DoD). This UFS does not apply to onsite water reuse, such as the reuse of wastewater at a building scale. Onsite water reuse involves decentralized, smaller-scale reuse systems that have a different risk profile than reuse of municipal wastewater. The requirements contained in this UFS apply to DoD facilities unless specifically referenced to a single service.

1-3 APPLICABILITY.

This UFS follows the same applicability as UFC 1-200-01, paragraph 1-3, with no exceptions.

1-4 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code*. UFC 1-200-01 provides applicability of model building codes and government-unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFS in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-5 CYBERSECURITY.

Plan, design, acquire, execute, and maintain all facility-related control systems (including systems separate from a utility monitoring and control system) in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

1-6 COMMENTARY

Limited commentary has been added to the chapters. Section designations for such commentary are preceded by a “[C]” and the commentary narrative is shaded.

1-7 GLOSSARY.

0 contains acronyms, abbreviations, and definitions of terms.

1-8 REFERENCES.

APPENDIX C contains a list of references used in this document. The publication dates of code and standards are not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

1-9 BEST PRACTICES.

APPENDIX A provides guidance for accomplishing engineering services related to non-potable reuse, indirect potable reuse, and direct potable reuse. The Designer of Record (DoR) is expected to review and interpret this guidance as it conforms to criteria and contract requirements and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from any UFC or the Unified Facilities Guide Specifications (UFGS), the UFC and the UFGS must be given a higher order of precedence.

CHAPTER 2 PLANNING AND DESIGN

2-1 INTRODUCTION.

In the planning of water reuse systems, consider the regulatory and technical components that may be required. This chapter generally discusses the major components of planning for a water reuse system.

2-2 WATER REUSE APPLICATIONS.

Water reuse involves treating and repurposing treated wastewater for beneficial purposes. Drivers for water reuse generally include:

1. Addressing urbanization and water supply scarcity.
2. Achieving efficient resource use.
3. Ensuring environmental and public health protection, such as through improved treatment of wastewater prior to discharge or greater intentionality in how the public is exposed to the discharge and reuse of treated wastewater.

Design water reuse systems with a “fit for purpose” approach, wherein the level of treatment and final water quality are tailored to meet the requirements for a particular use. For example, water used for irrigation is subject to a less complex and resource-intensive level of treatment than water used for directly augmenting a drinking water source. The three major categories of reuse are defined in the following sub-sections.

2-2.1 Non-Potable Reuse.

NPR encompasses all water reuse applications that do not involve potable reuse (USEPA 2012). Applications may include, but are not limited to, agricultural irrigation, landscape irrigation, impoundments, ecological enhancements, industrial reuse, and seawater intrusion barriers. Sources of water other than treated wastewater may also be used for non-potable water applications, such as stormwater or untreated surface or groundwaters, but those sources of water are not addressed by this UFS.

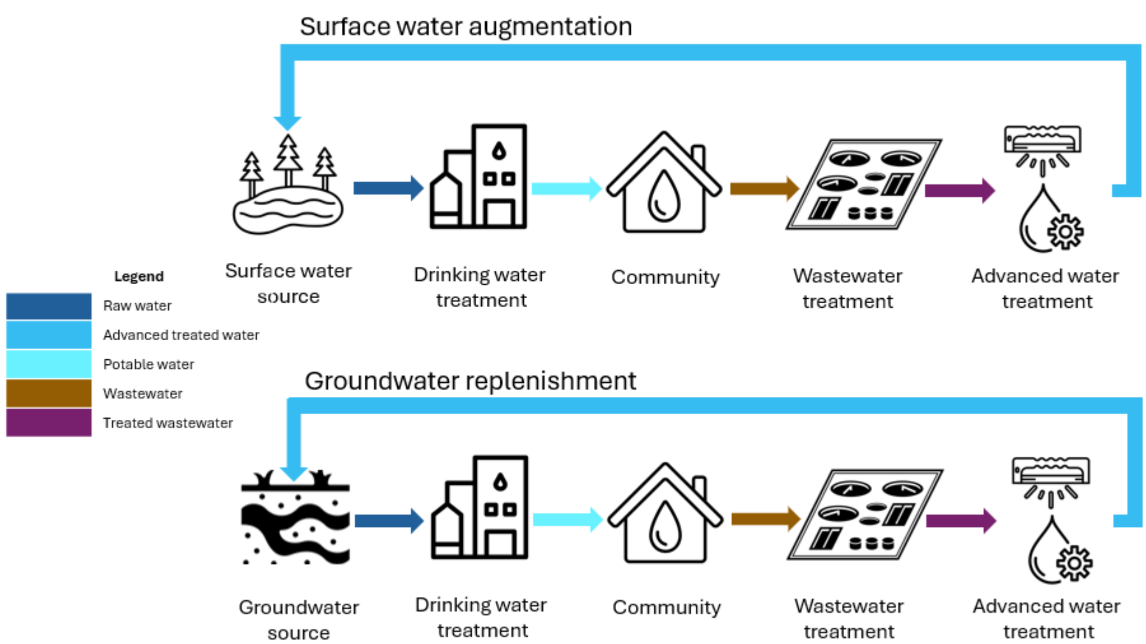
The feasibility and safety of using recycled water for a given NPR application is determined by the treated water quality level of the recycled water and risk of recycled water exposure to humans for the given use. For example, undisinfected water is not suitable for human contact or consumption and is used only in “non-contact” applications. Restrictions exist on the use of secondary wastewater for food crops and other applications that may entail human exposure or consumption, which require a higher quality of recycled water. Filtered and disinfected recycled water has the widest range of applicability for NPR, as it is safe for limited human exposure and agricultural applications where the water contacts the edible portion of the crop. A simple schematic of NPR is shown in Figure 2-1.

Figure 2-1 Overview of Non-Potable Reuse.

2-2.2 Indirect Potable Reuse.

IPR is the intentional introduction of recycled water into an environmental drinking water source (for example, surface water or groundwater aquifer) that acts as an environmental buffer (U.S. EPA 2017) between the recycled water treatment facility and the drinking water treatment facility. A simple schematic of IPR is shown in Figure 2-2.

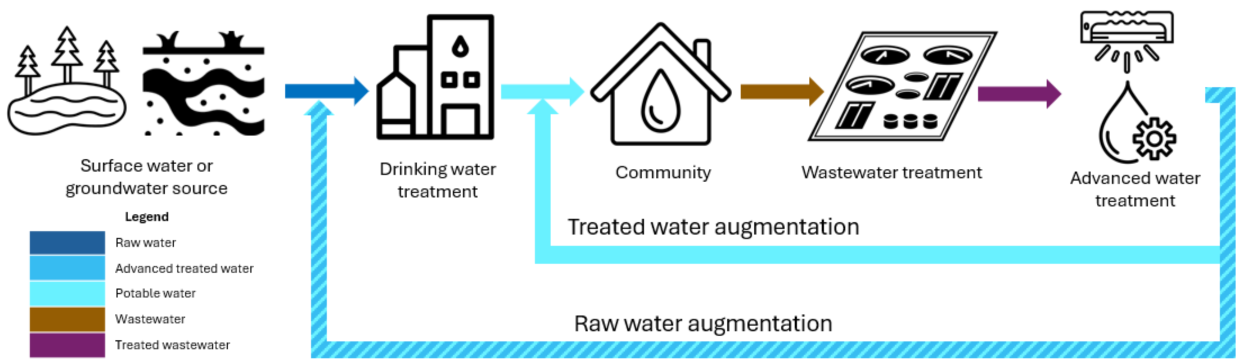
Figure 2-2 Overview of Indirect Potable Reuse.



2-2.3 Direct Potable Reuse.

DPR is the intentional introduction of an advanced, treated recycled water directly into raw or treated drinking water supplies without the use of an environmental buffer (U.S. EPA 2017). A simplified schematic of DPR is shown in Figure 2-3. DPR may be implemented in two ways: (1) “raw water augmentation,” where the source water to a drinking water treatment facility is augmented with reused water, or (2) “treated water augmentation,” where treated drinking water is augmented with reused water in the drinking water distribution system.

Figure 2-3 Overview of Direct Potable Reuse.



2-3 WATER SOURCES PRESENT IN REUSE.

This UFS applies to water reuse sourced from water that has, at a minimum, been treated at the equivalent of a municipal wastewater treatment plant. Municipal wastewater may consist of blends of domestic and commercial wastewater, industrial wastewater, stormwater, graywater, or other water sources. Depending on the water reuse type (for example, NPR, IPR, or DPR), carefully evaluate the risks of the source water (for example, presence of toxic metals in industrial source waters) on human health. A formal definition of a municipal wastewater treatment plant, as well as possible sources of municipal wastewater, are as follows:

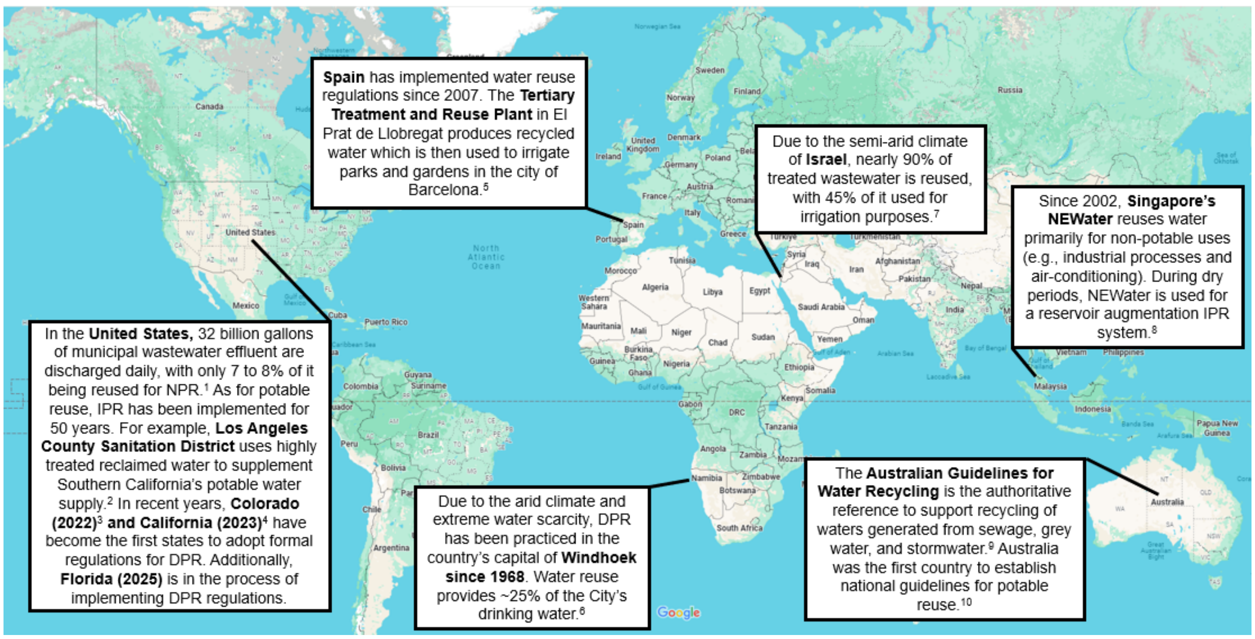
- According to the U.S. Environmental Protection Agency (EPA) 40 CFR 98.6, a municipal wastewater treatment plant is defined as a series of treatment processes used to remove contaminants and pollutants from wastewater collected in city sewers and transported to a centralized wastewater treatment system.

- Domestic wastewater is, according to U.S. EPA 40 CFR 503.9, defined as waste and wastewater from humans or household equivalent operations (for example, bathing, cooking, cleaning) that is discharged to or otherwise enters a treatment works.
- Industrial wastewater is, according to 40 CFR 98.358, water containing wastes from an industrial process. Examples of industrial wastewater include, but are not limited to, paper mill white water, wastewater from equipment cleaning, wastewater from air pollution control devices, rinse water, contaminated stormwater, and contaminated cooling water. Industrial wastewater treatment sludge means solid or semi-solid material resulting from the treatment of industrial wastewater, including but not limited to biosolids, screenings, grit, scum, and settled solids. Industrial pretreatment is often required before industrial waste can be discharged to a municipal wastewater treatment plant. Industrial wastewater may be limited to specific non-potable reuse applications due to possibility of trace metals, chemical residuals, or other constituents.
- Stormwater is, according to 40 CFR 122.26(b)(13), stormwater runoff, snow melt runoff, and surface runoff and drainage. This runoff is generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. The runoff picks up pollutants like trash, chemicals, oils, and dirt/sediment and can be harmful to human health if ingested.
- Graywater is, according to 40 CFR 122.2, wastewater that is collected separately from a sewage flow that originates from a clothes washer, bathtub, shower, and sink, but it does not include wastewater from a kitchen sink, dishwasher, or toilet.

2-4 CURRENT INDUSTRY PRACTICES.

The concept of water reuse has been discussed and implemented by various countries for many years. Historically, the reuse of treated wastewater has either occurred naturally by de facto reuse, when a drinking water source (such as a river) contains wastewater discharged by upstream communities, or intentionally through non-potable and potable reuse applications. It was not until the 20th century that regulations were implemented to ensure that the recycled water meets appropriate standards and quality for its respective use (for example, agricultural, industrial, drinking). As a result, the regulatory landscape around the world, and even the United States, has different perspectives and experiences with implementing water reuse. Figure 2-4 illustrates examples of countries that have implemented water reuse. Additionally, the WaterReuse Association and Water Services Association of Australia have co-developed an up-to-date map of potable reuse projects around the world known as Water360.

Figure 2-4 Global Map Showing Countries that have Implemented Water Reuse[1,2,3,4,5,6,7,8,9,10]



Many states have established their own regulatory frameworks for water reuse and have primary regulatory authority for water reuse systems. For example, California has a long history of pioneering water reuse initiatives in both non-potable reuse and

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[1] U.S. EPA, 2017, *Potable Reuse Compendium*
[2] Los Angeles County Sanitation Districts, *Water Reuse Program*
[3] 5 CCR 1002-11, *Colorado Primary Drinking Water Regulations*
[4] California Code of Regulations, Title 22, Division 4, Chapter 17, Article 10, *Direct Potable Reuse*
[5] *Water Reuse Project of the Barcelona Metropolitan Area*, 2011
[6] Water360, *Windhoek: New Goreangab Water Reclamation Plant*
[7] IsraelAgri, *Wastewater: A Hidden Resource for Agriculture*
[8] PUB Singapore's National Water Agency, *NEWater*
[9] Commonwealth of Australia, Water Quality Australia, *Australian guidelines for water recycling*
[10] Angelakis et al. 2018. Frontiers in Environmental Science, Vol. 6. *Water Reuse: From Ancient to Modern Times and the Future*

potable reuse; projects like Orange County Water District's (OCWD) Groundwater Replenishment System (GWRS) and City of San Diego North City Pure Water Project have set a global standard for safe and sustainable water management. In all states, water reuse projects must address local needs and water reuse regulations and frameworks often differ between states because of variations in related local regulations, state-specific water quality standards, and feasibility of treatment technologies in differing geographies. Many of the reuse frameworks share common perspectives, such as requirements for chemical and pathogen treatment and monitoring of contaminants common in wastewater. Given the breadth and depth of water reuse and expertise among U.S. states, industry practices in this UFS are largely based on U.S. publications and experiences. Overseas practices may be adapted to local needs and Host Nation regulations. Figure 2-5 and Figure 2-6 show maps of potable reuse projects and the status of potable reuse regulations and guidelines in the United States, respectively.

Figure 2-5 Map of Indirect and Direct Potable Reuse Projects in the U.S. (As of December 2023)

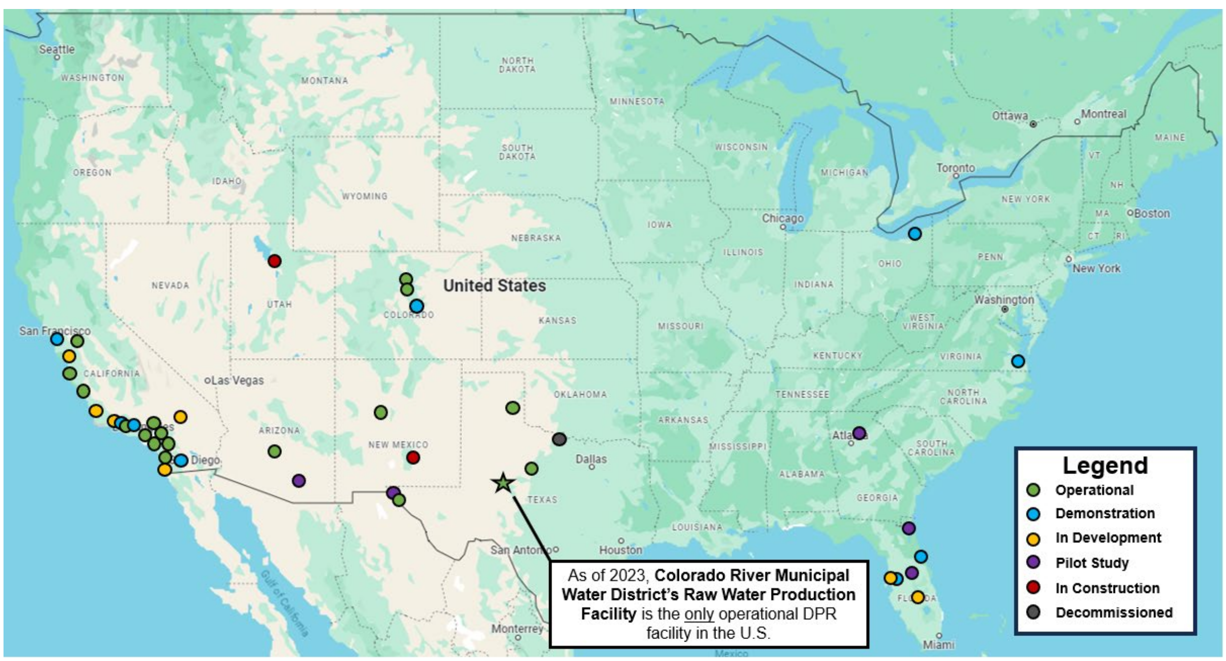
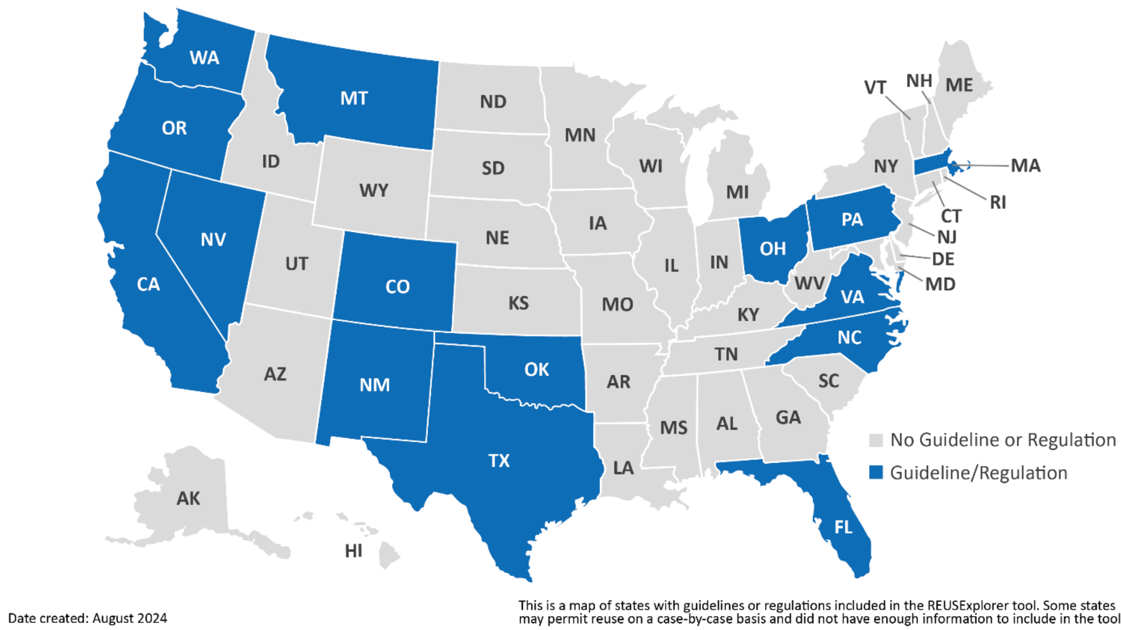


Figure 2-6 Map of Potable Water Reuse Regulations or Guidelines in the U.S. (U.S. EPA, 2024)



2-4.1 United States of America Regulations.

In the United States, the U.S. EPA does not directly permit or regulate water reuse and there are no established regulations for water reuse on the federal level. The U.S. EPA developed EPA 625-R-04-108 and EPA 600-R-12-618 and the Water Reuse Action Plan to provide suggested guidelines (for water reuse in the U.S.). These documents address the barriers related to implementing water reuse applications and provide action plans for utilities.

Many states have established specific rules, regulations, or guidance for water reuse project implementation. To find state reuse regulations or guidelines, the U.S. EPA developed the REUSExplorer, an online and searchable tool that summarizes and provides links to state-level reuse regulations and guidelines. The REUSExplorer can be found at: https://www.epa.gov/waterreuse/regulations-and-end-use-specifications-explorer-reusexplorer. Water reuse is permitted, where applicable, by individual states. The following scenarios require compliance with certain aspects of federal requirements and regulations:

- Potable water in the United States is subject to all applicable Safe Drinking Water Act (SDWA) requirements, including its implementing regulations (40 C.F.R. § 141).

- Discharge of treated wastewater (for example, augmenting groundwater or surface water supplies) to waters of the United States requires a federal National Pollutant Discharge Elimination Systems (NPDES) Permit (40 C.F.R. § 122) or authorized equivalent (for example, Waste Discharge Requirements in California).
- Discharge of treated wastewater to recharge groundwater may need to meet certain requirements of the *Underground Injection Control Program*.

2-5 PLANNING AND PRE-DESIGN.

Use UFC 3-201-01 for planning topics such as wetlands and flood hazard areas.

When initiating planning for a water reuse facility and prior to starting design of a project, review the following planning documents outlined in APPENDIX A Section A-1.

2-5.1 Water Demand Projections.

Future water demand projections are developed to assess the ability of water reuse to meet future demand considering seasonality, losses, and availability. Demand projections must take into consideration factors such as land use, population, climate, conservation measures, and intended use type. Additionally, the evaluation of water demands will consider quantity, quality, seasonal demands, seasonal storage needs, and delivery pressures appropriate to each customer. Using the best available data is key to developing demand projects. Using historical data for developing demand projections is sufficient to generate a baseline, but where major changes are anticipated, it may be required to use other data or apply assumptions to develop demand projections. Potable water and non-potable water demands are specific to geographic location, type of user, and many other factors.

Water demand projections include identifying acceptable community uses for recycled water, potential customers and their demands, and the quality of water required. There are numerous methodologies for projecting water demands and many manuals that will aid in forecasting water demands. Reference APPENDIX A Section A-1 for guidance. Consider the following when developing water demand projections:

- A market study can be performed to determine the potential demand for recycled water in the community. Evaluate the potential recycled water demand based on available data (for example, customer use records, irrigated acreage, or manufacturer’s literature for cooling-tower equipment). Use the installation’s existing utility maps and planning documents to develop population estimates and plans for new service areas. Determining the potential demand and end users for non-potable uses is important since not all demands can be served with non-potable water, whereas potable recycled water can satisfy any system demands.

- Planners determine the volume of recycled water available for distribution, paying attention to the diurnal discharge curve at the recycled water source (wastewater treatment plant, WWTP). This is an important consideration that can drive many other planning decisions, because water conservation practices often require evening or early morning irrigation when low flows to the WWTP occur. If irrigation will occur during low influent wastewater periods, the supply of recycled water may not be adequate to meet the instantaneous demands, unless the recycled water demand rate is low compared to current treatment plant capacity. Storage would be one option to resolve this supply/demand imbalance.
- Water conservation plays an increasingly important role in total water-demand management and may result in a stabilization or decrease in average per capita potable water use. The decrease in potable water demand from water conservation is limited and a recycled water system can represent a long-term solution by delivering non-potable water for appropriate uses.
- An average annual potable water consumption for each customer can be developed using consumption data. For existing customers, the recycled water market assessment must use potable water consumption data from the utility providing potable water to customers in the study area defined for the project. Consumption data for several of the most recent years must be reviewed to ensure that the data are not skewed based on a particularly wet or dry year or aberrant economic conditions. This is especially critical for irrigation applications. Also, reviewing several years' worth of data enables the proper assessment of the stability of a potential customer's potable water usage.

2-5.2 Feasibility Studies and Pilot Testing.

Feasibility studies and pilot testing may be performed as part of the planning effort. Feasibility studies and pilot testing can require a substantial time commitment, several months to years, to perform these tasks. Feasibility studies may be used to determine the selection of treatment facilities, considering all public health and safety, engineering, economic, energy, and environmental factors. A feasibility study must identify all legitimate alternatives and evaluate by life cycle cost analyses. When feasible, conduct laboratory or pilot tests, informed by published data of similar existing facilities or systems, to determine the optimal treatment approach.

In these evaluations, consider the following factors:

- Feasibility studies and pilot testing can be used to verify performance predictions or determine the effectiveness of unit treatment processes necessary for design of water reuse facilities.
- Feasibility studies and pilot testing may be conducted on the wastewater stream requiring treatment, when available, or on an equivalent wastewater stream.
- Energy use of treatment processes, trains, pumps, and associated infrastructure. For purposes of energy consumption, only the energy purchased or procured will be included in the usage evaluation.
- Need for additional chemicals required for water reuse treatment processes.
- Disposal of liquid and solid waste products from the treatment processes.
- Additional monitoring costs required to meet all water reuse requirements, such as higher frequency of water quality sampling and operational monitoring as compared to conventional water treatment facilities.
- The quality of water to be used and its effects in possible applications and on other compliance requirements (for example, the use of recycled water contaminated with Per- and Polyfluoroalkyl Substances (PFAS) for non-potable irrigation).
- The selection process and determination of the recycled water type(s) produced at the facility.
- The needs of the current and potential future use cases for recycled water, including use area restrictions and personnel demands.
- For IPR systems, the discharge of water to the selected environmental barrier must not result in another drinking water system exceeding a water standard.

2-5.3 Cost of Water.

With the development of lower-cost sources of supply already completed in many regions of the United States and other parts of the world, recycled water systems are being considered more frequently. Some projects may struggle to make the business case for developing recycled water systems on a benefit/cost basis alone.

The basic benefit/cost analysis methodology is described in AWWA M24. An alternative analysis method that expands the scope of review to all the benefits of recycled water is triple bottom line (TBL) analysis. The AWWA M50 covers the TBL analysis tool in detail. The TBL approach expands on the basic benefit/cost analysis by including social and environmental aspects of the project. This must be weighed before making any final go/no-go project decisions.

2-5.4 Pre-Design Existing Conditions.

Use UFC 3-201-01 and 3-230-01 for preliminary site analysis:

- Use UFC 3-201-01 for evaluation of existing conditions such as geotechnical site investigation, environmental considerations, surveying, and topographic surveying and for planning topics such as wetlands and flood hazard areas.
- Use UFC 3-230-01 for evaluation of site location, including flood-hazard and other treatment plant site considerations.

2-5.4.1 Land Requirements.

Consider the following when preparing preliminary land requirements:

- Major structures such as pump stations and storage facilities must be designed for easy expansion. Space must be provided for additional pumps and electrical equipment. Additional capacity frequently can be obtained through changes in impeller and motor size, which leave the pump housing unchanged.
- Yard piping connections and valves must be considered at storage tank locations to facilitate future system additions.
- Space for seasonal and operational storage must be considered. Seasonal storage can be utilized when the seasonal difference between the rate of treated wastewater production and recycled water demand can be buffered by large reservoirs. Operational storage, often provided using

storage tanks, may be required to meet daily or temporary fluctuations in demand. Surface impoundment, either open or covered, is a form of storage.

- The footprint requirements for treatment facilities will depend on the level of treatment required and the treatment capacity of the facility. This is determined during the planning and feasibility study steps of a project design.
- For treatment systems, consider the need for future expansion to address future water demands, storage for treatment chemicals and liquid or solid residuals, changes in regulatory requirements, or raw water quality that would require additional treatment processes.
- Disposal and emergency storage of liquid and solid waste products from the treatment process.
- Depending on geography, consider the need for treatment components to be outside or are required to be housed or covered.
- The location of new treatment facilities must consider the proximity of water sources and use areas. For example, for DPR, co-locating with a drinking water facility may provide the benefit of utilizing existing infrastructure for storage, pumping, and distribution.

2-5.5 Civil Engineering Design.

Use UFC 3-201-01 for topics such as surveying, site development, grading, and storm drainage systems.

2-5.6 Design Criteria.

2-5.6.1 Within the United States.

For installations located in the United States and its territories and possessions, comply with the following criteria precedence for the water reuse system:

- EPA or State as applicable and local regulations for the project location.
- Utility provider’s requirements.
- Criteria indicated in this UFS.
- UFC 1-200-02 for energy and sustainability.
- APPENDIX A for design guidance.

2-5.6.2 Foreign Countries.

For installations located outside of the United States and its territories and possessions, comply with the following criteria precedence for the water reuse system:

1. All construction outside of the United States is governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA).
2. Final Governing Standards (FGS).
3. DoD 4715.05-G, Overseas Environmental Baseline Guidance Document (OEBGD).
4. Navy Only for DPR: CNICINST 5090.1B and other relevant and similar requirements from appropriate Service Oversight Councils.
5. Utility provider's requirements.
6. Criteria indicated in this UFS.
7. UFC 1-200-02 for energy and sustainability.
8. APPENDIX A for design guidance.

DoD 4715.05-G, Overseas Environmental Baseline Guidance Document (OEBGD) applies when there are no FGSs in place. Therefore, in foreign countries this UFS will be used for DoD projects to the extent that it is allowed by and does not conflict with the applicable international agreements and the applicable FGS or OEBGD.

2-5.7 Design Approval.

The DoR is required to identify, assist, and provide, as applicable, all permits, approvals, and fees required for the design and construction of the new project from federal, state, and local regulatory authorities or overseas equivalent. The DoR is required to be a Professional Engineer experienced and licensed in the field of water treatment. Licensure in the location of the project may be required to obtain permits and approvals. For new or rehabilitated sanitary sewer systems or facilities that supply reuse, such as service extensions, municipal wastewater treatment, or industrial wastewater treatment, coordinate with the applicable primary agency or Government to determine permitting requirements. Consult with the Government Project Manager to determine the appropriate signatories for permit applications.

2-5.7.1 Within the United States.

In the United States and its territories and possessions, the Government will review permits for acceptability.

2-5.7.2 Foreign Countries.

In locations outside of the United States and its territories and possessions with Host Nation agreements, follow the permit approval procedure as directed in project scope and by the Government Project Manager.

In locations outside of the United States and its territories and possessions without Host Nation agreements, the Government will review and approve plans for compliance.

2-6 SECURITY.

Security must be an integral part of water reuse recovery system design. Planners, engineers, and security and antiterrorism personnel must determine site specific protective measures for water reuse systems. Use ASCE/EWRI 78-24 to establish protective measures. The protective measures should be consistent with the security design criteria development process conducted as part of UFC 4-020-01 and the threat and vulnerability assessments conducted by installation security or antiterrorism staff.

2-7 OPERATIONS AND MAINTENANCE.

2-7.1 Operations and Maintenance (O&M) Manual.

The DoR must develop a site-specific Operations and Maintenance (O&M) manual for water reuse systems that addresses the requirements of the operating permit(s). Use the monitoring requirements for the chosen water reuse project to determine appropriate equipment and laboratory space for the project. Guidance for the O&M Manual is provided in Section A-5 of the Best Practices. Additionally, UFC 3-230-03 and UFC 3-240-01 Section 2-8 must be reviewed for applicability.

2-7.2 Operations Plan.

Each reuse facility must have an Operations Plan (also known as a facility operating protocol) that covers all of the installed treatment processes and operating equipment. The facility operating protocol must address the following requirements, at a minimum:

- The process for recording all process or equipment failures triggering an alarm as a separate record file, including the time and cause of failure and corrective action taken.
- The plans for emergency communication with local health authorities and any other treatment facilities that impact or are impacted by the recycled water facility.
- The plans for reporting of discharges of untreated or partially treated wastewaters to use areas and subsequent cessations, to the applicable authorities.

2-7.3 Operating Records and Recordkeeping.

Operating records for each water reuse facility must be maintained at the facility or at a central repository, including all analyses specified by the water reuse facility operating permits, applicable regulatory criteria, records of operational problems, plant and equipment breakdowns, diversions to emergency storage or disposal, and all corrective or preventive actions taken.

Refer to the following requirements for recordkeeping for specific facility types:

- Section 2-19 of UFC 3-240-03 for recordkeeping requirements for facilities classified as wastewater facilities.
- Sections 2-4, 8-3.2, 9-7, 10-2.4.3 of UFC 3-230-02 for recordkeeping requirements for facilities classified as drinking water facilities.

2-7.4 O&M Factors that Influence Water Reuse Facility Design.

Certain aspects of O&M may strongly influence the design of a water reuse facility. The following O&M considerations must be evaluated in the planning and design of a water reuse facility.

- Facilities with very frequent or expensive sampling requirements may consider the use of continuous online monitoring instruments or advanced laboratory spaces.
- The use of standby equipment must be considered in the design to maintain continuous operations and account for facility downtime and other shutdown events. This includes, but is not limited to, cleaning, repairing, and replacing equipment and instrumentation.

- The facility design must be on par with OSHA or general construction industry standards to ensure safe and efficient operations and operators.
- The level of security and access must be evaluated for existing or potential future recycled water use areas. Security and access restrictions for recycled water use areas must be in place prior to any delivery of recycled water.
- Minimizes operation and maintenance requirements, including additional training, higher level of operator certifications, or equipment that is not provided by the project. The Authority Having Justification (AHJ) must approve any operating equipment that is not provided by the project and required to maintain continuous operation of the water reuse facility.
- Minimizes the number of operators required to operate the water reuse facility. For new water reuse facilities, the number of operators and level of training or operator certification required to operate the wastewater treatment facility must be approved by the AHJ. For existing water reuse facilities, any increases to the number of operators, level of training, or operator certification required to operate the water reuse facility must be approved by the AHJ. Give special consideration to minimizing operation and maintenance requirements in remote locations, including the limited availability of qualified operators available, technical support, and training opportunities.
- Includes operator training required to operate the water reuse facility.
- Where continuous operation of the water reuse facility is needed, provide more than one piece of equipment, tank, or piping and isolation valves. In such cases, size equipment, tanks, and piping to maintain continuous operation with one piece of equipment or tank out of service. Where continuous operation of the water reuse facility is not needed, the facility must be capable of routing process water to acceptable disposal or retreatment locations.
- Provides space for the repair and removal of equipment without requiring the removal of equipment or pipe not in need of repair or replacement.
- Provides access, walkways, and space that complies with the applicable OSHA general industry and construction standards for operations, maintenance, and inspections.

- Provides tanks with isolation valves and drains to facilitate cleaning, inspection, and maintenance.
- Provides drains with means of draining and containing pollutants that cannot be released to the environment.

2-7.5 Preventative Maintenance Plan.

Each water reuse facility must have a Preventive Maintenance Program to ensure all equipment is kept in a reliable operating condition.

2-7.6 Lab Analyses.

Laboratory analysis of water samples from the water reuse facility must be conducted in a laboratory certified by a U.S. or Host Nation regulatory authority or accredited through the DoD Environmental Laboratory Accreditation Program, for the applicable test method.

2-7.7 Staffing and Operator Certification.

Follow individual state (FGS or OEBGD for overseas) requirements regarding staffing and operator certification. If there is no requirement(s) from the corresponding state, FGS, or OEBGD, contact the individual DoD service responsible for the treatment staffing and certification requirements. Because they are typically permitted as wastewater treatment facilities, NPR and IPR facility staffing and certification requirements are typically covered by conventional wastewater treatment operator certification. For DPR, APPENDIX A-6 provides information on DPR staffing and operator certification requirements from different U.S. states.

The types of treatment technologies can strongly influence the staffing and certification requirements for reuse facilities. Develop a staffing plan concurrently with the design process to estimate the number and classifications of staff members, working hours, and required certifications for each staff member.

2-8 WASTEWATER SOURCE CONTROL.

In the planning of water reuse systems, it is critical to establish a robust source control program – especially for IPR and DPR applications. Source control programs are designed to further control, limit, or eliminate the discharge of constituents into wastewater that can be difficult to treat or impair the final quality of treated wastewater. Implement source control as early as possible to best control the constituents in reuse source water.

For NPR, source control requirements are typically similar to those already in place for conventional wastewater treatment and disposal. For IPR and DPR, additional requirements specific to potable reuse for source control and industrial pre-treatment are provided in the IPR and DPR chapters of this UFS. The following common elements of source control for NPR, IPR, and DPR must be addressed in the source control of a reuse system:

- Source water for water reuse must be from a wastewater management agency that complies with all applicable wastewater discharge requirements, is not in violation of their discharge permit requirements, and administers an industrial pre-treatment and pollutant source control program.
- Implementation of Land Use Management Plans.
- Implementation of Slug Control Plans, which are used to address measures taken by an industrial user to prevent accidental spills or leaks of chemicals into the sewer.
- Implementation of a response plan, which describes the specific communication channels to be followed in the event pollutants of concern are discharged to the wastewater collection system. Example criteria for a response plan are provided in Section A-5.2 of the Best Practices.

2-9 DEMONSTRATION OF FACILITIES.

For any reuse project, prepare a Test Plan to demonstrate the performance of treatment facilities following construction at full-scale prior to the delivery of any product water.

CHAPTER 3 GENERAL DESIGN REQUIREMENTS FOR NPR, IPR, AND DPR

This chapter provides general design criteria for NPR, IPR, and DPR systems. All reuse systems treat wastewater and must consider the need to discharge treated wastewater to the environment. The following wastewater-focused UFCs must be reviewed for applicability:

- UFC 3-240-01, and
- UFC 3-240-03.

3-1 ALARMS.

Alarms must be installed to monitor all installed treatment processes. The design and programming of alarms must address the following:

- The alarms must be programmed to warn of negative process trends or process failures of all installed treatment processes.
- Alarms must address and distinguish between “warning” and “critical” levels of alarm. A “warning” alarm is triggered when a monitored parameter is trending negative and provides a notification to the operators to respond. A “critical” alarm indicates an existing or impending process failure (for example, failure in operation of process equipment, fault in process or water quality monitoring systems, interruptions in SCADA connectivity) and triggers an automated response such as a diversion or shutdown.
- The individual alarm devices must be connected to a master alarm to sound and/or notify at a location where they can be conveniently observed by a facility operator. If a water reuse facility is not attended full-time, the alarms must sound and/or notify at a facility that is attended full-time and staffed by personnel capable of taking prompt corrective actions.
- All key alarm devices must be connected to an independent power supply (for example, uninterruptible power supply, or uninterruptable power source (UPS)) to ensure the uninterrupted ability for alarms to be triggered and received in the event of a power loss.

3-2 POWER SUPPLY.

At a minimum, water reuse facilities must have at least <u>one</u> of the following reliability features to address power loss and interruption events. Refer to UFC 3-240-01 and

UFC 3-230-02 and their respective referenced 10 States Standards for additional power supply requirements:

- Alarm(s) for power loss and automatic standby power source capable of maintaining critical facility treatment functionality and operation without interruption in case of power loss.
- Alarm(s) for power loss and automatically-actuated retention or disposal provisions.
- Automatically-actuated long-term storage or disposal provisions.

3-3 EMERGENCY STORAGE AND DISPOSAL.

Water reuse facilities must be equipped with the ability to retreat or dispose of process water that does not meet compliance standards or is inadequately treated (this is often called “off-spec” water, indicating the water is outside of design specifications). Process water may also need to be stored or diverted in emergency situations when treatment is inoperable, such as power outages or natural disasters. Where retention or disposal features are used, these features must be designed to store or dispose of untreated or partially-treated wastewaters for a period of time that allows for corrective actions to be taken to restore facility capabilities. The period of time required for each facility is site-specific and must be determined by the DoR using available site-specific information.

In the design of retention and disposal provisions, include all necessary diversion devices, provisions for odor control, conduits, pumping, and pump back equipment. All of the equipment other than the pump back equipment must be either independent of the normal power supply or provided with a standby power source. For automatically-actuated retention or disposal provisions, include all necessary sensors, instruments, valves, and other devices to enable fully-automatic diversion of untreated or partially-treated wastewater. This untreated or partially-treated wastewater must be diverted to approved emergency storage or disposal in the event of failure of a treatment process and a manual reset to prevent automatic restart until the failure is corrected.

3-3.1 Long-term Emergency Storage or Disposal.

Where long-term storage or disposal provisions are used as a reliability feature, consider the use of ponds, reservoirs, percolation areas, downstream sewers leading to other treatment or disposal facilities, or any other facilities reserved for the purpose of emergency storage or disposal of untreated or partially treated wastewater.

3-3.2 Diversion to Headworks or Lesser Demanding Use Areas.

The design of emergency or off-spec water process flow diversions must prioritize diverting flows to locations for reuse or retreatment to minimize water losses. For example, the design can divert flow to less demanding use locations where the partially treated wastewater is suitable for use or divert flow back to the sewer system or the headworks of the treatment facility to be re-treated and used.

3-4 PIPELINE COLORING AND IDENTIFICATION OF RECYCLED WATER INFRASTRUCTURE.

All recycled water piping and appurtenances must be clearly identified by recycled water markings, colorings, tags, signage, and other visual identifiers to clearly distinguish recycled water infrastructure from other types of infrastructure. All recycled water pipes must display standardized labeling for identification in accordance with the piping color code set in the 10 States Standards for Wastewater, which includes color codes for potable water and non-potable (including recycled water) water pipelines.

3-5 CROSS CONNECTIONS.

Except as allowed under UFC 3-230-01 or in this section, there must be no physical connections between any non-potable recycled water system and any separate system conveying potable water. Additionally, recycled water plumbing must comply with the following:

- UFC 3-420-01, and
- UFC 3-230-01, Section 5-8.

Prepare a Backflow Prevention and Cross Connection Control Plan to ensure the recycled water system design will prevent contamination of potable water lines with non-potable water. Define organizational responses in the event that accidental cross connections are discovered.

3-5.1 Backflow Prevention.

Evaluate the need to include backflow prevention devices on drinking water distribution system lines in the vicinity of recycled water distribution lines to protect against backflow from possible recycled water cross connections. Backflow prevention devices must be inspected and maintained in accordance with the cross connection and backflow prevention requirements of UFC 3-230-01 and UFC 3-240-01.

3-5.2 Use of Potable Water to Supplement Recycled Water.

If potable water from a public water supply system is used as a backup or supplemental source of water for a recycled water system, the recycled water must be introduced to the potable water system using one of the following methods, listed in order of preference. In either case, approval from the owner of the potable water system must be obtained prior to the use of potable water to supplement the recycled water system. Other methods to connect recycled water to a potable water system are considered unsafe cross connections and are prohibited:

1. Air-gap separation (*Preferred method*). The air gap separation must comply with the cross connection control and backflow prevention requirements of UFC 3-230-01. The air gap must be located as close as possible to the recycled water user's connection, with all piping between the user's connection and the receiving tank entirely visible unless otherwise approved by the AHJ.
2. Swivel-ell (*if an air-gap separation is not feasible).* Recycled water systems using a swivel-ell must use filtered and disinfected recycled water. Refer to Section A-2.4.1 of the Best Practices for recommended design and operational criteria for swivel-ells.

3-6 BYPASS.

Untreated or partially-treated wastewater must not bypass any required treatment processes to downstream unit processes or to a point of use. Any bypass of required treatment is considered a cross connection and is prohibited.

3-7 FLEXIBILITY OF DESIGN.

Design all process piping, equipment arrangement, and unit structures in water reuse facilities to allow for efficiency and convenience in operation and maintenance and provide flexibility of operation to permit the highest possible degree of treatment to be obtained under varying circumstances.

3-8 SIGNAGE IN RECYCLED WATER USE AREAS.

In all recycled water use areas – inclusive of any applications that utilize recycled water that is not of potable quality – include adequate numbers and types of signage to indicate the use of recycled water. The signs must provide high contrast with the local environment and be sufficiently large enough to be visible and legible from a distance. The sign must include international symbols to indicate "do not drink" and display wording of “RECYCLED WATER – DO NOT DRINK” in the locally-used common language(s).

3-9 WELL SETBACK DISTANCES AND WELLHEAD PROTECTION.

All recycled water uses must comply with any applicable Wellhead Protection Program requirements. At a minimum, recycled water must not be used within the well setback distances of Table 3-1. For the purposes of this UFS, the well setback distance is the distance between the edge of the recycled water use area and any domestic water supply well. No setback distance is required to any non-potable water supply well. These minimum distances must be increased to address recycled water uses that may pose greater risk to a domestic water supply well, such as use of recycled water in unsealed impoundments.

Table 3-1 Minimum Well Setback Distances from Recycled Water Use Areas

Recycled Water Type	Minimum Setback Distance (ft)	Notes
Undisinfected secondary recycled water	150 feet	
Disinfected secondary-2.2 and disinfected secondary-23 recycled water	100 feet	
Filtered and disinfected recycled water	50 feet (irrigation and other uses) 100 feet (impoundment)	The irrigation setback distance can be reduced if the requirements described below are met.

For the irrigation of filtered and disinfected recycled water within 50 feet of a domestic water supply well, the following design conditions must be met prior to the application of recycled water:

- A geological investigation demonstrates that an aquitard exists at the well between the uppermost aquifer being drawn from and the ground surface.
- The well contains an annular seal that extends from the surface into the aquitard.

- The well is housed to prevent any recycled water spray from coming into contact with the wellhead facilities.
- The ground surface immediately around the wellhead is contoured to allow surface water to drain away from the well.
- The owner of the supply well approves of the elimination of the buffer zone requirement.

CHAPTER 4 NON-POTABLE REUSE

This chapter provides criteria for non-potable water reuse systems, where wastewater is used for beneficial purposes other than providing a source of drinking water (see CHAPTER 5 for indirect potable reuse and CHAPTER 6 for direct potable reuse information).

The requirements in this chapter do not apply to the onsite use of recycled water at a water reuse facility or wastewater treatment plant, provided that public access to the area of onsite recycled water use is restricted. In these systems operating under this exception, qualified personnel at the wastewater treatment plant must be adequately trained on the safe use of recycled water to protect public health.

4-1 ENGINEERING REPORT.

An engineering report must be prepared to describe the water reuse treatment facility, recycled water distribution system, and all recycled water use areas. The engineering report must be prepared by a licensed engineer experienced in the field of wastewater treatment.

The engineering report must include, at a minimum, the following elements.

- Description of the means for compliance with all applicable regulations, any features specified by the regulating agencies, and this UFS.
- Identification of all agencies and entities that will be involved in the design, treatment, distribution, construction, operation, and maintenance of the recycled facilities, including a description of any legal arrangements outlining authorities and responsibilities between the agencies with respect to treatment, distribution, and use of recycled water. In areas where more than one agency/entity is involved in the reuse project, a description of arrangements for coordinating all reuse-related activities (for example, line construction and repairs) must be provided.
- Detailed descriptions of the proposed water reuse collection system, treatment facilities, and recycled water use areas.
- A process flow diagram of the recycled water treatment system, including all treatment processes, chemical dosing locations, flow metering, process monitoring, compliance sampling locations, and paths for diversion of non-compliant waters.

- A description of the raw wastewater, including chemical quality, flow conditions, source of wastewater, and Source Control Programs.
- Projected recycled water quality and water quality targets.
- Plans and Specifications for the proposed piping system, locations of all recycled water and nearby potable water pipes, type and location of outlets and plumbing fixtures, and methods and devices used to prevent backflow of recycled water into the public water system.
- A contingency plan to ensure no untreated or inadequately treated wastewater will be delivered to the recycled water use areas. The contingency plan must include a list of conditions that would require an immediate diversion or shutdown to take place and a description of the diversion or shutdown procedures.
- A description of all supplemental water supplies, including purpose, source, quality, and quantity of the water.

4-2 TYPES OF RECYCLED WATER FOR NON-POTABLE REUSE.

There are four types of recycled water, each defined by their level of treatment and the quality of the treated water. In further sections, allowable uses for each type of recycled water are described.

Water reuse systems must be designed with a “fit for purpose” approach, where the level of treatment and final water quality are tailored to meet the requirements for a particular use or portfolio of uses. A fit for purpose approach ensures water is neither over- nor under-treated for its specific use cases. The design must consider the potential future need for the facility to be upgraded to produce a higher water quality (for example, installation of a future reverse osmosis system to control salt).

[C] 4-2 There are differences in limits of human contact with each type of recycled water. The allowable uses of recycled water are determined by the level of risk tolerance for human contact with the general public. Generally, there is a higher risk tolerance for trained personnel using recycled water; therefore, the following use requirements do not apply to the onsite use of recycled water at a water reuse facility or wastewater treatment plant, provided that public access to the area of onsite recycled water use is restricted.

- Undisinfected Secondary - no contact with general public.
- Disinfected Secondary - very limited contact with general public.

- Filtered and Disinfected - limited contact with general public. This is not unlimited contact as potable water is the level of treated water quality that would have unlimited contact potential.

4-2.1 Undisinfected Secondary Recycled Water.

Undisinfected secondary recycled water is the lowest level of recycled water quality specified by this UFS, defined as an oxidized wastewater that has not been filtered or disinfected. Design criteria are provided in Section 4-4.1.1.

4-2.2 Disinfected Secondary-23 Recycled Water.

Disinfected secondary-23 recycled water is oxidized wastewater that has been subsequently disinfected to achieve the total coliform limits specified in Table 4-1. The designation “23” refers to the 7-day median total coliform limit for this type of recycled water, which is less strict than disinfected secondary-2.2. Design criteria are provided in Section 4-4.1.2.

4-2.3 Disinfected Secondary-2.2 Recycled Water.

Disinfected secondary-2.2 recycled water is oxidized wastewater that has been subsequently disinfected to achieve the total coliform limits specified in Table 4-1. The designation “2.2” refers to the 7-day median total coliform limit for this type of recycled water, which is stricter than disinfected secondary-23 and therefore has more allowable uses. Design criteria are provided in Section 4-4.1.2.

4-2.4 Filtered and Disinfected Recycled Water.

Filtered and disinfected recycled water is oxidized wastewater that has been filtered and subsequently disinfected. This is the strictest level of recycled water quality for NPR specified in this UFS. Design criteria are provided in Section 4-4.1.3.

4-2.5 Blending Recycled Water with Other Sources of Water.

When blending recycled water with other water sources (for example, treated stormwater), ensure the blended water meets all requirements for treatment, distribution, and use, through means of water quality evaluations, pilot studies, or other studies. The optimal location of blending the water sources (for example, prior to or after a treatment facility) must be evaluated using historical water quality and analyses of the chosen treatment train(s) ability to consistently achieve water quality goals.

Potential sources of water for blending prior to recycled water use include, but are not limited to, the following:

- Untreated or treated stormwater.
- Demineralization concentrate.
- Certain industrial process wastewaters, such as treated food wastewaters.

4-3 NON-POTABLE USES OF RECYCLED WATER.

In this section, various allowable recycled water uses are described. There are many possible uses for recycled water that are not described herein but can be acceptable and safe uses of recycled water. Additional use cases may be permitted on a site-specific basis on review and approval of the Government and in accordance with applicable regulations.

The level of risk for human contact for any particular recycled water application defines the recycled water type (defined in Section 4-2) required for that application. Lower quality recycled water types, such as undisinfected secondary recycled water, are prohibited in applications with greater risk of human contact with recycled water.

4-3.1 Irrigation.

The use of recycled water for irrigation is a widespread practice globally and is encouraged. This section documents numerous use cases and the appropriate level of recycled water quality for those uses, as well as general design requirements for irrigation systems using recycled water. As necessary, evaluate additional use cases for irrigation that is not documented herein and determine the appropriate level of water quality for the use case.

Agronomic irrigation rates must be used to prevent runoff of recycled water. Refer to Section A-2.6 for methods to determine agronomic irrigation rates.

4-3.1.1 Allowable Irrigation Uses for Undisinfected Secondary Recycled Water.

The following irrigation uses must utilize undisinfected secondary recycled water or a higher quality of water:

- Orchards where the recycled water does not come into contact with the edible portion of the crop. Include adequate measures to prevent contact with edible food crops.

- Vineyards where the recycled water does not come into contact with the edible portion of the crop.
- Non-food-bearing trees (for example, Christmas tree farms).
- Fodder, fiber crops, and pasture for animals not producing milk for human consumption.
- Seed crops not eaten by humans.
- Food crops that require commercial pathogen-destroying processing before being consumed by humans.
- Ornamental nursery stock and sod farms, provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access by the general public.

4-3.1.2 Allowable Irrigation Uses for Disinfected Secondary-23 Recycled Water.

The following irrigation uses must utilize disinfected secondary-23 recycled water or a higher quality of water:

- Cemeteries.
- Landscaping for freeways.
- Ornamental nursery stock and sod farms where access by the general public is not restricted.
- Pasture for animals producing milk for human consumption.
- Any non-edible vegetation where access is controlled. The irrigated area cannot be used as part of a park, playground, or school yard.

4-3.1.3 Allowable Irrigation Uses for Disinfected Secondary-2.2 Recycled Water.

The following irrigation uses must utilize disinfected secondary-2.2 recycled water or a higher quality of water:

- Surface irrigation of food crops where the edible portion is produced above ground and not contacted by the recycled water. Include adequate measures to prevent contact with edible food crops.

4-3.1.4 Allowable Irrigation Uses for Filtered and Disinfected Recycled Water.

The following irrigation uses must utilize filtered and disinfected recycled water or a higher quality of water:

- Food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop. Include adequate measures to limit contact with edible food crops.
- Parks, playgrounds, unrestricted access golf courses, and sports fields.
- School yards and public areas.
- Residential landscaping.
- Commercial landscaping where public access to the irrigated grounds is not controlled.

4-3.1.5 General Design Requirements for Irrigation.

Ensure the following design criteria are met for all irrigation systems:

- Do not include hose bibs on the portions of the recycled water piping system accessible by the general public or staff untrained in the safety of recycled water. In such areas, use only quick couplers that differ from those used on the potable water system.
- When hose bibs are used in restricted areas, include a vacuum breaker to prevent potential backflow into the recycled water distribution system.
- Confine all irrigation runoff to the recycled water use area unless the runoff of recycled water to specific area(s) is authorized by the Government.
- The recycled water spray, mist, and runoff must not enter dwellings, designated outdoor eating areas, or food handling facilities.
- Protect all drinking water fountains from contact with recycled water spray, mist, or runoff.
- Consider the likely timing of spray irrigation and weather conditions in the design to prevent exposure of recycled water to staff and the public.

4-3.2 Impoundments.

The type of recycled water quality for impoundments depends on the potential level of human contact with the recycled water in the impoundment. The following restrictions are imposed based on the type of impoundment:

- Non-restricted impoundments where no limitations are imposed on body-contact water recreational activities must use filtered and disinfected recycled water.
- Restricted impoundments, where recreation is limited to fishing, boating, and other non-body-contact water recreational activities, must use disinfected secondary-2.2 recycled water or a higher quality of water.
- Landscape impoundments that do not utilize decorative fountains must use disinfected secondary-23 recycled water or a higher quality of water.

Dechlorination of recycled water prior to discharge to the impoundment must be evaluated and included if necessary to protect aquatic species of flora and fauna.

4-3.3 Cooling.

Use filtered and disinfected recycled water for all industrial or commercial cooling or air conditioning that involves the use of a cooling tower, evaporative condenser, spraying, or any mechanism that creates a mist.

If such cooling systems do not create a mist, use at least disinfected secondary recycled-23 water or a higher quality of water. For any cooling system that uses recycled water where a mist is created, include the following provisions:

- A drift eliminator.
- A chlorine or other biocide to treat the cooling system recirculating water to minimize the growth of Legionella and other microorganisms.

4-3.4 Indoor Non-Potable Recycled Water Uses.

Potable water must be used for all plumbing fixtures that provide water for drinking, bathing, and culinary purposes, or for the processing of food, medical, or pharmaceutical products. As described in UFC 3-420-01 Section 4-7.2, recycled water ("non-potable water") may be used for indoor uses where potable water is not required, when contained in an entirely separate system. At a minimum, recycled water is permitted for the following indoor uses and may be allowed for other uses with approval by the AHJ and the Service's force health protection department:

- Toilet and urinal flushing.
- Trap primers for floor drains and floor sinks.
- Industrial or commercial cooling or air conditioning.
- Vehicle washing.

Indoor recycled water plumbing systems must be designed and operated in accordance with the following list:

- Filtered and disinfected recycled water or a higher water quality must be used for all indoor uses of recycled water.
- The indoor recycled water use plumbing system must be described and documented in detail, including the specific use for the recycled water at the facility and plans and specifications describing the proposed piping system, pipe locations of recycled and potable water systems, type and location of outlets and plumbing fixtures, and methods and devices used to prevent backflow of recycled water to the potable water system.
- The recycled water facility must deliver the recycled water directly to the recycled water use area. No other entity is permitted to deliver the recycled water.
- The recycled water facility must not provide recycled water to any residential units including free-standing structures, multiplexes, or condominiums.
- The indoor recycled water plumbing system must be inspected and tested for possible cross connections with the potable water system prior to operation and at least once every four years.
- A Cross- Connection Control Test Plan must be prepared with the engineering report to ensure the design of the recycled water plumbing system can accommodate the testing detailed in the test plan.

4-3.5 Other Non-Potable Uses.

This section details the required level of treatment for recycled water for various other use cases.

4-3.5.1 Other Uses for Undisinfected Secondary Recycled Water.

The flushing of sanitary sewers must use undisinfected recycled water or a higher quality of water.

4-3.5.2 Other Uses for Disinfected Secondary-23 Recycled Water.

The following use cases must use disinfected secondary recycled water or a higher quality of water:

- Industrial boiler feed.
- Backfill consolidation around non-potable piping.
- Soil compaction.
- Mixing concrete.
- Dust control on roads and streets.
- Cleaning roads, sidewalks, and outdoor work areas.
- Industrial process water that will not come into contact with workers.
- Environmental reuse (for example, to create wetlands, enhance natural wetlands, or sustain stream flows). Dechlorination may be necessary to protect aquatic species of flora and fauna.

4-3.5.3 Other Uses for Disinfected Secondary-2.2 Recycled Water.

No additional specific use cases are defined at this time for disinfected secondary-2.2 recycled water.

4-3.5.4 Other Uses for Filtered and Disinfected Recycled Water.

The following use cases must use filtered and disinfected recycled water or a higher quality of water:

- Priming drain traps.
- Industrial process water that may come into contact with workers.
- Decorative fountains.
- Commercial laundries.
- Consolidation of backfill around potable water pipelines.
- Artificial snow making for outdoor use.

- Car washes.
- Drinking water for non-dairy livestock and poultry

4-4 DESIGN REQUIREMENTS.

4-4.1 Design Criteria for Each Type of Recycled Water.

4-4.1.1 Undisinfected Secondary Recycled Water.

If stabilization ponds are used for secondary treatment to produce undisinfected secondary recycled water, the total retention time of the ponds must be at least 20 days.

4-4.1.2 Disinfected Secondary-2.2 and Secondary-23 Recycled Water.

The disinfection process for disinfected secondary-2.2 and secondary-23 recycled water systems must produce a treated effluent that meets the bacteria limits stated in Section 4-5 to ensure the secondary wastewater has been adequately disinfected. The treated water sent to distribution must contain a chlorine residual of at least 1 mg/L as Cl_2 to control for bio-growth in the distribution system.

4-4.1.3 Filtered and Disinfected Recycled Water.

The design of treatment systems that produce filtered and disinfected recycled water must include filtration followed by disinfection. The most common types of filtration technologies used in NPR include media bed filtration (such as natural soils or a filter media such as sand or granular activated carbon (GAC)) and membrane filtration (such as microfiltration, ultrafiltration, nanofiltration or reverse osmosis). Other types of technologies include cloth filtration, disc filters, and drum filters. Design requirements for the filtration process include, but are not limited to, the following items:

- If using a filter media bed, filter at a rate that does not exceed 5 gallons per minute per square foot of surface area in mono, dual, or mixed media gravity, upflow, or pressure filtration systems, or does not exceed 2 gallons per minute per square foot of surface area in traveling bridge automatic backwash filters. The filtration rate may be increased, subject to any site-specific rules and regulations, using site-specific demonstration tests on approval by the AHJ.
- Install turbidity meters to monitor for turbidity in the filtered effluent in accordance with Section 4-5.

Disinfection must follow the filtration step. The most common disinfection processes for NPR treatment systems utilize free chlorine, combined chlorine, or ultraviolet (UV) light. Design requirements for the disinfection process include, but are not limited to, the following items:

- The disinfection process must be designed to achieve at least a 5-log reduction of virus when treating the filtered effluent.
- The disinfection process must be validated to achieve the 5-log reduction of virus. If a site-specific validation is used to validate the disinfection system, a virus that is known to be the most resistant to the chosen disinfection process must be used in the site-specific validation test.
- A dedicated sampling tap must be installed on the effluent of the disinfection process for sample collection of total coliforms. The dedicated sampling tap must be resistant to fire torching (for example, constructed of metal) to allow for monitoring for total coliform in the disinfected effluent in accordance with Section 4-5.
- The treated water sent to distribution must contain a chlorine residual of at least 1 mg/L as Cl_2 to control for bio-growth in the distribution system.

[C] 4-4.1.3 The filtration and disinfection design and sampling requirements do not address specific reductions of protozoa because monitoring of protozoa is expensive and time-consuming. It is assumed that these adequately designed, operated, and maintained treatment processes will remove and or inactivate protozoa.

4-4.2 Process-Specific Reliability Features.

Include reliability features in the design of non-potable reuse systems to ensure the system water treatment processes can continue to function, provide compliant water, and prevent non-compliant water from being delivered to a customer. Reliability features include alarms, sensors, and monitoring systems to detect and respond to process upsets or failures in real time. These systems are installed at key points in the treatment process to track, predict, and respond to critical parameters such as pressure, flow, water quality, or chemical dosing. This section provides criteria for process-specific reliability features required to include alarms, sensors, or monitoring systems.

4-4.2.1 Primary Treatment.

Primary treatment processes must be designed with at least one of the following reliability features:

- Multiple primary treatment units capable of producing primary effluent with the largest capacity unit not in operation.
- Standby primary treatment unit process.
- Long-term storage or disposal provisions.

4-4.2.2 Biological Treatment.

Biological treatment processes must be designed with at least one of the following reliability features:

- Multiple biological treatment units capable of producing oxidized wastewater with the largest capacity unit not in operation.
- Short-term retention or disposal provisions and standby replacement equipment.
- Long-term storage or disposal provisions.
- Automatically-actuated long-term storage or disposal provisions.

4-4.2.3 Secondary Sedimentation.

Secondary sedimentation processes must be designed with at least one of the following reliability features:

- Multiple sedimentation units capable of treating the entire flow with the largest capacity unit not in operation.
- Standby sedimentation unit process.
- Long-term storage or disposal provisions.

4-4.2.4 Coagulation.

Coagulation unit processes must be designed with the following features to ensure uninterrupted coagulant feed:

- Standby coagulant feeding systems.
- Adequate chemical storage and conveyance facilities.
- Adequate reserve chemical supply.
- Automatic dosage control.

In addition to the previous requirements, coagulation unit processes must also be designed with at least one of the following reliability features:

- Multiple coagulation units capable of treating the entire flow with the largest capacity unit not in operation.
- Short-term retention or disposal provisions and standby replacement equipment.
- Long-term storage or disposal provisions.
- Automatically-actuated long-term storage or disposal provisions.
- Standby coagulation process.

4-4.2.5 Filtration.

Filtration processes must be designed with at least one of the following reliability features:

- Multiple filter units capable of treating the entire flow with the largest capacity unit not in operation.
- Short-term retention or disposal provisions and standby replacement equipment.
- Long-term storage or disposal provisions.
- Automatically-actuated long-term storage or disposal provisions.
- Standby filtration unit process.

4-4.2.6 Disinfection.

The type of reliability features for disinfection depends on the type of disinfection system used. Because of their widespread use for non-potable water disinfection, chlorine and UV disinfection processes are described herein. If an alternative disinfection system is used (for example, ozone), the alternative disinfection system must have reliability features equivalent to or better than the reliability features for chlorine and UV.

4-4.2.6.1 Chlorine Disinfection.

Chlorine disinfection may be supplied by a gaseous (chlorine gas) or liquid chlorine (for example, sodium hypochlorite or calcium hypochlorite) system. Chlorine systems must include the following design features to ensure uninterrupted disinfectant feed and reliability of the treatment system:

- Automatic measuring and recording of chlorine residual.
- Automatic residual control of chlorine dosage.
- Liquid chlorine systems only: sufficient onsite chlorine storage to accommodate local schedules for chlorine delivery to the site.
- Gaseous chlorine systems only: standby chlorine supply, manifold system to connect chlorine systems, chlorine scales, and automatic devices for switching to full chlorine cylinders.

All chlorine systems (gaseous or liquid) systems must include at least one of the following reliability features:

- Standby chlorinator.
- Short-term retention or disposal provisions and standby replacement equipment.
- Long-term storage or disposal provisions.
- Automatically-actuated long-term storage or disposal provisions.
- Multiple point chlorination, each with independent power source, separate chlorinator, and separate chlorine supply.

4-4.2.6.2 Disinfection (Ultraviolet).

Refer to Section A-2.1 of the Best Practices for design recommendations for UV disinfection systems for non-potable reuse.

4-5 SAMPLING AND ANALYSIS.

Each type of recycled water system must meet their respective constituent limits and sampling frequencies stated in Table 4-1. The subsequent subsections provide further details on sampling and analysis requirements.

Based on the use cases of the recycled water, an evaluation must be conducted to determine a need for limits or control practices for other water quality parameters. For example, irrigation may require the need for site-specific limits on salt and phosphorus to limit harm to local plant and wildlife.

Table 4-1 Constituent Limits and Sampling Frequencies for NPR

Constituent	Limit	Sampling Frequency
Undisinfected secondary recycled water		
Turbidity[1]	N/A	N/A
Total coliform	N/A	N/A
Total suspended solids[1]	<30 mg/L disinfected effluent (daily maximum)	At least once every 7 days
Nitrogen	See Section A-2.6 of the Best Practices for recommendations on nitrogen loading for irrigation.	N/A
Disinfected secondary-2.2 and secondary-23 recycled water		
Turbidity[1]	N/A	N/A
Total coliform	**Disinfected secondary-2.2 only** ≤2.2 MPN/100 mL (7-day median) ≤23 MPN/100 mL (does not exceed in more than one sample in 30-day period) **Disinfected secondary-23 only** ≤23 MPN/100 mL (7-day median) ≤240 MPN/100 mL (does not exceed in more than one sample in 30-day period)	Daily
Total suspended solids[1]	<30 mg/L disinfected effluent (daily maximum)	At least once every 7 days
Nitrogen	See Section A-2.6 of the Best Practices for recommendations on nitrogen loading for irrigation.	See Appendix A-2.6
Filtered and disinfected recycled water		

Constituent	Limit	Sampling Frequency
Turbidity[1]	If filtered by filter media, achieve filter effluent turbidity of ≤2 NTU (24-hour rolling average) ≤5 NTU (95% of time in 24-hours) ≤10 NTU (instantaneous maximum) (more than 5% of the time within a 24-hour period) If filtered by membrane process, achieve filter effluent turbidity of ≤0.2 NTU (95% of time in 24-hours) ≤0.5 NTU (instantaneous maximum)	Continuous monitoring
Total coliform	≤2.2 MPN/100 mL (7-day median) ≤23 MPN/100 mL (does not exceed in more than one sample in 30-day period) ≤240 MPN/100mL (never exceed)	Daily
Total suspended solids[1]	N/A	N/A
Nitrogen	See Section A-2.6 of the Best Practices for recommendations on nitrogen loading for irrigation.	See Appendix A-2.6

[1] Turbidity and total suspended solids must be monitored in the filter effluent and prior to disinfection.

4-5.1 Filter Turbidity.

Filter effluent must be monitored using a continuous turbidity meter and recorder. Depending on the filter design, filter influent may also need to be monitored to ensure filtration performance (for example, reduce filter clogging through use of an automated diversion of filter influent for high-turbidity events). If the continuous turbidity meter and recorder fail, grab sampling at a minimum frequency of once every 72 minutes (to provide 20 samples per day). This sampling may be used until the turbidity meter and recorder are operational.

4-5.2 Bacteria.

All disinfected recycled water effluents must be sampled using a local approved method at least once daily for total coliform bacteria. The analysis must be performed as soon as possible after collection but no later than the required timeframe to meet all sample holding time requirements.

4-5.3 Other Parameters.

The EPA 600-R-12-618 provide suggested limits on other water quality parameters depending on the recycled water use case, such as for pH, chlorine residual, conductivity, and total dissolved solids (salt), nitrogen, and phosphorus. Refer to APPENDIX A-2.7 for further details.

CHAPTER 5 INDIRECT POTABLE REUSE

In this chapter, criteria are provided to address two different forms of IPR. Unless specified, criteria apply to all forms of IPR:

- Groundwater Replenishment Reuse Project (GRRP), where recycled water is used to replenish a groundwater aquifer. There are two forms defined in this UFS: (1) surface application GRRP (also known as surface spreading), where recycled water is applied to the land surface and percolated into the groundwater, and (2) direct injection GRRP, where recycled water is injected directly into the groundwater.
- Surface water augmentation (SWA), also known as reservoir augmentation, where recycled water is used to augment a surface water body such as a drinking water supply reservoir that feeds a drinking water treatment facility.

5-1 ENGINEERING REPORT.

An engineering report for IPR must address the requirements described in Section 4-1, as well as the wastewater source water quality provided to the IPR project based on the wastewater characterization conducted in accordance with Section 5-1.1.

5-1.1 Wastewater Characterization Plan.

To determine treatment design, the source water to the IPR project must be sampled on a monthly basis for at least 12 consecutive months. To plan for the sampling, a Wastewater Characterization Plan that addresses the following elements must be prepared and incorporated into the Engineering Report:

- Different potential sample locations (for example, raw wastewater or wastewater treatment facility effluent).
- How each potential sample location would be most representative of the future source of water used in the IPR project.
- The effects of potential infrastructure upgrades (for example, at the wastewater facility) that will occur prior to the start of the IPR project and how these upgrades would affect the wastewater quality and future facility.
- The IPR system and associated discharges must not cause another water system to exceed a primary drinking water standard.

The Wastewater Characterization Plan must address the microbiological, physical, chemical, and radiological qualities of the source water on a frequency adequate to capture and characterize seasonal variability in the reuse source. For chemicals with drinking water standards, the detection limit for analysis must be specified at or below those specified by the U.S. EPA. At a minimum, the Wastewater Characterization Plan must include sampling and analysis of the following bulleted items. Additionally, consider including sampling and analysis of constituents described in APPENDIX A-3.1.

- General physical and chemical water quality parameters for water reuse treatment (for example, pH and temperature).
- Process design parameters for treatment processes that may be included in the design (for example, reverse osmosis scalants).
- Chemicals with a primary maximum contaminant level (MCL), a secondary MCL, or an action level.
- Priority Pollutants (chemicals listed in 40 CFR APPENDIX A to Part 423, “Priority Pollutants”).
- Chemicals in the source sewer shed based on a review of the Wastewater Source Control Program required to be implemented per Section 5-3.

5-1.2 Wastewater Characterization Results.

Based on the results from the Wastewater Characterization Plan, prepare a Wastewater Characterization Results Report and incorporate it into the Engineering Report. At a minimum, include the following elements in the report:

- All results generated from the study conducted in accordance with the Wastewater Characterization Plan in Section 5-1.1.
- The method detection limit and reporting/practical quantification limits with all monitoring data generated for the characterization.
- A comparison of the maximum concentrations of chemicals in wastewater with all applicable limits (for example, against MCLs).
- Information regarding anticipated changes to wastewater characteristics, including anticipated effects due to climate change.

5-2 JOINT PLAN.

Prior to the start of full-scale operations of an IPR project, a joint plan must be prepared that includes each wastewater and any drinking water agencies involved in the IPR project. The joint plan must be signed by each person with authority or responsibility to operate the IPR project and must comply with regulatory requirements for the IPR project. Revise the joint plan in the event of any subsequent change in applicable authority, responsibility, operation, or ownership of participating agencies in the joint plan, or if any of the information required by this section has changed. Revise the joint plan with sufficient time to implement any of the changes required by the revision and obtain necessary signatures from applicable parties. Refer to Section A-3.4 of APPENDIX A for guidance on updating wastewater treatment plant operations as part of the joint plan.

At a minimum, include the following information in the joint plan:

- Corrective actions to be taken in the event a delivery of recycled water from the IPR project to the groundwater or an augmented drinking water supply reservoir fails to meet water quality requirements.
- The procedures that participating wastewater agencies in the IPR project will implement for notifying drinking water agencies, in the event of operational changes that may adversely affect the quality of the wastewater treatment plant effluent, such as equipment failures or planned process changes.
- The events and corresponding corrective actions required to be identified in the event recycled water delivered to the groundwater or reservoir fails to meet water quality requirements.

5-3 WASTEWATER SOURCE CONTROL.

In addition to the wastewater source control requirements of Section 2-8, the source water for an IPR project must be from a wastewater management agency that implements and maintains a Source Control Program that includes the following elements, at a minimum:

- An assessment of the fate of chemicals and contaminants through the wastewater and recycled municipal wastewater treatment systems.
- Periodic chemical and contaminant source investigations and on-going chemical and contaminant monitoring.
- An outreach program to industrial, commercial, and residential communities within the portions of the sewage collection agency's service area that flows into the water reclamation plant subsequently supplying

the indirect potable reuse project, for the purpose of managing and minimizing the discharge of chemicals and contaminants at the source.

- A current inventory of chemicals and contaminants identified pursuant to this section, including new chemicals and contaminants resulting from new sources or changes to existing sources, that may be discharged into the wastewater collection system.
- Established process for communication with the IPR project staff when wastewater treatment plant effluent composition changes due to events such as equipment failure or process changes.

5-4 PATHOGEN CONTROL.

In the following sections, pathogen control criteria are described in terms of $\log_{10}$ reduction values (LRV) for the following three pathogens. A 1-$\log_{10}$ reduction is equivalent to a 90 percent reduction:

- Enteric virus (hereafter referred to as “virus”).
- Giardia lamblia cyst (hereafter referred to as “giardia”).
- Cryptosporidium spp. oocyst (hereafter referred to as “crypto”).

5-4.1 Minimum Log Reduction Values for Pathogen Control.

The IPR treatment train must provide a minimum LRV of 12-log for an enteric virus, 10-log for giardia, and 10-log for crypto. The treatment train LRV achieved for each pathogen (virus, giardia, and crypto) is the sum of the LRVs achieved for the respective pathogen by each treatment process in the treatment train.

The treatment train must be operated in a manner that, while in operation, continuously achieves the aforementioned pathogen log reductions using validated treatment LRVs. Immediately discontinue delivery of the IPR project water to any distribution system if the aforementioned log reductions are not met, based on the tracking of pathogen log reductions in accordance with Section 5-4.3.

5-4.2 Number and Type of Treatment Processes for Pathogen Control.

Each treatment step from the raw wastewater onward must be evaluated for its potential to be credited with pathogen LRVs (for example, pathogen LRVs can be obtained from the retention time underground for GRRP projects). For each pathogen, the treatment train must have at least three separate treatment processes that provide at least 1 LRV each. For each treatment process, the treatment process must achieve an LRV between 1 and 6 for a pathogen, with no treatment process providing less than 1 LRV and no more than 6 LRV for any pathogen. A treatment process is not required to provide LRV for more than one pathogen (for example, free chlorine disinfection can provide LRV for virus and giardia, but no LRV for crypto).

For each of the three pathogens (virus, giardia, crypto), provide at least one filtration process and one disinfection process. Additional treatment mechanisms may be used:

- Example LRV credit for demonstrating underground retention time for GRRPs are provided in Section A-7.1 of APPENDIX A.
- Guidance for crediting pathogen LRVs for conventional wastewater treatment processes is provided in Section A-7.1 of APPENDIX A.

5-4.3 Validation of Treatment Processes for Pathogen Control.

Each of the treatment processes must be validated for the assigned LRV using one of the following approaches:

- A validation approach widely accepted in the water reuse industry (for example, Water Research Foundation 4997 *Membrane Bioreactor Validation Protocols for Water Reuse*).
- Pathogen log inactivation tables pursuant to the U.S. EPA.
- A validation study prepared by a qualified engineer with at least three years of experience in water treatment and public water supply. Example criteria for a validation study protocol is provided in Section A-7.3 of APPENDIX A. A Validation Study Report that documents the results of the validation study must be prepared following the study.

Using the results from the validation approach previously described, the Engineering Report and operation documents must describe the on-going monitoring for the pathogenic microorganism of concern or a microbial, chemical, or physical surrogate parameter(s) that verifies the performance of each treatment process's ability to achieve its credited log reduction for the respective pathogen.

5-5 CHEMICAL CONTROL.

In the following subsections, criteria for the minimum level of treatment are provided for surface application GRRP, direct injection GRRP, and SWA.

5-5.1 Surface Application GRRP.

At a minimum, the recycled municipal wastewater used for surface application GRRPs must be treated in accordance with the following requirements:

- Wastewater is treated to meet the definition of filtered and disinfected recycled water as described in Section 4-2.3, prior to recharge into the groundwater (prior to discharge into a spreading basin).
- The filtered and disinfected recycled water is percolated into the groundwater through soil aquifer treatment (SAT). SAT requirements are described further in the following sections.

5-5.1.2 Soil Aquifer Treatment.

Prior to a surface application GRRP beginning initial operation, a study must be conducted to determine the occurrence of indicator compounds in the recycled municipal wastewater to be applied at the GRRP. Following completion of the study, at least three indicator compounds must be proposed for use to monitor the treatment performance of the SAT. The indicator compounds must be selected to ensure reliable detection to demonstrate adequate reductions by the SAT (see the following details) with each compound representing distinct groups of chemicals.

Using the indicator compounds previously identified, the SAT process must be monitored on a quarterly basis at a minimum, by measuring the indicator compounds in the recycled water prior to (for example, immediately prior to discharging recycled water into the recharge basins) and after (for example, in lysimeters) the SAT treatment process. The recycled water must be monitored after SAT treatment to ensure samples exclude the effects of dilution by ambient groundwater. The performance goal for indicator removal by the SAT is 90 percent or greater; if this target is not achieved by the SAT, investigate the reason for the low reduction.

5-5.2 Direct Injection GRRP and SWA.

Direct injection GRRP and SWA projects involve discharging recycled water directly into the ground or into a reservoir that acts as a source of drinking water supply. These projects lack an environmental buffer that provides chemical treatment like a SAT for surface spreading GRRPs. Direct injection GRRP and SWA projects require adequate treatment to reduce chemicals present in the source wastewater.

5-5.2.1 Chemical Treatment Barriers.

For direct injection GRRP and SWA projects, the treatment train must consist of oxidized wastewater further treated by at least two separate advanced treatment processes using at least two diverse mechanisms for chemical reduction. Refer to Section A-4 of APPENDIX A for recommended treatment trains for IPR.

5-5.2.2 Validation of Treatment Processes for Chemicals.

Each treatment barrier must be validated through site-specific tests after construction to verify treatment performance. The validation study protocol must include proposed surrogate and/or operational parameters to be used in the validation study. Re-validate the treatment process when the full-scale operating conditions or control strategy are inconsistent with the previous validation study conditions.

5-5.2.3 Surrogate Monitoring and Critical Control Points.

Each treatment process must include ongoing performance monitoring using at least one surrogate and/or operational parameter that is capable of being monitored continuously, recorded, and have associated alarms that indicate when treatment has been compromised. Identify the chemical control point and the surrogate(s) and/or operational parameter(s) and establish the critical limit(s) for the surrogate(s) and/or operational parameter(s) that indicate when treatment has been compromised.

Using the validation study results, identify the chemical control point(s) and the surrogate and/or operational parameter(s) and establish the critical limit(s) for the surrogate(s).

5-6 MONITORING PLAN.

A monitoring plan must be prepared for the GRRP that describes the sampling and analysis of the following constituent groups, at a minimum:

- Constituents with primary and secondary MCLs and action levels (ALs) as defined by the U.S. EPA.
- Total nitrogen.
- Total organic carbon.

5-6.1 Constituents with primary MCLs and ALs.

In the Monitoring Plan, plan to collect samples (grab or composite) that are representative of the recycled water applied to the ground or surface. For surface spreading GRRPs, samples may be taken after SAT.

Plan for samples to be analyzed for contaminants having primary MCLs and ALs (lead and copper) as defined by the U.S. EPA in 40 CFR Part 141 Subpart G. Plan for this sampling to have the following frequencies, at a minimum:

- Monthly for the first 12 months.
- After the first 12 months, for any constituent not exceeding an MCL in the previous 12 months, plan for the project to reduce the monitoring frequency to no less than quarterly.

5-6.2 Constituents with secondary MCLs.

In the Monitoring Plan, plan to collect samples (grab or composite) that are representative of the recycled water applied to the ground or surface, as well as from all GRRP monitoring wells (obtained independently from each major aquifer layer).

Plan for samples to be analyzed for contaminants having secondary MCLs as defined by the U.S. EPA in 40 CFR Part 143 Subpart A. Plan for this sampling to have the following frequencies, at a minimum:

- Monthly for the first 12 months.
- After the first 12 months, for any constituent not exceeding an MCL, plan for the project to reduce the monitoring frequency to no less than yearly.

5-6.3 Total Nitrogen.

In the monitoring plan, plan for two total nitrogen samples (grab or 24-hour composite) to be taken each week at least three days apart, that are representative of the recycled water discharged to the ground or surface. For surface spreading GRRPs, samples may be taken after SAT. Reduced monitoring frequencies for nitrogen (for example, once weekly) may be used if reliable nitrogen-denitrification processes are used by the wastewater facility that achieve effluent nitrogen concentrations less than 10 mg/L as N for at least one year.

Plan for samples to be analyzed for total nitrogen and analyzed within 72 hours of the sample being taken. Plan to report the result to the project within the same 72 hours if the result of any single sample exceeds 10 mg/L as N. Plan to initiate studies to determine the cause of nitrogen results exceeding 10 mg/L as N, including sampling at locations around the recycled water discharge location to identify elevated concentrations. Include the determination of whether such elevated concentrations exceed or may lead to an exceedance of a nitrogen-based MCL.

5-6.4 Total Organic Carbon.

In the Monitoring Plan, plan for at least one sample set to be taken weekly to be analyzed for total organic carbon (TOC), from samples as described in the following list:

- For surface application GRRP projects: plan to take one 24-hour composite sample from recycled water that is representative of recycled water discharged into the percolation basin and one sample after SAT, within the zone of percolation and prior to the effects of dilution by groundwater. Alternatively, use grab samples if they are demonstrated to be representative of the water quality throughout the 24-hour period. To discontinue collecting a sample after the SAT, plan to conduct a study of the SAT to determine a SAT treatment factor for TOC that can be applied to the one sample of the recycled water discharged to the percolation basin.
- For direct injection GRRP and SWA projects: plan to take, at a minimum, one 24-hour composite sample each week of the recycled water discharged to the ground or surface. Alternatively, use grab samples or continuous TOC analyzers if they are demonstrated to be representative of the water quality throughout the 24-hour period.

5-6.5 Additional Constituents with Known or Potential Health Concerns.

In the Monitoring Plan, consider sampling for constituents described in APPENDIX A-3.1 and A-3.2.

5-7 GROUNDWATER REQUIREMENTS [GRRP ONLY].

5-7.1 Water Quality Sampling to Establish Baseline for Aquifer.

Prior to operating a GRRP, collect at least one sample from each quarter, from each affected aquifer that may be impacted by the GRRP. Collect samples that are representative of water in each major aquifer layer, taking into consideration seasonal variations and other site-specific variations. Analyze samples for the suite of constituents described in Section 5-6.

5-7.2 Plan for Alternative Source of Drinking Water.

Prior to operation of a GRRP, prepare a plan describing the steps to be taken in the event that a downstream drinking water production well (described by the mapping requirements in Section 5-7.3) is degraded to a degree that is no longer a safe source of drinking water (for example, it violates a drinking water standard or receives water from the GRRP that has been inadequately treated for pathogens) because of the operation of the GRRP. In the plan, describe how an alternative source of drinking water or an adequate treatment system will be provided to users of the impacted wells.

5-7.3 Mapping of the GRRP.

Based on hydrogeologic flow paths, a map of the GRRP site must be prepared and submitted to applicable regulatory authorities and local well-permitting authorities. Prepare and provide a revised map when conditions change and the previous map no longer accurately reflects current conditions. The submittals required in this section must be prepared by or under the supervision of a licensed geologist, hydrogeologist, or equivalent. Include the following items:

- The location and boundaries of the GRRP.
- A boundary representing a zone of controlled drinking water well construction, the greatest of the horizontal and vertical distances reflecting the retention times required pursuant to Section 5-7.5.
- A secondary boundary representing a zone of potential controlled drinking water well construction, depicting the zone within which a well would extend the boundary in bullet (2). The secondary boundary must include existing or potential future drinking water wells that will require further study and potential mitigating activities prior to drinking water well construction.
- The location of all monitoring wells established pursuant to Section 5-7.7 and drinking water wells within two years groundwater travel time of the GRRP based on groundwater flow directions and velocities expected under GRRP operating conditions.

5-7.4 Hydrogeologic Assessment of the GRRP.

Prepare a hydrogeological assessment of the proposed GRRP's setting. Include the following in the assessment:

- The qualifications of the individual(s) preparing the assessment.

- A general description of geologic and hydrogeological setting of the groundwater basin(s) with the potential to be directly impacted by the GRRP.
- A detailed description of the stratigraphy beneath the GRRP, including the composition, extent, and physical properties of the affected aquifers.
- Based on at least four rounds of consecutive quarterly monitoring to capture seasonal impacts.
- The existing hydrogeology and the hydrogeology anticipated as a result of the operation of the GRRP.
- Maps showing quarterly groundwater elevation contours, along with vector flow directions and calculated hydraulic gradients.

5-7.5 Underground Retention Time.

Site the GRRP infrastructure to ensure the recycled municipal wastewater is retained underground for a period of time (minimum of two months) that ensures the following criteria are met:

- Pathogen removal requirements.
- Response retention time requirements: Period of time necessary to allow a project sufficient response time to identify treatment failures and implement actions, including those required pursuant to Section 5-7.2 and necessary for the protection of public health.
- Dilution of recycled water requirements: Design and operate the GRRP in a manner that ensures recycled water recharged at the GRRP is adequately mixed with other water sources underground prior to extraction by a downstream drinking water production well.

5-7.6 Groundwater Tracer Study.

To demonstrate the retention time underground required by Section 5-7.5, implement a tracer study utilizing a tracer under hydraulic conditions representative of normal GRRP operations. The retention time represents the difference in time from when the water with the tracer is applied at the GRRP to when either two percent of the initially introduced tracer concentration has reached the downgradient monitoring point, or ten percent of the peak tracer unit value observed at the downgradient monitoring point reached the monitoring point. Initiate the tracer study prior to the end of the third month of operation.

For the purpose of siting a GRRP location during project planning and until the groundwater tracer study has been completed, for each month of retention time estimated using the method in Column 1, credit the recycled municipal wastewater or recharge water with no more than the corresponding virus log reduction in Column 2 of Table 5-1.

Table 5-1 Underground Pathogen LRV or Response Time Credit based on Method for Demonstrating Underground Retention Time.

Method used to estimate the retention time to the nearest downgradient drinking water well	Virus Log Reduction	Response Time Credit per Month Demonstrated by Chosen Method
Tracer study utilizing an added tracer.	1.0-log	1.0 month
Tracer study utilizing an intrinsic tracer.	0.67-log	0.67 month
Numerical modeling consisting of calibrated finite element or finite difference models using validated and verified computer codes used for simulating groundwater flow.	0.50-log	0.5 month
Analytical modeling using existing academically-accepted equations such as Darcy's Law to estimate groundwater flow conditions based on simplifying aquifer assumptions.	0.25-log	0.25 month

5-7.7 Monitoring Wells.

Prior to operating a GRRP, plan to site, construct, and conduct an initial water quality characterization of at least two monitoring wells downgradient of the GRRP in accordance with the following:

- At least one monitoring well is located (a) no less than two weeks but no more than six months of travel through the saturated zone affected by the GRRP, and (b) at least 30 days upgradient of the nearest drinking water well. More than one well may be necessary to adequately characterize the movement of recycled water and impact of recycled water on the groundwater.

- At least one additional monitoring well between the well(s) between the GRRP and the nearest downgradient drinking water well.
- Collect at least two samples from each of the major aquifer layers of the monitoring wells previously mentioned, prior to the start of the GRRP operations. Plan for each sample to be analyzed for all constituents described in Section 5-5.2.1.

5-8 SWA REQUIREMENTS [SWA ONLY].

5-8.1 Reservoir Monitoring.

Prior to augmentation of a surface water reservoir with recycled water, plan a study to characterize the background water quality of the reservoir. Identify monitoring locations representative of the reservoir throughout the volume of the reservoir impacted by the SWA project. The study must address, (a) differing water quality conditions across the horizontal extent of the surface water reservoir, (b) each level in the surface water reservoir corresponding to the depths in which water may be withdrawn, and (c) the surface water reservoir’s epilimnion and hypolimnion.

Collect samples for at least 12 months prior to the start of SWA operations, at a frequency no less than monthly from the sample locations identified previously. Analyze for all constituents identified in Section 5-6.2 (Constituents with secondary MCLs.), Section 5-6.3 (Total Nitrogen.), and Section 5-6.4 (Total Organic Carbon.), as well as E. coli, total coliform bacteria, temperature, dissolved oxygen, chlorophyll a, and total and dissolved phosphorus. Continue to collect these samples for at least 24 months after the start of SWA operations.

5-8.2 Reservoir Theoretical Retention Time.

Ensure that at the design recycled water flow, the surface water reservoir receiving recycled water has a minimum theoretical retention time of no less than 60 days.

On a monthly basis, the theoretical retention time of recycled water in the reservoir will be calculated using the value (in units of days) resulting from dividing the volume of water in the surface water reservoir at the end of each month by the total outflow from the surface water reservoir during the corresponding month. The total outflow includes, but is not limited to, all outflows and withdrawals from the surface water reservoir.

5-8.3 Reservoir Tracer Studies.

Prior to augmentation of the reservoir with recycled water and anytime that previous tracer studies or hydrodynamic modeling may not accurately reflect current conditions, plan to conduct hydraulic tracer studies and hydrodynamic modeling of the reservoir to characterize the dilution of recycled water in the reservoir prior to drawing for drinking water treatment. The tracer studies and hydrodynamic modeling will be used to demonstrate that the volume of water withdrawn from the reservoir to be ultimately supplied for human consumption contains no more than ten percent, by volume, of recycled municipal wastewater that was delivered to the surface water reservoir during any 24-hour period.

Within the first six months of operation, conduct a hydraulic tracer study of the reservoir using an added tracer to validate the hydrodynamic modeling performed as previously described.

5-8.4 Impact Assessment for Existing Drinking Water Source, Treatment, and Distribution.

Prior to augmentation of a surface water reservoir with recycled water, prepare a plan describing the actions the project will take to assess and address potential impacts resulting from the introduction of recycled water into the reservoir and downstream drinking water treatment facility and distribution system. At a minimum, address the following in the plan:

- Maintaining chemical and microbial stability in the drinking water distribution system as the drinking water quality changes with anticipated increasing fractions of advanced treated water.
- Maintaining treatment effectiveness throughout the surface water treatment plant as the source water quality changes with anticipated increasing fractions of advanced treated water in the reservoir.
- Assessments to be performed prior to and during operation of the SWA of defined in the previous paragraphs.

CHAPTER 6 DIRECT POTABLE REUSE

In this chapter, criteria are provided to address DPR projects. If a potable reuse project is not defined as IPR, then it is a DPR project. There are two general types of DPR projects and the criteria in this chapter apply to both of the following types of DPR (described in detail in CHAPTER 2):

- “Raw water augmentation,” where the source water to a drinking water treatment facility is augmented with advanced treated recycled water, or
- “Treated water augmentation,” where treated drinking water is augmented with advanced treated recycled water in the drinking water distribution system.

DPR projects produce drinking water and the following drinking water UFCs must also be reviewed for applicability in the development of a DPR project:

- UFC 3-230-01
- UFC 3-230-02
- UFC 3-230-03

6-1 ENGINEERING REPORT.

The Engineering Report must be prepared by a licensed engineer with at least five years of experience performing as a licensed engineer in drinking water and wastewater treatment and evaluating treatment processes for pathogen and chemical control in a public water supply. At a minimum, the Engineering Report must address the following items:

- A description of how the DPR project will address every requirement in this Chapter and all applicable regulatory requirements from the regulating water agencies.
- A description of all facilities, personnel, and support services necessary for the operation of the DPR project.
- A description of the wastewater source water quality provided to the DPR project based on the wastewater characterization conducted in accordance with Section 6-1.1.
- Information regarding anticipated changes to wastewater characteristics, including anticipated effects due to climate change.

- Information regarding any existing or planned activities to optimize wastewater treatment operations, including influent flow and load equalization, enhancements to primary treatment, equalization and treatment of return flows, modification of biological treatment process operations, implementation of new biological treatment processes, and enhancements in process monitoring, effluent filtration, and effluent disinfection methods.
- Pathogen and chemical control point monitoring and responses, described further in Section 6-6.2.

6-1.1 Wastewater Characterization Plan.

To determine treatment design, the source water to the DPR project must be sampled on a monthly basis for at least 12 consecutive months. To plan for the sampling, a Wastewater Characterization Plan must be prepared and incorporated into the Engineering Report that addresses the following elements:

- Different potential sample locations (for example, raw wastewater or wastewater treatment facility effluent).
- How each potential sample location would be most representative of the future source of water used in the DPR project.
- The effects of potential infrastructure upgrades (for example, at the wastewater facility) that will occur prior to the start of the DPR project and how these upgrades would affect the wastewater quality and future facility.

The Wastewater Characterization Plan must address the microbiological, physical, chemical, and radiological qualities of the source water on a frequency adequate to capture and characterize seasonal variability in the reuse source. For chemicals with drinking water standards, the detection limit for analysis must be specified at or below those specified by the U.S. EPA. At a minimum, the Wastewater Characterization Plan must include sampling and analysis of the following bulleted items. Additionally, consider including sampling and analysis of constituents described in APPENDIX A-3.1 and A-3.3.

- General physical and chemical water quality parameters for water reuse treatment (for example, pH and temperature).
- Process design parameters for treatment processes that may be included in the design (for example, reverse osmosis scalants).
- Chemicals with a primary MCL, a secondary MCL, or an action level.

- Priority Pollutants (chemicals listed in 40 CFR APPENDIX A to Part 423, “Priority Pollutants”).
- Chemicals in the source sewer shed based on a review of the Wastewater Source Control Program required implemented per Section 6-3.
- Other chemicals specified that may pose a human health risk.

6-1.2 Wastewater Characterization Results Report.

Based on the results from the Wastewater Characterization Plan, prepare a Wastewater Characterization Results Report and incorporate it into the Engineering Report. At a minimum, include the following elements in the report:

- All results generated as a result of the study conducted in accordance with the Wastewater Characterization Plan of Section 6-1.1.
- Include the method detection limit and reporting/practical quantification limits with all monitoring data generated for the characterization.
- An evaluation of the data collected to assess the potential human health risks from detected chemicals.
- Compare the maximum concentrations of chemicals in wastewater with all applicable limits (for example, against MCLs).
- For any chemicals without primary MCLs and ALs, compare the maximum concentration of the chemical in wastewater with human health protective levels for drinking water. Human health protective levels include public health goals or the results of other human health risk assessments performed or compiled by the state Office of Environmental Health Hazard Assessment, or similar protective levels derived from human health risk assessments performed or compiled by state agencies, the U.S. EPA, scientific advisory bodies, or other similar public health protective levels required by other applicable health agencies.
- Present the evaluation, along with the cited document(s) that are the source of information of the health protective levels of a chemical in drinking water, in tables and with an accompanying narrative discussion to identify chemicals that may pose a risk to public health in the wastewater, their potential to cause exceedances of MCLs by the proposed DPR project, and their potential to be controlled by the use of local limits and other discharge control methods.

- In the narrative discussion, identify detected chemicals that lack available human health risk assessments and identify analytical methods used that do not have the necessary sensitivity for a comparison to a human health protective level in drinking water.

6-2 JOINT PLAN.

Prior to the start of the DPR project, develop a joint plan that includes each wastewater and drinking water agency involved in the DPR project (for example, entities that collect the municipal wastewater, provide the municipal wastewater to the DPR project, provide wastewater source control, provide treatment or use DPR project water as a source of supply for a water treatment plant that delivers water to a water distribution system of a public water system). Ensure the joint plan is signed by each person with authority or responsibility to operate the DPR project and comply with regulatory requirements for the DPR project. Revise the joint plan in the event of any subsequent change in applicable authority, responsibility, operation, or ownership of participating agencies in the joint plan, or if any of the information required by this section has changed. Revise the joint plan with sufficient time to implement any of the changes required by the revision and obtain necessary signatures from applicable parties. Refer to Section A-3.5 of APPENDIX A for guidance on updating wastewater treatment plant operations as part of the joint plan.

At a minimum, include the following information in the joint plan:

- Identification of each partner agency, the roles and responsibilities of each partner agency, the legal authority of each partner agency to fulfill its role and responsibilities, and the overall organizational structure involved in implementing the joint plan over a 20-year life cycle planning horizon.
- Procedures to ensure that operations are conducted in accordance with an approved Operations Plan pursuant to Section 6-7.
- Procedures to ensure that the entity responsible for the DPR project will have knowledge of the current status of treatment for the entire DPR project at all times.
- A description of corrective actions to be taken to protect public health if water delivered from a water treatment plant fails to meet any requirements specified in this UFS or specified by a regulatory agency.
- Procedures to ensure that monitoring is conducted in accordance with an approved monitoring plan pursuant to Section 6-6.

- Procedures to ensure that the entity responsible for the DPR project will have knowledge of the current status of water quality monitoring pursuant to Section 6-6 and water quality monitoring results.
- A plan to investigate and implement wastewater treatment improvement that would enable a water treatment plant that provides treatment pursuant to this chapter to reduce the level of chemicals to lowest achievable concentrations.
- Procedures to ensure the Wastewater Source Control Program complies with the requirements pursuant to Section 6-3 and any regulatory requirements.
- Procedures for providing access to all DPR project facilities, operations, and records for inspection at any time.
- A plan to communicate the water quality status and water quality monitoring results in a timely manner among the partner agencies for the DPR project.
- Procedures the entity responsible for the DPR project will take for notifying partner agency(ies) and regulatory authorities of (a) operational changes that may adversely affect the quality of DPR project water delivered by a water treatment plant and (b) treatment failure incidents and the corresponding corrective actions taken.
- Procedures to implement cross connection control requirements pursuant to Section 6-7.1 and any regulatory requirements.
- Procedures to optimize corrosion control to reduce lead and copper levels in the distribution system.
- The steps that the entity responsible for the DPR project and partner agency(ies) will take to provide an alternative source of domestic water supply or drinking water in the event the DPR project is unable to supply water.
- Copies of all agreements, such as Joint Powers Authority or bilateral agreements, that were executed to facilitate the operation of the DPR project.

6-3 WASTEWATER SOURCE CONTROL.

The municipal wastewater used in the DPR project must be from a wastewater management agency that complies with all applicable wastewater discharge requirements, is not in violation of discharge permit requirements, and administers an industrial pretreatment and pollutant source control program. The following sub-sections detail additional requirements for source control for DPR projects.

6-3.1 Industrial Pretreatment and Pollutant Source Control.

The entity supplying wastewater to the DPR project must have the legal authority to implement an industrial pretreatment and pollutant source control program, including authority for oversight and inspection, to control industrial and commercial waste discharges into the wastewater collection system. Further, the entity must also address the following in their industrial pretreatment and pollutant source control program:

- Identification and limitation of contaminants in wastewater through the use of local limits, local ordinances, or other discharge control methods.
- Assessment of the fate of chemicals in the wastewater treatment system prior to DPR advanced water treatment.
- Investigation of chemical sources and chemicals detected in monitoring pursuant to their various permits and monitoring programs.
- Periodic surveys of chemicals and contaminants in the sewer shed.
- Operation of an outreach program to industrial, commercial, and residential communities that discharge into a wastewater collection system that serves as the source for the DPR project, for the purpose of managing and minimizing the discharge of chemicals at the source.
- Maintenance of a current inventory of chemicals identified pursuant to this section, including new chemicals resulting from new sources or changes to existing sources that may be discharged into the wastewater collection system.
- Establishment of a process for communication with the DPR project staff when wastewater treatment plant effluent composition changes due to events such as equipment failure or process changes.

6-3.2 Local Limits.

Local limits and other discharge control methods must be established and administered by the wastewater provider(s) for the DPR project. A summary of the local limits and discharge control methods must be included in any annual reports prepared for the DPR project.

6-3.3 Early Warning System.

The design of the DPR system must include a program to receive early warning of a potential occurrence that could interfere with the operation of a treatment process at a water treatment plant that provides treatment for the DPR project, reduce the reliability or effectiveness of a water treatment process at a water treatment plant, or result in an increase in contaminant levels in the advanced treated water. At a minimum, the early warning program must include the following items:

- Online monitoring instrumentation that measures indicator compound(s) or surrogate parameter(s) and indicates an increase in chemical contamination that may adversely impact the operations of the DPR project treatment or cause contamination of the advanced treated water.
- A process for notification by the industrial pretreatment and pollutant source control program to the entity responsible for the DPR project, of any discharge that can potentially result in the release of contaminants above the limits established pursuant to Section 6-3.2.

6-3.4 Source Control Committee.

Form and maintain a source control committee that includes representatives from each partner agency that supplies municipal wastewater to the DPR project or that owns or operates a water treatment plant that provides treatment in the DPR project. This includes representatives from key industrial users and others that discharge chemicals to the wastewater collection system that may pose a risk to public health.

6-4 PATHOGEN CONTROL.

Pathogen risks are generally higher in DPR compared to IPR due to the absence of an environmental buffer. In DPR, treated wastewater is directly introduced into the municipal water supply system, which means there is less time for natural processes to further reduce or blend out pathogen levels. Pathogen control requirements differ for DPR compared to IPR and are more stringent.

In the following sections, pathogen control criteria are described in terms of LRV for the following three pathogens. A 1-$\log_{10}$ reduction is equivalent to a 90 percent reduction:

- Enteric virus (hereafter referred to as “virus”).
- Giardia lamblia cyst (hereafter referred to as “giardia”).
- Cryptosporidium spp. oocyst (hereafter referred to as “crypto”).

6-4.1 Minimum Log Reduction Values for Pathogen.

The DPR treatment train must be designed to provide a minimum LRV of 15-log for enteric virus, 11-log for giardia, and 11-log for crypto. The treatment train LRV for enteric virus, giardia lamblia cyst, and cryptosporidium oocyst is the sum of the treatment process LRVs for the respective pathogen.

The treatment train must be operated in a manner that, while in operation, continuously achieves the aforementioned pathogen log reductions using validated treatment LRVs. Immediately discontinue delivery of DPR project water to any distribution system if the aforementioned log reductions are not met, based on the tracking of pathogen log reductions per Section 6-6.2.1.

6-4.2 Number of Type of Treatment Processes for Pathogens.

Each treatment step from the raw wastewater onward must be evaluated for its potential to be credited with pathogen LRVs. For example, pathogen LRVs can be obtained from the wastewater facility, advanced treatment facility, or the drinking water facility. For each pathogen, the treatment train must have at least three separate treatment processes that provide at least 1 LRV each. For each treatment process, the treatment process must achieve an LRV between 1 and 6 for a pathogen, with no treatment process providing less than 1 LRV and no more than 6 LRV for any pathogen. A treatment process is not required to provide LRV for more than one pathogen (for example, free chlorine disinfection can provide LRV for virus and giardia, but no LRV for crypto).

For each of the three pathogens (virus, giardia, crypto), provide at least one filtration step and one disinfection step, with each treatment mechanism validated for at least 1.0-log reduction for each of the three pathogens. Additional treatment mechanisms may be used to meet the total log reduction requirements.

6-4.3 Validation of Treatment Processes for Pathogens.

Each of the treatment processes must be validated for the assigned LRV using one of the following approaches:

- A validation approach widely accepted in the water reuse industry (for example, Water Research Foundation 4997 Membrane Bioreactor Validation Protocols for Water Reuse).
- Pathogen log inactivation tables pursuant to the U.S. EPA.

- A validation study prepared by a qualified engineer with at least three years of experience in water treatment and public water supply. Example criteria for a validation study protocol is provided in Section A-7.3 of APPENDIX A. A Validation Study Report that documents the results of the validation study must be prepared following the study.

Using the results from the validation approach previously described, the Engineering Report and operation documents must describe the on-going monitoring for the pathogenic microorganism of concern or a microbial, chemical, or physical surrogate parameter(s) that verifies the performance of each treatment process's ability to achieve its credited log reduction for the respective pathogen.

6-4.4 Residual Disinfectant.

All DPR water sent to the drinking water distribution system is drinking water and must meet the disinfection performance standards pursuant to Section 4.4.2 of the 10 States Standards for Water.

6-5 CHEMICAL CONTROL.

6-5.1 Chemical Treatment Barriers.

The DPR treatment train must have at least three separate treatment processes using at least three diverse mechanisms for chemical reduction. Refer to Section A-4 of APPENDIX A for recommended treatment trains.

6-5.2 Validation of Treatment Processes for Chemicals.

Each treatment barrier for chemicals must be validated through site-specific tests after construction to verify treatment performance. In a validation study protocol for a treatment process, include proposed surrogate and/or operational parameters to be used in the validation study. Re-validate the treatment process when the full-scale operating conditions or control strategy are inconsistent with the previous validation study conditions.

6-5.3 Surrogate Monitoring and Critical Control Points.

For each treatment process, include ongoing performance monitoring using at least one surrogate and/or operational parameter capable of being monitored continuously, recorded, and have associated alarms that indicate when treatment has been compromised. Identify the chemical control point and the surrogate(s) and/or operational parameter(s) and establish the critical limit(s) for the surrogate(s) and/or operational parameter(s) that indicate when treatment has been compromised.

Using the validation study results, identify the chemical control point(s), surrogate and/or operational parameter(s), and establish the critical limit(s) for the surrogate(s).

6-5.4 Continuous Mixing.

The DPR treatment train must provide a mixing of flow that can attenuate a one-hour elevated concentration of a contaminant in the municipal wastewater by a factor of ten. This requirement can be met through the use of mixing that occurs between the wastewater treatment plant inlet chamber and the DPR project finished water, including treatment processes, storage tanks, detention basins, reservoirs, related pipelines, and water conveyance.

6-6 MONITORING PLAN.

Prepare a monitoring plan that addresses the following elements, as well as all requirements in the following sub-sections:

- Identification of all entities who have roles and responsibilities in the monitoring, a description of roles and responsibilities, and contact information.
- Monitoring locations, schedules, and procedures to track monitoring status and review of analytical results.
- Laboratories used and anticipated laboratory turn-around times to receive analytical results.
- Analytical methods used pursuant to Section 6-6.1 for each constituent monitored, sample collection, handling, and processing procedures.
- Analytical detection limits and laboratory reporting levels for each constituent monitored.
- A description of training and instruction provided to sample collectors, sample schedulers, sample handlers, water quality data reviewers, water quality data submitters, and other personnel associated with sampling and sample data quality assurance.
- A description of procedures for keeping and maintaining records.
- Procedures for communication and coordination among sample collectors, treatment operators, water quality data reviewers, and laboratory(ies).

- A description of the follow-up actions that will be taken when a laboratory analysis identifies a concentration above an MCL or AL.

6-6.1 Laboratory Sampling.

Develop a sampling plan that describes the following regarding samples submitted to laboratory analysis:

- Sampling location.
- Constituent and associated limits (for example, maximum concentration allowed by regulation).
- Sampling frequency. At the beginning of the project, consider using greater frequencies (for example, monthly for regulated constituents and weekly for acutely toxic constituents like nitrate, nitrite, perchlorate, and lead). Also use greater frequencies for constituents with higher risk based on an evaluation of the treatment process used, the treatment effectiveness, and the concentration of the constituent found in the feed water source. After an extended operation period (for example, three years), consider reducing the frequency of any constituents with low concentrations or infrequent detections (for example, from monthly to quarterly).
- Approximate time of day for sampling.
- Sampling method (for example, grab or 24-hour composite).
- Laboratory name, location, and contact information (with necessary certifications).
- Laboratory method and associated detection or quantification limits. Drinking water methods are used whenever possible.

6-6.1.1 Minimum Sampling (Required).

At a minimum, sample the following constituents at three locations: (1) municipal wastewater that feeds the DPR Project at a location after secondary wastewater treatment, (2) advanced treated water at a location immediately after the advanced oxidation process, and (3) finished water prior to an entry point to the distribution system:

- Constituents with U.S. EPA primary MCLs and ALs as defined in 40 CFR Part 141 Subpart G.

- Constituents with U.S. EPA secondary MCLs as defined in 40 CFR Part 143 Subpart A.
- Total nitrogen.
- Physical characteristics, including but not limited to, bicarbonate, carbonate, and hydroxide alkalinity, calcium, magnesium, sodium, pH, and total hardness.
- Constituents based on a review of the Wastewater Source Control Program implemented per Section 6-3.

6-6.1.2 Recommended Sampling (Site-Specific).

At the locations identified in Section 6-6.1.1, consider sampling constituents described in APPENDIX A-3.1, A-3.2, and A-3.3.

6-6.2 Critical Control Point Monitoring and Response for Pathogens and Chemicals.

Describe the pathogen control points and chemical control points that will be used to demonstrate control of acute and chronic exposure threats. Utilize at least one critical limit for each pathogen control point and chemical control point employed in the treatment train.

6-6.2.1 Pathogens.

Pathogens are an acute exposure threat when consumed. Prevent water posing an acute exposure pathogen threat from entering the water distribution system of a public water system when the water fails to provide the pathogen log reductions identified in Section 6-4.1.

6-6.2.2 Nitrate and Nitrite.

Nitrate and nitrite are acute exposure threats when consumed. Establish a control point, control limit (maximum concentration), and monitoring location for nitrate, nitrite, and nitrate plus nitrite, that provides representative sampling of the advanced treated water prior to distribution. Prevent any water with nitrate, nitrite, or nitrate plus nitrite in excess of their MCLs, from entering the distribution system.

6-6.2.3 Total Organic Carbon.

TOC represents an acute exposure threat because TOC is a surrogate for all organic contaminants, some of which may be acute threats at low concentrations. The following elements of TOC monitoring must be implemented:

- Establish a TOC control point, control limit (maximum concentration), and monitoring location that provides representative sampling of the advanced treated water prior to distribution. Monitoring of TOC must be continuous at a frequency no less than once every 15 minutes. Any water with TOC in excess of the TOC control limit must not enter the drinking water distribution system. Establish sub-critical limits for TOC (for example, 50 percent of the critical limit) with associated responses (for example, collecting samples for laboratory analysis or initiation of a source control evaluation) to limit the possibility of exceeding the TOC control limit.

When developing the TOC control limit, consider the attenuation of elevated TOC concentrations in the finished water due to mixing in a reservoir downstream of advanced treatment as justified through hydrodynamic modeling, tracer testing, and the diluent capacity of the reservoir.

6-6.3 SCADA Requirements.

Utilize a Supervisory Control and Data Acquisition (SCADA) system to manage information generated at the pathogen and chemical control points. Equip each pathogen and chemical control point with online monitoring sufficient to determine whether a critical limit is being met. If the online monitoring utilized per this section is unable to demonstrate compliance with a critical limit regardless of the cause, the associated critical limit(s) will be deemed to not have been met. Any pathogen control point surrogate and/or operational parameter that is not meeting the associated critical limit means the treatment process is not credited with the associated pathogen LRV.

Design the SCADA system to identify a failure of a treatment process to meet its critical limit(s) and to automatically discontinue delivery of DPR project water if the treatment train does not meet the minimum pathogen reduction values defined in Section 6-4.1. Design the SCADA system to discontinue delivery of DPR project water to any distribution system within the time provided by the flow path and response times determined in Section 6-6.4. In addition to the cybersecurity requirements of Section 1-5 and the SCADA requirements from UFC 3-230-01, design and operate the SCADA systems of all water treatment plants included in the DPR project with the following features and capabilities. Design the SCADA system to achieve the following features:

- Provide alarms that alert the operator when a pathogen or chemical control point is not operating as designed and halt the flow of water if necessary.
- Identify trending degradation and significant excursions of water quality or surrogate and/or operational parameters that indicate a need for treatment adjustment, maintenance, or other operator intervention. Alert the operator of the trending degradation or significant excursion incident and generate a record.
- Communicate and interoperate with the SCADA systems of all water treatment plants included in the DPR project that provide treatment.

6-6.4 Automated Response Times.

Provide a path for water to flow from each pathogen and chemical control point to a point of diversion or shutoff through the treatment train, storage facilities, related pipelines, and water conveyance facilities. For acute exposure threats (pathogens, nitrate, nitrite, TOC), ensure the time it takes for the first ten percent of the water to flow along the flow path from each pathogen and chemical control point to the point of diversion or shutoff is no less than the time required for the identification and diversion or shutoff of inadequately treated water as determined in the following list.

Calculate the time for the water to travel along the path of flow from each pathogen and chemical control point to a point of diversion or shutoff based on the summation of the times required for the following, at a minimum:

- The maximum time between online measurements.
- The maximum time it takes for online measurements to be accessed by the SCADA system and an assessment made as to whether the critical limit is being met.
- The maximum time it takes for the SCADA system to determine if any limits for pathogens (per Section 6-6.2.1), nitrate, nitrite, and nitrite plus nitrite (per Section 6-6.2.2), or TOC (per Section 6-6.2.3) have been exceeded and for the system to actuate a diversion or shutoff valve and divert or shut off flow to the distribution system.

6-7 OPERATIONS PLAN.

In addition to the requirements stated in Section 2-7.2, an Operations Plan must be prepared to describe how the DPR project will be operated to meet all regulatory and permit requirements. At a minimum, the following elements must be included in the Operations Plan:

- A description of how each treatment process is operated within the entire treatment train used to comply with the requirements of this UFS and how the reliability features of the DPR project are implemented in the operation of the entire treatment train. Include the standard operating procedures to be used.
- A description of the treatment process performance monitoring pursuant to Sections 6-4, 6-5, 6-6.2, and 6-7.1, including (a) identification of each surrogate and operational parameter for each pathogen control point, chemical control point, and a description of the equipment sampling and recording frequency for continuously monitored parameters, (b) identification of the monitoring location for each surrogate and operational parameter, and (c) identification of critical limit(s) associated with each surrogate and operational parameter.
- Information demonstrating that the personnel operating and overseeing the DPR project operations have received training in the following: (a) the proper operation of the treatment processes utilized, (b) the Safe Drinking Water Act (or equivalent) and its implementing regulations, (c) the potential adverse health effects associated with the consumption of drinking water that does not meet drinking water standards, and (d) implementation of a Wastewater Source Control Program required as defined in Section 6-3.
- A description of the type and level of operator certification for each water treatment plant that provides treatment, a continuing education program that includes the elements of the training provided, provisions for training of new personnel, and a description of the staffing level at each water treatment plant.
- A description of the plans to optimize the treatment processes to maximize reduction of microbial contaminants, regulated chemicals, disinfection byproduct precursors and byproducts, and other chemicals identified by the Wastewater Source Control Program.
- A description of provisions to conduct re-validation or additional onsite re-evaluation whenever validations for treatment process are no longer applicable.

- A description of the SCADA system and how the SCADA system uses the data it gathers to determine regulatory compliance. Describe how the SCADA system (a) acquires and uses monitoring data to inform operators, generate reports, and take autonomous action, and (b) identifies and responds to failure of a control point to meet a critical limit and halt the flow of water if necessary; communicates and interoperates with the SCADA systems of all water treatment plants included in the DPR project that provide treatment, (c) identifies the LRV performance status of each process for which an LRV has been credited and uses that status to determine compliance with the required pathogen log reductions as required as defined in Section 6-4.1, and (d) addresses the control system requirements.
- A protocol to test the SCADA system to ensure the ability of the system to perform necessary functions, including a schedule for testing of the SCADA system.
- A description of how the SCADA system meets and will be maintained to the standards of UFC 4-010-06, as well as any service-specific cybersecurity requirements.
- A description of the process for investigating failures, taking corrective action, and remedying the cause of a failure.
- A description of the protocols for diversions or shut-off and for returning to normal operation after a diversion or shutoff.
- A description of the treatment process equipment inspection and maintenance program, including control point monitoring equipment inspection, maintenance, and calibration.
- A description of the records maintained to document the operations of the DPR project. Retain records for a period of time as required by applicable authorities.

6-7.1 Cross Connection Control Plan.

Prepare a Cross Connection Control Plan that includes a plan to conduct a cross connection control survey and hazard assessment of the water treatment plants and other facilities included in the DPR project that treat, store, convey, or distribute DPR project water. Incorporate these plans in the Operations Plan. In these plans, include the following components:

- Describe how the DPR project water will be protected from contamination or pollution from onsite hazards.
- Ensure the initial survey and hazard assessment will be completed within one year of the start of full-scale operation and subsequent surveys and hazard assessments will be completed at least annually thereafter.
- Ensure all requirements in UFC 3-230-01 to address cross connection control and backflow prevention are met.
- Describe how chemical and microbial stability will be maintained in the drinking water distribution system receiving DPR project water.
- If applicable, describe how treatment effectiveness will be maintained of for any drinking water treatment facilities receiving DPR project water as the source water quality changes.

APPENDIX A BEST PRACTICES

APPENDIX A is intended to supplement the primary language in the main body of the UFS and does not represent a substitution for the criteria described outside of this section. The term “Best Practices” is used in the context of this appendix to describe a summary of the current state of water reuse industry standards and practical experiential knowledge.

A-1 GENERAL PLANNING GUIDANCE.

When initiating planning for a water reuse facility and prior to starting design of a project, review the following documents:

- Manual of Practice - *How to Develop a Water Reuse Program*;
- AWWA M-24;
- AWWA M-50; and
- AWWA M-52.

A-2 NON-POTABLE REUSE - GENERAL DESIGN CRITERIA.

A-2.1 Ultraviolet Systems.

The following reports provide design guidance for UV systems for disinfection in water reuse systems:

- *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse*.
- *Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems*

A-2.2 Recycled Water Storage and Impoundments.

Water quality of recycled water can change during storage or impoundment. Therefore, consider sampling recycled water at impoundment effluents prior to points of water application. Example reasons to sample at the impoundment effluent include:

- Monitoring for excessive bio-growth that impacts downstream uses (for example, algal slime that clogs recycled water sprinklers).
- Monitoring and controlling for maintenance of a disinfectant residual to control for bio-growth.

A-2.3 Bacterial Control.

Control bacterial growth in the NPR distribution system (for example, use in cooling systems) through the following measures in combination with disinfection:

- Frequent flushing.
- Elimination of dead ends.
- Temperature control.

A-2.4 Plumbing for Non-potable Water Systems.

A-2.4.1 Swivel-Ells.

Refer to the California State Water Resources Control Board Cross Connection Control Policy Handbook for criteria and further details on the use of swivel-ells for supplementing water reuse systems with potable water.

A-2.5 Agronomic Rates of Irrigation.

The method to determine the agronomic rate of nitrogen is provided in WQP-21

A-2.6 Recommended Limits for Constituents in Reclaimed Water for Irrigation.

EPA 600-R-12-618 provide suggested limits for various constituents for different types of recycled water use. These limits will vary depending on site-specific factors and conditions:

- **All Use Cases:** for suggested limits on pH, chlorine residual, and fecal coliforms, refer to Table 4-4 of EPA 600-R-12-618.
- **Boiler Water:** for suggested limits on various constituents for boiler water, refer to Table 3-8 of EPA 600-R-12-618.
- **Irrigation:** for suggested limits on salt, conductivity, total dissolved solids (TDS), sodium, chloride, boron, nitrate, and bicarbonate, refer to Table 3-4 of EPA 600-R-12-618.
- **Irrigation:** for suggested limits on metals, refer to Table 3-5 of EPA 600-R-12-618.

A-3 IPR AND DPR – SUPPLEMENTARY DESIGN CRITERIA.

A-3.1 California Notification Levels.

Contaminants in drinking water are regulated through the SDWA, which establishes MCLs for chemical contaminants found in traditional drinking water sources (for example, surface water). In addition to MCLs, the California Division of Drinking Water designates notification levels (NLs) for unregulated contaminants in drinking water. Since DPR projects do not use a traditional drinking water source, MCLs do not fully address the range of possible contaminants in DPR project water. California requires that DPR projects monitor and limit contaminants with NLs to minimize the risk of unregulated chemicals to consumer health. NLs are created in response to, or in anticipation of, contamination, so the list is revised and updated accordingly.

A current list of NLs can be found on the California State Water Resources Control Board website (www.waterboards.ca.gov). Recycled water may be sampled quarterly prior to discharge.

A-3.2 Priority Pollutants.

The Priority Pollutants List contains toxic pollutants that are regulated by the EPA as part of the Clean Water Act (CWA), which regulates pollutant discharge and surface water quality standards. Under the CWA, states are required to adopt criteria for toxic pollutants, and the Priority Pollutants List names toxic pollutants to consult in developing water quality criteria. The U.S. EPA has published analytical test methods for Priority Pollutants.

The Priority Pollutants List is published in Code of Federal Regulations Title 40 APPENDIX A to Part 143. Sample quarterly in the recycled water prior to discharge to the receiving water body.

A-3.3 Additional Constituents for DPR Monitoring.

For DPR projects, it is recommended that the following constituents be included for monitoring in wastewater characterization studies and at major monitoring locations:

- The following solvents: acetone, N,N-dimethylacetamide, methanol, and methyl ethyl ketone.
- Treatment byproduct precursors (for example: natural organic matter) and treatment byproducts (for example: trihalomethanes and halo acetic acids).

- Chemicals associated with business and household sources of hazardous substances, pharmaceuticals, and personal care products, and based on published or otherwise available results of analyses of wastewater and environmental waters sampled locally from nearby watersheds or within nearby urban areas with similar demographics.

A-3.4 Source Control.

Refer to the following documents for further information on wastewater source control for both IPR and DPR systems:

- WRF #4960:
- WRF #5048:
- WEF MOP FD-6:

A-3.5 Joint Plan.

As part of an IPR or DPR project, consider evaluating and updating the wastewater treatment plant operations to include the establishment of upset conditions, associated monitoring, alert and alarm conditions, and the corresponding response conditions. Some wastewater treatment facilities may not already have a comprehensive alarm and response system that is sufficiently responsive or protective for IPR and DPR projects.

A-3.6 DPR – Additional General Resources.

Refer to the following documents for further information on DPR:

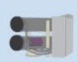
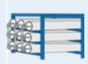
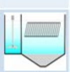
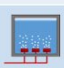
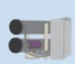
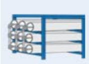
- Water Reuse and AWWA, Framework for Direct Potable Reuse.
- Example response plan criteria are provided in Arizona's Advanced Water Purification Draft Rule, Arizona Administrative Code Title 18 Section R18-9-F836.

A-4 IPR AND DPR - TREATMENT TRAIN CONCEPTS.

Select a treatment train to meet the requirements of this UFS and all established specific rules, regulations, or guidance for water reuse project implementation by the relevant governing authority applicable to the project. Example treatment trains for both indirect potable reuse and direct potable reuse are shown in Figure A-1 and described further in this section for consideration, with definitions for all acronyms provided in APPENDIX B-1. Example treatment trains shown are only relevant to the specific IPR or DPR application as stated. Validation of LRVs for treatment processes must follow standard methods, requirements and/or recommendations set by the U.S. EPA and/or relevant governing state/local authorities. In addition, each DoD service has the discretion to add requirements for additional LRV validation requirements supplementary to those listed in this UFS, given compliance with the relevant governing authority. LRVs (Virus/Giardia/Crypto) shown in Figure A-1 are represent a sum of typical LRVs from each unit process. These values are not requirements but rather representations of commonly seen LRVs in similar applications. The actual LRV for each process will depend on development of process design criteria, operations planning, and treatment monitoring:

- Ozone: 6/6/1 (Virus/Giardia/Crypto).
- Biologically Activated Carbon (BAC): 2/2/3 (Virus/Giardia/Crypto).
- Membrane Filtration (MF): 0/4/4 (Virus/Giardia/Crypto).
- Reverse Osmosis (RO) (Virus/Giardia/Crypto): 2/2/2.
- Ultraviolet Light Advanced Oxidation (UVAOP) (Virus/Giardia/Crypto): 6/6/6.
- Free Chlorine: 5/0/0 (Virus/Giardia/Crypto).

Figure A-1 Best Practices IPR and DPR Treatment Trains for Water Reuse Applications

Concept and Purpose	Coag, Floc, Sed	Ozone	BAC	MF/UF	RO	GAC	AOP	Free Chlorine	Virus LRV	Giardia LRV	Crypto LRV	Reuse Application
RO-AOP Train									13	12	12	IPR Only
RO-AOP-GAC Train									13	12	12	IPR or DPR
Non-RO Concept Train									19	18	14	IPR or DPR
CA DPR "Default" Train									19	18	13	IPR or DPR

Additional example potable reuse treatment train concepts for IPR and DPR are shown in Figure 8-1 of the 2016 California Expert Panel Report on the *Evaluation of the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse* (Olivieri et al. 2016). Recommended treatment trains are provided in this sub-section and are described further in the following section.

A-4.1 California DPR “Default” Train.

This treatment train represents a common approach to DPR in context of the California Division of Drinking Water (DDW) regulation requirements. At a minimum, this treatment train includes the following processes:

- Ozonation immediately followed by a Biological Activated Carbon (BAC) filter (referred to as ozone/BAC).
- Membrane Filtration (MF). This is not required by the regulations, but is included to protect the RO.
- Reverse Osmosis (RO).
- Advanced oxidation process (AOP) treating the RO permeate.
- Disinfection (Chlorination).

A-4.1.1 Ozone/BAC.

Ensure the ozone/BAC treatment train provides no less than 1.0-log reduction of each of the following indicators: formaldehyde, acetone, carbamazepine, and sulfamethoxazole. Design the ozone/BAC process to meet the following criteria:

- Design the ozonation process to provide a ratio of the applied ozone dose to the design feed water total organic carbon (TOC) concentration greater than 1.0. Include ozone demand effects from influent nitrite (NO2). A different design ratio may be used if it can be demonstrated that the ratio will achieve the reduction of the indicator’s carbamazepine and sulfamethoxazole at a pilot scale as part of the design of the ozonation process.
- Design the BAC with an empty bed contact time of at least 15 minutes. A different empty-bed contact time may be used if it can be demonstrated to achieve the reduction of the indicator’s formaldehyde and acetone at a pilot scale as part of the design of the BAC process.
- The ozonation and BAC processes must be individually validated to ensure that the processes designed can reliably achieve the reductions of indicators at full-scale operation as described in Section A-4.1.1.1 Validation.

A-4.1.1.1 Validation.

Develop a validation study protocol for the ozone/BAC process that includes challenge tests using formaldehyde, acetone, carbamazepine, and sulfamethoxazole to demonstrate that the proposed ozone/BAC process will reliably achieve the minimum 1.0-log reduction of each indicator under the proposed normal full-scale operating conditions of the ozone/BAC process. Include proposed surrogate and/or operational parameters to be used in the validation study in the protocol. Re-validate the ozone/BAC process when the full-scale operating conditions or control strategy are inconsistent with the previous validation study conditions.

Individually validate the ozonation process and the BAC through the validation study to ensure that an ozone/BAC process can reliably achieve the reductions of indicators at full scale operation as follows. Submit a validation study report, including all results generated by the validation study, to the Government as part of the engineering report prepared pursuant to Section 6-1. In the Validation Study Report, identify the chemical control point(s) and the surrogate and/or operational parameter(s) and establish the critical limit(s) for the surrogate(s) and/or operational parameter(s) that indicate whether the following items are present:

- For the ozonation process, the minimum 1.0-log carbamazepine and sulfamethoxazole reduction design criteria are being met during full-scale operation. Monitor continuously, record, and have associated alarms that indicate when the ozonation process is not operating as designed for at least one surrogate or operational parameter.
- For the BAC, the minimum 1.0-log formaldehyde and acetone reduction design criteria are being met during full-scale operation. Monitor continuously, record, and have associated alarms that indicate when the BAC process is not operating as designed for at least one surrogate or operational parameter.

A-4.1.1.2 Monitoring.

Provide the following monitoring for the ozone/BAC system:

- Continuous monitoring of operational parameters and of at least one surrogate to monitor the treatment process performance for each of the ozone and BAC systems. Examples include ultraviolet transmittance (UVT) for ozone and total organic carbon (TOC) for BAC.

- Continuously monitor the ozonation process feedwater for TOC and nitrite (NO2).

A-4.1.2 MF.

Refer to A-4.2.2.

A-4.1.3 RO.

Select RO membranes that have achieved a minimum rejection of sodium chloride of no less than 99.0 percent and an average (nominal) rejection of sodium chloride of no less than 99.2 percent, as demonstrated through Method A of ASTM International's method D4194-03 (2008) using the following substitute test conditions: (1) tests are operated at a recovery of no less than 15 percent; (2) sodium chloride rejection is based on three or more successive measurements, after flushing and following at least 30 minutes of operation having demonstrated that rejection has stabilized; (3) an influent pH no less than 6.5 and no greater than 8.0; and (D) an influent sodium chloride concentration of no greater than 2,000 mg/L, to be verified prior to the start of testing.

Include in the engineering report a written plan for on-going performance monitoring (for example, conductivity or TOC) that indicates when the integrity of the process has been compromised, including at least one form of continuous monitoring, as well as the associated surrogate and/or operational parameter limits and alarm settings that indicate when the integrity has been compromised. This report shall also describe and identify the chemical control point and surrogate and/or operational parameters for integrity monitoring.

A-4.1.3.1 Validation.

The reverse osmosis system must be validated in the first 20 weeks of full-scale operation to produce a permeate with no more than 5% of the sample results having a TOC concentration greater than 0.25 mg/L. This must be confirmed through monitoring with a frequency of no less than once per week.

A-4.1.3.2 Monitoring.

Provide the following monitoring for the reverse osmosis system:

- Conduct ongoing performance monitoring using at least one surrogate and/or operational parameter that is capable of being monitored continuously. Monitoring must include associated alarms and indicators of when the integrity of the reverse osmosis membrane has been compromised through exceedance of the chemical control point by the surrogate.

- During full-scale operation of the reverse osmosis system, operational logs of the surrogate measurements and control points shall be recorded continuously.
- Performance of the reverse osmosis system through measurement of the influent and effluent TOC measurements must be tracked.
- If the combined permeate TOC exceeds 0.15 mg/L continuously for greater than 120 hrs., the integrity of the membranes must be investigated with a conductivity profile to identify the underperforming vessel and corrective action taken.

A-4.1.4 AOP.

Include an AOP that can achieve at least 0.5-log (69 percent) reduction of 1,4-dioxane. Examples of AOP include ultraviolet-based AOP (UVAOP) and ozone-based AOP (for example, ozone-hydrogen peroxide). Include surrogate and/or operational parameters that reflect whether the minimum 0.5-log 1,4-dioxane reduction design criteria is being met, including at least one surrogate or operational parameter that is capable of being monitored continuously, recorded, and have associated alarms that indicate when the process is not operating as designed.

Include in the engineering report a written Validation And Monitoring Plan pursuant to Sections A-4.1.4.1 and A-4.1.4.2. This is to also identify and describe the chemical control points and surrogates and/or operational parameters required for validation and monitoring.

A-4.1.4.1 Validation.

The validation protocol shall demonstrate that the proposed AOP will achieve the minimum 0.5-log reduction of 1,4-dioxane under the proposed AOP's normal full-scale operating conditions. Example of a testing protocol may include challenge or spiking tests. The AOP shall be re-validated when the full-scale operating conditions or control strategy are inconsistent with the previous validation study conditions for an additional check.

A-4.1.4.2 Monitoring.

The AOP system shall be continuously monitoring at the defined control points to measure and record surrogate and/or operational parameters for compliance or exceedance.

A-4.2 RO-AOP Treatment Train.

This treatment train provides a robust minimum level of treatment for IPR direct injection and IPR surface water augmentation projects. At a minimum, this treatment train includes the following treatment processes:

- Wastewater oxidation (for example, Biological Oxidation).
- Membrane filtration (MF).
- Reverse osmosis (RO).
- Advanced oxidation process (AOP) treating the RO permeate.

A-4.2.1 Wastewater Oxidation.

“Wastewater oxidation” refers to the wastewater treatment process that involves the stabilization of organic matter in wastewater through a biochemical reaction where microorganisms use oxygen to break down organic matter. Refer to 40 CFR Part 133 for minimum numerical limits for secondary treated wastewater.

A-4.2.2 MF.

“Membrane filtration” (MF) in potable reuse design refers to low-pressure membrane filtration of either microfiltration or ultrafiltration. MF is a pressure or vacuum driven separation process in which particulate matter is rejected by an engineered barrier, primarily through a size-exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test. A microfiltration membrane filtration process typically employs hollow-fiber membranes with a pore size range of 0.1 - 0.2µm. A ultrafiltration membrane filtration process typically employs hollow-fiber membranes with a pore size of 0.01 – 0.05 µm. Membrane filtration system must be designed and/or selected with demonstration of performance and removal efficiency during challenge testing and direct integrity testing. For MF design, reference the Membrane Filtration Guidance Manual.

A-4.2.2.1 Validation and Monitoring.

The membrane used by the system must have undergone challenge testing to evaluate removal efficiency, and the system must report the results of direct integrity and challenge testing to the Government. Challenge testing may be completed offsite and the results can be applied to the membrane system used at different project sites. The level of treatment credit a system receives is equal to the lower of the values determined by the following elements:

- The removal efficiency demonstrated during challenge testing conducted under the conditions in this section.
- The maximum removal efficiency that can be verified through direct integrity testing used with the membrane filtration process under the conditions in this section.
- Challenge testing must be conducted on either a full-scale membrane module, identical in material and construction to the membrane modules used in the system's treatment facility, or a smaller-scale membrane module, identical in material and similar in construction to the full-scale module. A module is defined as the smallest component of a membrane unit in which a specific membrane surface area is housed in a device with a filtrate outlet structure.
- Challenge testing must be conducted using Cryptosporidium oocysts or a surrogate that is removed no more efficiently than Cryptosporidium oocysts. The organism or surrogate used during challenge testing is referred to as the challenge particulate. The concentration of the challenge particulate, in both the feed and filtrate water, must be determined using a method capable of discretely quantifying the specific challenge particulate used in the test; gross measurements such as turbidity may not be used.
- The maximum feed water concentration that can be used during a challenge test is based on the detection limit of the challenge particulate in the filtrate and must be determined according to the following equation: Maximum Feed Concentration = 3.16 × 106 × (Filtrate Detection Limit).
- Challenge testing must be conducted under representative hydraulic conditions at the maximum design flux and maximum design process recovery specified by the manufacturer for the membrane module. Flux is defined as the throughput of a pressure driven membrane process expressed as flow per unit of membrane area. Recovery is defined as the volumetric percent of feed water that is converted to filtrate over the

course of an operating cycle uninterrupted by events such as chemical cleaning or a solids removal process (for example, backwashing):

- Removal efficiency of a membrane module must be calculated from the challenge test results and expressed as a log removal value according to the following equation: LRV = LOG10 (Cf) − LOG10 (Cp), where LRV = log removal value demonstrated during the challenge test; Cf = the feed concentration measured during the challenge test; and Cp = the filtrate concentration measured during the challenge test. Equivalent units must be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, the term Cp is set equal to the detection limit for the purpose of calculating the LRV. An LRV must be calculated for each membrane module evaluated during the challenge test.
- The removal efficiency of a membrane filtration process demonstrated during challenge testing must be expressed as a log removal value (LRVC-Test). If fewer than 20 modules are tested, then LRVC-Test is equal to the lowest of the representative LRVs among the modules tested. If 20 or more modules are tested, then LRVC-Test is equal to the 10th percentile of the representative LRVs among the modules tested. The percentile is defined by (i/(n+1)) where i is the rank of n individual data points ordered lowest to highest. If necessary, the 10th percentile may be calculated using linear interpolation.
- The challenge test must establish a quality control release value (QCRV) for a non-destructive performance test that demonstrates the Cryptosporidium removal capability of the membrane filtration module. This performance test must be applied to each production membrane module used by the system that was not directly challenge tested in order to verify Cryptosporidium removal capability. Production modules that do not meet the established QCRV are not eligible for the treatment credit demonstrated during the challenge test.

Direct integrity testing. A direct integrity test is defined as a physical test applied to a membrane unit in order to identify and isolate integrity breaches (for example, one or more leaks that could result in contamination of the filtrate). Systems must conduct direct integrity testing in a manner that demonstrates a removal efficiency equal to or greater than the removal credit awarded to the membrane filtration process and meets the requirements described in the following list:

- The direct integrity test must be independently applied to each membrane unit in service. A membrane unit is defined as a group of membrane modules that share common valving that allows the unit to be isolated from the rest of the system for the purpose of integrity testing or other maintenance.
- The direct integrity method must have a resolution of 3 micrometers or less, where resolution is defined as the size of the smallest integrity breach that contributes to a response from the direct integrity test.
- The direct integrity test must have a sensitivity sufficient to verify the log treatment credit awarded to the membrane filtration process by the State, where sensitivity is defined as the maximum log removal value that can be reliably verified by a direct integrity test.
- For direct integrity tests that use an applied pressure or vacuum, the direct integrity test sensitivity must be calculated according to the following equation: $LRV_{DIT} = LOG10 (Q_p /(VCF \times Q_{breach}))$, where: LRV_{DIT} = the sensitivity of the direct integrity test; Q_p = total design filtrate flow from the membrane unit; Q_{breach} = flow of water from an integrity breach associated with the smallest integrity test response that can be reliably measured, and VCF = volumetric concentration factor. The volumetric concentration factor is the ratio of the suspended solids concentration on the high pressure side of the membrane relative to that in the feed water.
- For direct integrity tests that use a particulate or molecular marker, the direct integrity test sensitivity must be calculated according to the following equation: $LRV_{DIT} = LOG10 (C_f) - LOG10 (C_p)$, where LRV_{DIT} = the sensitivity of the direct integrity test; C_f = the typical feed concentration of the marker used in the test; and C_p = the filtrate concentration of the marker from an integral membrane unit.
- Systems must establish a control limit within the sensitivity limits of the direct integrity test that is indicative of an integral membrane unit capable of meeting the removal credit awarded by the Government.
- If the result of a direct integrity test exceeds the control limit established in this section, the system must remove the membrane unit from service. Systems must conduct a direct integrity test to verify any repairs, and may return the membrane unit to service only if the direct integrity test is within the established control limit.

- Systems must conduct direct integrity testing on each membrane unit at a frequency of not less than once each day that the membrane unit is in operation. The Government may approve less frequent testing, based on demonstrated process reliability, the use of multiple barriers effective for cryptosporidium, or reliable process safeguards.

A-4.2.3 RO.

Refer to Section A-4.1.2.

A-4.2.4 AOP.

Refer to Section A-4.1.4.

A-4.3 Non-RO Treatment Train.

At a minimum, this treatment train includes the following treatment processes:

- Coagulation, Flocculation, Sedimentation.
- Ozone/BAC.
- MF.
- Granular activated carbon (GAC).
- Advanced Oxidation Processes.
- Disinfection.

A-4.3.1 Coagulation, Flocculation, Sedimentation.

A-4.3.1.1 Coagulation.

“Coagulation” means a process using coagulant chemicals and rapid mixing, by which colloidal and suspended material are destabilized and agglomerated into settleable and/or filterable flocs. Coagulation is to use a coagulant dose and pH that results in an effluent TOC concentration of ≤ 0.3 mg/L. The detention period should be instantaneous, but not longer than thirty seconds with mixing equipment capable of imparting a minimum velocity gradient (G) of at least 750 fps/ft. Basins should be equipped with devices capable of providing adequate mixing for all treatment flow rates. Static mixing may be considered where the flow is relatively constant and will be high enough to maintain the necessary turbulence for complete chemical reactions.

All coagulation unit processes shall be provided with the following mandatory features for uninterrupted coagulant feed:

- Standby feeders.
- Adequate chemical stowage and conveyance facilities.
- Adequate reserve chemical supply.
- Automatic dosage control.

A-4.3.1.2 Flocculation.

“Flocculation” means a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable or filterable particles through gentle stirring by hydraulic or mechanical means. Inlet and outlet design shall minimize short-circuiting and destruction of floc. Series compartments are recommended to further minimize short-circuiting and to provide decreasing mixing energy with time. Basins shall be designed so that individual basins may be isolated without disrupting plant operation. The detention time for floc formation should be at least 30 minutes with consideration to using tapered (for example, diminishing velocity gradient) flocculation. The flow-through velocity should be not less than 0.5 nor greater than 1.5 feet per minute. Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second.

A-4.3.1.3 Sedimentation.

“Sedimentation” means a process for removal of settleable solids before filtration by gravity or separation. The velocity through a sedimentation basin should not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification. A minimum of four hours for of settling time shall be provided for conventional sedimentation or two hours for high-rate sedimentation (for example, plate settlers). All secondary sedimentation unit processes shall be provided with one of the following features:

- Multiple sedimentation units capable of treating the entire flow with one unit not in operation.
- Standby sedimentation unit process.
- Long-term storage or disposal provisions

A-4.3.1.4 Validation.

Whenever a coagulation and flocculation process is used, the process selection shall be based on pilot plant or laboratory scale (jar test) or equivalent results that demonstrate effectiveness of the coagulant chemicals over the full range of water quality conditions expected. The effectiveness of these processes shall be demonstrated by either at least an 80 percent reduction through the filters of the monthly average raw water turbidity or jar testing, pilot testing or other means to demonstrate that optimum coagulation is being achieved

A-4.3.1.5 Monitoring.

All coagulation unit processes shall be provided with one of the following reliability features:

- Effluent TOC must be continuously monitored and recorded.
- Alarm and multiple coagulation units capable of treating the entire flow with one unit not in operation.
- Alarm, short-term retention or disposal provisions, and standby replacement equipment.
- Alarm and long-term storage or disposal provisions.
- Automatically actuated long-term storage or disposal provisions.
- Alarm and standby coagulation process.

A-4.3.2 Ozone/BAC.

Refer to Section A-4.1.1.

A-4.3.3 GAC.

GAC filter beds with an empty-bed contact time of 10-20 minutes based on average daily flow and a carbon reactivation frequency of once every 180 days. Filters must achieve an average daily effluent turbidity goal of 0.2 NTU. Filtration loading rates are recommended to be between 4 – 10 gpm/SF. The design criteria includes the following items:

- At least two units shall be provided.
- Protect against contamination by backflow.

- Provide for filter-to-waste for each filter unit or addition of coagulant chemicals to the water used for backwashing.
- Provide solids removal treatment for filter backwash water if it is recycled into the treatment process. Recycled backwash water shall be returned to the headworks of the treatment plant.
- Multiple filter units which provide redundant capacity when filters are out of service for backwash or maintenance.

A-4.3.3.1 Monitoring.

Performance compliance for GAC shall be conducted through a written monitoring plan, which must include the following items:

- Turbidity monitoring of each filter continuously and recorded at least once every 15 minutes.
- Turbidity monitoring of the combined filter effluent continuously and at least once every 15 minutes.

All filtration unit processes shall be provided with one of the following reliability features:

- Turbidimeters used for continuous turbidity monitoring must be calibrated.
- Alarm and multiple filter units capable of treating the entire flow with one unit not in operation.
- Alarm, short-term retention or disposal provisions and standby replacement equipment.
- Alarm and long-term storage or disposal provisions.
- Automatically actuated long-term storage or disposal provisions.
- Alarm and standby filtration unit process.

A-4.3.4 AOP.

Refer to Section A-4.1.4.

A-4.4 RO-AOP-GAC Treatment Train.

This concept train for DPR was investigated by the Metropolitan Water District (MWD) of Southern California in the 2020 *Considerations for Direct Potable Reuse Downstream of the Groundwater Recharge Advanced Water Treatment Facility* (https://d1q0afiq12ywwq.cloudfront.net/media/19008/final-dpr-awtf-tech-memo.pdf). The concept involves the use of GAC to remove low molecular weight organics that pass-through RO and AOP. At a minimum, this treatment train includes the following treatment processes:

- MF.
- RO.
- Advanced oxidation process (AOP) treating the RO permeate.
- GAC.
- Disinfection (Chlorination).

A-4.4.1 MF.

Refer to Section A-4.2.2.

A-4.4.2 RO.

Refer to Section A-4.1.2.

A-4.4.3 AOP.

Refer to Section A-4.1.4.

A-4.4.4 GAC.

Refer to Section A-4.3.3.

A-5 OPERATIONS AND MAINTENANCE.

A-5.1 Reporting Metrics.

The following metrics are important to record and report for all types of water reuse projects:

- Volume of recycled water supplied monthly/annually to each of the areas.
- Onsite and external laboratory analytical results.
- Process performance monitoring data.
- Process failures, off-spec water, and corrective actions.

A-5.2 Emergency Response Plan.

Prepare a cross-connection emergency response plan to plan for responses to the discovery of new cross connections between the potable water distribution system and any other non-potable water infrastructure where a risk of contamination of the potable water exists. Refer to the California State Water Resources Control Board Cross Connection Control Policy Handbook for backflow incident response and reporting guidance.

A-5.3 Non-Potable Reuse Facility Operating Protocol.

Example criteria to develop an operating protocol for a non-potable reuse facility are provided in the Florida Administrative Code Section 62-610.320 “Operation and Maintenance Requirements and Operating Protocols.”

A-6 OPERATOR CERTIFICATION FOR DPR.

Provide appropriately trained and certified operations staff for any facilities that provide chemical or pathogen treatment as part of the DPR project. Designate at least one chief operator for each treatment facility and for the entire treatment train. Ensure that all chief operators and staff operators are properly certified in advanced water treatment.

For the first 12 months of operation of a DPR project, for each treatment facility in a DPR project, it is recommended that a designated chief operator or shift operator is onsite at all times at each treatment facility when the DPR project is providing DPR project water to the drinking water distribution system. After 12 months of operation, evaluate the capacity of the project to demonstrate an equivalent degree of operational oversight and treatment reliability with either unmanned operation or operation under reduced operator oversight. Ensure that under conditions when the chief operator or shift operator is not required to be onsite at all times, that the operator can monitor operations and exert physical control over the water treatment plant within the period specified in the Operations Plan, or one hour, whichever is shorter.

A-6.1 DPR OPERATOR CERTIFICATION PATHWAYS AND APPROACHES.

Water Professionals International (WPI) provides an existing pathway for drinking water treatment plant (DWTP) and WWTP operator certification. WPI is recognized in the water sector and has an existing relationship with DoD. A list of the certification levels and topics can be found on the WPI Need-to-Know Criteria (https://www.gowpi.org/services/abc-testing/need-to-know-criteria/). WPI does not provide any trainings or certifications specific to advanced water treatment (AWT). Additionally, there are notable challenges with WPI's certification pathway, such as struggles to hire and retain certified operators overseas and limited available language translations for training and certification materials.

For DPR facilities, operators will need additional and specialized training to operate AWT processes that are often required in DPR systems. Presently, the four states with draft or adopted DPR regulations have reviewed their operator certification requirements in the context of the needs for DPR. California provides an industry operator certification pathway with CA-NV AWWA, whereas Arizona, Colorado, and Florida provide a state certified operator certification pathway. Table A-1 provides information on Arizona, California, Colorado, and Florida certification pathways. Refer to the additional references for each state provided in the following list:

- Arizona = Operator Certification Program and Operator Certification Examination.
- California = Advanced Water Treatment Operator Certification.
- Colorado = CCWP - Which certificate is right for you?.
- Florida = Water and Domestic Wastewater Operator Certification Program.

Table A-1 DPR Certification Pathways for Arizona, California, Colorado, and Florida

	Arizona	**California**	**Colorado**	**Florida**
Does conventional certification pathways cover AWT Processes?	No	No	Yes	Yes
Is there an existing AWT-specific certification pathway?	Yes	Yes	No	No
Body offering Operator Examinations and Certification	AZ Dept of Environmental Quality	CA-NV AWWA	CO Water and Wastewater Facility Operators Certification Board	FL Department of Environmental Protection

A-7 PATHOGENS.

A-7.1 Pathogen LRV for Conventional Wastewater Treatment Facilities.

Refer to Water Research Foundation (WRF) Project #5047 titled *Pathogen Removal Credits for Wastewater Reuse: Guidance for Study Plans and Reporting*.

A-7.2 Pathogen LRV for Underground Retention Time for GRRPs.

For each month of demonstrated underground retention time for any type of GRRP, the recycled municipal wastewater can be credited with 1-log virus reduction.

A surface application GRRP that demonstrates at least six months retention underground can be credited with 10-log giardia reduction and 10-log crypto reduction.

A-7.3 Pathogen Validation Study Protocol.

In a pathogen validation study protocol, describe the following:

- Identify the treatment mechanism(s) of pathogen reduction by the treatment process.
- Identify the pathogen(s) being addressed by the treatment, or appropriate surrogate(s) for the pathogen(s), that are used in the validation study. The pathogen(s) and surrogate(s) selected for the validation study shall be one(s) most resistant to the treatment mechanism(s).
- Ensure that the pathogen(s) or surrogate(s) for the pathogen(s) are present in the test water in concentrations sufficient to demonstrate a pathogen log reduction.
- Identify the factors that influence the pathogen reduction efficiency for the treatment mechanism(s). Influencing factors include feed water characteristics such as temperature and pH, hydraulic loading, deterioration of components, and integrity failure.
- Identify the surrogate and/or operational parameters that can be measured continuously and that will correlate with the reduction of the pathogen(s) or surrogate(s) for the pathogen(s).
- Identify the validation methodology to demonstrate the pathogen log removal capability of the treatment process. The validation methodology shall involve a challenge test to quantify the reduction of the target

pathogen or appropriate surrogate while concurrently monitoring the operational parameters to determine an operating envelope.

- Describe the method to collect and analyze data to formulate evidence-based conclusions.
- Describe the method to determine the critical limit(s) and the operational monitoring and control strategy.
- Describe the method to be used to calculate the LRV for the treatment process for each pathogen. The validated LRV shall not exceed that achieved by 95 percent of the challenge test results when the treatment process is operating in compliance with the critical limit(s).
- Identify the circumstances that would require a re-validation or additional onsite validation (for example, when conditions are inconsistent with the previous validation study conditions).

APPENDIX B GLOSSARY

B-1 ACRONYMS.

ADEQ	Arizona Department of Environmental Quality
AFCEC	Air Force Civil Engineer Center
AL	Action Level
AOP	Advanced Oxidation Process
AWWA	American Water Works Association
AWT	Advanced Water Treatment
BAC	Biologically activated carbon filtration, also known as BAF
BIA	Bilateral Infrastructure Agreement
CWA	Clean Water Act
DoD	Department of Defense
DoR	Designer of Record
DPR	Direct Potable Reuse
DWTP	Drinking Water Treatment Plant
EPA	Environmental Protection Agency
FGS	Final Governing Standards
GAC	Granular Activated Carbon
GRRP	Groundwater Replenishment Reuse Project
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreements
IPR	Indirect Potable Reuse

LRV	Log Reduction Value
MCL	Maximum Contaminant Level
MF	Membrane Filtration (or Microfiltration)
mg/L	Milligrams per Liter
MoP	Manual of Practice
MPN	Most Probable Number
NAVFAC	Naval Facilities Engineering Systems Command
ng/L	Nanograms per Liter
NL	Notification Level
NPDES	National Pollutant Discharge Elimination System
NPR	Non-Potable Reuse
NTU	Nephelometric Turbidity Units
O3	Ozone
OEBGD	Overseas Environmental Baseline Guidance Document
O&M	Operations and Maintenance
PFAS	Per- and Polyfluoroalkyl Substances
RO	Reverse Osmosis
SAT	Soil Aquifer Treatment
SCADA	Supervisory Control and Data Acquisition
SOFA	Status of Forces Agreements
SWA	Surface Water Augmentation
SWRCB	(California) State Water Resources Control Board

TBL	Triple Bottom Line
TCEQ	Texas Commission of Environmental Quality
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UF	Ultrafiltration
UFC	Unified Facilities Criteria
UFS	Unified Facilities Supplement
UFGS	Unified Facilities Guide Specifications
µg/L	Micrograms per Liter
UPS	Uninterruptible Power Supply
U.S.	United States of America
UV	Ultraviolet Light
UVAOP	UV-based Advanced Oxidation Process
WQOC	Water Quality Oversight Council (Navy)
WPI	Water Professionals International
WRF	Water Research Foundation
WWTP	Wastewater Treatment Plant

B-2 DEFINITION OF TERMS.

24-hour composite sample: an aggregate sample derived from no fewer than eight discrete samples collected at equal time intervals or collected proportional to the flow rate over the compositing period. The aggregate sample reflects the average source water quality covering the composite 24-hour sample period.

Acute exposure threat: the increased imminent risk of adverse health effects, including infectious disease and toxic effects from short-term exposures to contaminants in water.

Added tracer: a non-reactive substance, with measurable characteristics distinctly different from the receiving groundwater, intentionally added to the water applied at a Groundwater Replenishment Reuse Project (GRRP) for the purpose of being a tracer such that the tracer can be readily identified in the groundwater downgradient of the GRRP to determine the underground retention time of the applied water.

Advanced water treatment facility (AWTF): A water treatment facility that through a series of unit treatment processes that produces an advanced treated recycled water suitable for IPR or DPR, depending on the level of advanced treatment and ultimate end use.

Advanced treated water: a general term for recycled water that has undergone treatment sufficient for direct injection GRRP, SWA, or DPR.

Augmented reservoir: "Augmented Reservoir" means a surface water reservoir used as a source of domestic drinking water supply that receives recycled municipal wastewater in a potable reuse project.

Biological activated carbon or BAC: Biological activated carbon filtration (BAC or BAF) is a treatment process that utilizes a microbial film developed on the granular activated carbon medium to metabolize contaminants.

Challenge test: a study comparing a pathogen, surrogate parameter, or indicator compound concentration between the influent and effluent of a treatment process to determine the removal capacity of the treatment process. Ensure the influent concentration is high enough that a measurable concentration is detected in the effluent.

Chemical control point: an activity, procedure, or process that is applied and is essential for preventing, reducing, or eliminating a chemical hazard threat.

Chronic exposure threat: the increased risk of adverse health effects including cancer or other longer-term effects or disease from continued exposures to contaminants in water.

Critical limit: means a maximum and/or minimum value of a continuously monitored parameter that indicates that a treatment process or an operation is effectively controlling the pathogen or chemical risk.

Coagulated wastewater: oxidized wastewater in which colloidal and finely divided suspended matter have been destabilized and agglomerated upstream from a filter by the addition of suitable floc-forming chemicals.

Conventional treatment: a treatment chain that utilizes a sedimentation unit process between the coagulation and filtration processes and produces an effluent that meets the definition for filtered and disinfected recycled water.

De facto reuse: The unplanned process of treated upstream wastewater that has influenced downstream or downgradient sources of drinking water.

Direct potable reuse or DPR: DPR is the introduction of recycled water directly into raw or treated drinking water supplies without the use of an environmental buffer (USEPA 2017).

Disinfected secondary-23 recycled water: Refer to Section 4-2.2 for a definition and further information.

Disinfected secondary-2.2 recycled water: Refer to Section 4-2.3 for a definition and further information.

Drift: the water that escapes to the atmosphere as water droplets from a cooling system.

Drift eliminator: a feature of a cooling system that reduces to a minimum the generation of drift from the system.

Indoor recycled water plumbing system: a system that utilizes separate piping systems for recycled water and potable water within a facility and where the recycled water is used to serve plumbing outlets (excluding fire suppression systems) within a building.

Environmental buffer: surface water body or groundwater aquifer that serves as an intermediate discharge and holding point for recycled water in a potable reuse system (USEPA 2017).

F-Specific bacteriophage MS-2: a strain of a specific type of virus that infects coliform bacteria that is traceable to the American Type Culture Collection (ATCC15597B1) and is grown on lawns of E. coli (ATCC 15597).

Facility: any type of building or structure, or a defined area of specific use that receives water for use or further treatment.

Filtered and disinfected recycled water: Refer to Section 4-2.3 for a definition and further information.

Finished water: the potable water that is introduced into the drinking water distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system (for example, booster disinfection, addition of corrosion control chemicals).

Food crops: any crops intended for human consumption.

Graywater or greywater: Untreated wastewater that has not been contaminated by any toilet discharge or infection, contaminated or unhealthy bodily wastes. Examples of graywater include wastewater from bathtubs, showers, clothes washing machines and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers.

Groundwater: water below the land surface in a saturated zone.

Groundwater replenishment reuse project or GRRP: a project involving the planned use of recycled municipal wastewater that is operated for the purpose of replenishing a groundwater basin for use as a source of municipal and domestic water supply.

Hose bib: a faucet or similar device to which a common garden hose can be readily attached.

Indicator compound or indicator: a chemical in municipal wastewater that represents the physical, chemical, and/or biodegradation characteristics of a specific family of trace organic compounds and that is present in concentrations that may be used to monitor the efficacy of trace organic compound reduction by a treatment process, and/or that provides an indication of treatment process failure.

Indirect potable reuse (IPR): Deliberative augmentation of a drinking water source (surface water or groundwater aquifer) with recycled water, which provides an environmental buffer prior to subsequent use and treatment into drinking water supplies (U.S. EPA 2017).

Intrinsic tracer: a substance or attribute present in the recharge water at levels different from the receiving groundwater such that the substance in the water applied at the GRRP can be distinctly and sufficiently detected in the groundwater downgradient of the GRRP to determine the underground retention time of the water.

Landscape impoundment: an impoundment in which recycled water is stored or used for aesthetic enjoyment or landscape irrigation, or which otherwise serves a similar function and is not intended to include public contact.

Local limits: restrictions on the discharge of pollutants established by an industrial pretreatment and pollutant source control program to protect a wastewater treatment plant's operations and the receiving water provided to an IPR or DPR project.

Log reduction: the logarithm base 10 of the ratio of the levels of a pathogenic organism or other contaminant before and after treatment.

Log reduction value or LRV: the measure of the ability of a treatment train or a treatment process to remove or inactivate microorganisms such as bacteria, protozoa, and viruses. LRV is the log reduction validated or credited for a treatment process or treatment train.

Maximum Contaminant Level or MCL: the maximum permissible concentration of a contaminant established by the United States Environmental Protection Agency.

Microfiltration: a pressure-driven membrane filtration process that typically employs hollow-fiber membranes with a pore size range of approximately 0.1 – 0.2 μm (nominally 0.1 μm).

Modal contact time: the amount of time elapsed between the time that a tracer, such as salt or dye, is injected into the influent at the entrance to a chamber and the time that the highest concentration of the tracer is observed in the effluent from the chamber.

Municipal wastewater: wastewater that includes a mixture of untreated domestic waste, commercial and industrial waste, stormwater, and any other waste streams in the sewer shed. For the purposes of this UFS, municipal wastewater is considered a surface water.

Non-potable reuse (NPR): All water reuse applications that do not involve potable reuse (USEPA 2012).

Non-potable water: Water that is considered unsafe, unpalatable, or both for drinking. Other sources of non-potable water may include brackish or mineralized surface waters and groundwaters, including seawater, certain industrial wastewaters, fracking wastewaters, stormwater runoff, polluted natural waters, and irrigation return flows.

Nonrestricted recreational impoundment: an impoundment of recycled water, in which no limitations are imposed on body-contact water recreational activities.

NTU: "NTU" (Nephelometric turbidity unit) means a measurement of turbidity as determined by the ratio of the intensity of light scattered by the sample to the intensity of incident light.

Operating envelope: the specified range of a set of continuously monitored parameters, including those with critical limits, of a treatment process within which an operation is consistent with validation conditions.

Operational parameter: a measurable property used to characterize or partially characterize the operation of a treatment process.

Oxidized wastewater: wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen.

Ozone/BAC: an ozonation process immediately followed by biologically activated carbon.

Pathogen control point: an activity, procedure, or process that may be applied to remove or reduce the pathogen hazard threat.

Peak dry weather design flow: the arithmetic mean of the maximum peak flow rates sustained over some period of time (for example three hours) during the maximum 24-hour dry weather period. Dry weather period is defined as periods of little or no rainfall.

Potable water: Water that is safe and satisfactory for drinking and cooking. Also referred to as treated drinking water and finished drinking water.

Public water system: “Public Water System” has the same meaning as the U.S. EPA’s definition of a Public Water System in 40 CFR Part 141.2.

Recharge water: recycled municipal wastewater, or the combination of recycled municipal wastewater and any credited diluent water, which is utilized by a GRRP for groundwater replenishment.

Recycled municipal wastewater: recycled water that is the effluent from the treatment of wastewater of municipal origin.

Recycled water: Treated municipal wastewater (among other sources) that is used for a variety of purposes before it passes back into the water cycle. Recycled water may also be referred to as reused water or reclaimed water.

Recycled water agency: the public water system, or a publicly or privately owned or operated recycled water system, that delivers or proposes to deliver recycled water to a facility.

Recycling plant: an arrangement of devices, structures, equipment, processes, and controls which produce recycled water.

Restricted access golf course: a golf course where public access is controlled so that areas irrigated with recycled water cannot be used as if they were part of a park, playground, or school yard and where irrigation is conducted only in areas and during periods when the golf course is not being used by golfers.

Restricted recreational impoundment: an impoundment of recycled water in which recreation is limited to fishing, boating, and other non-body-contact water recreational activities.

Saturated zone: an underground region or regions in which all interstices in, between, and below natural geologic materials are filled with water, with the uppermost surface of the saturated zone being the water table.

SCADA system: a supervisory control and data acquisition system.

Spray irrigation: the application of recycled water from sprinklers to crops or vegetation.

Spreading area: a natural or constructed impoundment with a depth equal to or less than its widest surface dimension used by a GRRP to replenish a groundwater basin with recharge water infiltrating and percolating through a zone that, in the absence of a GRRP, would be an unsaturated zone.

Standby unit process: an alternate unit process or an equivalent alternative process which is maintained in operable condition and which is capable of providing comparable treatment of the actual flow through the unit for which it is a substitute.

Subsurface application: the application of recharge water to a groundwater basin(s) by a means other than surface application.

Surface application: the application of recharge water to a spreading area.

Surface water: all water open to the atmosphere and subject to surface runoff. For purposes of this chapter, water runoff originating from the lined walls and other man-made appurtenant structures of treated water distribution reservoirs, is excluded from the definition of surface water.

Surface water source augmentation project or SWSAP: a project involving the planned placement of recycled municipal wastewater into a surface water reservoir that is used as a source of domestic drinking water supply, for the purpose of supplementing the source of domestic drinking water supply.

Surrogate parameter or surrogate: a measurable chemical or physical property, microorganism, or chemical that has been demonstrated to provide a direct correlation with the concentration of an indicator compound or pathogen; that may be used to monitor the efficacy of trace organic compound or pathogen reduction by a treatment process; and/or that provides an indication of a treatment process failure.

Swivel-ell: a reduced pressure principle backflow prevention assembly combined with a changeover piping configuration (swivel-ell connection).

Total nitrogen: the sum of concentrations of ammonia, nitrite, nitrate, and organic nitrogen-containing compounds, expressed as nitrogen.

Total organic carbon or TOC: the concentration of organic carbon present in water. TOC is a bulk water quality parameter that indicates the potential level and risk of chemical exposure in water.

Treatment mechanism: means a physical, biological, or chemical action that reduces the concentration of a pathogen or chemical contaminant.

Undisinfected secondary recycled water: Refer to Section 4-2.1 for a definition and further information.

Ultrafiltration: a pressure-driven membrane filtration process that typically employs hollow-fiber membranes with a pore size range of approximately 0.01 – 0.05 μm (nominally 0.01 μm).

Unsaturated zone: the volume between the land surface and the uppermost saturated zone.

Use area: an area of recycled water use with defined boundaries. A use area may contain one or more facilities.

Validation: a demonstration of the pathogen or chemical contaminant reduction capacity of a treatment process.

Verification: monitoring to demonstrate the effectiveness of a treatment process for compliance determination.

Water reuse / water recycling: Water reuse is the practice of using treated wastewater for beneficial purposes including, but not limited to, agricultural and landscape irrigation, drinking water supplies, industrial processes, surface or ground water replenishment, and watershed restoration.

Wastewater treatment facilities also known as municipal wastewater treatment facilities. For the purposes of this UFS, these terms apply only to municipal wastewater treatment. This terminology is not interchangeable with industrial wastewater treatment facilities.

Water resource recovery facility (WRRF): A newer term for a wastewater treatment facility, first publicly championed by the Water Environment Federation (WEF), to reflect recent shifts in the wastewater industry to recover water, energy, and chemicals from municipal wastewater.

Water treatment plant: a group or assemblage of structures, equipment, and processes that treats, blends, or conditions the water supply of a public water system.

APPENDIX C REFERENCES

GOVERNMENT

CODE OF FEDERAL REGULATIONS

40 CFR 122, *EPA Administered Permit Programs: The National Pollutant Discharge Elimination System*

40 CFR Part 141, *National Primary Drinking Water Regulations*

40 CFR Part 143, *Other Safe Drinking Water Act Regulations*

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UFC 3-230-01, *Water Storage, Distribution, and Treatment*

UFC 3-230-02, *Operation and Maintenance: Water Supply Systems*

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AWWA M52, *Water Conservation Programs—A Planning Manual* (AWWA 2017b)

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Manual of Practice - *How to Develop a Water Reuse Program (WRA 2009),*

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Project #5047, *Pathogen Removal Credits for Wastewater Reuse: Guidance for Study Plans and Reporting*

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