WateReuse Colorado
Advancing Direct Potable Reuse to Optimize Water Supplies and Meet Future Demands

Technical Memorandum 1

DEVELOPMENT OF DPR REGULATIONS IN COLORADO

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Abbreviations

ATW	advanced treated water
AWT	advanced water treatment
AWTF	advanced water treatment facility
AWWA	American Water Works Association
BAF	biologically active filtration
Carollo	Carollo Engineers, Inc.
CCP	critical control point
CDPH	California Department of Public Health
CDPHE	Colorado Department of Public Health and Environment
CEC	constituents of emerging concern
CRMWD	Colorado River Municipal Water District
CWCB	Colorado Water Conservation Board
CWS	Clean Water Services (Hillsboro, Oregon)
DDW	State of California Division of Drinking Water
DEQ	Department of Environmental Quality
DPR	direct potable reuse
DWTF	drinking water treatment facility
EPA	United States Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
FTE	full time employee
FGF	Forest Grove Facility
GAC	granular activated carbon
IPR	indirect potable reuse
LRV	log removal value
MCL	maximum contaminant levels
MF	microfiltration
mg/L	milligrams per liter
mgd	million gallons per day
NMED	New Mexico Environment Department
NRC	National Research Council
NWRI	National Water Research Institute

OAR	Oregon Administrative Rule
RO	reverse osmosis
SB	senate bill
SWIG	Sustainable Water Infrastructure Group
SWP	State Water Project
SWRCB	State Water Resource Control Board
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TM	technical memorandum
TMF	technical, managerial, and financial capacity
TN	total nitrogen
TOC	total organic carbon
TOX	total organic halides
TWDB	Texas Water Development Board
UF	ultrafiltration
USEPA	United States Environmental Protection Agency
UV AOP	ultraviolet advanced oxidation process
WERF	Water Environment Research Foundation
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division
WRCO	WateReuse Colorado
WRF	Water Reclamation Facility or Water Research Foundation
WRRF	WateReuse Research Foundation
WWTP	wastewater treatment plant

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DEVELOPMENT OF DPR REGULATIONS IN COLORADO

This technical memorandum (TM) provides a detailed path forward for the development of direct potable reuse (DPR) regulations in Colorado. Although Colorado is referencing previous and ongoing DPR regulatory and guideline development from other states, the Colorado Department of Public Health and Environment (CDPHE) is currently taking a holistic approach in developing DPR regulations for Colorado. The key goals for developing DPR regulations in Colorado are to develop a comprehensive, flexible, implementable, and safe regulatory framework (Figure 1).

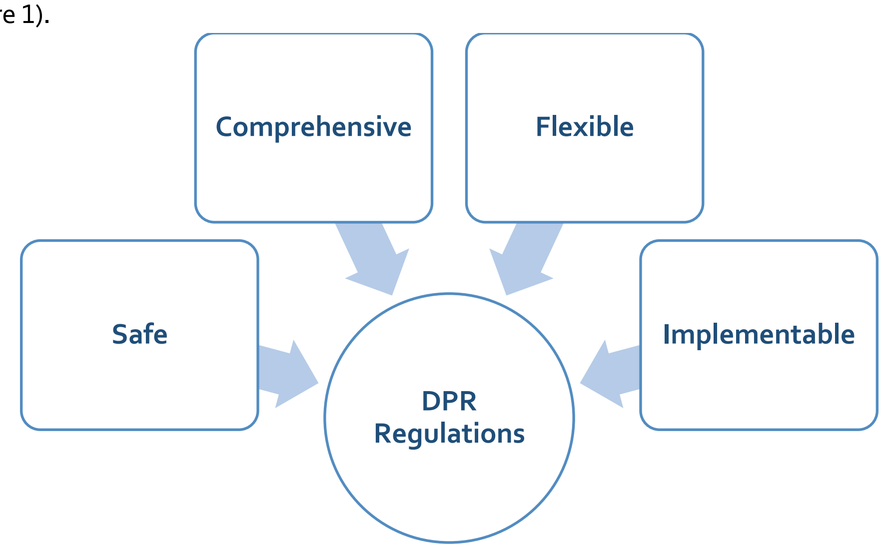

Figure 1 Goals for Regulating DPR in Colorado

This TM outlines the steps taken to develop this framework, and is intended to:

- Provide national context on potable reuse regulations.
- Provide a review of past DPR efforts in Colorado.
- Highlight key regulatory issues in Colorado related to potable reuse.
- Detail the resources needed for implementing DPR regulations in Colorado.

1.0 A National Perspective

Potable reuse regulations and guidance have been developed at the state and national levels, as referenced within this TM. Extensive treatment, water quality, and public health evaluations have led to formal regulations and/or regulatory guidance documents for potable reuse for groundwater augmentation and/or surface water augmentation in several states. A number of states are working on the development of regulations and/or guidance. States that currently have potable reuse regulations or regulatory frameworks include California, Arizona, Nevada, Texas, Oklahoma, Oregon, Washington, Virginia, and Florida. A number of states are progressing with regulations or regulatory guidance for direct potable reuse, including California, Arizona, New Mexico, Texas, and Florida.

To date, the existing and developing regulations and regulatory frameworks for potable reuse center around defining and achieving risk-based water quality criteria for public health protection. These criteria include all standards implemented by existing federal and state drinking water regulations (e.g., maximum contaminant levels or MCLs), and to varying extents, also the benchmarks for treatment methods contained in those existing regulations, but include additional provisions in recognition that wastewater was not intended as a source water under the existing federal regulations (i.e., the Safe Drinking Water Act).

In general, regulatory efforts for potable reuse focus upon eleven key issues, as summarized in Table 1.

Table 1 Key Regulatory Issues for Potable Reuse

Issues	Concept
1. Terminology	Clear definitions are needed for effective regulations. Defining DPR also helps establish when the regulation applies to a given system or scenario, and when it does not.
2. Source Control	Wastewater source control programs protect treatment processes and downstream ecosystems; additional scrutiny is required for potable reuse. The concept of the Enhanced Source Control Program is developing.
3. Wastewater Treatment	In addition to NPDES compliance, consistently high quality effluent becomes the focus for potable reuse. Higher quality nitrified/denitrified effluent is ideal to reduce impact on subsequent advanced treatment systems.
4. Pathogen Disinfection/Removal	Due to the acute risk to public health represented by pathogens, these are the primary focus of potable reuse treatment. This is similar to the focus in conventional water treatment.
5. Chemical Removal	Removal of chemicals remains important, maintaining all regulated chemicals below mandated levels and providing an additional protection for unregulated chemicals that may pose a risk and chemicals that pose an acute risk.
6. Advanced Treatment Processes	The nature of the source water (i.e., wastewater) requires more treatment for chemicals and pathogens than conventional water supplies. Advanced treatment processes provide this additional treatment.
7. Monitoring Requirements	Each key treatment unit process must have performance verification measures (e.g., chlorine Ct for chlorination) to demonstrate that each unit process is attaining its respective performance goal. The monitoring location for these critical tests is known as a Critical Control Points (CCP).
8. Reporting	Potable reuse facilities will need clear determination of responsibility and detailed reporting, including monitoring of WWTP and advanced water treatment facility operations and accounting for pathogen and chemical removal.

Table 1 Key Regulatory Issues for Potable Reuse (continued)

Issues	Concept
9. Facility Operations and Certification Programs	Potable reuse facilities must have qualified operations staffs who are trained to operate advanced treatment processes. Typically Class A or equivalent operators are to be in charge of the facility. The California/Nevada AWWA is developing a new Advanced Water Treatment (AWT) certification program which is specifically designed to address potable reuse operations.
10. Education and Outreach	Potable reuse provides tremendous value to a community, providing a high quality, drought resistant water supply. Successful project implementation (and maintenance) requires an open and continuous dialogue with the community about the value of water and the safety of potable reuse.
11. Technical, Managerial, and Financial (TMF) Capacity	Facilities that move forward with potable reuse must demonstrate the ability to fund and manage the complex nature of these types of projects. They must also demonstrate the technical depth, as listed above in this table, to maintain public health protection.

1.1 Definition of DPR

For the purposes of this TM, DPR can generally be defined as a water reuse treatment scheme where there is no environmental buffer. There are two forms of DPR. As defined by the National Water Research Institute (NWRI) (2016a), in the first form, advanced treated water (ATW) produced in an advanced water treatment facility (AWTF) is introduced into the raw water supply immediately upstream of a drinking water treatment facility (DWTF) shown as Figure 2. In the second form of DPR, finished water produced in an AWTF that is also classified as a DWTF is introduced directly into a drinking water distribution system (Figure 3). The former option was implemented in Big Spring, Texas by the Colorado River Municipal Water District (CRMWD), whereas the latter option will be implemented by El Paso Water in El Paso, Texas.

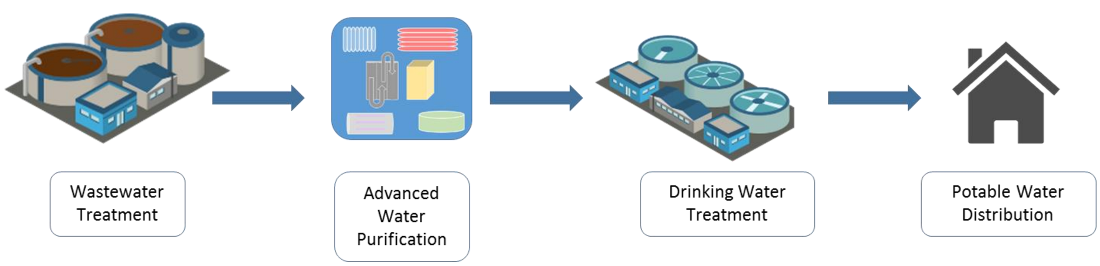

Figure 2 DPR Schematic where AWT is Introduced Upstream of the DWTF

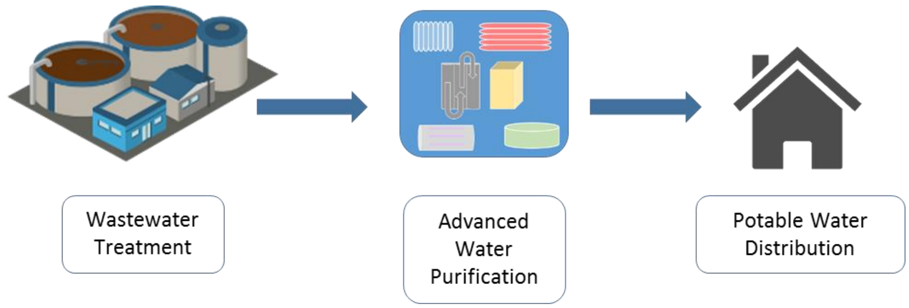

Figure 3 DPR Schematic where AWT is Introduced Directly in the Potable Water Distribution System

Other considerations for the definition of DPR include blending ratios, response time, monitoring, and presence of an environmental buffer. These considerations were discussed amongst the working group and will be under further consideration in the next phase of work.

1.2 Overview

Resources are available to help guide the development of a DPR program. An important reference for DPR development is the Framework for Direct Potable Reuse by the National Water Research Institute (NWRI, 2016a). This detailed document provides step by step recommendations on the elements needed to implement DPR.

There are several options for treatment systems that have been shown to reliably produce potable water protective of public health. Example DPR treatment trains are shown in Figure 4 and Figure 5. These trains are, respectively, currently implemented by the CRMWD in Big Spring, Texas (at full scale) and for a recent DPR demonstration facility in Altamonte Springs, Florida. The key differences are that the Big Spring facility includes reverse osmosis (RO) membranes, whereas the Altamonte Springs treatment train instead is based on the use of ozone and biologically active filtration (BAF, biofiltration).

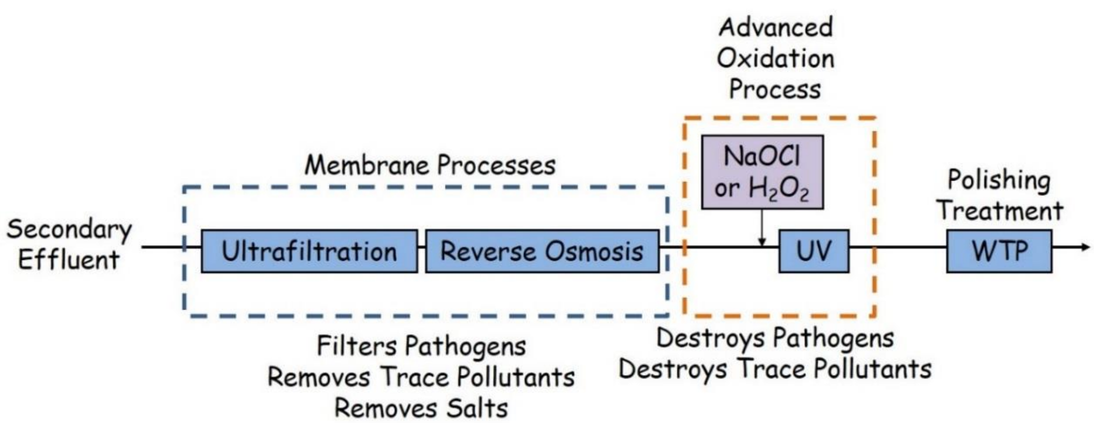

Figure 4 Example DPR Treatment Train Using Reverse Osmosis (Big Spring, Texas)

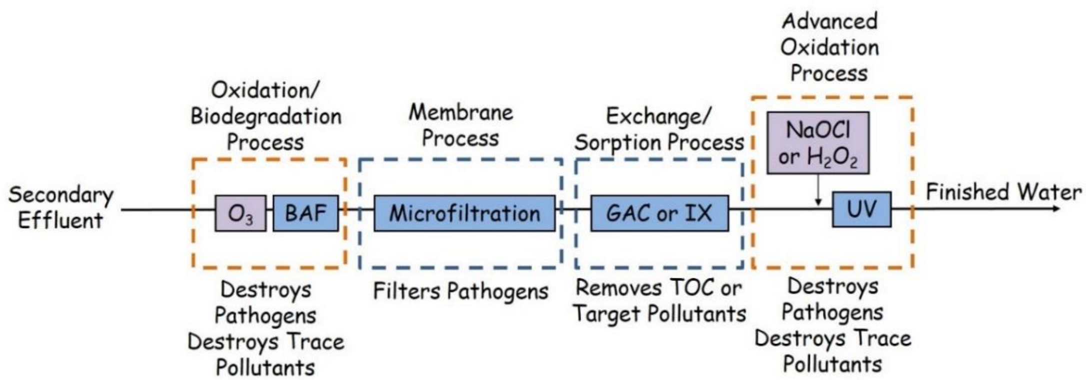

Figure 5 Example DPR Treatment Train Using Ozone and Biofiltration (Altamonte Springs, Florida)

With respect to public health protection, the goal of advanced treatment is to minimize risk through the destruction and removal of specific microbial and chemical constituents. To meet this goal, DPR treatment trains should be designed to minimize potential chronic risks (best exemplified by chemical constituents) and eliminate acute risks (best exemplified by pathogens) (Salveson et al., 2014). As part of an NWRI study (NWRI, 2016b), the following guidance on risk minimization was provided:

> *With few exceptions, the standards for organic compounds in drinking water are based on the chronic risk they pose (i.e., the risk of illness or death that a person faces as a result of drinking the water over a 70-year lifetime). In contrast, pathogens in drinking water pose an acute risk as illness can be caused by a single exposure to an infectious agent. When considering standards for DPR, it has been recognized that the greatest risk to a consumer is the acute risk that may result from a treatment system failure that allows pathogenic organisms to pass through the treatment system and be introduced into the distribution system. A similar failure might expose the community to chemical constituents, but over such a short time that the chronic risk would be insignificant. This distinction has two consequences. First, performance criteria for [advanced water treatment facilities] for DPR application are primarily based on pathogen removal. Second, it is important that a robust and effective monitoring program be established to rapidly detect system failures to prevent pathogen exposure. There is an implicit assumption that such a monitoring system will also suffice to prevent exposure to chemical constituents that pose a chronic risk to the public* (NWRI, 2016b).

The California State Water Resources Control Board's Division of Drinking Water (DDW) regulates groundwater replenishment (via direct injection or surface spreading) indirect potable reuse (IPR) projects based upon 12-log virus removal, 10-log *Cryptosporidium* removal, and 10-log *Giardia* removal, from the point of raw wastewater to the point of potable water consumption (California Department of Public Health [CDPH], 2014a). In 2018, the State Water Board approved surface water augmentation regulations based on the same log removal targets. The safety of the aforementioned log reduction approaches has been documented by the National Research Council (NRC) report on Water Reuse (NRC, 2012).

NWRI convened an expert panel as part of a larger effort for a grant from the WateReuse Research Foundation (WRRF) to investigate the Equivalency of Advanced Treatment Trains for Potable Reuse (under WRRF Project No. 11-02). As part of the project, the expert panel confirmed California's targets of pathogen control that achieves at minimum 12-log reduction of virus, and 10-log reduction of protozoa (i.e., *Giardia* and *Cryptosporidium*) (NWRI, 2013). In addition, the panel also recommended a 9-log reduction or inactivation of bacteria (NWRI, 2013).

The key difference between the potable reuse approach used by California regulators and the approach taken by the Texas Commission on Environmental Quality (TCEQ) in regulating DPR is the starting point for log removal targets. California's log removal value (LRV) targets are based on the conversion of raw wastewater for indirect potable reuse, whereas the TCEQ uses treated wastewater effluent as the starting point for defining further treatment requirements. In addition, the TCEQ develops LRV targets for each project individually, based on an evaluation of the pathogen content in the treated wastewater effluent that will serve as the source for the potable reuse project.

Both the California and Texas regulatory approaches fundamentally rely on the same risk-based approach to defining pathogen concentration targets in finished drinking water, which is to achieve a goal of less than 1 in 10,000 annual risk of infection with each pathogen group. This standard is consistent with the approach taken in federal drinking water regulations (United States Environmental Protection Agency [USEPA or EPA], 1989a and 2006a).The specific pathogen concentration targets are also based on the literature cited in and underpinning current federal drinking water regulations, which defines the concentration targets for enteric virus, *Giardia*, and *Cryptosporidium* as 2.2×10^{-7} MPN/L (Regli et al, 1991), 6.8×10^{-6} cysts/L (Regli et al, 1991), and 3.0×10^{-5} oocysts/L (Haas et al, 1999), respectively.

The treatment requirements in California may seem higher because the LRV targets include treatment (and credits) provided by conventional wastewater treatment, which are not included under the TCEQ's approach.

1.3 Texas, Florida, New Mexico, Oregon, and California

Potable reuse regulations and projects have been successfully implemented in several states using a broad range of treatment and monitoring technologies. Texas, Florida, Oregon, and California have facilities that are examples of successfully operating potable reuse projects. These facilities and each state's regulations are briefly reviewed in this section. Other examples of states and facilities that have successfully implemented potable reuse, but are not detailed within this section, include Nevada (Clark County Water Reclamation District to Lake Mead), Georgia (Gwinnett County to Lake Lanier) and Virginia (Upper Occoquan Service Authority to Occoquan Reservoir).

1.3.1 Summary

Tables 2 and 3 summarize the potable reuse regulatory requirements and pathogen log removal values (LRVs) for different states.

Table 2 Approach to Potable Reuse Regulation in Selected States

State	Approach		Required Technology[1]			IPR			DPR		
	Risk	**Prescribed Technology Requirement**	**MF**	**RO**	**UV AOP**	**Guidelines/ Framework**	**Draft Regulations**	**Final Regulations**	**Guidelines/ Framework**	**Draft Regulations**	**Final Regulations**
Texas	✓								✓[2]		
Florida	✓							✓	✓[4]		
New Mexico	✓								✓		
Oregon	✓								✓		
Nevada	✓							✓			
Virginia[3]		✓						✓			
California	✓	✓	✓	✓	✓				✓		
California (surface water augmentation)	✓	✓	✓	✓	✓			✓			
California (groundwater injection)	✓	✓	✓	✓	✓			✓			
California (surface spreading groundwater recharge)	✓	✓[5]						✓			

Notes:

(1) Alternatives to reverse osmosis (RO) including O_3 BAC are under consideration in different states.

(2) While not considered a formal "guidance document" by the TCEQ, the Texas Water Development Board DPR Resource Document (TWDB, 2015) provides guidance on approaching DPR projects in Texas.

(3) Requires multiple barrier approach, with no technologies specified. Existing IPR projects (prior to 2014) are permitted by an existing VPDES permit. Outlined in Title 9 Chapter 740 of Virginia SWCB regulations.

(4) Beginning phase of DPR regulatory framework development July 2018.

(5) Surface spreading projects do not require MF, RO, UV AOP treatment, they can be done with tertiary effluent if TOC and other goals are met prior to spreading.

Table 3 Pathogens Log Removal Guidelines or Regulatory Requirements

State	Virus [log_{10} removal]	*Giardia* [log_{10} removal]	*Cryptosporidium* [log_{10} removal]	Contaminants
Texas(1)	≥8	≥6	≥5.5	MCLs
Florida	not specified	not specified	not specified	MCLs, Secondary MCLs, TOC, TOX
New Mexico(3)	12	10	10	MCLs, Secondary MCLs, CECs(2)
Oregon	12	10	10	MCLs, Secondary MCLs, CECs(2)
Nevada(4)	12	10	10	MCLs, Secondary MCLs
Virginia(5)	not specified	not specified	not specified	MCLs, Secondary MCLs
California (Groundwater spreading and injection)	12	10	10	MCLs, Secondary MCLs, CECs(2)
California (Surface Water Augmentation)(6)	12	10	10	MCLs, Secondary MCLs, CECs(2)

Notes:
(1) Site specific goals are established for each project.
(2) Follows recommended values and recycled water policy (NWRI, 2013).
(3) Expert panel recommendations (NWRI, 2016).
(4) Specified in Adopted Regulation R101-16 (*finalized December 2016*), credit for travel time given for virus removal.
(5) Title 9 Chapter 740 of Virginia SWCB regulations.
(6) Might require a study to demonstrate 2 log virus attenuation in reservoir.

1.3.2 Texas

At present, the most relevant state for DPR is Texas, with a successful track record of two operational facilities (Big Spring and Wichita Falls) and a third facility in the near future (El Paso Water). The Big Spring DPR system is a permanent installation, whereas Wichita Falls decommissioned its DPR system as planned once severe drought conditions eased. El Paso Water is now moving ahead with the design of its own DPR project, which will be the first "direct to distribution" project in the United States, in which the purified water will be conveyed directly to the potable water distribution system.

The Big Spring and Wichita Falls projects (Figures 6 and 7, respectively) were approved by Texas regulators on a case-by-case basis in accordance with the innovative/alternative treatment clause in 30 TAC (Texas Administrative Code) 290 regulatory document that allows “any treatment process that does not have specific design requirements” listed in that chapter to still be permitted. The Texas Water Development Board (TWDB) commissioned a technical team to develop a resource document to support water utilities, consultants, and others who are considering future DPR projects in Texas. The "Direct Potable Reuse Resource Document" (TWDB, 2015) provides information on issues to address for DPR, how to address these issues, and a timeline for consulting with regulators about a project and site-specific considerations.

Figure 6 CRMWD Raw Water Production Facility in Big Spring, Texas (*successfully operational since spring 2013)*

Figure 7 RO System at the Cypress Hill Water Treatment Plant in Wichita Falls Texas, used for Direct Potable Reuse *(no longer in operation due to easing of drought conditions)*

DPR projects in Texas must be designed to meet all existing requirements for drinking water standards. Additionally, monitoring of unregulated constituents (pharmaceuticals and personal care products) is encouraged by TCEQ, but not mandated. These constituents are sometimes referred to as constituents of emerging concern (CECs). TCEQ's approach is to understand the pathogen concentrations in the feed water to the AWTF, then require a multiple-barrier treatment system to provide the necessary pathogen reduction to meet acceptable risk standards.

TCEQ adopted its pathogen risk standards for potable reuse in general accordance with the approach taken in existing federal drinking water regulations, which is to achieve a goal of less than 1 in 10,000 annual risk of infection from each pathogen group (USEPA, 1989 and 2006a). As noted above, and similar to California's (CDPH, 2014a) and the NWRI's (2013) subsequently published approaches, the specific pathogen concentration targets are based on the literature underpinning current federal drinking water regulations, which defines the concentration target for enteric virus, *Giardia*, and *Cryptosporidium* as 2.2×10^{-7} MPN/L (Regli et al, 1991), 6.8×10^{-6} cysts/L (Regli et al, 1991), and 3.0×10^{-5} oocysts/L (Haas et al, 1999).

LRV targets for each project are determined by calculating the difference between the target concentrations listed above and actual values measured in the treated effluent, which is considered the "source water" for the potable reuse project. In addition, the TCEQ has defined minimum "benchmark" LRV targets of 8-log virus, 6-log *Giardia*, and 5.5-log *Cryptosporidium*.

In all cases, LRV credits can only be achieved in accordance with drinking water guidance, such as the EPA's Ultraviolet Disinfection Guidance Manual (EPA, 2006b) for UV systems, the EPA's Membrane Filtration Guidance Manual (EPA, 2005) for membrane systems, the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) Toolbox Guidance Manual (U.S. EPA, 2010), and others.

In effect, the TCEQ has developed a system of source water characterization analogous to the existing "binning" process for *Cryptosporidium* under the LT2 (U.S. EPA, 2006a). The TCEQ's approach, however, also acknowledges the substantially more impaired water quality of typical wastewater effluent compared to conventional surface water sources by extending the source water characterization to all three pathogen groups and imposing minimum treatment requirements that go beyond that required for conventional source waters.

The appropriateness of this higher treatment standard is evident from the results of effluent characterization studies completed for the existing and proposed potable reuse projects in Texas to date: In each case, the pathogen concentrations present in the effluent supported the establishment of LRV targets in excess of the minimum 8-log virus, 6-log *Giardia* and 5.5-log *Cryptosporidium* benchmarks.

Another perspective on the same issue comes from comparing the pathogen concentrations typically found in treated effluent to the results of the first round of LT2 sampling on conventional surface water sources. As noted by Dr. Eva Steinle-Darling (2016), "While well-treated effluent is unquestionably a valuable water resource, and can be further treated to become an important part of a water supply, it is not a suitable source of raw water for conventional drinking water without additional treatment." Dr. Steinle-Darling is the Principal Investigator of a 2-year detailed water quality evaluation of the Big Spring DPR Facility, which also included elements of the effluent characterization program now required of DPR projects in Texas (TWDB, 2016).

Dr. Steinle-Darling also reflects on "indirect reuse" in Texas, which is not subject to the same regulation as DPR projects, that "the current indirect and *de facto* reuse projects across the state (and the nation) appear to be protective of public health, likely through some amount of pathogen attenuation within the natural environment. This attenuation, however, is not well characterized, and thus utilities considering new indirect reuse projects, especially those where travel time and mixing in the environment are minimal, are well advised to consider evaluating whether additional treatment is warranted" (Steinle-Darling, 2016).

1.3.3 Florida

The Florida Department of Environmental Protection (FDEP) has clear regulations on indirect potable reuse (Chapter 62-610 Reuse of Reclaimed Water and Land Application and drinking water regulations Chapter 62-550 Drinking Water Standards, Monitoring, and Reporting), but no current guidance on DPR. In additional to standard primary and secondary maximum contaminant levels (MCLs), the FDEP requires indirect potable reuse projects to attain a total organic carbon requirement of 3 milligrams per liter (mg/L) (or less) and to attain a total organic halides (TOX) result of <0.2 mg/L.

The Altamonte Springs DPR demonstration project (see Figures 5 and 8) is a full-scale demonstration of ozone, biologically active filtration, ultrafiltration, granular activated carbon, and ultraviolet light advanced oxidation (note: no RO used in this process). The extensive analytical work demonstrated that the listed purification process met and exceeded all FDEP regulations as well as all national guidance on potable reuse. The analytical work included MCLs, a broad range of hormones, pharmaceuticals, and personal care products, pathogens, surrogates, and innovative use of tissue bioassays and non-target analysis to best characterize the potential impact of trace levels of pollutants in the purified water. All test results met the project objectives.

Figure 8 Altamonte Springs Florida Demonstration-Scale DPR Facility using Ozone and Biofiltration

1.3.4 New Mexico

The New Mexico Environment Department (NMED) has clear guidance for non-potable reuse projects (NMED, 2007), developed by an NWRI panel, and is currently developing potable reuse guidance, with the latest information on potential regulatory criteria found in two guidance documents, NWRI (2015) and NWRI (2016b). From a regulatory perspective, DPR treatment facilities undergo the same application and approval process as a new surface water treatment facility, with the additional requirement of either a pilot or performance demonstration study.

Potable reuse projects in New Mexico are expected to be evaluated using a risk-based approach, in which project teams select treatment processes and log reduction requirements based on *either* measuring pathogen concentrations in secondary effluent to determine pathogen LRV requirements analogous to the TCEQ approach, *or* by applying the 12-log virus and 10-log protozoa requirements specified by DDW (CDPH, 2014a) and NWRI (2013). For chronic contaminant risks, the State of New Mexico enforces USEPA requirements, and includes additional state-specific requirements for potable water quality (https://www.env.nm.gov/dwb/regulations). This includes sampling for constituents with the USEPA-mandated maximum contaminant levels (MCLs) and secondary MCLs, specific compounds with Drinking Water Health Advisory values, as well as CECs that include steroids, hormones, pharmaceuticals, occurrence-based chemicals, and other widespread constituents of interest (USEPA, 2012).

At this time, there are no DPR projects in New Mexico. Cloudcroft was on the path to DPR and has installed substantial purification equipment that currently sits idle. Cloudcroft is a mountain resort town in southern New Mexico with a permanent population of approximately 750 people and seasonal population of approximately 3,000. Several years of drought have made it harder to meet the water demand using existing groundwater sources. Cloudcroft's geographic location has made it difficult to find new water sources. The need to find a reliable and sustainable source of water has driven Cloudcroft's interest in potable reuse.

For future projects, the NMED Sustainable Water Infrastructure Group (SWIG) has developed a draft DPR Preliminary Assistance Work Plan Checklist (Checklist). The Checklist identifies three key points for consideration:

- Capacity development.
- DPR project planning.
- Prior operation of a public DPR project.

The Checklist is organized using a priority based system, where priorities range from immediate (less than 2 weeks) to moderate (less than 6 months) for situation response. For example, emergency response and operation and maintenance plans would classify as an immediate priority, while a water loss control program is listed as a moderate priority. Among other considerations, NMED listed technical, managerial, and financial capacity (TMF) for the owner and operator of a DPR system as an important component of developing DPR projects.

Figure 9 Cloudcroft DPR Treatment Plant (UF, RO, and UV AOP Processes) under Construction

1.3.5 Oregon

Currently, Oregon regulations do not allow DPR treatment, however, the Oregon Administrative Code (OAR) allows the Department of Environmental Quality (DEQ) to approve "other beneficial water reuse purposes currently not identified in rule [OAR 340 055- 0016(6)]". This includes projects for potable reuse [OAR 340-55-0017(5)], as determined on a case-by-case basis.

The High Purity Water Project spearheaded by Clean Water Services (CWS, Hillsboro, Oregon) (Figure 10) used a DPR demonstration facility to purify municipal disinfected secondary effluent to raise awareness regarding the safety of reclaimed water for various uses, such as semiconductor processing, agriculture and food crops, product manufacturing, and human consumption. The end goal was to elevate the discussion of water in Oregon and to increase support for a future potable reuse project. The project integrated brewing beer as a focal point for raising awareness and support for potable reuse.

The DPR process design included the following advanced water treatment technologies, which, when combined, provided robust pathogen and chemical treatment: ultrafiltration (UF), RO, and ultraviolet light advanced oxidation process (UV AOP). The boiling process required in the beer brewing process was not counted as part of the treatment process for purposes of assigning LRV credits. These processes were used in series to purify disinfected secondary effluent from CWS's Forest Grove Facility (FGF). Water quality goals for the project were based on previous research studies by NWRI (2013) and Trussell *et al.* (2013). Water quality testing demonstrated that the FGF finished water, when treated with UF, RO, and UV AOP, provides a very high quality water absent of trace pollutants and pathogens. As a result, the purified water was deemed suitable for potable consumption, and a single use DPR permit was obtained from the Oregon DEQ to use for producing the beer made from DPR water, called Pure Water Brew.

Figure 10 Clean Water Services DPR Pilot Treating Grove Facility Effluent

1.3.6 California

California has been implementing IPR projects since the early 1970s based upon case by case regulatory approval based on draft regulations. IPR regulations for groundwater recharge were finalized in 2014 (CDPH, 2014). Three different types of IPR projects have been approved in California. The first involves spreading (percolation) of a "tertiary" reclaimed water. The second is the injection of a purified reclaimed water directly into the groundwater aquifer. The augmentation of surface water bodies (such as a reservoir) with purified reclaimed water has been given preliminary approval in at least one location to date. All three of these approaches to potable water are considered to be IPR because they incorporate an environmental buffer (e.g., groundwater aquifer, surface water reservoir). Potable reuse projects that do not have an environmental buffer, or projects that have a very small environmental buffer, are classified as DPR projects.

California has seven actively producing potable reuse projects, totaling 206 million gallons per day (mgd) of new water, with "flagship" projects from the Orange County Water District (Figure 11) and the Los Angeles County Sanitation Districts. The California health criteria for these types of projects are summarized in Table 4, below.

Table 4 California Groundwater Recharge IPR Standards

Parameter	Criteria
Pathogen Microorganism Control	
Enteric Virus	12-log reduction(1,2)
Giardia cyst	10-log reduction(1,2)
Cryptosporidium oocysts	10-log reduction(1,2)
Total Organic Carbon (TOC)	Maximum 0.25 mg/L in 95% of samples within first 20 weeks Maximum 0.5 mg/L 20-week running average
NDMA and NMOR	Notification levels of 10 and 5 ng/L, respectively
1,4-dioxane	0.5-log reduction in AOP process
Total Nitrogen (TN)	10 mg/L

Notes:
(1) Log reductions are from the point of raw wastewater to the point of finished water for drinking.
(2) Additional pathogen log reduction credits are awarded based on qualifying subsurface travel time of treated water.

Figure 11 OCWD GWRS RO Membranes Used to Purify Reclaimed Water for Potable Reuse

In addition, there is strong interest in advancing DPR as a water supply option in California. In 2010, Senate Bill (SB) 918 directed the State Water Resource Control Board (SWRCB) to investigate the feasibility of developing uniform water recycling criteria for DPR, convene an Expert Panel to study the technical and scientific issues, and provide a final report to the California State Legislature by December 31, 2016.

In 2013, SB 322 further required that the SWRCB convene an Advisory Group comprised of utility stakeholders to advise the SWRCB and its Expert Panel on the development of the feasibility report. SB 322 also amended the scope of the Expert Panel to include identification of research gaps that should be filled to support the development of uniform water recycling criteria for DPR.

In 2012, the WateReuse Research Foundation, in partnership with WateReuse California, began the DPR Initiative, a $6 million effort to advance DPR as a water supply option in California and to inform the Expert Panel process investigating the feasibility of developing DPR criteria in California. The $6 million was leveraged into over $24 million of research involving 34 DPR research projects that addressed regulatory, utility, and community topics.

Based on the recommendations of the Expert Panel, the SWRCB DDW released its final report on the feasibility of direct potable reuse in California in December 2016. The report is titled "The Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse," and was issued pursuant to requirements set forth in SB 918. The SWRCB found that developing regulations for DPR projects was feasible and that a common framework across the various types of DPR will help avoid discontinuities in the risk assessment and management approach. The SWRCB noted that indicated that further research demonstrating reliability is necessary in order to finalize regulatory criteria for DPR in California. In the feasibility report, the SWRCB identified six specific research needs.

The report provides recommendations on topics that must be addressed in order to successfully adopt uniform water quality criteria for DPR that are protective of public health. The SWRCB has developed Draft criteria for DPR in April 2018, in parallel with conducting the research needed.

In 2017, the California legislature passed AB 574 in response to the feasibility report. The bill defined the two forms of DPR as "raw water augmentation" and "treated drinking water augmentation." In addition, the bill requires the SWRCB to adopt uniform water recycling criteria for "raw water augmentation" by December 31, 2023. The bill requires the state board to establish and administer an expert review panel to review the criteria.

In 2017, the SWRCB awarded a grant to the Water Research Foundation to fund and administer the research projects identified in the 2016 feasibility report.

2.0 Past Colorado Efforts

De facto potable reuse is common in the U.S., including in a headwaters state like Colorado, where eight major river systems start their path toward the Pacific Ocean or the Gulf of Mexico and no major rivers enter the state. Today, it is increasingly common to consider intentional, engineered potable reuse alternatives as part of a utility's water supply planning efforts.

2.1 Denver Water DPR Efforts

Recognizing a need to investigate additional water supply strategies, Denver Water conducted industry-pioneering research in DPR from 1979 to 1993. Denver Water constructed and operated a 1-mgd DPR demonstration facility in Denver that was used to investigate and characterize water quality, treatment reliability, process operability, public acceptance, and cost. This demonstration facility built upon foundational work conducted by the University of Colorado, Denver Metropolitan Sewage Disposal District (later renamed Metro Wastewater Reclamation District), Federal Water Quality Administration (predecessor to the USEPA), and Denver Water that included 10 years of small-scale pilot treatment investigations starting in 1970 (Lauer 2015).

The 1-mgd demonstration facility used a multiple barrier treatment approach, using numerous process technologies including both ozonation and options for RO or ultrafiltration. A multidisciplinary advisory committee guided study plans and interpretation of results. Significant efforts also went into regulatory buy-in and public acceptance, including facility tours, media outreach, and conducting several public opinion surveys. Those surveys generally found that Denver residents would support the use of DPR as a water source, provided that public health was protected and water quality was equal to or better than existing supplies (Lauer 2015).

The Denver Water demonstration concluded that DPR was in fact technically feasible and could be supported by the public and regulators. Ultimately, Denver Water did not move forward with implementation of full-scale DPR. Today, the 30-mgd Denver Water Recycling Plant stands on the site of the former DPR demonstration facility, providing non-potable recycled water to numerous irrigation and industrial users throughout Denver.

Since conclusion of the Denver Water DPR demonstration work, numerous Colorado utilities have investigated systems to augment their potable water sources with treated wastewater return flows. This includes several different approaches that could be characterized as IPR systems. The largest-scale of these is the City of Aurora's Prairie Waters Project, which diverts the City's reusable return flows from the South Platte River several miles downstream of the Denver metropolitan area. Water is diverted through a series of riverbank filtration wells, then can be injected and recovered through an artificial groundwater recharge and recovery system before being conveyed some 30 miles to the Peter D. Binney Water Purification Facility, home to a multiple-barrier advanced treatment process. Treated water from this train is blended with conventionally-treated mountain water supplies before being sent to distribution.

Currently, there is no formal regulatory structure in Colorado specifically designed for IPR or DPR. However, regulatory systems are in place that reflect *de facto* reuse practices. Specifically, beneficial uses of the state's surface waters approved by the Water Quality Control Commission (WQCC) can include a water supply use designation. Surface waters with this designation have water quality standards that reflect the use of the water body for drinking water supply, and in turn, this drives water quality conditions and permit limits in discharge permits written by the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD or Division) for water reclamation facilities that discharge to that receiving water. After diversion from the water body, Safe Drinking Water Act requirements are imposed on the potable water treatment facility, just as they are for every potable water treatment facility in the state. Requirements for potable treatment facilities are driven in part by the microbial and chemical quality of the source water.

2.2 Research for a Pathway to DPR

Colorado's Water Plan, completed in 2015, identified water reuse as a path to help reduce the gap between future demand and supply as the state's population continues to grow and supplies are impacted by climate change. In 2015, the Water Environment Research Foundation (WERF), now the Water Research Foundation (WRF), developed a white paper to investigate potential challenges Colorado utilities might face in implementing DPR (Brandhuber *et al.*, 2015). The white paper's conclusions, with input from the Colorado Water Conservation Board (CWCB) and regional and national experts convened in a May 2015 workshop, focus on three major topics:

regulatory development, RO concentrate management and investigation of alternate treatment technologies, and public education and outreach programs.

2.2.1 DPR Regulations and Feasibility in Colorado

The 2015 WRF white paper concludes that DPR is technically feasible in Colorado and the state should establish regulations or guidelines for DPR consistent with utilities' interest in DPR. To develop a regulatory pathway for DPR in Colorado, the white paper recommended that a group of experts to be organized to develop a better understanding of DPR's benefits and challenges in Colorado. Using the extensive research and experience from other states (e.g., Texas, Arizona, New Mexico, and California) was advised (Brandhuber *et al*., 2015). The WateReuse Colorado DPR project's regulatory workgroup, for which this report is being authored, served in this important capacity.

2.2.2 RO Alternatives and Concentrate Management

RO is commonly assumed by planners and/or required by regulators in DPR treatment schemes. When implementing RO, developing reliable and cost-effective concentrate management strategies is essential to the success of the project. For Colorado and other inland locations, RO brine disposal provides additional challenges, in that there is no ocean disposal option. Non-RO based treatment capable of producing high purity water for DPR is being heavily researched, primarily due to the cost of RO-based purification and the resulting brine disposal challenge. As part of the WateReuse Colorado (WRCO) DPR regulatory development efforts, CDPHE workgroup members expressed an openness to consideration of both RO-based and non-RO based DPR treatment options.

A permanent non-RO DPR demonstration project in Altamonte Springs, Florida investigated the use of ozone in combination with biofiltration (O_3/BAF) followed by membrane and absorption processes as an alternative to RO-based treatment processes to produce DPR water (Figure 5). Altamonte Springs investigated the potential for using DPR to supplement its fresh water supplies, but does not have a viable or cost-effective solution for RO concentrate management. The non-RO DPR treatment train demonstrated the ability to meet all Florida regulated standards for IPR and meeting all health criteria published by NWRI (2016a).

As an extension of this WRCO DPR Project, the PureWater Colorado demonstration project was hosted by Denver Water on behalf of Colorado’s water utilities and WRCO in early 2018. This new project also demonstrated a non-RO potable water reuse treatment train with many similarities to the Altamonte Springs treatment train. The PureWater Colorado demonstration was funded by in-kind contributions from Carollo Engineers, Denver Water, Xylem Inc., Pall Corporation, and Calgon Carbon, and supported by a Water Efficiency Grant from CWCB. The PureWater Colorado project demonstrated robust treatment of pathogens and near-total removal of trace organic constituents without the use of RO, while also providing an opportunity for outreach and education for tour attendees. Other efforts, funded by WRF, are also underway to further understand alternatives to the RO-based treatment train for potable reuse.

2.2.3 Public Education and Outreach

The 2015 WRF white paper concluded that education regarding DPR's potential benefits and safety is key for the successful implementation of DPR in Colorado. Education should be tailored to both public officials and the general public. The white paper recommended that a DPR education program for water utilities, the general public, and officials/regulators should be developed. The WateReuse Colorado DPR project's outreach workgroup served in this capacity, documented in WateReuse Colorado DPR project TM 2.

3.0 WRCO Regulatory Development

The WRCO DPR Project Regulatory Workgroup (Table 5) met four times between late 2016 and early 2018 in support of DPR regulatory development. Among the goals of the workgroup were to:

- Gain a common understanding and consensus on the goals for DPR regulations.
- Consider and discuss how DPR regulations could be integrated into an existing regulatory structure.
- Develop a draft regulatory matrix and identify gaps and needs.

The end goal for the workgroup's efforts was to make significant progress towards the development of a framework for DPR regulations in Colorado, with a reasonable and implementable path to completion.

Table 5 WRCO DPR Project Regulatory Workgroup Members

Name	Organization
Richard Leger, Sean Lieske, Greg Baker	Aurora Water
John Rehring, Austa Parker, Andrew Salveson	Carollo Engineers
Julie Tinetti	Centennial Water & Sanitation District
Larry Schimmoller, Jason Assouline	CH2M
Ron Falco, Brandi Honeycutt, Tyson Ingels	Colorado Department of Public Health & Environment
Tara Kelley, Donene Dillow	Colorado Springs Utilities
Kevin Reidy, Mara Mackillop	Colorado Water Conservation Board
Damian Higham, Brenley McKenna	Denver Water
Dave Takeda	MSK Consulting
Jeff Mosher	NWRI/WERF
Edward Bonham, Kirby Clark, Wes Martin	Plum Creek Water Reclamation Authority
Logan Burba, Rick Marsicek	South Metro Water Supply Authority
Matt Benak, Sandi Aguilar	Town of Castle Rock
Laura Belanger, Joan Clayburgh	Western Resource Advocates

3.1 CDPHE Regulatory Approach for DPR

3.1.1 Regulation, Policy, and Guidance

WQCD representatives encouraged the WRCO team to work within the three structures of "regulation," "policy," and "guidance." Workgroup members expressed a strong desire for future Colorado DPR regulations to be flexible and adaptable, with DPR details handled through policy or guidance, as opposed to regulation. Definitions for regulation, policy, and guidance as detailed by the WQCD in the "Implementation Policy Framework" (CDPHE 2013) are as follows,

- "'Regulation' or 'rule' are interchangeable terms and mean binding requirements officially promulgated by federal or state agencies within the authority of such agencies as provided by federal or state statute."
- "Implementation Policy is a policy that defines how the Division interprets law or regulations or determines the appropriate approach to exercising flexibility in the law or regulations while making case specific decisions where the underlying applicable law or regulation is ambiguous or provides the implementation program with discretion."
- "Guidance is a non-binding recommendation practice intended to assist and guide actions of internal staff, regulated entities or the public. Guidance documents are used for encouraging or educating a targeted audience. Guidance documents may also provide background information or supporting details regarding a statute, regulation, or policy."

A simple example of how WQCD uses its regulation, policy and guidance framework can be found in its handling of storage tank inspections. For storage tanks, the regulation states that water systems must inspect storage tanks quarterly or on an alternate schedule. The policy for this rule outlines the criteria and explains acceptable reasons to not inspect storage tanks quarterly. The guidance provides a form detailing the inspection specifics to help with quality assurance and compliance.

3.1.2 Regulation 11

CDPHE workgroup representatives indicated that a DPR rule could fit under the existing Reg. 11 (Colorado Primary Drinking Water Regulations). Within Reg. 11, there is no information pertaining to the health and water quality risks associated with potable reuse in general, or direct potable reuse in particular (as discussed in numerous documents, such as NWRI (2016a)). By statute, CDPHE is not allowed to promulgate MCLs for new parameters or more stringent MCLs for existing parameters than federal MCLs unless CDPHE follows a rigorous process mimicking EPA's process for adopting new MCLs. As such, there would be a need to better define policy and guidance for direct potable reuse.

For a new DPR Rule under Regulation 11, CDPHE would likely include "treatment technique requirements," which would allow for achieving water quality for potable reuse. In Regulation 11, a Treatment Technique Requirement is defined as "a requirement that specifies a treatment technique(s) for a contaminant which leads to a sufficient reduction in the level of the contaminant to comply with the requirements of the *Colorado Primary Drinking Water Regulations*. A treatment technique may also be a requirement that is intended to prevent situations that have the potential to have serious adverse effects on human health."

3.2 Workgroup Brainstorming

Before working through regulatory policy and guidance for DPR, the project team developed several initial definitions related to DPR, as follows:

- Class 1 DPR. Little to no time between wastewater treatment and potable water treatment and use (minimal reaction time, defined as Failure Response Time by WRRF (Salveson et al., 2015)). Minimal advanced treatment through the wastewater treatment process, placing the burden of purification at the water treatment plant.

- Class 2 DPR. Advanced water purification as part of wastewater treatment. Greater Failure Response Time to respond to process upsets than Class 1 DPR. Class 2 DPR would have greater operational flexibility.
- Dilution. Minimum dilution values were discussed. The value of dilution pertains to acute chemical concerns, such as nitrate. Dilution's benefit to pathogen removal is minimal and should not be relied upon.
- Water Treatment Plant. The general assumption of the group is that a regulated drinking water treatment plant (WTP) could be employed as part of a DPR project and count as a final critical step for chemical and pathogen control/reduction/destruction. This WTP could be an existing or new facility to help meet treatment needs.

The list above is only a starting point, and as discussed below, a broad definitions list is necessary. It is recommended that the next phases of detailed regulatory development include emphasis on specifically defining "DPR" and the exact scenarios under which the DPR regulations would apply.

In discussion groups, a list of high priority needs and goals was developed, with initial concepts as follows:

- Define DPR in terms of water quality (feed quality ahead of potable water treatment) and time (between effluent discharge and intake for potable water treatment).
- Determine if a very small environmental buffer (e.g., hours) falls within the DPR classification.
- Determine who would be regulated by the new DPR rule (water and/or wastewater utilities).
- Have robust source control programs.
- Use multiple barriers for treatment.
- Use advanced monitoring systems.
- Focus on acute risk.
- Relate DPR regulations to the Safe Drinking Water Act, where applicable.
- Evaluate "grandfathered" projects, including compliance schedules.
- Define DPR operator training and certification needs.
- Evaluate the integration of staff/full time employees (FTE).
- Evaluate the integration of non-staffing needs such as databases and electronic resources.

3.3 Regulatory Matrix

Incorporating the information above, the project team developed a detailed breakdown of the key 11 categories (see Table 1). Each of the 11 categories is further characterized in the Colorado DPR Regulatory Matrix (Table 6) in terms of the type of information that should be populated in each of the three regulatory structures: Regulation, Guidance, or Policy.

Table 6 Regulatory Matrix

Category	Including	Regulation	Policy	Guidance
1. Terminology	The Framework for Direct Potable Reuse (NWRI/WEF/AWWA/WateReuse) provides a detailed list of terminology. Consider inclusion/adoption to maintain consistency within the industry. Example important definitions/terminology include: • Source Control – First describe national pretreatment program material. Next, define source control as it could apply to potable reuse projects. • Potable reuse - define the basic concept of potable reuse, and that any type of potable reuse is intended to result in the same water quality that is protective of public health. Then, define de facto potable reuse, indirect potable reuse, and then direct potable reuse. Context of the urban water cycle is important. Define the key building blocks to convert and use purified water for public consumption, which includes treatment and infrastructure. • Environmental Buffer - define the environmental buffer as it applies to IPR projects and how the use of Engineered Storage can provide diversion. Define also how the environmental buffer is used within the current regulatory context in Colorado.	✓ Determine which definitions are regulatory and specific to DPR.	✓ Some terms should not have regulatory definitions – some can be set in policy and guidance. These terms should be referred to as "terminology" and not "definitions."	✓To be determined at a later date
2. Source Control	• Build on existing pretreatment programs. • Source control programs for potable reuse are "water first" programs, with a different focus compared to conventional pretreatment programs (which are focused on WWTP processes protection and NPDES permit compliance). • Recognize that potable reuse requires a source control program that is "enhanced," typically requiring more sampling and analysis of industrial users and broader pollutant monitoring within the collection and treatment system compared to conventional programs. • Rigorously and repeatedly inventory industrial users. • Define other user concerns (e.g., truck haulers). • Emergency response - an emergency response plan should be designed for sampling and determination of source control violations.	✓ List regulations that match the Reg. 11 contaminant control. ✓ Require a source control program that focuses on finished potable water quality. ✓ Require frequent updates and review of the source control program. ✓ Require regulatory review of the source control program periodic monitoring results.	✓ Specify requirements for all DPR scenarios. ✓ Detail how to reclassify existing water sources for use in DPR. ✓ Specify a robust communication protocol between WWTP and AWTF (ERP) ✓ Specify required components of the program. ✓ Specify requirements for monitoring and compliance including frequency, location, pollutants to analyze, and emergency response plans.	✓ Each DPR scenario should have best practices. ✓ All DPR projects should have a public/industrial outreach program. ✓ Include forms and best implementation plans for pretreatment. ✓ List best practices for sampling and emergency response.

Table 6 Regulatory Matrix (continued)

Category	Including	Regulation	Policy	Guidance
3. Wastewater Treatment	• Specify treatment targets and/or objectives for secondary effluent ○ Same as current discharge requirements ○ DBP minimization ○ Nitrogen Control • Recognize the value of flow equalization on process performance and efficiency. • Recognize operational impacts of secondary effluent quality on downstream purification processes. • Develop an emergency response plan to protect AWPF source. • Consider wastewater treatment optimization for downstream DPR.	✓ Meet requirements in existing Reg. 22, ensure secondary treatment compliance.	✓ Specify additional monitoring for WWTP upstream of a DPR facility. ✓ Recommend levels and types of wastewater treatment to provide more stable water quality for downstream purification. ✓ Specify criteria and/or objectives for secondary treatment, and minimum requirements of an ERP.	✓ Ensure reliability of WW supply and water quality. ✓ Best practices for ERPs; process for state approval of ERP; optimization guidance. ✓ Review the value of flow equalization. ✓ Link DBP minimization and nitrogen control with subsequent purification processes. ✓ Review how purification processes can compensate for lower secondary effluent quality, but they come at higher cost.
4. Pathogen Disinfection/ Removal	• Meet all federal and state drinking water regulations • Meet source water standards • Create pathogen reduction goals that include reduction across an entire treatment scenario (source to distribution). • Targets Pathogens ○ Protozoa (*Cryptosporidium* and *Giardia*) ○ Viruses • Treatment goal ○ Risk-based Approaches: ▪ California/NWRI approach with 12-10-10 log removal requirements (*Virus/Giardia/Crypto*) ▪ Data Driven Model - Texas Approach ○ Log removal vs. concentration	✓ Require pathogen removal and disinfection to meet all federal (and state) drinking water regulations. ✓ Require pathogens be removed or inactivated, with a goal of 10^{-4} annual risk of infection. This method and risk level have been adopted in CA, NM, NV, TX, and in national regulatory guidance documents. ✓ Require a multiple barrier treatment approach. Approach uses precise and conservative monitoring systems to measure treatment process performance based on a 10^{-4} risk level. ✓ Develop log credit system based upon approved treatment technologies. ✓ Two potential approaches to regulation: 1. Set the log reduction requirements from raw wastewater through treatment to potable water for virus, *Giardia*, and *Cryptosporidium* to be 12-log, 10-log, and 10-log, respectively. This is the "California" model. 2. Set the log reduction requirements to meet a 10^{-4} annual risk of infection based upon treated effluent characterization to determine LRV requirements. This is the "Texas" model.	✓ Detail pathogen log removal requirements. ✓ Recommend online control and monitoring systems. ✓ Recommend periodic off-line pathogen monitoring. ✓ Detail how to interpret log credit system.	✓Highlight performance and credits for purification processes that have been used in other states.

Table 6 Regulatory Matrix (continued)

Category	Including	Regulation	Policy	Guidance
5. Chemical Removal	• Contaminants ○ List of approved regulatory methods for chemicals ○ Which chemicals to regulate (MCLs, Secondary MCLs, NLs, CECs, DBPs) ○ Short list of unregulated chemicals and CECs to regulate or monitor, statewide or site-specific ○ Regulate or monitor TOC , turbidity, other water quality parameters ○ 1,4-dioxane and NDMA, applications in other locations ○ Review or modify frequency for classes of contaminants ○ Perfluorinated compounds (PFOS, PFOA, etc.) ○ Evaluate acute vs. chronic risk impacts of chemical contaminants	✓ Only require MCLs	✓Other monitoring requirements. Define a broad range of trace level chemicals that are under investigation by EPA for potential health concerns as well as chemicals that are of interest to the public. This demonstrates proactive monitoring by the water utility. Review treatment targets and technology application in other States as they apply to unregulated chemicals. Relate classes of contaminants and monitoring to reporting requirements and public notification.	✓ Provide latest information/research (ex. DBP formation). ✓ Utilize terminology "health action level" or recommendation for terminology developed in conjunction with the outreach program messaging.
6. Advanced Treatment Processes	• Membranes (MF/UF/RO) • Ozone or Ozone AOP • Ozone and Biologically Active Filtration • The use of non-RO systems • UV/ UV AOP • Chlorine AOP • Best Available Demonstrated Control Technology (BADCT) approach • Required processes • Site-specific treatment (focus on salts) • Multiple-barriers required • Redundancy • Pilot testing - Define need and value.	✓ Allow for a flexible combination of any or of a large list of approved treatment technologies. ✓ Use EPA drinking water criteria where appropriate ✓ Following the surface water treatment rules, define a minimum number of barriers (2 or 3) ✓ Pilot plant used for treatment demonstration to be offline, side-stream, and sent to waste. ✓ Pilot testing required only for novel technologies or for novel applications.	✓Develop a list of approved treatment technologies with pathogen/chemical removals. ✓Define varying classes of DPR with increased LRV goals based on risk with each scenario. ✓A BADCT approach that can validate specific treatment trains or unit processes ✓Recognize where EPA drinking water criteria are inaccurate and cannot be applied to wastewater treatment and purification. ✓Highlight performance and credits for purification processes that have been used in other states.	✓Describe DPR treatment scenarios and treatment trains used with corresponding results and pros/cons.
7. Monitoring Requirements	• Monitoring leads to ERP and diversion of off-spec water - clearly defining the upset to match the reporting and response (notification vs. stop supply) • Monitoring ○ Define purpose for all monitoring requirements ○ Frequency ○ Defining detection limits • Use of indicators and surrogates - to include surrogates already utilized in CO for RO and other technologies such as sulfate/TOC for RO as opposed to an EC requirement. • Limits for "off spec" water conditions • Critical control points ○ Purpose ○ Where to place online monitoring • Demonstration of treatment performance • Use of long-term monitoring ○ Documentation and trending of surrogates	✓Require online monitoring and specific critical control points for DPR unit processes in the treatment trains. ✓ Define failure and response time requirements.	✓Recommend surrogates to measure for each unit process with a CCP. ✓Recommend methods to monitor and respond to monitoring results, including pathogen and chemical concerns. ✓ Define and example critical control point monitoring system for unit processes in several treatment trains.	✓Provide analyzer information and historical data. ✓Describe the use of CCPs for operations.

Table 6 Regulatory Matrix (continued)

Category	Including	Regulation	Policy	Guidance
8. Reporting	• Who (which agencies/board/?) • What (data, violations) • When (frequency - monthly, yearly, only in case of violation) • Definition of compliance • Use of engineer's report for project description • Annual report • Public right-to-know applicability	✓ Build/expand on the current standard drinking water reporting requirements. ✓ Use of engineer's (or project) report ✓Use of annual report to regulators and the public	✓ TBD	✓ Detail record keeping requirements for online monitoring. ✓ Detail record keeping requirements for grab-sample monitoring and online equipment calibration.
9. Facility Operations/ Certification Programs	• Type of operator certification - water, wastewater, other • Level of operator certification required • Further training for Advanced Water Treatment	✓ Specified operator certification Augment existing operations certification program with "Advanced Water Treatment" program. Allow operation of purification systems as the AWT program is developed.	✓Provide examples of AWT responsibilities that are in addition to current wastewater and water training certifications.	✓Development and use of operator training.

10. Education and Outreach	• Public hearings
	• Example successful programs
	• Information / education for:
	  ○ Regulators
	  ○ Politicians
	  ○ Environmental groups
	  ○ Advocates
	  ○ Public
		✓ Public outreach strategy required.	✓ Detail public outreach needed to ensure customer equity.
			✓ Building on Reg. 22 requirements, but no formal regulatory requirement needed.
			✓ Minimum number of public meetings.
			✓ Required periodic meetings with partner utilities (i.e., where utility jurisdiction and function overlap).
				✓ Example communications and outreach plan with specific items to address such as source control, recommended number of public meetings and right to know information.
				✓Example education and outreach programs; references.

11. Technical, Managerial, and Financial (TMF) Capacity	• Certifications for preparing engineering report/document to submit to the state • Construction and contractor certifications	✓ State TMF review (build on state SDWA TMF program)	✓ Specific requirements and applicability of TMF requirements. Regulatory requirement needed.	✓ Provide information on an IGA plan that includes: contact early in project, water rights requirements, information on who is paying for the project and clear expectations. ✓Develop training and supporting programs.

4.0 Path to DPR Regulation in Colorado

The Regulatory Matrix presented in Table 6 accomplishes the goals of the WRCO DPR Project to set an overall framework for developing DPR regulations for Colorado. This framework draws from lessons learned from potable reuse regulatory development work in other states, while reflecting Colorado's drinking water regulatory structure and local stakeholders' interests in providing a system that is flexible and adaptable for future changes.

However, this framework requires additional detail before moving through the CDPHE WQCC Rulemaking process to become formally considered for adoption into state regulation. Figure 12 illustrates the major elements of the path forward from the development of the Regulatory Matrix (on the left side of Figure 12) to formal adoption of a regulation (on the far right side of Figure 12).

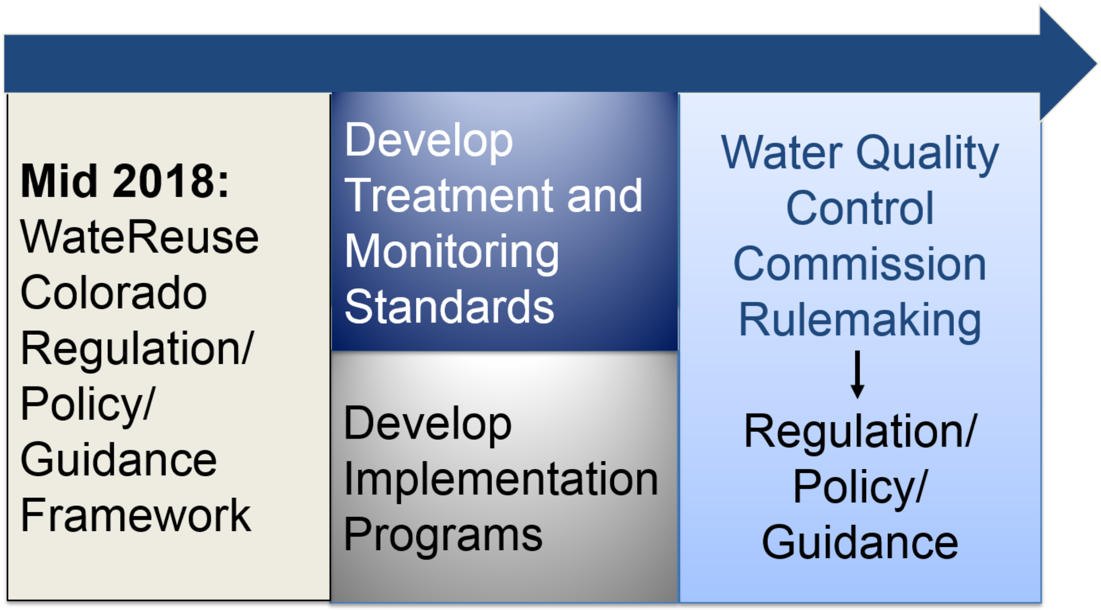

Figure 12 Path to DPR Regulation in Colorado

Key steps as illustrated on the figure include:

- The Regulatory Framework as documented in this TM (Table 6) serves as the foundation for subsequent steps.
- Development of Treatment and Monitoring Standards, to populate details of the matrix with respect to Matrix Categories number 1 through 7 and number 10.
- Development of Implementation Programs, to populate details of the matrix with respect to Matrix Categories number 8, 9, and 11.
- Moving through with the formal WQCC Rulemaking process once the full details of the detailed proposed regulatory language have been developed through the above two steps, including the stakeholder processes leading up to and including a formal Rulemaking Hearing.
- Development of supporting policies and guidance.

The next steps toward regulatory development build on the Regulatory Framework documented in this TM. The development of Treatment and Monitoring Standards and the development of

Implementation Programs could happen in parallel, elaborating, and providing details to the framework critical to development of a formal regulatory proposal that can be submitted for WQCC Rulemaking consideration. The WRCO DPR Project Regulatory Workgroup, working in close consultation with its WQCD participants, determined that the development of Treatment and Monitoring Standards for the following Matrix Categories could be led by technical experts outside of WQCD, and would benefit from national and local expertise in public health, advanced treatment, pathogen removal, chemistry, and other states' regulatory experience to date:

1. Terminology.
2. Source Control.
3. Wastewater Treatment.
4. Pathogen Disinfection/ Removal.
5. Chemical Pollutant Removal.
6. Advanced Treatment Processes.
7. Monitoring Requirements.
10. Education and Outreach.

Matrix Category 10 is less "technical" than the other seven Matrix Categories in this group, but WQCD representatives noted that education and outreach is beyond WQCD's core skill sets and thus asked that the Treatment and Monitoring Standards group also develop the requirements for this category. It is not anticipated that the education and outreach requirements will specify significant details of program requirements, as indicated in Table 6, but the importance of having a local outreach program for DPR warrants its inclusion in Colorado's DPR regulatory structure. Although a non-WQCD group can lead the development of Treatment and Monitoring Standards, it will be critical to have WQCD participation in the process, along with local stakeholder input, before moving this into the WQCC Rulemaking phase.

The WRCO DPR Project Regulatory Workgroup concluded, in consensus with WQCD representatives, that it would be most appropriate for WQCD to take the lead on the development of the detailed requirements for the elements of the regulation that are primarily associated with administration of the DPR regulatory program and facility operator requirements. These include the remaining Matrix Categories:

8. Reporting.
9. Facility Operations/ Certification Programs.
11. Technical, Managerial, and Financial (TMF) Capacity.

Of concern regarding progress toward the development of the remaining steps toward DPR regulatory rulemaking are the WQCD's significant resource constraints, which today challenge the Division's ability to meet its existing workload and schedule obligations, and forced significant staff cutbacks in 2017. There are no resources or budgets allocated to development of new DPR regulations, nor to administration of such regulations if and when adopted by the WQCC and when DPR systems are implemented by Colorado utilities. Therefore, the timing of the steps outlined above is uncertain unless and until means are identified to fund the Division's resources necessary to participate in this process. The WRCO DPR Project team is appreciative of the time and effort provided to the WRCO DPR Project by WQCD staff, which was provided in lieu of any allocation of CDPHE budgets or resources toward this project.

In one step toward resolving that challenge, WRCO identified a means to move forward with the development of Treatment and Monitoring Standards while significantly reducing the impact on

WQCD resources. In late 2017, WRCO applied for and was awarded a Colorado Water Conservation Board Water Plan Grant to support the convening of an independent advisory panel (IAP) through the National Water Research Institute (NWRI) to develop the Treatment and Monitoring Standards. The grant application received written support from the Colorado Basin Roundtable, the Metro Roundtable, and the South Platte Basin Roundtable, recognizing the potential widespread benefits of DPR to watersheds and communities across the state. Complementing the grant and to provide the required local cost-share, WRCO also garnered commitments for $25,000 in cash contributions and significant in-kind contributions to support the effort from Colorado utilities and consultants.

The development of Treatment and Monitoring Standards will rely on a panel of state and national experts, CDPHE, and stakeholders to:

- Define proposed DPR treatment, monitoring and management guidelines that are protective of public health and enable communities to make sound investments in infrastructure,
- Detail content of proposed CDPHE Regulations, Policy, and Guidelines, and
- Recommend chemical concentrations and removal rates based on peer-reviewed research.

The panel will create an interim "Colorado Guidelines for Direct Potable Reuse" including all technical information needed to draft a formal proposal for regulations. The project is expected to conclude its approximately one-year effort by mid-2019.

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