Chapter 6

Operator Certification and Training

6.1 Introduction

Operator certification and training programs are used across the United States in order to provide a minimum standard of operational skill and knowledge for the operations of wastewater treatment plants, water treatment plants, and the management of drinking water distribution systems. Currently, potable reuse does not have its own certification curricula, but rather utilities rely on these existing wastewater and water certifications from which the pool of operations staff is drawn. While this covers a number of important elements for potable reuse, there currently remain gaps for both some of the technologies applied, as well as some of the operational tasks and methodologies.

The water and wastewater curricula have been developed in order to cover the requirements for the majority of water and wastewater treatment operators. Recycled water is currently produced by a small percentage of utilities overall, and while rapidly increasing in its application, IPR and DPR remain a relatively small enterprise in comparison to the vast number of water and wastewater treatment plants. As a result, IPR and DPR has not seen significant coverage in existing operator training curriculum or examinations.

Direct potable reuse necessitates the application of a variety of relatively advanced water treatment technologies in order to meet water quality requirements. Some of these technologies are covered to an extent in the existing curriculum. For example, reverse osmosis is applied not only in reuse applications but also for groundwater desalting and seawater desalination for drinking water applications and as a result it has some, albeit limited, coverage in the existing drinking water certification curriculum. Similarly, microfiltration and UV disinfection are relatively minor components of the curriculum. Other technologies however, such as advanced oxidation, are not currently covered at all.

IPR and in particular DPR are perceived as a higher risk to public health relative to normal drinking water production, due to the nature of the source water employed. In addition to the gaps in training for specific technologies employed, a key focus on the management of this higher risk to health (whether perceived or real) is imperative to the success of operations. More intensive requirements for water quality sampling and analysis; specific requirements for instrument calibration and verification; critical operational monitoring, reporting, and effective operational responses must all be considered in the development of a training and certification process to meet the requirements of DPR.

6.2 California - Existing Training and Certification Programs

In California, training and certification programs exist for both drinking water and wastewater treatment operators. Wastewater and water treatment operations are managed separately, and until recently had been handled by separate organizations when the administration of the Drinking Water Program (DWP) was transferred from the Department of Public Health (DPH) to the State Water Resources Control Board (SWRCB) in July 2014. While they remain as two separate certification tracks, there are nonetheless a number of commonalities between the two programs including:

- An operator grade level from 1 to 5, based on a combination of experience and the passing of examinations. For wastewater operators this is referred to as a grade (1 - 5), for drinking water it is referred to as T1 - T5. The higher number refers to a more experience and a higher level of

coursework and certification.

- A classification system for permitted facilities, based on size and complexity. This classification demands a minimum requirement for operator grade certification for chief plant operator and shift operator.

- Some commonality of curriculum material, noting the use of some treatment technologies in both water and wastewater programs.

Recycled water from wastewater origin is handled under the jurisdiction of the California SWRCB and contained within the wastewater curriculum. This covers recycled water at tertiary filtration levels (commonly referred to as Title 22 water) - although does not include significant content for IPR and none for DPR.

6.2.1 Drinking Water Training and Certification

Laws and regulations governing certification of potable water treatment facility operation were enacted in California in 1971. These established the level at which water treatment facilities should be manned, the minimum qualifications for testing and criteria for renewal and revocation of operator certificates.

Water treatment plant operator certification is managed by the SWRCB since the transfer of these functions from the California Department of Health in 2014. It is currently managed by the Office of Operator Certification within the Division of Financial Assistance. The certification requirements are specified in Title 22 California Code of Regulations (CCR) Sections 63900 and 63905 for water treatment operators and distribution operators respectively.

Operator certification progresses through 5 levels, from T1 to T5, with each level requiring a demonstration of increased operational expertise and experience. Each level requires an educational pre-requisite and successful passing of an examination based on the knowledge, skills and abilities set forth in the regulation. Educational pre-requisites include such qualifications as high school diplomas or General Educational Development (GED), and also courses specific to water treatment. Examinations are offered twice per year. From level T3 upwards, the demonstration of applicable operating experience is also required. Certificates must be renewed every three years, with proof of continuing education required at all levels.

The required knowledge, skills, and abilities of each certification level are developed based on job analyses conducted by subject matter experts, who are typically water treatment system operators and managers with extensive field experience. There is an ongoing validation process to ensure that examination questions are representative of operator duties and responsibilities, with workshops attended by the subject matter experts to validate existing exam questions and to write new questions [Operator Certification Annual Report for State Fiscal Year 2013-2014].

The table below provides a summary of the educational and qualifying experience requirements for each level of drinking water certification in California.

Table 6.1 – Water Treatment Plant (WTP) Operator Certification Requirements California (1)

WTP OPERATOR CERTIFICATION REQUIREMENTS TABLE per Title 22 CCR, Division 4, Chapter 13 sections 63775 and 63800

PATH	EDUCATION REQUIREMENT		QUALIFYING EXPERIENCE
T1			
1	H.S. diploma or GED		N/A
2	Successful completion of the "Basic Small Water System Operations" course provided by the Department		N/A
3	1 year as an operator of a facility that required an understanding of chemical feeds, hydraulic systems, and pumps.		N/A
T2			
1	H.S. diploma or GED **AND** Successfully completed at least one course of specialized training covering the fundamentals of drinking water treatment		N/A
2	Successful completion of the "Basic Small Water System Operations" course provided by the Department **AND** Successfully completed at least 1 course of specialized training covering the fundamentals of drinking water treatment.		N/A
3	1 year as an operator of a facility that required an understanding of chemical feeds, hydraulic systems, and pumps **AND** Successfully completed at least 1 course of specialized training covering the fundamentals of drinking water treatment.		N/A
T3			
1	H.S. diploma or GED **AND** Successfully completed a total of at least 2 courses of specialized training that includes at least 1 course covering the fundamentals of drinking water treatment	and	At least 1 year of operator experience working as a certified T2 operator for a T2 facility or higher **AND** At least 1 additional year of operator experience working as a certified treatment operator
A bachelor of science or a master of science degree **AND** the completion of a comprehensive operator training program may be used to fulfill the "initial" operator experience requirements.			

A degree earned at an accredited academic institution may be used to fulfill the "additional" experience requirements as follows:
* An **Associate degree or certificate** in water or wastewater technology that includes at least 15 units of physical, chemical, or biological science may be used to fulfill 1 year of operator experience.
* A **Bachelors degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 1.5 years of operator experience.
* A **Masters degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 2 years of operator experience.

A certified operator may substitute on a day-for-day basis the "additional" experience requirements with experience gained while working with lead responsibility for water quality related projects or research.

Experience gained as a certified waste water treatment plant operator may be used to fulfill up to 2 years of the "additional" operator experience requirements. Each 2 months of experience as a waste water treatment plant operator shall be considered equivalent to 1 month of water treatment facility operator experience

T4			
1	Successfully completed at least 3 courses of specialized training that includes at least 2 courses in drinking water treatment	and	A valid Grade T3 operator certificate **AND** At least 1 year of operator experience working as a shift or chief operator, while holding a valid T3 operator certificate, at a T3 facility or higher **AND** At least 3 additional years of operator experience working as a certified treatment operator.

A bachelor of science or a master of science degree **AND** the completion of a comprehensive operator training program may be used to fulfill the "initial" operator experience requirements.

A degree earned at an accredited academic institution may be used to fulfill the "additional" experience requirements as follows:
* An **Associate degree** or certificate in water or wastewater technology that includes at least 15 units of physical, chemical, or biological science may be used to fulfill 1 year of operator experience.
* A **Bachelors degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 1.5 years of operator experience.
* A **Masters degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 2 years of operator experience.

Experience gained as a certified waste water treatment plant operator may be used to fulfill up to 2 years of the "additional" operator experience requirements. Each 2 months of experience as a waste water treatment plant operator shall be considered equivalent to 1 month of water treatment facility operator experience

T5			

1	Successfully completed at least 4 courses of specialized training that includes at least 2courses in drinking water treatment.		A valid Grade T4 operator certificate **AND** At least 2 years of operator experience working as a shift or chief operator, while holding a valid T4 operator certificate, at a T4 facility or higher **AND** At least 3 additional years of operator experience working as a certified treatment operator.
A degree earned at an accredited academic institution may be used to fulfill the "additional" experience requirements as follows: * An **Associate degree** or certificate in water or wastewater technology that includes at least 15 units of physical, chemical, or biological science may be used to fulfill 1 year of operator experience. * A **Bachelors degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 1.5 years of operator experience. * A **Masters degree** in engineering or in physical, chemical, or biological sciences may be used to fulfill 2 years of operator experience.			
Experience gained as a certified waste water treatment plant operator may be used to fulfill up to 2 years of the "additional" operator experience requirements. Each 2 months of experience as a waste water treatment plant operator shall be considered equivalent to 1 month of water treatment facility operator experience			

To provide preparation for examinations, the SWRCB provides a course for the first two levels of certification “Basic Small Water System Operations”. Beyond this, there are a recommended list of reading materials and external courses which best map the requirements for examination preparation.

Chief among these is the Office of Water Programs at Sacramento State University. There are several correspondence and on line courses available that are specifically designed to support operator certification.(2) http://www.owp.csus.edu/courses/drinking-water.php. At the core of these courses are two text book volumes that are used as *de facto* core material for water treatment plant operator examination preparation:

- "Water Treatment Plant Operations, Volume 1".
- "Water Treatment Plant Operations, Volume 2."

These books are commonly referred to as the "Ken Kerri" books, as they were developed by Kenneth D. Kerri at the Office of Water Programs. The books are designed for use with a correspondence course, provide accepted continuing education units (CEUs) as well as material to pass the examination. In addition, the school has developed “Small Water System Operation and Maintenance” which is recommended reading for T1 operators, but does not provide CEUs.

Additional material is also recommended, including material from the American Water Works Association (AWWA), New York State Department of Health and other sources.

Plant Classification

The state of California requires that the size and complexity of water treatment systems is matched to an appropriate skill and experience level of operator. Across the state, water treatment plants are classified based on a points system that is based on the water source, specific elements of influent water quality, the treatment processes employed and the plant capacity.

The criteria and scoring system in the development of plant classification is shown in the table below:

Table 6.1 - Water Treatment Plant Classification – California (3)

Classification of Water Treatment Plants Based on Total Points Title 22 CCR, Division 4, Chapter 15 - Domestic Water Quality and Monitoring, Article 2			
Area	**Criteria**	**Points**	**Section** **(Title 22 CCR Div 4, Chapter 15)**
Source of Water	Groundwater and/or purchased treated water meeting primary and secondary drinking water standards, as defined in section 116275 of the Health and Safety Code	2	64413.1.b.1
	Water that includes any surface water or groundwater under the direct influence of surface water	5	
Microbiological water quality of influent	MPN less than 1 per 100 mL	0	64413.1.b.2
	MPN 1 through 100 per 100 mL	2	
	MPN greater than 100 through 1,000 per 100 mL	4	
	MPN greater than 1,000 through 10,000 per 100 mL	6	
	MPN greater than 10,000 per 100 mL	8	
Water Turbidity of Influent (for facilities treating surface water or groundwater under the direct influence of surface water)	Less than 15 NTU	0	64413.1.b.3
	15 through 100 NTU	2	
	Greater than 100 NTU	5	
Nitrite/Nitrate in Influent	Less than or equal to the maximum contaminant level (MCL), as specified in Table 64431-A	0	64413.1.b.4

	Greater than the MCL	5	
Contaminants with primary MCLs in Influent (for all contaminants)	Less than or equal to the MCL	0	64413.1.b.5
	Greater than the MCL	2	
	5 Times the MCL or greater	5	
Treatment Processes used at a surface water treatment plant for compliance (Sum of points from each applicable line item)	Conventional, direct, or inline filtration	15	64413.1.b.6
	Diatomaceous earth filtration	12	
	Slow sand, membrane, cartridge, or bag filter	8	
	Backwash recycled as part of process	5	
Treatment process used to reduce the concentration of one or morecontaminants for which a primary MCL exists.	Each process that was not previously counted	10	64413.1.b.7
Treatment process used to reduce the concentration of +1 contaminants for which a secondary MCL exists.	Each process that was not previously counted	3	64413.1.b.8
Treatment process used for corrosion control or fluoridation.	Each process that was not previously counted	3	64413.1.b.9
Disinfection Process used for Log Inactivation Credit	Ozone	10	64413.1.b.10
	Chlorine and/or chloramine	10	
	Chlorine dioxide	10	
	Ultraviolet (UV)	7	
Disinfection/Oxidation Treatment without Inactivation Credit	Ozone	5	64413.1.b.11
	Chlorine and/or chloramine	5	
	Chlorine dioxide	5	

	Ultraviolet (UV)	3	
	Other oxidants	5	
Other treatment process that alters the physical or chemical characteristics of the drinking water and that was not included above		3	64413.1.b.12
(Maximum rated) **Flow Capacity**	per MGD (maximum of 50 pts)	2 x MGD Flow	64413.1.b.13

Total Points	**Minimum Chief Operator Certificate Grade**
Less than 20	T1
20 through 39	T2
40 through 59	T3
60 through 79	T4
80 or more	T5

The state requires that each water supplier will nominate at least one Chief Plant Operator and at least one shift operator for each water treatment facility utilized by the water system for each operating shift. The Chief Plant Operator must have an operator certificate grade equal to or greater than the Plant Classification (e.g. Class T3 WTP requires that CPO has a valid, unexpired T3 Certificate).

6.2.2 Wastewater Training and Certification

Wastewater treatment operator certification is also managed by the SWRCB.

Similar to drinking water, plants are classified and operator requirements set to meet those classifications which are outlined in Title 23, Chapter 26, Division III. These requirements are intended to ensure that operators meet a minimum level of competence and are matched to the size and complexity of the wastewater treatment plant that they will be operating.

Currently, water recycling plants are covered under this regulation and consequently water recycling plants require that operators are certified as wastewater treatment operators. This is reflective of the

many recycled water plant operations including those providing water for irrigation as well as more advanced technology systems such as groundwater recharge.

Wastewater operator certification progresses through 5 levels, from Grade 1 to Grade 5 with each level a demonstration of increased operational expertise and experience. Similar to drinking water, each level requires an educational pre-requisite and successfully passing of an examination based on the knowledge, skills and abilities set forth in the regulation. Examinations are offered twice per year. In contrast with drinking water, demonstration of applicable operating experience is required for all levels of certification, not just from level three onwards. Certificates must be renewed every three years, with proof of continuing education required at all levels.

The required knowledge, skills, and abilities of each certification level are developed based on job analyses conducted by subject matter experts, who are typically wastewater treatment system operators and managers with extensive field experience. There is an ongoing validation process to ensure that examination questions are representative of operator duties and responsibilities, with workshops attended by the subject matter experts to validated existing exam questions and to write new questions.

The table below provides a summary of the educational and qualifying experience requirements for each level of certification in California.

Table 6.2 - WWTP Operator Certification Requirements California (4)

WWTP OPERATOR CERTIFICATION REQUIREMENTS TABLE Title per 23 CCR, Division 3, Chapter 26 section 3688			
PATH	**EDUCATION**		**QUALIFYING EXPERIENCE**
GRADE I			
1	H.S. diploma or equivalent and 6 educational points[1]	and	1 year of full-time qualifying experience
GRADE II			
1	H.S. diploma or equivalent and 9 educational points	and	18 months of full-time qualifying experience as a Grade I operator
2	H.S. diploma or equivalent and 12 educational points	and	2 years of full-time qualifying experience
3	Associate's degree, a higher degree, or a minimum of 60 college semester units, including a minimum of 15 semester units of science courses	and	1 year of full-time qualifying experience
GRADE III			

1	H.S. diploma or equivalent and 12 educational points	and	3 years of full-time qualifying experience as a Grade II operator
2	H.S. diploma or equivalent and 18 educational points	and	4 years of full-time qualifying experience
3	Associate's degree or a minimum of 60 college semester units, including a minimum of 15 semester units of science courses	and	2 years of full-time qualifying experience
4	Bachelor's degree or a higher degree, including a minimum of 30 semester units of science courses	and	1 year of full-time qualifying experience
GRADE IV			
1	H.S. diploma or equivalent and 32 educational points	and	6 years of full-time qualifying experience
2	Associate's degree or a minimum of 60 college semester units, including a minimum of 15 semester units of science courses	and	4 years of full-time qualifying experience
3	Bachelor's degree or a higher degree, including a minimum of 30 semester units of science courses	and	3 years of full-time qualifying experience
4	Valid registration as a chemical, civil, or mechanical engineer issued by the California Board for Professional Engineers and Land Surveyors or by another state, territory, or Indian tribe	and	2 years of full-time qualifying experience
GRADE V			
1	H.S. diploma or equivalent and 48 educational points	and	10 years full-time qualifying experience
2	Associate's degree or a minimum of 60 college semester units, including a minimum of 15 semester units of science courses	and	6 years of full-time qualifying experience
3	Bachelor's degree or a higher degree, including a minimum of 30 semester units of science courses	and	5 years of full-time qualifying experience
4	Valid registration as a chemical, civil, or mechanical engineer issued by the California Board for Professional Engineers and Land Surveyors or by another state, a territory, or an Indian tribe	and	4 years of full-time qualifying experience

(Note 1: Educational points are granted based on the completion of wastewater related courses or approved continuing education units. These are specified as:

(1) One completed three-unit semester course which is directly related to wastewater treatment and which is part of the curriculum of an accredited college or university is equal to eight educational points. Completed courses which result in more or less than three units or which are quarter units rather than semester units will be credited with educational points on a proportional basis.

(2) All other courses will be assigned educational points at the rate of one educational point per 10 hours of completed classroom instruction. Subjects which are directly related to wastewater treatment shall be assigned full credit for educational points. Subjects which are indirectly related shall be given one half credit.

(3) One Continuing Education Unit which is directly related to wastewater treatment is equal to one educational point.)

Wastewater treatment plants are classified from lowest (I) to highest (V) based on treatment processes employed and the overall plant's design flow. The table below outlines this classification:

Table 6.3 - Wastewater Treatment Plant Classification Table (5)

WASTEWATER TREATMENT PLANT CLASSIFICATION TABLE

Class	Wastewater Treatment Process	**Design Flow** (in million gallons per day)
I	Primary	1.0 or less
	Conventional Treatment Pond	All
II	Primary	Greater than 1.0 through 5.0
	Biofiltration	1.0 or less
	Modified Treatment Pond	All
III	Primary	Greater than 5.0 through 20.0
	Biofiltration	Greater than 1.0 through 10.0
	Activated Sludge	5.0 or less
	Sequencing Batch Reactor	1.0 or less
	Tertiary	1.0 or less
IV	Primary	Greater than 20.0
	Biofiltration	Greater than 10.0 through 30.0
	Activated Sludge	Greater than 5.0 through 20.0
	Sequencing Batch Reactor	Greater than 1.0 through 10.0
	Tertiary	Greater than 1.0 through 10.0
V	Biofiltration	Greater than 30.0
	Activated Sludge	Greater than 20.0
	Sequencing Batch Reactor	Greater than 10.0
	Tertiary	Greater than 10.0

A Chief Plant Operator (CPO) must be certified at the same level of the plant, or higher. The designated operator in charge of a shift must be certified at no more than one grade below the plant classification with the exception that a Class I plant requires a Grade 1 operator or higher, and a Class V plant may use a Grade III operator. Class IV and V plants must have over 50% of operators at Grade II or higher.

As noted above, recycled water plant operations are currently included under the wastewater certification umbrella. Additionally however, a certified water treatment plant operator may also operate a recycled water plant at a grade level appropriate for the class of wastewater plant being operated. This allowance

opens the door to both certified water and wastewater treatment plant operators at water recycling facilities. Figure 6.1 provides a graphical representation of the operator certification requirements for water and wastewater operators within the California regulatory framework.

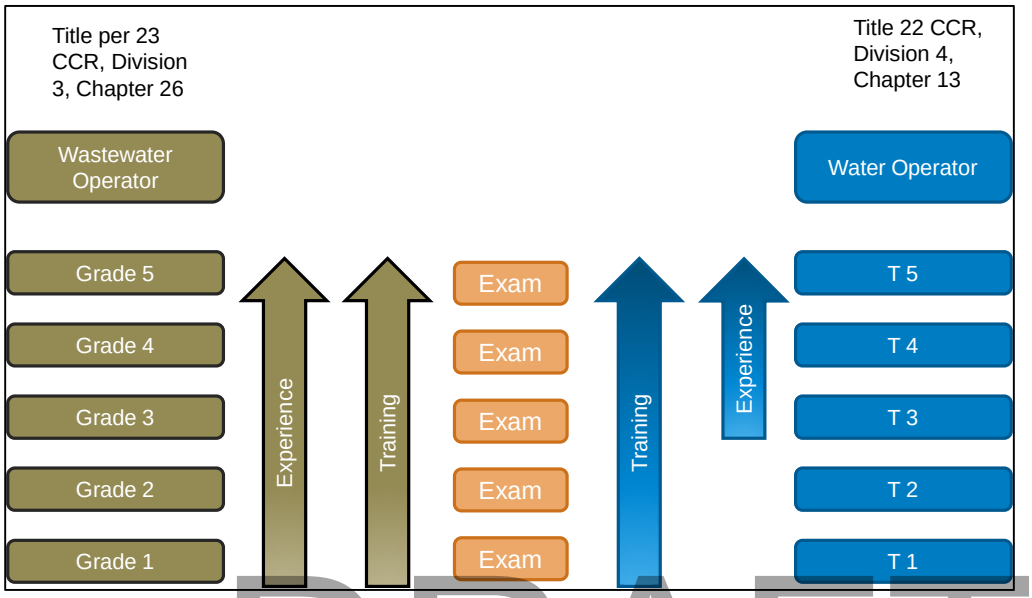

Figure 6.1 - Existing Water and Wastewater Operator Certification Framework - California

6.2.3 Example Operator Certification at Advanced Reuse Facilities in California.

Orange County Water District's Groundwater Replenishment System (GWRS), in Fountain Valley California, utilizes wastewater treatment operators with only a few exceptions. This plant is an IPR facility with processes that include microfiltration, reverse osmosis, and UV with advanced oxidation treatment steps to produce water for groundwater injection and surface spreading. The selection of wastewater-certified operators is a preference of the facility managers who are of the view that wastewater operators often have a range of experience with different treatment processes and are more adept at the challenges of the relative complexity of the system. In addition, Orange County Water District does not operate any other water or wastewater facilities (the wastewater facility is operated by the Orange County Sanitation District – a distinct entity), and as a result there are no other facilities, either drinking water or wastewater from which operators are transferred to the GWRS.

The history of advanced recycled water treatment at this facility extends to the mid-1970s when reverse osmosis was first employed for recycled water as a means to control salinity, and as a result there is a great deal of organizational knowledge and institutional memory with some key operational staff still engaged in operations from that time.(6)

For GWRS, operator certification is considered to provide the minimum knowledge to work at the facility, and operator training is supplemented with over 150 hours of unique training which has been developed by consulting engineers, equipment manufacturers and operational staff. The Chief Plant Operator requires that operators pass an examination, developed in-house, for promotion which is geared to operations specifically at this facility.

Similar to OCWD, the City of Los Angeles Bureau of Sanitation (LABOS) Terminal Island recycled water facility, with processes that include microfiltration and reverse osmosis, also utilizes wastewater certified operators for their facility. This facility places a high value on certification and has also developed substantial site-specific training and lesson plans.(7)

In contrast, the Santa Clara Valley Water District's Silicon Valley Advanced Water Treatment Plant, also a microfiltration, reverse osmosis, and ultraviolet light disinfection (with potential upgrade to advanced oxidation) utilizes primarily drinking water certified operators. This is primarily driven by opportunities for operator career advancement at other operated drinking water treatment facilities within the district.(8)

There is, however, a challenge with this approach in that water treatment operators working at a reuse facility can only accrue water treatment operator-qualified experience at half time because the plant is not technically a potable water treatment facility. This reduced credit for experience may be a barrier to operator advancement for the operator who runs significantly more advanced treatment systems than most drinking water facilities and is yet penalized due to this requirement. Therefore, there is a need for a unified certification system that allows for career advancement and lateral moves between types of operating facilities.

6.3 Certification in Other States/Countries

In addition to California, a review of a number of additional state operator certification frameworks was conducted. The intent was to determine firstly if direct potable reuse had been considered, how indirect potable reuse was considered, and also to review any alternative framework approaches that may be of benefit to a new certification program. A review of six states, along with a review of the Australian approach, were conducted as a part of this review.

The findings provided some useful additional options that could be adopted to enhance a future DPR certification program.

6.3.1 Washington

Drinking water operator certification in Washington State is managed by the Washington State Department of Health, and Wastewater is managed by the State Department of Ecology. Both of these departments have developed standards for reclaimed water use and jointly administer a reclaimed water program, however operator certification is managed distinctly by each organization.

There are five levels of wastewater operator certification and four levels of water treatment plant operator certification. Similar to California, an operator in responsible charge must be certified at a level that is equal to or greater than the classification of the wastewater treatment plant. Progression through different certification has a minimum educational and experience requirement and requires the applicant to pass an examination.

6.3.2 Virginia

The Board for Waterworks and Wastewater Works Operators and On Site Sewage System Professionals regulates individuals who operate water and wastewater treatment facilities and alternative on-site water reclamation systems. This board is comprised of two ex-officio members including the Director of the Office of Water Programs of the State Department of Health and the Director of the Department of

Environmental Quality, a faculty member of a state university or college whose principal field of teaching is management or operation of water/wastewater works, and a citizen member representing operators.

The Virginia Department of Professional and Occupational regulation administers water and wastewater certification programs. As for other states, operators must hold certificates equal to or greater than the facility classification. Water facilities are classed from 1 through to 6 (with 1 being highest and 6 being no treatment). Wastewater facilities are classed from 1 through to 4.

6.3 3 Texas

Water and wastewater operator certification is managed by the Texas Commission on Environmental Quality (TCEQ). Drinking water operations has four classes, with A the highest and D the lowest. Additionally, there is a distinction between licenses geared to specific water sources including surface water and groundwater. The class of operator required for a particular drinking water system is outlined based on the number of system connections served, types of treatment and type of disinfection used.

Effective in September of 2016, a specific requirement for reverse osmosis and nanofiltration membrane systems will require that operators complete an approved training course for operations and maintenance of those systems. (9)

Wastewater treatment operators also have four classes, from A to D. In this case the chief operator of each facility must possess a license equal to or higher than that of the category of treatment facility. Wastewater categories are determined by type of treatment and plant capacity. (10)

Texas recently had two temporary operating DPR systems. The Colorado River Municipal Water District's Raw Water Production facility in Big Spring, Texas treats secondary municipal effluent utilizing microfiltration, reverse osmosis, and UV Advanced oxidation treatment. For this plant, TCEQ require that a Class B surface water (drinking water) operator be employed by the CRMWD reclamation facility, with class C surface water operator able to operate the facility if the Class B operator is on call. Water and wastewater licensed operators may also operate the facility, however there is a prohibition on operators from the wastewater facility operating at the raw water production facility during the same shift to prevent introduction of contaminants. (11)

6.3.4 Arizona

Reuse of suitably-treated wastewater effluent (reclaimed water) has been practiced in Arizona for over 50 years. Originally, the predominant method of reuse was direct non-potable reuse for irrigation of crops and turf grass. Beginning in the mid-1980s, Arizona utilities began what amounted to indirect potable reuse (IPR) projects involving the recharge of water supply aquifers using reclaimed water. With the state's water conservation standards requiring safe-yield from groundwater, reclaimed water recharge is a widely-used method of generating credits to enable the pumping of an equivalent volume of groundwater back out of the ground for consumption. Since most municipalities in Arizona operate combined water/wastewater operations, the same entity that seeks recharge credits has control of reclaimed water that can be used to generate those credits. Over the past several decades, there has been a steady trend of decentralization in the direction of a greater number of smaller, local facilities developed by individual municipalities to optimize the resources as they best see fit to meet their individual needs. It has been estimated(12) that approximately 95% of the wastewater treated in the Phoenix metropolitan area is converted to reclaimed water and reused for some beneficial purpose.

As is the case elsewhere in the nation, the potential for *direct* potable reuse (DPR) of reclaimed water now has begun to draw attention in Arizona. As an outgrowth of a larger effort to plan for Arizona's water future,(13) the Steering Committee for Arizona Potable reuse (SCAPR) was initiated in March 2013, with its stated purpose being "to guide Arizona water interests in mitigating impediments to potable reuse (real or imagined) within industry standards of practice."(14) One element of the SCAPR's work has been to define potential treatment trains that might be feasible alternatives to the "industry-standard" full advanced treatment (FAT) train. Because of Arizona' inland location, disposal of reverse osmosis brine has emerged as a major impediment to the deployment of RO treatment facilities in the state. At present, there are three alternative treatment trains (A, B, and C) proposed for consideration by the SCAPR:

A: WWTP – ozonation – membrane biofiltration – advanced oxidation – blend – WTP

B: WWTP – ozone – biologically active carbon – microfiltration – advanced oxidation – blend – WTP

C: WWTP – ozone – biologically active carbon – microfiltration – granular activated carbon – blend – WTP

In Arizona, reclaimed water used in existing IPR efforts generally is produced simply as an extension of a typical wastewater treatment plant (WWTP), and these facilities are typically referred to as "water reclamation facilities" (WRFs). The principal processes to implement IPR at Arizona WRFs are biological denitrification, tertiary filtration, and a high level of disinfection (but not advanced oxidation) in addition of to what otherwise would be considered conventional wastewater treatment facilities. In most cases the reclaimed water has the opportunity to percolate downward for several hundred feet through the vadose zone before reaching the aquifer, thus providing the potential for soil-aquifer treatment as well.

Some Arizona utilities do provide advanced treatment (beyond filtration and denitrification) to water being reclaimed for reuse. The most widely-known example is the City of Scottsdale Water Campus, which includes microfiltration, reverse osmosis, and advanced oxidation processes to produce a very-high quality reclaimed water; some of this is delivered directly to reuse customers, principally golf courses, and the remainder is recharged into the local aquifer by vadose-zone recharge drywells. The Fountain Hills Sanitary District has a stand-alone microfiltration facility that further treats denitrified and filtered reclaimed water from the District's wastewater treatment plant. This water is then recharged at an elevation below the water table (i.e., injected) into the local aquifer which at times serves as a back-up water supply to the community. Several communities, including Peoria, Bullhead City, Lake Havasu City, and Chino Valley have constructed membrane bioreactors to produce very-low turbidity reclaimed water but that water still is either recharged or delivered for non-potable direct reuse.

In each of these cases, the advanced treatment facilities provided for reuse are operated by wastewater treatment plant operations staff simply as part of the overall treatment facility. The operators of the WWTP are responsible for the added processes to produce reclaimed water for non-potable reuse, IPR, and potentially DPR.

In Arizona, the Arizona Department of Environmental Quality (ADEQ) has regulatory authority to certify operators of water and wastewater systems. ADEQ's operator certification program includes certifications in four categories: Water Treatment, Water Distribution, Wastewater Collection, and Wastewater Treatment. Within each of the four certification categories in Arizona are four levels of certification, ranging from a nearly entry-level certification at Level 1 to advanced operator standing at Level 4. Operators must progress through each of the levels beginning with Level 1. ADEQ's certification requirements include required periods of employment in the field of operations along with examination requirements.

There is no certification program in Arizona specifically for potable reuse (and at present direct potable reuse (DPR) remains prohibited). As discussed above, as a practical matter, reclaimed water in Arizona is produced at wastewater treatment facilities. The operators responsible for producing reclaimed water generally are wastewater treatment operators, even though unit processes relevant to potable reuse conceptually fall under both Water Treatment and Wastewater Treatment.

For approximately the past five years, Arizona has used the standard national operator certification examinations developed by the Association of Boards of Certification (ABC). Arizona is now one of over 40 states that use the operator certification exams provided by ABC. ADEQ contracts with ABC to provide the state with the examinations for the various categories and grade levels, and contracts with the Phoenix-area Gateway Community College (GCC) to administer the registration process and proctor the exams state-wide. The exams consist of 100 questions; 70% is the passing score.

The ABC examinations' designs are based on "need to know criteria" in several categories, with the required depth and breadth of knowledge increasing with the level of certification being sought. ABC makes guidance documents available that summarize the design and content of the examinations, but they do not provide training per se or study materials for exam preparation. Questions on the examinations fall into six areas of "core competencies." The number of questions per category varies only slightly between certification levels. Within each of the core competency category specific potential topics are listed in the ABC need to know criteria. Those are also listed below, along with a summary total of the other potential topics included in the competency categories.

Table 6.4 - ABC Water and Wastewater Core Competencies

Water Treatment	No. questions	**Wastewater Treatment**	No. questions
Evaluate Characteristics of Source Water Bacteriological Biological Chemical *6 other topics*	5 - 6	Evaluate Physical Characteristics of Wastestream *(8 categories)*	5 - 6
Monitor, Evaluate, and Adjust Treatment Processes Chemical addition Chlorine dioxide Chlorine gas Ozonation Ultraviolet		Monitor, Evaluate, and Adjust Treatment Processes Preliminary treatment (5 subtopics) Primary treatment: clarifiers Secondary treatment (14 subtopics) Tertiary treatment Advanced waste treatment, chemical	32 - 35

Water Treatment	No. questions	**Wastewater Treatment**	No. questions
4 other subtopics Coagulation and flocculation (3 subtopics) Clarification and sedimentation (5 subtopics) Filtration Membranes 7 other subtopics Residuals disposal (8 subtopics) Additional treatment tasks (12 subtopics)		recovery, carbon regeneration Biological or biological/chemical advanced waste treatment Chemical/physical advanced waste treatment following secondary Ion exchange Media filtration RO, ED or other membrane filtration techniques Disinfection Chlorination Dechlorination Hypochlorination Ozonation UV irradiation Chemical Addition (dry, gas, or liquid) Effluent discharge For Reuse For Discharge Solids Handling (14 subtopics)	
Operate and Maintain Equipment Evaluate Operation of Equipment (6 subtopics) Operate Equipment (17 subtopics)	24 - 27	Operate Equipment *(25 categories)*	16

Water Treatment	No. questions	Wastewater Treatment	No. questions
Perform Maintenance *(20 subtopics)*			
Comply With Drinking Water Regulations: 19 EPA rules	10 - 12	Evaluate and Maintain Equipment Evaluate equipment *(10 subtopics)* Perform Preventive and Corrective Maintenance *(34 subtopics)*	27 - 28
Laboratory Analyses (22 categories)	11 - 13	Laboratory Analysis (33 categories)	7
Perform Security, Safety, and Administrative Procedures (5 categories)	13 - 18	Perform Security, Safety, and Administrative Procedures (6 categories)	10 - 11

As can be seen from the above table, reuse-related topics are included but only to a limited extent on the existing ABC water and wastewater certification exams used in Arizona. With 100 questions on the examination, and many more potential categories and topics to be covered, it is clear that the existing water and wastewater certification examinations only scratch the surface in terms of measuring operator applicants' capabilities relevant to potable reuse.

There is a widely noted lack of relevant training offered in Arizona to assist operators in preparing for water and wastewater certification exams in general. ADEQ offers some training classes, but they typically focus on ADEQ rules, administrative matters and safe drinking water topics. Most of ADEQ's funding for training comes from the U.S. EPA safe drinking water program and therefore cannot be used for "wastewater" topics. There are several private companies that offer some training programs, but in general those get mixed reviews from personnel who have taken the classes.

6.3.5 North Carolina

North Carolina requires the certification of water and wastewater operators to ensure competency in treatment as well as water distribution and wastewater collection. The certification of operators is the responsibility of the NC Department of Environment and Natural Resources (NCDENR). Certified operators have been required since 1971 under the purview of NCDENR and their respective Certification Boards.

Drinking Water Treatment certification is handled under the Water Treatment Facility Operators Board of Certification. Wastewater certification is overseen by the Water Pollution Control System Operators Certification Commission. NCDENR is responsible for training of operators in association with educational institutions and other private or public entities.

Drinking Water Systems are classified into general categories of surface water, groundwater (or well systems) and distribution systems. Certification for cross connection control is also part of the Drinking Water certification program.

Drinking Treatment facilities with surface or groundwater are classified based on a ***point system*** and designated as Class A, B, C or D. The points are assigned based on a range of parameters such as population served, type of source water, processes used, chemicals applied in treatment, and quality control complexity and associated analytical needs. Twenty three (23) different categories, processes and systems are scored (see attached -Subchapter 18D – Water Treatment Facility Operators).

Examples of scoring include:

- Population Served: 1 point per 1,000 served = 50 points max.
- Plant Capacity: 1 point per 1 MGD capacity = 25 points max.
- Sedimentation: Standard rate = 5 points; Tube Settlers = 3 points; Pulsators and plates = 5 points
- Disinfection: Gas Cl_2 = 10 points; Hypochlorite = 7 points; Ozone = 13 points; ammonia and chlorine = 12 points.
- Reverse Osmosis = 15 points
- Filtration: Sand = 10; Anthracite/GAC = 12; with surface wash or air scour= 2

Class A systems with large capacity and/or complex treatment are categorized as "A" and score over 110 points; Class "B" systems are in the 51-110 range, etc.

Drinking Water Distribution certification (again Class A through D) is simply based on the number of service connections. A Class A system would have over 3300 service connections.

Grades of drinking water operator certification mirror the A, B, C and D system classification. All treatment systems and distribution systems must have an "operator in responsible charge" that is licensed with the appropriate Grade of A,B,C, or D. In order to become certified, individuals must complete educational and experience requirements, pass examinations, as well as continuing education credits on an annual basis. Operator schools and examinations are conducted throughout the State on an annual basis. Experience requirements in order to achieve a higher grade generally range are from 6 months to a year and increase with higher levels.

Water Pollution Control Systems (i.e., WWTPs) include certification for treatment systems, collection systems, surface irrigation, land application, and subsurface water pollution control. Treatment is generally categorized as Biological Water Pollution Control Systems with Grades I thought IV. Grade I is basically passive systems such as septic, lagoons or wetlands. Higher Grades include activated sludge or fixed growth processes as well as more sophisticated processes are classified by daily flows in mgd (Grade IV is achieved at > 2.5 mgd). Physical/Chemical systems for such activities such as groundwater remediation also are classified as Grade I or II and have individual certifications. Collection systems are based on population served with Grade IV being the highest with > 50,000 served.

Grades of Water Pollution Control Operator Certification mirror the Grade I, II, III, IV system classification. All treatment systems and distribution systems must have an "operator in responsible charge" that is licensed with the appropriate Grade of the facility or collection system.

In order to become certified, individuals must complete educational and experience requirements, pass examinations, as well as continuing education credits on an annual basis. Operator schools and examinations are conducted throughout the State on an annual basis. Experience requirements in order to achieve a higher grade certifications generally range are from *6 months to 3 years*, and increase with higher levels of certification. College education from both two and four year institutions with relevant course work can substitute for some experience time. Continuing education requirements are required as well. Reciprocity is possible from States that have programs that meet or exceed NC requirements.

While DPR in North Carolina was legislatively allowed as of July 31, 2014 (NC Senate Bill 163, State Legislation 2014-113, "Reclaimed Water as a Source Water"), there is no clear path or requirement for operator certification. Likewise, the legislation does not provide specific treatment or water quality requirements (other than meeting state and federal drinking water standards), nor does it indicate the need for a separate advanced water treatment facility. Therefore it is likely that operation of the specific processes used for DPR would fall under the supervision of the operators staffing that facility (i.e., wastewater operators would operate any processes located at their facility while drinking water operators would operator any additional treatment processes at the DWTP). However, process-specific training will be required for advanced treatment that has not been typically used at the DWTP or WWTP.

6.3.6 Wisconsin

All of the previous states noted, including California, use a similar approach of education and work experience to qualify for an examination which when passed will allow the operator to gain a license and progress to subsequent higher license levels. One of the disadvantages of this approach is that the certification is more generalist, and not necessarily representative of the competencies required to perform particular tasks. For example, an operator that manages a trickling filter will be required to answer questions on activated sludge processes, or an oxidation pond operator may be tested on centrifuge operation and anaerobic digestion.

Wisconsin offers a different approach to wastewater plant classification. Certification categories for both operators and wastewater facilities changed from four levels (prior to 2015) to two levels (basic and advanced). There is also a Grade T level, or operator-in-training.Subclasses are assigned to the wastewater treatment plants that correspond to the processes used at each plant. To become a certified wastewater treatment plant operator, both a general examination and at least one subclass examination must be passed, which should be relevant to the plant at which the operator is engaged, or may be relevant to a plant that the operator will work in the future.

The categories of subclasses are shown in the table below:

Table 6.5 - Wisconsin Wastewater Operator Subclass Categories (15)

Category	Subclass Name	Description
Biological Treatment	Suspended Growth Processes	Activated Sludge and Variants
	Attached Growth Processes	Trickling filters, RBCs and biotowers

	Recirculating Media Filters	
	Ponds, Lagoons and Natural Systems	
	Anaerobic Treatment of Liquid Waste	High strength liquid waste treatment system.
Solids Separation	Biological Solids/Sludge Handling, Processing and Reuse	Aerobic and anaerobic digestion, thickening, dewatering, land application.
Nutrient Removal	Total Phosphorus	
	Total Nitrogen	
Disinfection	Disinfection	Chlorination, ultraviolet radiation, ozone.
Laboratory	Laboratory	Registered or certified on-site laboratories.
Special	Unique treatment systems	Unique, special treatment plants that use biological, chemical or physical methods.
Collection System	Sanitary Sewage Collection System	

The Wisconsin approach to wastewater operator certification provides the advantage of a general examination that achieves the goal of having all operators aware of rule, regulations, general treatment technologies and troubleshooting; while subclass examinations provides for a focused detail on the processes that those operators are responsible for operating.

6.3.7 Australia

Australia has been developing a national drinking water operator certification scheme to provide a consistent criteria that defines and recognizes the minimum level of competency and capability required of operators who treat and/or sample drinking water. A national framework has yet to be adopted, however a trial of the proposed system is in operation in two Australian states (Queensland and New South Wales) while a longer established system is being used in the state of Victoria.

Water treatment plants are ranked not according to plant capacity or technologies employed, but rather a level of microbial risk. Each water treatment facility is required to undertake a water supply public health (microbial) risk classification. The rationale is that the greater the microbial risk, the more technologically complex the water treatment system becomes to manage that risk. A relatively simple scoring table provides facilities with a ranking mechanism for each of those plants:

Table 6.6 - Scoring table for water supply system public health (microbial) risk classification (16)

Item	Max Points	Comments
Raw water sources (rating based on public health significance)		
Catchment: • Protected (0 points) • Unprotected (60 points)	60	A fully protected catchment is one where the entire catchment is protected from watershed to water treatment facility. Where this is not the case the catchment is considered to be unprotected.
Raw Water Source: • Seawater/saltwater (0 points) (assumes reverse osmosis treatment) • Groundwater (confined aquifer) (0 points) • Surface Water o Reservoir with greater than 30 days detention time under normal operating conditions (5 points) o Reservoir with less than 30 days detention time under normal operating conditions (10 points) o River or stream (30 points)	30	Surface waters (either reservoirs or river/streams) score mor highly than other sources because of the risk of contamination. Streams score more highly than reservoirs since there is no holding period for the water.
Raw Water Quality		
Average raw water quality variation • Little or no variation (0 points) • Minor variations: 'high quality' surface or groundwater source (1 point) • Moderate variations: during variations in raw water quality, coagulant dose (or pH adjustment chemicals dose) changes are made monthly (3 points), weekly (4 points), or daily (5 points).	5	
Rainfall event raw water quality variation • Minor variations: during rainfall events the increase in raw water turbidity is less than 50% of the dry weather figure, or raw water turbidity remains < 25 NTU during rainfall events (10 points) • Moderate variations: during rainfall events the increase in raw water turbidity is	30	Rainfall events have been identified as major hazard and significantly increase the risk of pathogen breakthrough.

between 50% and 100% of the dry weather figure, or the raw water turbidity is between 25 and 100 NTU during rainfall events (20 points) • Severe variations: during rainfall events the increase in raw water turbidity is greater than 100% of the dry weather figure, or raw water turbidity is greater than 100 NTU during rainfall events (30 points)		
Pollutant input to raw water • Raw water source subject to: o Agricultural or septic tank inputs (20 points) o Sewer overflows during rainfall events (15 points) o Treated effluent from sewage treatment plants (10 points) o Light industrial waste (5 points) o None of the listed inputs (0 points)	50	Point source discharge, in particular any source that may be contaminated with fecal material increases the risk to public health.
Other raw water characteristics critical to treatment processes • Presence of tasted and/or odor compounds for which treatment process adjustments are routinely made (2 points) • Presence of cyanobacteria and possible toxins (4 points) • Iron and/or manganese > Australian Drinking Water Guideline limits (4 points) • 1 point per average mg/L DOC to maximum of 20 mg/L	30	Various attributes of raw water have an impact on the treatment processes and if not managed may have an adverse impact on the quality of water or on the management of the distribution system.
Filter Ripening Period		
• Water produced during filter ripening to waste (0 points) • Water produced during filter ripening not sent to waste (5 points)	5	Filter ripening (the period immediately after backwash) is characterized by high turbidity water which in turn represents a risk to consumers.
Residuals management		
• Sludge supernatant/backwash water not returned to head of plant (0) • Sludge supernatant/backwash water treated with ozone or UV and returned to raw water storage (0 points)		Return of backwash water or sludge supernatant to the head of the plant carries with it a risk of returning viable protozoan pathogens to the influent.

• Clarified and/or settled sludge supernatant/backwash water, treated with ozone or UV and returned to head of plant prior to coagulation point (5 points) • Unsettled and/or untreated sludge supernatant/backwash water returned to head of plant prior to coagulation points (10 points) • Unsettled and/or untreated sludge supernatant/backwash water returned to head of plant after coagulation point (30 points)		Wherever any recycled stream is returned to the head of plant, best practice is that the flow is continuous and less than 5% of inflow and that coagulation dosing is flow paced and includes an allowance for changes in flow.

The microbial risk classification is calculated by adding the individual points and expressing them as a percentage of the total possible. The levels of each water treatment facility is then based on the following criteria:

Table 6.7 - Microbial Risk Plant Classifications (16)

Score	**Microbial Risk Classification**
70% and above	Level 4
Between 50% and 70%	Level 3
Less than 50%	Level 2

For each of these plant classifications, a responsible person should be qualified to a minimum level of certification. The responsible person is defined as the staff member who has day-to-day operational responsibility for a particular water treatment facility. The level of certification is noted in the following table. The structure of certification for the Australian system includes a number of certification levels including:

Table 6.8 - Minimum qualifications, experience and refresher training requirements for the responsible person at water treatment systems per classification (16)

Microbial Risk Classification	**Certification Level**	**Experience**	**Refresher Training**
Level 2	Certificate II in Water Operations	At least nine months in a water treatment or water quality role	Refresher Training Required
Level 3	Certificate III in Water Operations	Two years responsibility for a Level 2 facility or above, or two years assisting in	Refresher training required, plus a mandatory safe drinking water issues

		the operation at a Level 3 facility	update course, during every three year period.
Level 4	Certificate IV in Water Operations	Two years responsibility for a Level 3 facility	Refresher training required, plus a mandatory safe drinking water issues update course, during every three year period.

An important differentiator of the Australian system of water operator certification, relative to systems in the US, is that certification is not gained via an examination and experience, but it is achieved by mastering and demonstrating specific modules of competence. There are both core competencies that must be mastered for each specific level of certification, as well as a number of elective competencies, in which the operator can focus on those areas that are most relevant to the plant or plants at which they work.

Competency based training is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training or based on workplace experience and learning. Progress within a competency-based training program is not based on time. As soon as students have achieved or demonstrated the required competency, they can move to the next competency.

By way of example, the Certificate III requirements in water operations require that the candidate demonstrate competency in eleven units of competency, comprising three core and eight elective units, taken from the following list:

Table 6.9 - Certificate III Water Operations Competency Requirements (Water Industry Training Center NWP -07 Training Handbook)

Core (These units must be completed)	
NWP301B	Implement, monitor and coordinate environmental procedures
BSBWOR301B	Organize personal work priorities and development
BSBOHS303B	Contribute to OHS hazard identification and risk assessment
Electives – (8 of these electives must be completed).	
NWP300B	Provide and promote customer service
NWP345B	Monitor, operate and control water treatment processes
NWP346B	Monitor, operate and control wastewater treatment processes
NWP347B	Monitor, operate and control coagulation and flocculation processes
NWP348B	Monitor, operate and control sedimentation and clarification processes

NWP349B	Monitor, operate and control sedimentation and incineration processes
NWP350B	Monitor, operate and control trickling filter processes
NWP351B	Monitor, operate and control activated sludge processes
NWP352B	Monitor, operate and control dissolved air flotation processes
NWP353B	Monitor, operate and control anaerobic bioreactor processes
NWP354B	Monitor, operate and control granular media filtration processes
NWP355B	Monitor, operate and control membrane filtration processes
NWP356	Monitor, operate and control ion exchange processes
NWP357	Monitor, operate and control reverse osmosis and nanofiltration processes
NWP359	Monitor, operate and control nutrient removal processes
NWP360	Monitor, operate and control dewatering processes
NWP361	Monitor, operate and control gas scrubber processes
NWP362	Monitor, operate and control reclaimed water irrigation
NWP363	Monitor performance and control maintenance of treatment plant assets
NWP364	Perform laboratory testing
NWP365	Identify and confirm blue green algae outbreaks
NWP366	Monitor, operate and control chloramination disinfection process
NWP367	Monitor, operate and control activated carbon adsorption process
NWP368	Respond to blue green algae incidents
NWP369	Monitor, operate and control lagoon processes
NWP370	Perform industry calculations

Each of the individual modules can be provided by attendance at specific training courses (often delivered by technical colleges, private training providers or on line). The training organization that delivers the competency module will organize an assessment through a combination of specific examination of knowledge components as well as an assessment of practical application in the workplace. This may be done in a simulated or real situation in the workplace.

Assessors of competencies may be representatives that provide the training courses, or often are supervisory and/or more experienced staff at the water treatment facility itself.

Example of a competency module – NWP355B Monitor Operate and Control Membrane Filtration Processes

Table 6.10 - Example of a competency module - NWP355B Monitor Operate and Control Membrane Filtration Processes - Australian Government Industry Skills Panel NWP07 Water Training Package (17)

Unit Descriptor

This unit of competency describes the outcomes required to monitor, operate and control membrane filtration plant, including micro and ultra-filtration; and to measure and report on system performance and process quality control. The ability to identify faults, determine and apply technical adjustments, conduct chemical dosing procedures and produce technical reports are essential to performance.

Application of the Unit

This unit supports the attainment of skills and knowledge required for operational staff with a specific responsibility for ensuring that membrane filtration processes in treatment plants conform to organizational standards and comply with statutory requirements.

Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
1 Monitor membrane filtration plant performance.	1.1 Monitor test results and ***processes*** to maintain the parameters of operation. 1.2 Identify and report process faults and the operational condition of plant according to ***organisational and statutory requirements***. 1.3 Correctly select, fit and use required safety equipment, including personal protective equipment.
2 Control chemical use.	2.1 Use, handle and store chemicals according to organisational procedures and statutory requirements. 2.2 Determine chemical dosing according to plant processes and organisational procedures and statutory requirements. 2.3 Maintain chemical supply and usage records according to statutory requirements.
3 Operate and control membrane filtration processes.	3.1 Carry out ***routine plant inspections*** according to organisational and plant requirements 3.2 Conduct and analyse process ***tests*** and determine performance against plant operational requirements. 3.3 Make integrated ***process adjustments*** to improve system performance according to organisational and statutory requirements. 3.4 Collect, interpret and record process data according to organisational and plant requirements.

Required Skills and Knowledge

This describes the essential skills and knowledge and their level, required for this unit.

Required skills:

- identify and correct operational problems
- produce reports and logs
- use safety and personal protective equipment
- interpret plans, charts and instructions
- interpret policies, procedures and standards
- communicate with employees and customers
- use communication equipment
- give and receive instructions
- determine chemical dosing requirements
- perform system calculations
- operate computerised equipment
- identify control system faults
- sample and test products

Evidence Guide

The Evidence Guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for the Training Package.

Critical aspects for assessment and evidence required to demonstrate competency in this unit

The candidate should demonstrate the ability to monitor, operate and control membrane filtration processes, including:

- monitoring test results and processes
- identifying and reporting faults
- conducting routine plant inspections
- taking samples and performing basic tests
- preparing and applying chemical dosing
- making basic process adjustments according to instructions
- collecting data and completing required documentation

Context of and specific resources for assessment

Access to the workplace and resources including:

- documentation that should normally be available in a water industry organisation
- relevant codes, standards, and government regulations

Where applicable, physical resources should include equipment modified for people with disabilities. Access must be provided to appropriate learning and/or assessment support when required.

Assessment processes and techniques must be culturally appropriate, and appropriate to the language and literacy capacity of the candidate and the work being performed.

Validity and sufficiency of evidence requires that:

- competency will need to be demonstrated over a period of time reflecting the scope of the role and the practical requirements of the workplace

- where the assessment is part of a structured learning experience the evidence collected must relate to a number of performances assessed at different points in time and separated by further learning and practice
- a decision of competence only taken at the point when the assessor has complete confidence in the person's competence over time and in various contexts
- all assessment that is part of a structured learning experience must include a combination of direct, indirect and supplementary evidence
- where assessment is for the purpose of recognition (RCC/RPL), the evidence provided will need to be authenticated and show that it represents competency demonstrated over a period of time
- assessment can be through simulated project-based activity and must include evidence relating to each of the elements in this unit

In all cases where practical assessment is used it will be combined with targeted questioning to assess the underpinning knowledge. Questioning will be undertaken in a manner appropriate to the skill levels of the operator, any cultural issues that may affect responses to the questions, and reflecting the requirements of the competency and the work being performed.

Range Statement

The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. ***Bold italicised*** wording, if used in the Performance Criteria, is detailed below. Add any essential operating conditions that may be present with training and assessment depending on the work situation, needs if the candidate, accessibility of the item, and local industry and regional contexts.

Processes may include:

- micro filtration
- ultra-filtration

Organisational and statutory requirements may include:

- by-laws and organisational policies
- standard operating procedures
- Australian Drinking Water Guidelines
- National Water Quality Management strategy
- environment protection
- occupational health and safety, including the use of personal protective equipment
- chemicals
- dangerous goods
- lifts and cranes
- Environment Protection Authority regulations
- World Health Organisation standards
- licensing agreements
- electrical standards

Routine plant inspections may include:	• the use of equipment, including: • electronic monitoring and metering systems • chart recording systems • basic hand tools • sampling and laboratory testing equipment • computerised equipment • on- and off-road vehicles • communication equipment • personal protective equipment • interaction and communication with other employees, other authorities and the general public • visual observation • implementation of reporting procedures that may also include procedures for the implementation of by-laws, organisational policies and statutory requirements
Tests may include:	• turbidity • colour • pH • transmembrane pressure

6.4 – Summary of Existing Systems

In the cases of all of the states within the United States reviewed as a part of this study, there is a heavy emphasis on a combination of an examination, and years of experience in the field in order to progress through different levels of operator certification. Drinking water and wastewater treatment operator certification is managed separately, with recycled water often considered a part of the wastewater treatment portfolio. There is no separate certification for reuse operators, and in particular nothing specific for IPR or DPR. Operators in existing IPR reuse systems are drawn from both wastewater and drinking water operations certifications, depending upon the history and circumstances of their particular plant and other municipal operations. Each level of certification is matched to a rating of the treatment plant at which the operator works – with a focus on ensuring a minimum level of competence particularly for the Chief Plant Operator and any supervisors. This rating is based typically on treatment processes employed, raw water quality and plant capacity.

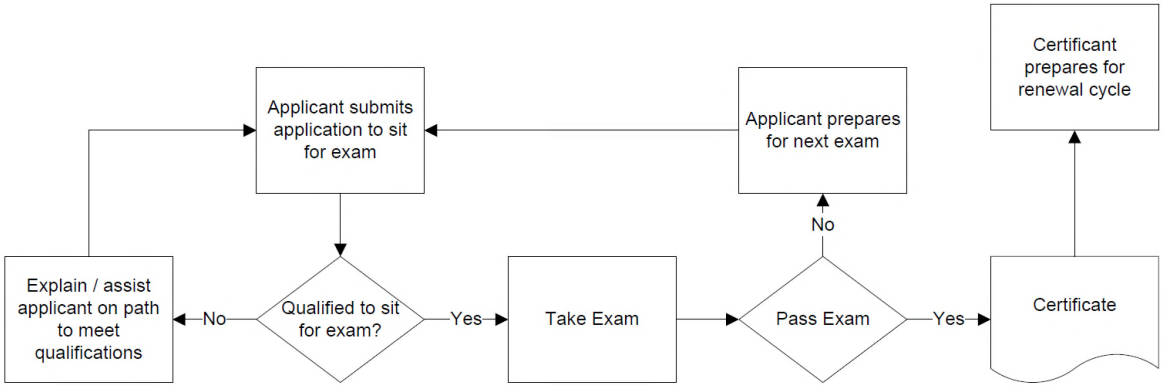

Figure 6.2 Process of Water and Wastewater Treatment Plant Operator Certification (courtesy CA/NV AWWA)

An interesting approach is offered by the system used in Wisconsin, in which a number of electives that are tailored to process selection enable plant operators to focus on processes that are consistent with the plants that they operate.

By contrast, the Australian system provides an alternative approach of using competency-based training and assessment – ensuring that operators can demonstrate their competence of specific tasks that are important to the delivery of their jobs. As systems in the US are heavily invested in the examination approach, it is not anticipated that a switch to a wholly competency-based approach is realistic. However, consideration of elements of this approach are nonetheless worthwhile either in terms of adding more specific requirements for the operator experience component, or for use in site specific training programs that are in addition to any operator certification.

One of the challenges of operator certification currently, especially noted in California, is the ability of operators to progress to higher certification levels, due to the requirement of operating experience at water or wastewater treatment facilities of a sufficient certification level. Many smaller utilities may not have these plants within their portfolio, and consequently operators within that utility may be unable to progress without moving to another utility. It is common practice for some utilities to share higher level operators between themselves in order to cover absence of an operator for sickness, vacation, or while a new recruit is to be hired. Given that the number of DPR systems (and likely IPR systems) will be relatively low compared with the number of water and wastewater facilities, consideration will need to be given as how to both:

- Gather sufficiently trained staff from the existing operating pool.
- Ensure experience can be gathered sufficiently to progress through certifications.

In addition, consideration of the existing pool of IPR system operators should be taken into account, with an acknowledgement of their capability through some kind of grandfathering to any future certification program. The requirements of operator certification for any DPR system cannot be too onerous as to discourage operational staff from investing their time and effort. At the same time, , the operational certification process should be sufficiently portable back to water and wastewater operations such that the certification process does not preclude that person from making lateral moves or career-advancing moves to facilities other than IPR or DPR plants.

As a summary, from this review an operator certification program for DPR (and IPR) should take the following into consideration:

- How to leverage experience and content from existing water and wastewater certification programs.
- Consideration of the use of elective modules specific to the operating plant (as per the Wisconsin Model) in order to tailor to the treatment technologies used in IPR/DPR systems.
- Consideration of competency modules, to more clearly define some of the operational experience requirement for certification.
- Ensure key technologies used for IPR/DPR are included in the curriculum

Our proposed recommendation for the operator certification will consider these important aspects.

6.5 Proposed Operator Certification IPR/DPR Curriculum

One of the most important elements of a workable operational certification program is to ensure that the curriculum best matches the technology mastery and skills that will be required for the operator. While this project was not specifically designed to develop the content for DPR operator certification, a review of existing curricula for water and wastewater certification has been conducted, along with a preliminary gap analysis to assess what additional material will be required.

6.5.1 Treatment Processes for Consideration

The treatment processes under consideration for this project are consistent with those that were assessed under the WRRF 13-03 project "Critical Control Point Assessment to Quantify the Robustness and Reliability of Multiple Barriers of a DPR Scheme". These processes differ slightly from those provided in the project brief as they have both undergone critical control point assessment, and additional barriers where required have been included. The two processes include.

- A reverse osmosis (RO) membrane-based treatment train consisting of membrane filtration (either microfiltration or ultrafiltration), reverse osmosis, UV advanced oxidation and final chlorination. Based on the critical control point selection work conducted in project WRRF 13-03, pre-chloramination and stabilization have also been included as necessary components of the treatment system.

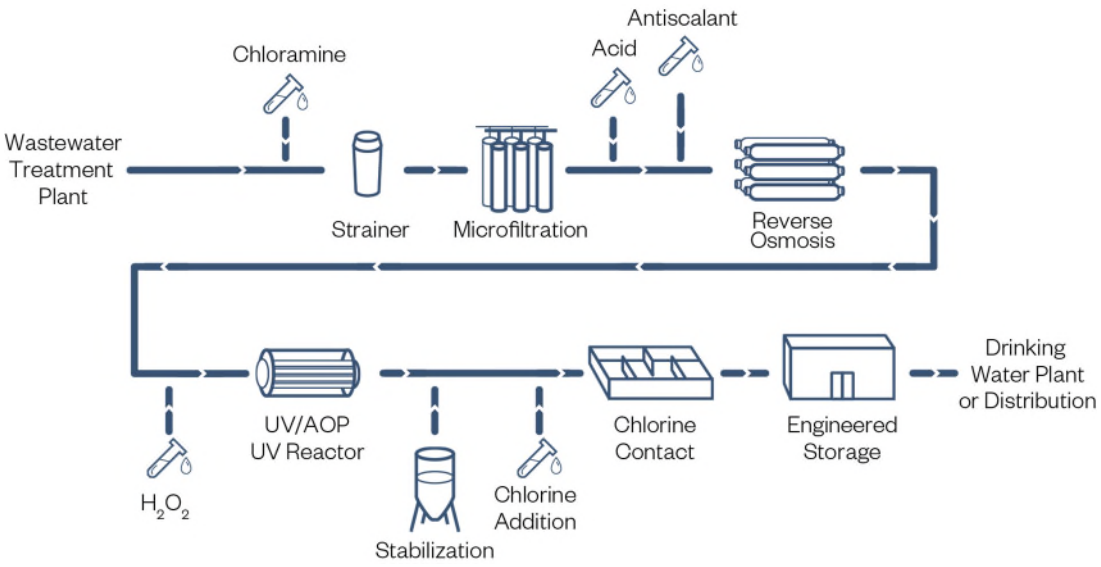

Figure 6.3 - RO Membrane-Based Treatment Train

- An ozone-BAC based treatment train consisting of ozone, biological activated carbon, granular activated carbon, UV disinfection, and final chlorination. As with the RO based train, additional processes were included as a result of the critical control point selection from WRRF 13-03. This includes the addition of a coagulation/settling process ahead of the ozone and biological activated carbon.

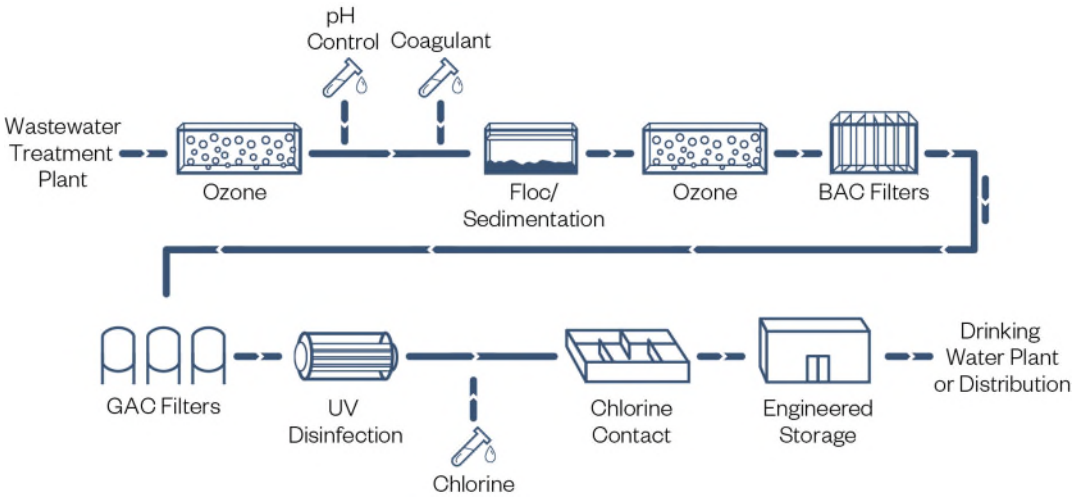

Figure 6.4 – Ozone-BAC-Based Treatment Train

Based on these treatment options and the unit processes contained therein, a detailed review of the existing California water operator and wastewater treatment operator curriculum was conducted in order to determine what content and requirements are already suitable for DPR operations, and to conduct a gap analysis to determine what additional material will be required.

6.5.2 Existing Water and Wastewater Curricula in California

Water and wastewater examination content was reviewed, along with supporting reference material, as a key to the curriculum material that is covered in the examinations. Actual copies of past examinations could not be obtained, as this material is considered sensitive and will not be released for fear of compromising the examination process. A gap analysis was then conducted reviewing requirements for DPR both in terms of technologies employed and also additional operational requirements considered critical to the success of DPR operations.

Wastewater treatment plant examination content is outlined as per the specific regulation (Section 3701 Title 23. Waters Division 3. State Water Resources Control Board and Regional Water Quality Control Boards Chapter 26. Classification of Wastewater Treatment Plants and Operator Certification)(18). The table below details the content, along with the grade of certification for which exam it is relevant.

Table 6.11 - Wastewater Treatment Plant Operator Examination Content - California

Wastewater Treatment Plant Operator Examination Content per Section 3701					
Examinations shall test the applicant's knowledge of:	**Grade I**	**Grade II**	**Grade III**	**Grade IV**	**Grade V**
Basic safety practices and hazards related to wastewater treatment plant operation	X	X	X	X	X
Wastewater constituents including simple and routine sampling and analysis procedures	X	X	X	X	X
Procedures involved in operating and maintaining preliminary and primary treatment facilities including sludge digestion and disinfection	X	X	X	X	X
Specifics regarding the operation of stabilization ponds	X	X	X	X	X
State regulations regarding wastewater treatment plant classification, waste discharge requirements, and operator certification	X	X	X	X	X
Commonly used processes for preliminary, primary, and secondary treatment including disinfection, sludge handling, and digestion		X	X	X	X
Routine sampling and analysis procedures for evaluation of process and overall wastewater treatment plant performance		X	X	X	X
Basic supervision responsibilities		X	X	X	X
Limitations, controls, and performance calculations for primary and secondary treatment and sludge-handling processes			X	X	X
Basic principles of tertiary treatment processes			X	X	X
State regulations regarding water recycling			X	X	X
Public health issues			X	X	X
Limitations, controls, and performance calculations for tertiary treatment processes				X	X
Requirements and practices for water reclamation and reuse				X	X
Supervision and management responsibilities including energy management, safety program development and control, operator training, and budget development and control.				X	X
Knowledge of the components of the Grade IV exam (see above) as applied in more difficult and complex situations					X

The water treatment plant operator certification provides a greater breakdown of curriculum material that is required for the examination. A summary of content is provided below:

Table 6.12 - Drinking Water Treatment Exams Expected Range of Knowledge

Exam Content	**Number of questions**			
Grade	**T1**	**T2**	**T3**	**T4**
Source Water	25	25	20	15
Watershed Protection, Wells/Groundwater, Surface Water/Reservoirs, Raw Water Storage, Clear well Storage				
Water Treatment Processes	25	25	35	20
Coagulation/Flocculation/Sedimentation, Filtration, Disinfection, Demineralization, Corrosion Control, Iron and Manganese removal, Fluoridation, Water Softening, BAT (Best Available Technology)				
Operation and Maintenance	20	20	15	15
Chemical Feeders, Pumps and Motors, Blowers and Compressors, Water Meters, Pressure Gauges, Electrical Generators, Safety, SCADA Systems				
Laboratory Procedures	15	15	15	15
Sampling, General Lab Practices, Disinfectant analysis, Alkalinity analysis, pH analysis, turbidity analysis, specific conductance, hardness, fluoride analysis, color analysis, taste and odor analysis, dissolved oxygen analysis, algae count, bacteriological analysis				
Regulation/Administrative Duties	15	15	15	35
Planning, organizing, directing, controlling, staffing, implementing regulations, record keeping, safe drinking water act and amendments, surface water treatment rule and amendments, primary contaminants, secondary contaminants, lead and copper rule, fluoride regulations, operator certification regulations				

For both water and wastewater operator examination content, a detailed gap analysis was conducted to determine what elements of for IPR/DPR were covered, what was partially covered, and what additional material will be required for DPR. In this assessment, each of the components of the water treatment operations examination expected knowledge is detailed and is consequently a large list. As a result, the detailed analysis of specific items is included in appendix xx to this chapter.

A summary gap analysis is included in the table below:

Table 13 - Water and Wastewater Operations Certification Curriculum - Gap Analysis

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
Source Water/Water Quality (Groundwater/Surface Water/Raw Water Storage)	Provides basic knowledge of water quality assessment and characteristics, including a knowledge of microbial contamination. This will provide a solid base for operators moving to a future DPR certification. Some of the important items include: • Water quality characteristics. • Source water assessment • Ability to recognize abnormal conditions. • Microbial contamination. • Interpretation of water quality reports • Flow and flow measurement. • Calculation of chemical dose. • Measuring pH	Relatively small amount of information on sewer shed and source control.	Additional information for sewershed management and source control. Understanding of industrial waste contributions and other source contaminants that may risk treatment processes. The source water for DPR treatment processes is municipal wastewater. For drinking water operators, a basic knowledge of wastewater processes. In addition, • Understanding source water risks from wastewater source. • Ability to develop and manage a water quality risk register. • Understanding process changes and impacts from wastewater treatment processes. • Understand important key process monitoring parameters at inlet of advanced treatment plant.
Treatment Processes			

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
Coagulation/Flocculation/Sedimentation	Provides a thorough coverage of these processes. This knowledge is likely adequate for DPR operators where this technology is employed (non RO based treatment train)	Some knowledge of clarification processes for primary sedimentation and secondary clarification.	No additional curriculum required for DPR.
Filtration	Provides a thorough coverage of conventional media filtration, with a limited coverage of granular activated carbon.	Minimal information.	Conventional filtration appears well covered, however granular activated carbon and biologically carbon will require significantly more coverage. Membrane filtration (MF/UF) will require substantial coverage.
Disinfection	Provides a thorough knowledge of chlorination practices including analysis of free and total chlorine, calculation of CT, calculation of chemical dose and a knowledge of breakpoint chemistry. Includes some material for ozone, UV disinfection and chloramines.	Provides some knowledge of calculating chlorine demand, operation and maintenance procedures for disinfection, calculating disinfection usage.	Will require additional detail for chloramine dosing, which is used for membrane disinfection. Additional content required includes: • Knowledge of chloramine control. • Protection of RO membranes from chlorine. Ozone also requires additional information including: • Basic understanding of ozone chemistry.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	Wastewater Operations	
			• Basic ozone generation management. • Knowledge of UV absorbance analyzer calibration. • Ozone residual analyzer management • Ozone dose-control strategies
Demineralization (RO, NF and Ion Exchange Treatment)	This contains some water quality analysis content, knowledge of electrical conductivity and total dissolved solids analysis. There is subject matter relating to ion exchange but none for reverse osmosis.	Not included	Reverse osmosis is a core technology for the RO based treatment train. Content for this process is required, including: • Operation and maintenance of membranes • Measurements of process performance and membrane integrity • Monitoring and measurement of chemical rejection and log removal of pathogens
Corrosion Control	Useful basic knowledge of corrosion, including health effects from lead and copper.	Not included	Will provide useful basis for additional chemical stabilization process required for the RO based treatment train.
Iron and Manganese Removal	Thorough knowledge of iron and manganese removal.	Not included	Not specific to DPR treatment processes, however will provide some useful knowledge for RO system membrane scaling and fouling.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
Fluoridation	General knowledge of fluoridation processes.	Not included	Not specific to DPR treatment, unless fluoridation is required in a DPR system that operates directly to distribution.
Softening	Knowledge of water hardness chemistry, hardness removal and softening processes.	Not included	Not directly related to DPR, but some value to RO treatment processes. May also be important for non-RO membrane-based treatment
Wastewater Treatment Technologies	Not included	Material that is focused on the main wastewater treatment processes including: • Preliminary treatment (screening, grit removal) • Primary treatment processes. • Anaerobic sludge digestion • Stabilization ponds • Secondary processes including trickling filters and activated sludge • Sludge handling and solids thickening • Tertiary treatment • Overall process control.	Valuable knowledge for DPR treatment to understand impacts upstream of advanced treatment. It is also important to understand the difference between monthly compliance goals/environmental impacts versus continuous water quality goals for DPR and drinking water quality goals.
Best Available Technology	Knowledge of waterborne pathogens, best available technologies for removal, adverse	Not included	Specific knowledge of technologies / BATs used in drinking water treatment (and DPR) is required.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
	health effects from regulated contaminants and knowledge of emerging contaminants.		
Operations & Maintenance (O&M)	Requires knowledge of key process plant mechanical components including: • Chemical feeder. • Pumps and motors • Blowers and compressors • Water Meters • Instruments and analyzers • SCADA components and on line analyzers • Calibration of some key instruments.	Thorough review of some maintenance requirements including: • Electrical equipment • Motors • Pumps • Valves	Specific knowledge of treatment process maintenance requirements including items such as membrane management, UV lamps, ozone generation and lime/CO_2 systems for stabilization. The understanding of detailed instrument verification and calibration for multiple analyzers is an important addition for DPR.
Laboratory	Thorough requirements for laboratory analysis, chains of custody, sampling and analysis requirements as well as detail on a number of specific, common water quality analyses.	Thorough review of sampling and analysis requirements for wastewater treatment applications.	Some additional knowledge for management of numerous water quality analysis parameters, including knowledge of sampling and sample management for complex contaminants.
Safety	General knowledge of safety, safe working practices, lock out-tag out procedures and some first aid.	General knowledge of safety, including importance of hygiene, lock out tag out, safe work practices and specific safety requirements for wastewater technologies.	Suitable for DPR, with a focus on safety requirements included for technologies specific to DPR.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
Administration	Covers a broad range of administrative requirements including organization, monitoring and reporting requirements, reviewing and transcribing data, review of overall plant performance, review of reports, evaluating facility performance.	Covers a broad range of administrative requirements including staffing, financial management, capital planning, and data management.	Additional requirements include: • Critical control point methodology • Critical control point response procedures and communication protocols • Critical control point incident investigation and follow up action methodology
Regulations	Knowledge of key regulatory requirements including disinfection requirements, knowledge of MCLs, consumer confidence reports, Surface Water Treatment Rule, development of operations plans, disinfection requirements and other regulatory aspects.	Some regulatory content including classification of wastewater treatment plants and operator certification regulations, and requirements for reclamation and reuse (although not focused on IPR/DPR).	Additional knowledge of future DPR regulatory requirements must be included. In addition, any specific reporting and communication protocols for regulators must be included. An important aspect will be the comparison and contrast with water and wastewater regulations. A specific example will be how water quality treatment requirements will likely be a single maximum target, rather than monthly averages or means as is common in wastewater treatment.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	**Wastewater Operations**	
Math	Specific calculations for major water treatment operations including: • Flow rate calculation • Volume calculation • Chemical dosing rates. • Detention times • Backwash rates • Production rates • CT calculations	Specific calculations for wastewater treatment operations including: • Removal efficiencies • Overflow rates • Hydraulic loading • Solids loading • Chemical dosing • Evaluation of specific processes.	Additional calculations will be required for specific unit processes not covered in the existing curricula but required for DPR.
Communication			Effective communication is critical for the success of DPR. Operators must understand the importance of timely communication within their operating facility to assist in rapid and effective operational responses to issues. They must also understand the importance of clear communication across operational interfaces, and to external stakeholders including regulators and the public.
Management of analyzers and instruments.			There is a high reliance on analyzers and instruments for successful IPR and DPR plant operation. Specific curriculum material that covers the importance of regular instrument verification, calibration and key maintenance requirements for important instruments is required.

Topic Area	Existing Curriculum Helpful for DPR		Additional Requirements for DPR
	Drinking Water Operations	Wastewater Operations	
SCADA, reporting and alarm management			Covering important SCADA management and reporting with a focus in particular on alarm management and operator response.
Operational Interfaces	General knowledge of water treatment processes.	General knowledge of wastewater treatment processes.	Knowledge of requirements at operator interfaces between wastewater treatment and advanced treatment, and advanced treatment and drinking water treatment is required. For some utilities, the full suite of treatment may be operated by a single entity. For others, there will be different organizations operating these entities. An understanding of process and treatment at these interfaces is required.
Critical Control Point and the HACCP Process			An understanding of the critical control point approach, including specific critical control points for DPR processes, water quality risk management and operational responses.

The existing curriculum content for both wastewater and water treatment operator certification is relevant to DPR system operation and will provide a strong basis for many of the aspects of both RO based and non-RO based treatment trains. There are, however, gaps as noted in the table above, there are specific requirements for process technology that will require additional coverage including the general content described in Table 6-14 and the specific material listed in Table 6-15:

Table 6-14: Availability of Training Content for DPR Processes

Process Technology	Training Content Availability
Chlorine Disinfection	Good Content Available
Coagulation/Settling	Good Content Available
Chloramines (Pre-MF or Pre-RO Biofouling Control)	Some Content Available
Microfiltration	Some Content Available
Reverse Osmosis Membranes	Some Content Available
Chemical Stabilization (Corrosion Control)	Some Content Available
Ozone	Some Content Available
Granular Activated Carbon	Some Content Available
UV Disinfection	Some Content Available
Biological Activated Carbon/ Biofiltration	Minimum Content Available
UV Advanced Oxidation Processes	Minimum Content Available

Table 6-15 - Required additional material for DPR processes

RO Based Treatment Train	Non RO Based Treatment Train
Chloramination • Basic understanding of chloramine chemistry. • Ability to measure chloramine in water • Ability to measure ammonia in water • Importance of chemical dosing location • Protection of RO systems from excess chlorine or chloramine	**Ozone** • Basic understanding of ozone chemistry • Basic ozone generation management • Knowledge of UV absorbance analyzer calibration • Ozone residual analyzer management • Calculation of ozone CT • Ozone system monitoring • Ozone system safety

Membrane Filtration (Microfiltration and Ultrafiltration) • Membrane terminology • Membrane system configurations • MF system monitoring including TMP and permeability • MF system flux maintenance and cleaning • MF membrane integrity monitoring • MF membrane troubleshooting and repair • Management/Monitoring of turbidity analyzers	**Ozone-BAC** • Filtration theory & importance of upstream pre-treatment (i.e., coagulation) • Basics of biological activated carbon • Understanding of maturation time for organic absorption • Management/monitoring of turbidity analyzers • Know how to calculate empty bed contact time • BAC system monitoring • BAC system safety
UV/Advanced Oxidation • UV reactor basic operation • Management/monitoring of UV transmittance analyzer • UV lamp care, maintenance and replacement • UV lamp ballast care, maintenance and replacement • Handling and management of hydrogen peroxide • Basics of advanced oxidation • Sampling and analysis of NDMA, 1,4 dioxane	**GAC** • Basics of granular activated carbon • Understanding different carbon types and uses • Know how to calculate empty bed contact time • How to determine contaminant breakthrough • Managing filter media replacement. • GAC system monitoring • GAC system safety
Stabilization • Understand how to measure hardness • Understanding management of pH analyzer • Calculation of stability indices (LSI, CCPP, Ryznar Index) • Understanding carbon dioxide dosing systems • Understanding lime dosing systems • Understanding calcite filters • Managing hardness and alkalinity • Understanding the risks from lead and copper in distribution systems. • Lime and CO_2 system safety	**UV Disinfection** • UV reactor basic operation • Management/monitoring of UV transmittance analyzer • UV lamp care, maintenance and replacement • UV lamp ballast care, maintenance and replacement • Calculating UV Dose • UV system monitoring • UV system safety

6.5.3 Existing Sources for Additional Curriculum

Membrane Treatment Processes (Microfiltration and Reverse Osmosis)

There are commercially available courses for reverse osmosis membrane treatment systems that provide a level of certification. An example is David H Paul www.dhptraining.com which provides four levels of reverse osmosis treatment certification for treatment plant operators. These courses provide a combination of classroom and hands-on training covering most aspects of reverse osmosis operation and troubleshooting. These certificates are not recognized by any regulatory agency as directly operator certification, however is a recommended provider of training for some state agencies including TCEQ (Texas Commission for Environmental Quality) where the course can provide continuing education units CEUs.

A Membrane Operator Certification (MOC) has also been developed by the South East Desalting Association based in Florida. This provides training in reverse osmosis and membrane filtration technologies (microfiltration and ultrafiltration). As of 2015, other regional membrane associations including the South Central Membrane Association and the South West Membrane Operator's Association have developed MOCs to cover both membrane filtration and membrane bioreactor technologies. These courses are often conducted by the respective organization at an operating plant or at technical colleges.

These membrane associations, along with the national American Membrane Technology Association (AMTA) also provide a number of operator focused training workshops and conferences which provide training opportunities for operators focused on membrane technologies.

The American Water Works Association (AWWA) has also developed several manuals of practice for membrane systems including:

- Manual of Practice M46 – Reverse Osmosis and Nanofiltration and
- Manual of Practice M53 – Microfiltration and Ultrafiltration Membranes for Drinking Water

UV

There is some content covering UV as a disinfection system in the Californian Water Operator certification curriculum, with a portion of the Disinfection Chapter of "Water Treatment Plant Operation" by Ken Kerri et al.

The AWWA has also developed "The Ultraviolet Disinfection Handbook" as a technical guide for disinfection of drinking water.

Otherwise, UV training is often provided by UV system equipment vendors and engineers on new plant installations, and can be offered by many providers as a stand-alone training service for existing installations.

Advanced Oxidation

Advanced oxidation is a less common water treatment technology that has applications in advanced water recycling, taste and odor control for surface water treatment systems, and as for treatment of groundwater for some organic contaminants. Training is currently provided almost exclusively by equipment vendors, with some additional material provided by engineering consultants. This particular process area will require a significant curriculum development.

Ozone

As with UV, ozone dosing for disinfection is also briefly covered in the Disinfection chapter of "Water Treatment Plant Operation" Kerri et al, 2007. In addition, a recently published book "Ozone in Drinking Water Treatment: Process Design, Operation, and Optimization", Raknes 2015 is available.

Ozone/BAC

Ozone/BAC processes, and biofiltration in general, are not currently covered in existing curriculum material. While there are numerous journal articles and conference papers that cover this material, it has not yet been established as training content for certification programs and we could not find in our review any operationally-focused reference material. There is some material covering the use of ozone/BAC covered in "Activated Carbon, Solutions for Improving Water Quality", Chowdhury et al, 2013, AWWA.

6.6 Proposed Operator Certification Framework for DPR

A successful operator certification framework for DPR must be one that is workable for operations staff and utilities. It must provide value in developing ensuring the capacity of operational staff and underpin safety and reliability for this supply of drinking water.

As described in the previous sections, a DPR operator certification must provide:

- Adequate coverage of DPR technologies.
- Understanding of source water risks and risk management.
- Incorporation of the critical control point methodology.
- Specific DPR regulatory requirements are included.
- Management of operational responses are covered.

However, not only must the certification framework account for this important curriculum content, it must also be a framework that operators and utilities alike find workable and that does not provide substantial impediments for finding and developing operator staff for facilities. On the contrary, it must incentivize operators and utilities to obtain and be recognized for the skills and knowledge required to manage DPR.

At the outset, it must be acknowledged that future DPR facilities will be operated by staff that are drawn from the existing pool of certified water and wastewater operators. Consideration must therefore be given to how to integrate DPR certification into the existing system, and how to leverage from the existing certification programs. It must also be acknowledged that DPR facilities will likely remain a small fraction of the overall water and wastewater treatment facilities in any given state, and therefore a difficult or cumbersome operational framework may be a major disincentive for operational staff and provide challenges for utilities to staff their new facilities. While this project does not intend to water down the requirements considered necessary for a DPR certification, developing a program that is accommodating given these realities is nonetheless important to its success.

In order to determine a preferred program, a number of options are discussed below.

6.6.1 Option 1 – Specific DPR Certification Curriculum

This option considers the development of a stand-alone operator certification for DPR that draws from a base of water and wastewater certified operators (Figure 6.4). In this case, for lower operator grades (1 & 2), an operator would progress through either water or wastewater certification, with an additional DPR

examination module to cover some elements of DPR technology and other important introductory curriculum.

For these two lower grades, the operators would remain certified as water or wastewater operators, but would have an additional DPR accreditation. This additional accreditation should cover core elements of the advanced technologies utilized at their facility, along with other key elements of DPR (detailed in table xx below).

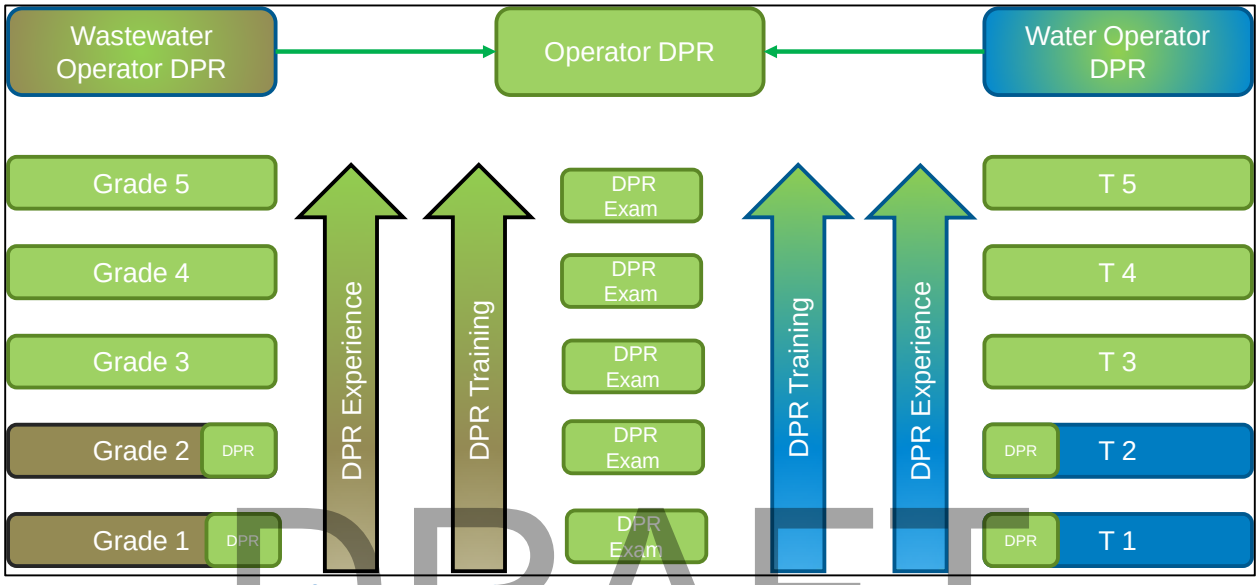

Figure 6.4 - DPR Operator Certification Framework Option 1

In terms of operating experience, consideration could be given to allow water and wastewater plant operation for those grades to be counted toward total experience. This would allow operators from non-DPR facilities to begin preparation to work at a facility that is being built for DPR, or allow them to transfer from a water or wastewater facility to a DPR facility. This provision would likely increase the available pool of operators for new facilities which will be important during the time where the number of DPR facilities will be limited relative to the operations pool of resources.

From a grade 3 or T3 onwards, in this model the operator certification would transition to a specific DPR certification. From this point the examination would focus on DPR technologies and experience and will be required for operating a DPR facility.

The examination would contain a common core of important DPR elements, along with elective technology modules, in order for staff to tailor the technology component to the plant at which they are working, or are considering working. The table below outlines proposed content.

Table 6.16 - General Curriculum for DPR certification grade levels.

Operator Grade	DPR Curriculum Summary	General content/curriculum material.
1	Technology modules (MF, RO, UV-H_20_2, GAC, Ozone-BAC, Stabilization),	Focused on providing additional content for DPR, leveraging

	Source water risks. Critical Control Point Process and response procedures. Safety for DPR. DPR regulations. Sampling and analysis for DPR. Analyzer management.	from water and wastewater curriculum.
2	Technology modules (MF, RO, UV-H_20_2, GAC, Ozone-BAC, Stabilization) – (more advanced) Source water risks. Critical Control Point Process and response procedures. Safety for DPR. DPR regulations. Sampling and analysis for DPR. Analyzer management.	
3	Technology modules (MF, RO, UV-H_20_2, GAC, Ozone-BAC, Stabilization) – (more advanced) Source water risk management and responses. Critical Control Point Process and response procedures. Safety for DPR. Sampling and analysis for DPR. DPR regulations. Analyzer management. Laboratory management for DPR.	Content focused specifically on DPR requirements, with greater emphasis on managing specific DPR requirements.

	Wastewater and drinking water treatment interface management. Importance of effective communication with stakeholders.	
4	Technology modules (MF, RO, UV-H_20_2, GAC, Ozone-BAC, Stabilization) – (more advanced). Managing water quality risk assessment. Critical Control Point Process management, response procedures. Safety for DPR. Sampling and analysis management for DPR. Analyzer management. DPR regulations. Communication with stakeholders, management and regulators.	Greater focus on operational management aspects and communication requirements.
5	DPR system management. DPR regulations. Critical control point system management. Water quality and operational risk management. Communications with stakeholders, regulators and the public.	Greater operational management focus.

This approach provides the advantage of a clear pathway for DPR, drawing from both the water and wastewater pool of operators. However there are some significant disadvantages including:

- A specific operator certification for DPR may restrict operators to a relatively small pool of operating facilities, unless they become transferable for water or wastewater certification.

- Operators that are already grade 3 or grade 4 may be required to drop to lower levels to cover curriculum, experience and certification requirements specific for the DPR curriculum. Consideration would need to be given in particular to grandfathering certified operators that are currently operating IPR systems if those systems become upgraded to DPR. Alternatively consideration of a phase-in period to allow transfer of highly qualified operators from water and wastewater plants to take on senior operating roles of new DPR facilities.

6.6.2 Option 2 – DPR "Add On" to Existing Certification Frameworks.

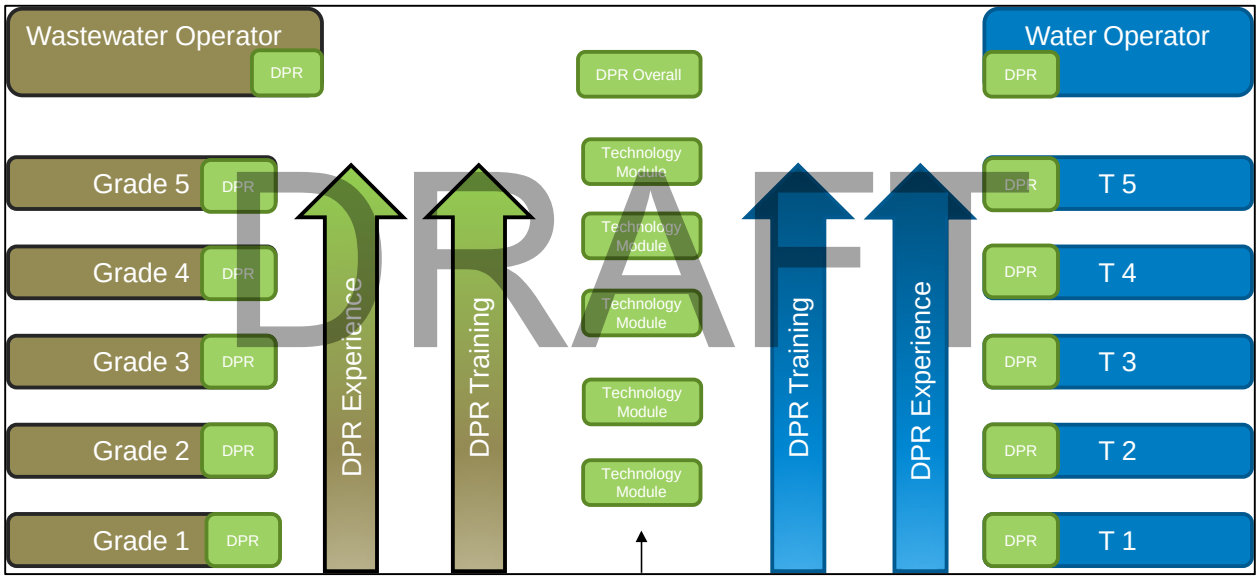

Figure 6.5: DPR Operator Certification Framework 2

This option considers the use of the existing operator and certification framework for both water and wastewater, with an additional module for DPR included at that level of certification. For this approach, an additional examination would be required to cover elements that are particular to DPR. An operator would progress as a water or wastewater operator, but would also be required to obtain an additional certification for DPR.

In this case, there would be a major benefit in taking advantage of the existing operator certification curriculum, and adding on this basis, as this would increase the pool of available operators for plant operation substantially. As an add-on, it would provide greater incentive for operators as they would be working to add material specific to their roles, but would also continue with an existing certification path and not become stranded in DPR if they wanted to move to other non IPR/DPR facilities.

As for option 1, there would be a set of core material for DPR, however tailored to build on existing curriculum material and act to bridge gaps. Elective modules would also be included to allow operators to focus on specific technology.

Experience could be gained either from a water or wastewater plant, however consideration would need to be given as to whether specific DPR experience is required beyond a certain grade of certification (as for Option 1). While DPR-specific experience would be desirable, it must be noted that the relatively small number of DPR facilities may limit the ability for new and transfer operators to achieve certification. A possible work-around would be the consideration of identifying specific experience requirements for various process components (for example focus on some technologies in application outside of a DPR environment, such as reverse osmosis treating groundwater for drinking for example).

The California/Nevada AWWA has currently commissioned an Advanced Water Treatment Certification Committee, which is focused on developing operator certification for advanced technologies – including those used for DPR, but also used in IPR, groundwater treatment and other applications. This development may assist in the development of technology modules that could be appended to the existing certification framework.

6.6.3 Option 3 - DPR "Add On" to Existing Certification Frameworks covering Water/Wastewater Certification Gaps

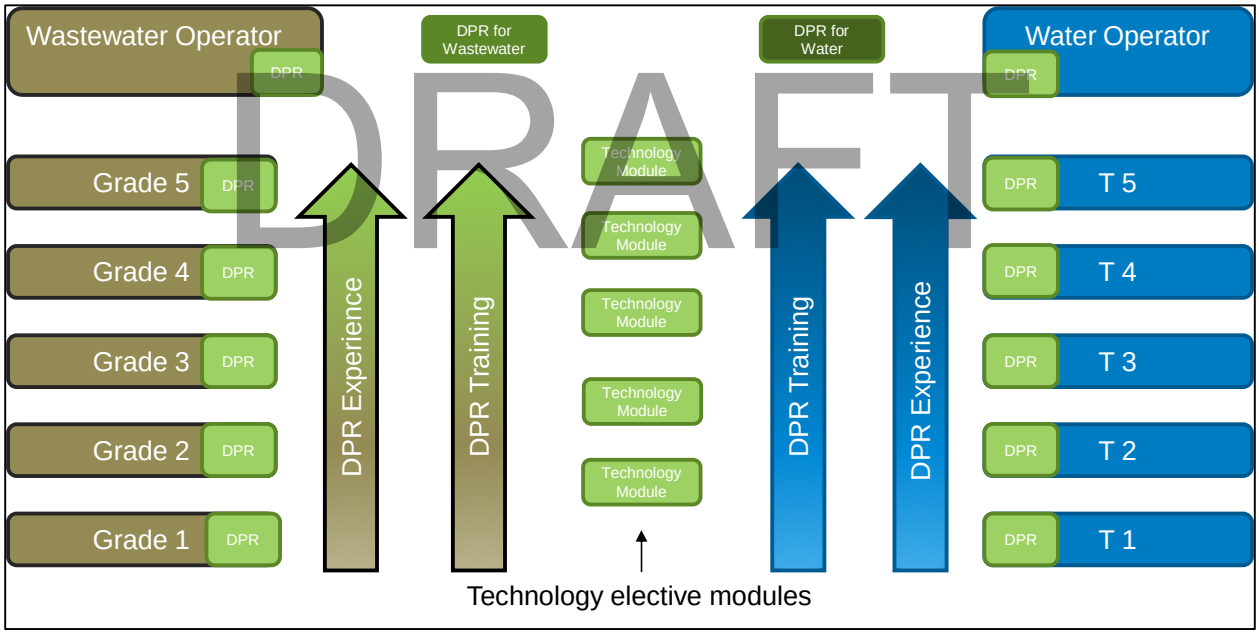

Figure 6.6: DPR Operator Certification Framework 3

This option is similar to Option 2, but also acknowledges that there is material in the curriculum from either water or wastewater certification curriculum that is important for operations. That is, it is important for water derived DPR operators to have knowledge of wastewater operations and vice versa.

This framework would operate in a manner analogous to Option 2, however the DPR core examination material would be different for water-derived and wastewater-derived operators to assist in covering gaps in each other's knowledge.

6.6.4 – Consideration of Competency Based Curriculum

As noted for each of the three options above, an examination and experience component would be required for each progressive level of operator certification. One of the challenges faced in gaining certification for operators from the existing pool of water and wastewater will be in obtaining specific experience in DPR if they are not working at a DPR facility. In addition, even if operators are working at a DPR facility, it will be critical to have a methodology for quantifying and validating specific experience.

A competency-based assessment program may assist in providing greater structure and provide important validation for the experience component of operator certification. By placing emphasis on demonstrating specific skills and tasks in the field, we can have greater certainty that the operator has the necessary skills to operate the facility. There will be surety that the operator can perform important tasks – not just pass an examination. This competency-based approach could also allow for many elements of the experience to be conducted at non-DPR facilities, if the requirements are similar enough to DPR. Further, by the use of competency-based assessments, there may be an ability to reduce the amount of material that is required for an examination, and instead replace this with competency based modules.

A key concern raised for competency-based approaches is ascertaining the veracity of site testing, and the scrutiny of the examiner or reviewer. It is true, that there is a higher risk of subjectivity relative to a direct examination. However, if well-developed, a testing of in-field skills can provide a greater mitigation of operating risk than passing an exam. For example, demonstrating the completion of a response procedure for a critical control point, rather than simply answering an exam question about it, will provide great certainty that the operator understand the material and can apply it accordingly.

It is highly recommended that facilities consider this approach for operations staff, even if this remains an internal utility arrangement independent of state certification.

6.6.5 Educational Requirements and Continuing Education Credits.

Overall, it is recommended that educational requirements and educational units be consistent with those currently required for water and wastewater operator certification. It is recommended that continuing education units be pursued at relevant venues for both DPR technologies, and for reuse itself. These can be achieved from external training opportunities (for example the membrane association MOC schools, regional reuse conferences and training seminars) or from in-house training sessions that receive certification for education credits. As DPR systems become more prevalent, consideration of training programs developed by regional AWWA, WEF, and WateReuse organizations should be considered.

6.6.6 – Overall Recommendation

It is recommended that a DPR operator certification be a system that is appended to the existing water and wastewater certification, consistent with Option 3 noted above.

This will ensure that there is a substantial pool of operators that can be drawn from for new DPR facilities, and that any operator that chooses to take on DPR will still have opportunities for transfer and promotion to other, non-DPR facilities in the future. This system will also leverage from existing operator certification programs for water and wastewater and thus attention can be focused on developing the additional curriculum that is required, rather than starting a system afresh. Recommendations on the required additional curriculum have been included in the sections above.

It is also recommended that consideration be given to a competency-based approach to the experience portion of certification required. A competency based approach will provide some certainty that operations staff not only have the knowledge, but are truly competent at specific, required tasks.

References:

(1) California Code of Regulations Title 22, Division 4, Chapter 13 sections 63775 and 63800.

(2) Office of Water Supply Programs Sacramento State University
http://www.owp.csus.edu/courses/drinking-water.php

(3) Title 22 CCR, Division 4, Chapter 15 - Domestic Water Quality and Monitoring, Article 2

(4) WWTP OPERATOR CERTIFICATION REQUIREMENTS TABLE Title per 23 CCR, Division 3, Chapter 26 section 3688.

(5) (http://www.swrcb.ca.gov/water_issues/programs/operator_certification/wwtp.shtml)

(6) Workshop discussion, M Patel, T Neilly, Orange County Water District GWRS.

(7) Los Angeles Bureau of Sanitation Workshop, Terminal Island Facility.

(8) Santa Clara Valley Water District, Pam Johns.

(9)
http://texreg.sos.state.tx.us/public/readtac%24ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=290&rl=46

(10) www.tceq.texas.gov

(11) Revision to the Previously Granted Exception to Use Membrane-Treated Reclaimed Wastewater from the Big Spring Wastewater Treatment Plant as a Raw Water Source for Public Drinking Water Systems Colorado River Municipal Water District – PWS ID No. 1140038, Howard County Texas (Letter – April 11, 2013).

(12) U.S. Department of the Interior, Bureau of Reclamation, *Colorado River Basin Stakeholders - Moving Forward to Address Challenges Identified in the Colorado River Basin Water Supply and Demand Study: Phase 1 Report,* p. 3-20, 2015.

(13) State of Arizona, Blue Ribbon Panel on Water Sustainability, *Final Report*, November 30, 2010, p. 28.

(14) Presentation by Tim Thomure, Arizona Steering Committee to Advance Potable reuse, "*Potable Reuse in Arizona An Update on the Statewide Initiative"* presented at AZ Water Association monthly meeting, April 14, 2015.

(15) http://dnr.wi.gov/regulations/opcert/wastewater.html.

(16) Victorian framework for water treatment operator competencies Best practice guidelines. Victorian Department of Health and Victorian Water Industry Association.

(17) Australian Government Industry Skills Panel NWP07 Water Training Package Water Industry Training Center NWP -07 Training Handbook.

(18) Section 3701 Title 23. Waters Division 3. State Water Resources Control Board and Regional Water Quality Control Boards Chapter 26. Classification of Wastewater Treatment Plants and Operator Certification