A PROPOSED FRAMEWORK FOR REGULATING DIRECT POTABLE REUSE IN CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

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IN CALIFORNIA

Contents

1. Introduction

1.1. Potable Reuse in California

California has seen considerable development in potable reuse, the planned use of recycled water to supplement drinking water supplies. The planned replenishment of groundwater basins with recycled water, a form of indirect potable reuse (IPR), has been practiced in the State for over 50 years. Los Angeles County has operated the Montebello Forebay Spreading Grounds since the 1930's to replenish the groundwater basins underlying the greater metropolitan area, and in 1962 started supplementing imported water and local storm water with recycled water for use in the spreading basins. Orange County Water District has operated a system of groundwater injection wells at the Talbert Gap to keep seawater out of the groundwater basin underlying Orange County since 1965, and in 1976 started supplementing imported water with recycled water as a source of injection water.

California first adopted regulations for groundwater replenishment with recycled water in 1978. Since then, the California Department of Public Health (CDPH) developed several major draft revisions of the groundwater replenishment regulations, reflecting research and technological advances that allowed for improved regulation for the protection of public health. In 2014, CDPH adopted revised regulations for groundwater replenishment using recycled water.

Following the 2014 transfer of the State's Drinking Water Program from CDPH to the State Water Resources Control Board (State Water Board), the Board in 2018 adopted regulations for another form of IPR, surface water augmentation. Surface water augmentation allows for recycled water to be added to a surface water reservoir that is used as a source of drinking water. Unlike groundwater replenishment projects and their long history in

California, the development of surface water augmentation projects is in its infancy. The first two projects proposed, both in San Diego County, are expected to be completed in the 2022 time frame.

1.2. SB 918 and SB 322

In 2010 and 2013, the California Legislature enacted Senate Bill (SB) 918 and SB 322, respectively, which defined the term "direct potable reuse" (DPR) and directed CDPH to investigate the feasibility of developing uniform water recycling criteria for DPR and report to the Legislature by December 31, 2016. SB 918 also directed CDPH to convene an expert panel to advise on public health issues and scientific and technical matters regarding the investigation, as well as to assess whether additional areas of research are needed to be able to establish uniform regulatory criteria for DPR. The responsibility for completing and submitting the final report to the Legislature was transferred to the State Water Board on July 1, 2014.

> *"Direct potable reuse" means the planned introduction of recycled water either directly into a public water system, as defined in Section 116275 of the Health and Safety Code, or into a raw water supply immediately upstream of a water treatment plant. [Water Code section 13561(b)]*

1.3. Feasibility of Developing Uniform Water Recycling Criteria for DPR

In December 2016, the State Water Board submitted the report to the Legislature. Entitled "Investigation on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse", the report concluded:

> *"The State Water Board finds that the key knowledge gaps and key research recommendations must be addressed before uniform water recycling criteria for DPR can be adopted. While the State Water Board can move ahead and start the process of developing criteria for DPR, completion of the six research recommendations*

> *and filling in the key knowledge gaps must be achieved in order to be able to successfully adopt a set of uniform water recycling criteria for DPR that is protective of public health.*
>
> *A common framework across the various types of DPR will help avoid discontinuities in the risk assessment/risk management approach as progressively more difficult conditions are addressed. Accordingly, developing DPR criteria will require a deliberate and phased approach to ensure public health protection and continued consumer confidence in the public water supply.*
>
> *It is also important to note that significant work is needed to address the recommendations provided by the Expert Panel and the Advisory Group regarding the non-treatment barriers that are part of ensuring the safety of DPR, including source control, wastewater treatment plant optimization, operator certification, and technical, managerial, and financial capacity."*

The State Water Board developed recommendations for research based on research areas identified by the Expert Panel. The research will be conducted concurrently with the development of uniform water recycling criteria for direct potable reuse, such that the findings from the research can inform the development of those criteria. The status of the required research is discussed in Section 8 of this report.

1.4. AB 574

Assembly Bill (AB) 574 (Chapter 528, Statutes of 2017) introduced new terminology and statutory definitions for two distinct forms of DPR, "raw water augmentation" and "treated water augmentation":

> *"Direct potable reuse" means the planned introduction of recycled water either directly into a public water system, as defined in Section 116275 of the Health and Safety Code, or into a raw water supply*

immediately upstream of a water treatment plant. Direct potable reuse includes, but is not limited to, the following:

(1) "Raw water augmentation," which means the planned placement of recycled water into a system of pipelines or aqueducts that deliver raw water to a drinking water treatment plant that provides water to a public water system, as defined in Section 116275 of the Health and Safety Code.

(2) "Treated drinking water augmentation," means the planned placement of recycled water into the water distribution system of a public water system, as defined in Section 116275 of the Health and Safety Code.

By repealing the definition of "surface water augmentation" and establishing a definition for "reservoir water augmentation"[1], AB 574 clarified IPR involving the augmentation of reservoirs used as raw drinking water sources to include scenarios where raw water transmission pipeline(s) deliver advanced treated recycled water to such a reservoir. Because the State Water Board has recently adopted regulations for surface water augmentation, this change in statute requires the State Water Board to undertake a regulatory process to revise the regulations per the Administrative Procedure Act. This is further discussed in Section 9 of this report.

AB 574 requires the State Water Board to adopt uniform water recycling criteria for direct potable reuse through raw water augmentation by December 31, 2023, with provisions for extension of the deadline. AB 574

[1] AB 574 amends Water Code section 13561 to replace the term "surface water augmentation" with the term "reservoir water augmentation". However, for the purposes of this report, the term "surface water augmentation" is used.

also recommends that the State Water Board establish a framework for the regulation of potable reuse projects by June 1, 2018.

1.5. Purpose of this Document

The public health objectives used to develop drinking water standards and other requirements under the California Safe Drinking Water Act are applicable to all sources of drinking water, from pristine sources to extremely impaired sources. Hence, the goals and principles pertaining to public health do not fundamentally change in considering potable reuse.

There are a number of public health threats, risk management opportunities, and permitting options that will vary as the State Water Board proceeds through the range of potable reuse types -- from IPR, through the intermediate forms of DPR, and to what is commonly referred to as flange-to-flange[2] DPR. While the goals and principles for public health do not fundamentally change, the expression and application of the goals and principles will differ over the range of potable reuse forms. This is due to factors of varying importance such as natural sources of supply, treatment through natural attenuation, environmental buffers, reliability of engineered treatment, and monitoring and control systems.

In its report to the Legislature, the State Water Board identified the need to develop a common framework across the various types of DPR to help avoid discontinuities in the risk assessment/risk management approach as progressively more difficult conditions are addressed.

This document provides that framework, and evaluates how each of the factors described above is expected to change over the range of potable

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[2] Flange-to-flange DPR, in the context used, refers to the introduction of recycled water directly into the drinking water distribution system.

reuse forms, and shows how public health will be protected as the form of potable reuse changes. This document also satisfies the recommendation in AB 574 to establish a health-protective framework for the regulation of potable reuse projects that takes into account the State Water Board's report to Legislature, a schedule for completing the recommended research as described in the report, and a process and timeline for updating the uniform water recycling criteria for surface water augmentation.

2. Types of Potable Reuse

Although many conventional water supplies in California have a small municipal wastewater discharge component from unplanned (*de facto*[3]) potable reuse, this document will focus on planned potable reuse. Planned potable reuse has been the subject of a great deal of scientific study that emphasizes the threats and risk management strategies for the contaminants found in municipal wastewater.

The State Water Board has considered indirect potable reuse to be the planned placement of recycled water into an environmental buffer, such as a groundwater system or surface water reservoir, before the blended water is used as a source of drinking water by a public water system. Therefore, the regulations for IPR include minimum requirements for assuring the environmental buffer utilized has a meaningful protective benefit to public health.

Consistent with the statutory definition, direct potable reuse (DPR) refers to the planned introduction of recycled water directly into a public water system's potable water pipelines or tanks for distribution to customers ("treated water augmentation"), or the planned introduction of recycled water into a raw water supply that directly feeds a water treatment plant that supplies potable water to a public water system ("raw water augmentation"). Therefore, DPR regulations will need to include additional criteria to compensate for the loss of the protective benefits assured by the presence of a meaningful environmental buffer in IPR projects.

[3] *De facto* potable reuse is the unplanned or incidental presence of treated wastewater in a downstream water supply source.

3. DPR Scenarios

AB 574 distinguishes between the regulation of raw water augmentation and the regulation of treated water augmentation. The definition of raw water augmentation allows for a wide variation of project scenarios that include the type and quality of raw water augmented, blending ratios, and the nature of the water treatment plant. A main challenge in developing appropriate DPR criteria is clarifying the definitions of raw water augmentation and treated water augmentation in order to distinguish between the two types of DPR.

Therefore, for the purpose of developing raw water augmentation regulations, the State Water Board intends to consider raw water augmentation to mean projects where:

- The drinking water treatment plant is a filtration facility that has reliably demonstrated that it meets the requirements of California's Surface Water Treatment Rule[4] over a period of time;
- The recycled water is mixed with raw water in the conveyance to a drinking water treatment plant such that the blend provides a meaningful public health benefit; and
- The project does not meet the requirements of the SWA (and future reservoir water augmentation) criteria.

As an example, if a project includes a mixture of recycled water and groundwater that is then treated at a drinking water treatment plant that simply provides iron and manganese treatment to meet secondary (aesthetic) drinking water standards (i.e., the treatment does not address

[4] For California's Surface Water Treatment Rule, see California Code of Regulations, Title 22, Division 4, Chapter 17.

the public health issues associated with DPR), the project would be a treated water augmentation project.

Future regulations that will address treated water augmentation will consider the following scenarios:

- Flange-to-flange DPR;
- Projects unable to meet IPR or raw water augmentation criteria, such as environmental buffer and/or dilution criteria;
- Recycled water conveyed to a water treatment plant other than a filtration facility that meets the requirements of the Surface Water Treatment Rule.

4. Environmental Buffer

The existence of an environmental buffer, passage of recycled water through an aquifer or reservoir, is the key difference between indirect potable reuse (IPR) and direct potable reuse (DPR). Although there can be numerous unquantifiable benefits of an environmental buffer, there must be measurable and significant public health benefits from an environmental buffer for a potable reuse project to qualify as IPR.

When the environmental buffer is inadequate or not present, the loss of the environmental buffer must be addressed in order to maintain an equivalent level of public health protection. The SB-918 Expert Panel suggests that the benefits of the environmental buffer can be substituted with enhanced reliability provided by mechanical systems and treatment plant performance.

4.1. Groundwater Benefits

The environmental buffer for a groundwater replenishment IPR project must provide a minimum 2-month time of travel underground before the water is suitable for potable consumption. This minimum time of travel is deemed sufficient for a public water system to detect, recognize, and respond to potential treatment failures and/or water quality problems, such that water used for potable consumption is safe to drink at all times. Additionally, groundwater replenishment IPR projects provides some removal of organic compounds and pathogen reduction.

4.2. Reservoir Benefits

The environmental buffer for a surface water augmentation IPR project must provide adequate mixing capacity to address a short-term failure of treatment of up to 24 hours. In addition, the theoretical retention time of the augmented reservoir must be no less than 60 days, which establishes a simple operational criterion as a means of assuring the reservoir would be of sufficient size to be able to provide greater opportunity and options for responding to and potentially mitigating significant treatment failures.

5. Risk Management Approach

The risk management approach for pathogens and chemicals across the various types of potable reuse is described in the following sections.

5.1. Pathogens

The density of microbiological pathogens (e.g., viruses, bacteria, parasites) in raw municipal wastewater is high enough to cause unacceptable levels of illness after a single, brief exposure. The density must be greatly reduced continuously by removal or inactivation in the environment and/or engineered treatment to yield safe drinking water.

5.1.1 General Potable Reuse Regulatory Pathogen Control Approach

The approach used to control the threat from pathogens is to identify a set of reference pathogens, identify the log removal values (LRVs) necessary to meet the health objective for each, and validate treatment processes for treatment trains that achieve the LRVs with the required reliability.

The set of reference pathogens should be comprehensive enough to represent the risk posed by all pathogens. It is not practical, however, to regulate water quality using a large number of reference pathogens. Reference pathogens are selected based on a number of factors including pathogenicity, potential occurrence in the source wastewater, and susceptibility to treatment. Enteric virus, *Giardia*, and *Cryptosporidium* were used to regulate IPR. Additional and/or alternative pathogens are likely to be considered for DPR.

The required LRV for each reference pathogen is calculated using the organism density that can occur in the raw wastewater and the density in finished drinking water that will result in an appropriate level of public health protection.

Individual treatment processes, both natural and engineered, are validated for a specific LRV in a manner that assures they will be achieving the credited LRV reliably. A treatment train LRV is the sum of the individual process LRVs for the train.

5.1.2 Potable Reuse Form Influences Pathogen Control Regulation Structure

Differences among the various forms of potable reuse require criteria customized to the threats and health protective features of each.

IPR is the planned augmentation of a surface or groundwater supply with treated municipal wastewater. Recycled water treatment is required to reduce contaminants to the acceptable levels for a similar conventional source. A significant fraction of the pathogen LRV may occur through natural treatment in the environmental buffer. Critical circumstances of the recycled water passage through the environment are specified in regulation to assure that significant contaminant attenuation is provided and/or that there is time to identify and react to a pre-discharge treatment failure. A groundwater replenishment IPR project must meet 2014's groundwater replenishment regulations to ensure protection of public health, as well as any additional permit requirements and applicable Waste Discharge Requirements necessary to protect the groundwater basin. A surface water augmentation project must meet the recently adopted surface water augmentation regulations to ensure protection of public health, as well as any additional permit requirements and applicable Waste Discharge Requirements necessary to protect the lake (i.e., reservoir).

DPR is the use of recycled water as a source of drinking water where the influence of an environmental buffer is small, minimal, or absent. Engineered treatment, and the accompanying monitoring and controls, must be sufficient to consistently make safe drinking water out of municipal wastewater. DPR projects might be regulated with both Waste Discharge

Requirements and public drinking water system permits, or simply a public drinking water system permit. With the establishment of DPR Regulations, protection of public health would be addressed via compliance with the regulations, as well as permits issued to public water systems.

5.1.3 The Nature of the Threat Posed by Pathogens Changes across the Forms of Potable Reuse

The importance of knowing the status of treatment process LRV efficacy in real time is a function of the proximity of the treatment process to the drinking water consumer and the severity of a treatment failure. The more proximate the treatment process to the consumer, the more urgent it is to know the status of the treatment process. Likewise, the more severe the treatment failure, the greater the urgency in knowing the status of the treatment process. Severity is proportional to the LRV expected of the treatment – the LRV that may not occur in the event of a treatment failure. The urgency for action in response to a treatment deficiency increases with proximity and severity.

The environmental buffer in IPR can involve dilution and natural treatment to reduce pathogen densities, and afford time to address treatment failures. The environmental buffer greatly lessens proximity. Natural treatment is usually very reliable and provides robust and resilient pathogen reduction because of the mechanisms involved and because it is not subject to the same failure modes associated with operated equipment.

DPR projects minimize the role of an environmental buffer. The loss of the benefits of the environmental buffer must be offset with equally effective and reliable engineered treatment proximate to the drinking water user. The potential urgency for protective action is at its greatest with DPR.

5.1.4 Risk Management Tools that can be Adapted in Criteria for the Potable Reuse Types

There are a number of instruments (e.g. engineered treatment reliability and redundancy, monitoring, system controls, LRV specifications) that can be required in a manner that compensates for the diminishing role of the environmental buffer. The threats associated with proximity and severity are different and theoretically could be addressed with different risk management instruments. However, because no individual instrument is proven to be absolutely effective (e.g. there is no monitoring technology that can show that individual pathogens are reduced to a safe level) several will be used in combination to address those threats.

5.1.4.1 Specify in Criteria How the Health Goal and LRVs Are To Be Met

The 10^{-4} annual per capita risk of infection has been used as the public health objective for controlling involuntary exposure to microbial contaminants and has been the fundamental objective for pathogen control for all forms of IPR. The manner in which the objective is implemented in criteria will change with the type of DPR due to the varying circumstances of the DPR projects and nature of the pathogen threat.

For IPR, LRVs are established, treatment processes are validated, operations plans are approved, and the allowable deviations from the LRVs are specified. The allowed LRV deviations in the pre-discharge treatment are determined with recognition of the attenuation of pathogen densities in the environmental buffer and are commensurate with the degree of fluctuation accepted in similar conventional sources.

For DPR, LRVs will be established, treatment processes will be validated, operations plans will be approved, and allowable deviations from the LRVs will be specified.

The connection between the raw wastewater, intervening treatment, and the drinking water system is much closer in terms of time and distance for

DPR than for other forms of potable reuse. Rather than allow water microbial quality and risk of infection to fluctuate significantly and meet the risk objective on an annual average, the treatment scheme is expected to be regulated to provide consistently safe water by imposing a daily risk objective that would not exceed 2.7×10^{-7} per day (10^{-4} per year/365 days per year = 2.7×10^{-7} per day). Treatment that consistently meets the daily risk objective will also meet the annual risk objective.

To minimize the chance that the LRVs necessary to meet the health objective are not consistently met, DPR projects must provide log reduction capacity in excess of the basic LRVs (redundant LRV treatment). Determination of the extra log reduction capacity will involve:

- Identifying an acceptable probability for failing to meet the log reduction targets,
- Using probabilistic analysis of treatment train performance to evaluate the ability of candidate treatment trains to achieve the probability,
- Identifying the extra LRV capacity provided by treatment trains achieving the probability

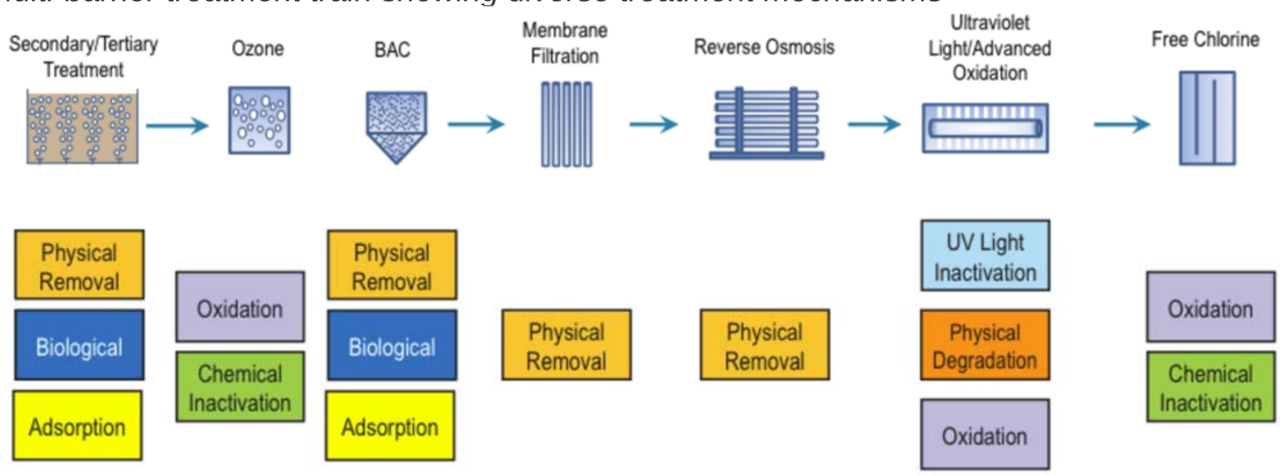
5.1.4.2 Environmental Buffer

The contaminant attenuation and treatment failure response opportunities decrease as the environmental component is reduced. IPR provides an environmental buffer with quantifiable benefits. DPR may have a reduced environmental buffer with lesser quantifiable benefits, merely qualitative benefits, and in some cases, no environmental buffer at all. Because of the difficulty defining small benefits on a uniform statewide basis, any benefit credited to a DPR environmental buffer must be demonstrated by a project proponent. This would be approved on a case-by-case basis.

5.1.4.3 Engineered Treatment

IPR consists of wastewater treatment, substantial soil aquifer treatment (SAT) or advanced treatment prior to recycled water discharge to the environmental buffer, and, in some cases, LRV-credited natural treatment. The treatment processes used to comply with the required LRV must be validated by the project proponent and approved by the State Water Board. The validation consists of demonstrating that the treatment will reliably achieve the credited LRV using the target organism or an approved surrogate. The LRV must be correlated with a parameter that is routinely measured and indicates ongoing attainment of the LRV. The use of a

Multi-barrier treatment train showing diverse treatment mechanisms



Source: May 2017 City of San Diego Pure Water Program Title 22 Engineering Report

performance standard for each treatment process allows verification of its LRV independent of how well other processes are working. The IPR criteria place limits on the minimum number and LRV of treatment barriers to assure a multi-barrier treatment train.

DPR depends entirely on engineered treatment to meet the LRV requirement. The validation process, as used for IPR treatment, is effective but has limits. It is practical to validate individual treatment processes to achieve an LRV at the 5th percentile, which can be done using at least 20 data points. Validating technologies at an extremely low probability (i.e., < 1%) of not achieving the design LRV would require considerably more sampling and is generally not practical. Requiring redundant treatment barriers is a more practical means of assuring highly consistent LRV performance. The multi-barrier concept can be enhanced for DPR by increasing the number of effective barriers required and requiring diversity of organism reduction mechanisms.

The log reductions provided by a SWTP could be used to meet the extra log reduction capacity for a DPR project, but not the basic LRVs. This is for two reasons:

- A SWTP is designed to treat natural surface water, not RO permeate, and
- The potable reuse LRV validation procedures are very different from those used for surface water treatment.

5.1.4.4 Monitoring

The need for accurate real-time information on the actual LRV provided by individual treatment processes increases with proximity to the drinking water consumer and increases to a maximum for DPR. This information is necessary for the operators and automated alarms or control systems.

5.1.4.5 Control System

With DPR the urgency for action if treatment fails increases substantially beyond that for IPR. Relying on approval of an operations and maintenance (O&M) plan incorporating best conventional practices may not be sufficient. A critical control point (CCP) program, where a treatment process loses LRV credit when monitoring no longer indicates effective treatment, is likely to be a requirement of DPR. An effective CCP program is essential to the implementation of a fail-safe DPR project.

5.1.4.6 Quantitative Microbial Risk Assessment and Probabilistic Analysis of Treatment Train Performance

A probabilistic analysis of treatment train performance (PATTP) can be used to evaluate treatment trains for their ability to meet the LRV treatment objectives of the DPR criteria. Compliant treatment trains could be authorized in the criteria and/or PATTP could be included in the criteria for the approval of treatment trains on a case-by-case basis.

Quantitative microbial risk assessment (QMRA) can be used to test proposed DPR criteria for the ability to assure achievement of the fundamental health objective. QMRA could also be used to evaluate DPR project safety whenever additional pathogen monitoring results vary from the pathogen assumptions used in criteria development.

5.2. Chemicals

Municipal wastewater treatment plants receive wastes from a variety of different types of dischargers that consists of a wide variety of ever changing known and unknown chemicals with widely varying concentrations and at concentrations that may pose a health risk. Ongoing effort to characterize and identify these chemicals and their toxicological relevance is critical for DPR criteria, and treatment must be provided to remove these chemicals to levels that are below public health concern in order to yield safe drinking water.

5.2.1 General Potable Reuse Regulatory Approach for Chemical Control

The general approach used to control the threat from chemicals is to identify treatment mechanisms that are effective at controlling broad categories of chemicals, identify treatment surrogates and conduct monitoring of surrogates and a suite of regulated and unregulated health-based and performance-based chemical indicators, conduct validation testing of treatment technologies, and specify performance criteria to ensure effective treatment to reduce concentrations below the level of health concern. This approach is coupled with regulatory requirements for industrial source control programs to help reduce the discharge of toxic chemicals into the municipal wastewater collection system that is the source of supply for potable reuse, and other requirements that evaluate and reduce the risk of treatment failure.

5.2.2 Potable Reuse Form Influences Chemical Control Regulation Structure

Differences among the various forms of potable reuse require criteria customized to the threats and health protective features of each.

As noted in Section 4, there are benefits provided by the environmental buffer in IPR. For DPR, the lack of a meaningful environmental buffer also means that the results of laboratory analyses for regulated and unregulated chemicals from sampled water will be available days or weeks after the water has already left the DPR plant and consumed by customers. Hence, the regulatory structure for DPR must utilize other methods for chemical control and to verify chemical quality. Such approaches might include the use of treatment surrogates and indicators to determine whether treatment is working, and additional treatment to improve reliability, robustness, and diverse mechanisms.

5.2.3 The Nature of the Threat Posed by Chemicals Changes across the Forms of Potable Reuse

The threats posed by chemicals are assessed based on potential health effects (chronic or acute) and exposures (long term or short exposures), and the relative threat from each group varies across the forms of potable reuse. The regulated and unregulated chemicals are addressed in IPR regulations. The SB-918 Expert Panel recommended that a new group of chemicals be addressed due to their ability to persist through RO/AOP treatment and their potential public health impact to DPR (e.g., high concentration, short-term exposures).

A DPR system lacks the intermediate physical barriers of an indirect potable reuse project using groundwater or a surface water (since the groundwater or surface water body provide time, distance and natural attenuation before the recycled water is present in drinking water). Because DPR does not provide an environmental barrier, failure or other chemical release can immediately affect drinking water supplies. Therefore, it is important to minimize the likelihood of the hazards.

5.2.4 Risk Management Tools That Can Be Adapted in Criteria for the Potable Reuse Types

5.2.4.1 Specify in Criteria How the Health Goal for Chemicals Are To Be Met

Due to the high number of known and unknown chemicals present in wastewater, it is unlikely that MCLs, or Notification Levels or other health-based advisory levels for each chemical can be developed. Additionally, analytical methods are unavailable for a large number of chemicals. Where methods are available, the turn-around time for a laboratory to analyze a sample and report the results does not allow adequate time to prevent inadequately treated water from being delivered to the public.

Therefore, DPR criteria must rely solely on monitoring treatment plant performance and measurement of treatment performance-based indicators and appropriate surrogates to determine whether the treated water is safe to drink. Routine chemical sampling of the influent and effluent of the advanced treatment to determine percent removals and characterization of the effluent will be required to provide additional assurance that treated water delivered to the public was protective of public health.

5.2.4.2 Wastewater Treatment Optimization

Optimization of wastewater treatment may be an option to help reduce chemical concentrations before water reaches the DPR treatment plant.

5.2.4.3 More Effective Source Control

For DPR, criteria will likely include source control requirements more stringent than current requirements to reduce the discharge of regulated and unregulated contaminants to the wastewater collection system.

An enhanced industrial source control program for DPR would include enforcement requirements to address failure to control permitted discharges. Research will inform on other strategies that may be effective.

5.2.4.4 Public Education

Public education is important; industrial and commercial operations that discharge chemical wastes into a sewer system that provides wastewater to DPR projects should be informed that the chemicals they discharge have the potential to end up in their drinking water.

The public, too, should be informed that its household disposal of products and pharmaceuticals can potentially end up in their drinking water. A public education program is an important component of a recycled water project, and would be particularly important for a DPR project.

5.2.4.5 Use of Drinking Water Notification Levels to Address Contaminants of Concern to DPR projects

The State Water Board, through the Division of Drinking Water, has established Notification Levels (NL) which are health-based advisory levels that address unregulated drinking water contaminants found in drinking water supplies or considered to pose a likelihood of drinking water contamination. These NLs are established by standard risk assessment methodologies (see the State Water Board Notification Level webpage, http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/NotificationLevels.shtml).

Currently, recycled water used to supplement drinking water supplies via IPR must be monitored for the contaminants with notification levels. DPR project will also include this monitoring requirement.

Chemicals that are problematic for DPR are good candidates for notification levels.

5.2.4.6 Monitoring and Use of Surrogates and Indicators

How consistently a DPR project must demonstrate chemical removal requirements depends on the type of chemical and whether it has an acute or chronic health effect. That is, a chemical with an acute effect would likely be subject to more frequent monitoring. Chemicals that are of concern to the health of susceptible populations during critical times (e.g., developing fetuses and infants) would be subject to more frequent monitoring.

A potential monitoring tool for unknown organic chemicals could be a stricter limit on surrogates such as TOC. The use of bioassays and non-targeted analysis are potential monitoring screening tools and are research topics.

Given the concern about short-duration, high concentration releases of contaminants that might be missed by non-continuous sampling (or might be minimized by averaging), it appears appropriate to have a daily peak that must not be exceeded for DPR projects. A daily limit placed on the concentration level(s) of surrogate(s) and/or indicator(s) would keep the majority of organic contaminants to levels below those anticipated to be of concern for short-duration exposures.

5.2.4.7 Control Systems

On-line continuous monitoring is a means to detect, either directly or via a surrogate/indicator compound short-duration, high concentration chemical peaks, which is a particular concern for DPR due to the close proximity between wastewater and drinking water.

On-line monitoring should include critical control points, alarm set points and automatic shutdown. Frequent monitoring of control systems will be required to make sure they are functioning properly.

Continuous monitoring, use of surrogates and indicators at critical control points downstream can resolve whether peaks (see below) are coming through, and whether action should be taken, such are more sampling, investigation, etc.

Monitoring can be for informational purposes (e.g., helpful to track down illegal dischargers) or used to trigger an action (e.g., used as a critical control point). If used for informational purposes, it would not be specified in criteria.

5.2.4.8 Peak Attenuation of Short-Term Pulses of Chemicals Likely to Persist Through Advanced Treatment

DPR criteria will include requirements to mitigate peaks (i.e., high concentrations of chemicals that may be released into the treatment process, as from an industrial spill). Upstream monitoring can be done to characterize peaks and can be used to determine whether the monitoring scheme used for the peak averaging mechanism is sufficient. How this would work is a research question.

6. Criteria Elements

The following is a list of general topics that are expected to be in criteria (regulations) for raw water augmentation.

6.1. Definitions

AB 574 updated terminology for potable reuse. Definitions will be provided that are consistent with statutory definitions.

6.2. Permitting Authority

Similar to regulations for IPR, DPR regulations may not directly address all permitting issues. For IPR, the issuance of a Waste Discharge Permit is necessary to address environmental concerns beyond protection of public health, such as maintaining healthy ecosystems. However, DPR projects present some scenarios where a Waste Discharge Permit may not be necessary and, therefore, the permitting authority and subsequent oversight may vary. Although not all permitting issues should be expected to be addressed via a regulation, the circumstances under which Waste Discharge Requirements may or may not apply must be considered when developing DPR regulations.

Regional Boards may include requirements for the protection of the environment, which may include more restrictive water quality limits than specified for public health.

6.3. Public Hearings

Public hearings are required for IPR projects. The statutory requirements specify that three public hearings must be held for SWA projects[5]. It is

[5] Health and Safety Code section 116551

expected that one or more public hearings will also be required for DPR projects.

6.4. Technical, Managerial, Financial Capacity

The technical, managerial, and financial (TMF) capacity required to build, maintain, monitor, and operate a potable reuse project increases with the complexity and sophistication of the system required. The complexity and sophistication is a function of the number and types of treatment processes, monitoring methods, and control points. These increase as the type of potable reuse goes from IPR to DPR.

The evidence required to demonstrate sufficient TMF varies with type of potable reuse. IPR regulations have requirements for TMF capacity. DPR projects will be expected to achieve higher demonstrated TMF capacity, and it is appropriate that TMF assessment be conducted to qualify DPR project sponsors. It is also appropriate that the risks of a proposed DPR project be evaluated, in addition to full consideration of other options for potable water supply augmentation. These considerations are essential for sound decision making on whether a project is viable.

6.5. Operator Certification

For IPR, advanced water treatment plants are required to be operated by operators trained in the advanced treatment processes. For DPR, California Water Environment Association and the California-Nevada American Water Works Association (CA-NV AWWA) are jointly developing a certification program for operators specializing in potable reuse. An advanced water treatment certification program should be available by the time DPR regulations are adopted. Experienced and highly capable operators are needed for DPR.

6.6. Joint Plan for Regional Projects

Similar to current requirements for IPR, a joint plan must be in place between wastewater providers, water recycling agencies, and the public drinking water systems receiving advanced treated water, prior to delivery of the DPR water. Any discharger of recycled water into a raw water conveyance system must obtain approval from all users of the water conveyance system.

6.7. Addressing Pathogens

Extra log reduction requirements beyond IPR may be specified in order to reduce the probability of the treatment train falling below the minimum log removal (LRV) requirement. For IPR, the minimum log reduction requirements are based on microbial risk assessments (MRA), and the State Water Board anticipates a similar process for DPR. The State Water Board is undertaking two research projects to provide additional information to the MRA, including raw wastewater pathogen monitoring and evaluation of QMRA as a potential tool.

6.8. Chemical Control

Current IPR criteria include minimum treatment requirements, such as full advanced treatment (reverse osmosis/advanced oxidation processes, RO/AOP). For DPR, the minimum treatment requirements will be no less than required for IPR. Additional treatment and water quality monitoring will be required to ensure reliability, redundancy, robustness and process diversity (e.g. ozone-biological activated carbon, BAC).

In addition, short-term chemical peaks must be addressed, due to a lack of a meaningful environmental buffer in DPR projects.

Specification of a minimum treatment train addressing short-term chemical peaks may be developed following findings from the recommended research. This research includes suitable treatment options for final treatment processes that can provide some attenuation with respect to potential chemical peaks, and research on methods to identify low molecular weight unknown compounds, including using non-targeted analysis as a screening tool, and the use of bio-analytical methods.

Additional considerations for addressing short-term chemical peaks may include more frequent monitoring to characterize the type and nature of these peaks. If short-term chemical peaks include chemicals that may have reproductive/developmental effects, the reliability of treatment may need to be increased.

6.9. Regulated Contaminants & Physical Characteristic Control

For DPR, the State Water Board anticipates increased compliance monitoring frequencies of the recycled water than required for IPR. Samples may be collected at the water reclamation plant, and for raw water augmentation, point(s) upstream of the SWTP. Determination of compliance with standards (for response action, not necessarily public notification) may be more rigorous, and will vary depending on the form of DPR.

6.10. Additional Chemical and Contaminant Monitoring

The State Water Board anticipates more frequent monitoring of the recycled water for DPR than what is required for IPR, and monitoring for a broader suite of chemicals, like low molecular weight chemicals that are a concern for DPR (see Section 5.2).

6.11. Laboratory Analysis

The analysis of samples must use approved drinking water methods to the extent that approved drinking water methods are available. Laboratories must have Environmental Laboratory Accreditation Program certification and will be required to submit electronic data records to the State Water Board.

6.12. Source Assessment and Source Control

The State Water Board is convening an expert panel to provide recommendations on strategies for source control that can be effective in controlling the discharge of chemicals into municipal sewage collection systems supplying DPR projects. The source control requirements for DPR will be at least as stringent as specified for IPR, and may be more prescriptive, based on findings from the research. The source control requirements may need to be enhanced to address short-term chemical peaks, including the potential use of local limits as a tool to control discharge of identified toxic chemicals.

6.13. Operations Plan

As with IPR, the submittal of an operations plan will be required for DPR. As part of the operations plan, it is appropriate for a DPR project proponent to conduct a treatment failure analysis similar to ones that the State Water Board requires in the permitting of other severely impaired sources. The treatment failure analysis will address the likelihood of equipment failure or malfunction throughout the treatment process, as well as the potential for human error.

6.14. Critical Control Point Approach

For DPR, the State Water Board envisions using a critical control point approach, which specifies conditions for failure detection, alarm and response, and triggers for corrective action.

Critical control points tell us when a unit is working as expected or not. If a process does not have a critical control point (no surrogate correlated with removal), then no credit will be given for that process. The necessary resolution and sensitivity of CCP readings remains to be defined.

6.15. Environmental Buffer Monitoring

Recycled water discharged to a reservoir or groundwater basin that is used as a source of drinking water must not degrade the water quality of the reservoir or groundwater basin. Requirements for baseline monitoring in IPR regulations assure that background water quality is well characterized before a potable reuse project is initiated. DPR projects using only constructed conveyances may not impact reservoirs or groundwater basins to the same extent as IPR projects, but they still may need to be similarly evaluated. The Regional Boards will continue to review projects for the protection of these resources for beneficial uses.

6.16. Reporting

Existing reporting requirements for public water systems will be applied to DPR projects. This includes the annual Consumer Confidence Report issued by retail and wholesale agencies to their customers. Monthly compliance reporting, including regular electronic reporting of water quality data, treatment plant performance data and summary data will be expected.

6.17. Cross-Connection

IPR projects connect wastewater treatment plants with treatment plants designed to produce a raw source of drinking water, which is then subject to further treatment in the environment and/or at a drinking water treatment plant. For DPR, projects will potentially connect, by hard-piped connection, wastewater treatment plants and drinking water treatment plants, creating significant cross-connection scenarios. Oversight of cross-connection control programs, including cross-connection evaluation of the DPR treatment plant and infrastructure during design, construction and operation of the facilities by trained cross-connection control specialists, will be critical in ensuring that inadequately-treated or unapproved sources of water are not distributed to the public as potable water.

6.18. Application of the California Waterworks Standards

For varying types of DPR, elements of the California Waterworks Standards, such as indirect and direct additives and the applicability of AWWA Standards, would be applicable to the various components of a DPR project.

6.19. Corrosion Control

The type of treatment required to turn municipal wastewater into drinking water could increase the corrosivity of the water. As with IPR, the minimum DPR treatment train will include the use of RO and AOP. The product water is expected to be corrosive, and projects must ensure the chemical stability of the water is compatible with materials used in the treatment plant as well as all points downstream.

6.20. Alternative Water Supply

IPR regulations require that an alternative water supply be available, should there be problems in the IPR project that would result in an inability to provide drinking water that is protective of public health. Similar requirements are anticipated for DPR.

7. Other Considerations

The State Water Board is also considering the following topics as they relate to the requirements for the various forms of DPR.

7.1. Potable Reuse Inspection and Supervision Program

An effective regulatory program to inspect and audit DPR projects is essential to assess the capability of a DPR project to supply safe drinking water and to confirm the operation of the project. Inspection and auditing of a proposed DPR project could be included at various stages, from project development, design, and construction through permitting, plant startup and ongoing operation.

The State Water Board is also considering whether additional benefits can be derived from independent oversight of DPR projects.

7.2. Treatment System Resilience

The State Water Board continues to consider other circumstances that may lead to the delivery of inadequately treated water, including low probability high consequence events. The analysis of risks due to natural or man-made perils, the mitigation of these risks, and the planning for emergency response should be implemented for any DPR project. Because the safety of DPR relies so heavily on on-line monitoring and control systems that are electronic- and computer-based, the reliability and resilience of treatment monitoring and control systems should be assessed and tested. In addition, such systems should be protected from cyber threats.

For IPR, the environmental buffer provides the benefit of decoupling the wastewater treatment system from the provision of safe drinking water. For DPR, the ability to decouple processes at key points throughout the project from wastewater source to treated drinking water, including decoupling the treatment system from the distribution of safe drinking water, would provide treatment system protection and prevent upstream events from adversely affecting downstream systems.

7.3. Operations Quality Control

The State Water Board is also considering strategies for DPR that could help minimize the potential for human error and minimize the impact of the threats due to human factors, and how such strategies should be incorporated into DPR criteria. The risk due to human errors increases from IPR to DPR.

Operations quality control also depends on a reliable resilient monitoring and control system, and highly competent human-machine interactions.

7.4. Public Health Protection Culture

The State Water Board has an expectation of an organizational "public health protection culture" that is not easily addressed in regulation but is critical in ensuring the safety of DPR.

7.5. Public Health Surveillance

The role of public health surveillance is to: (1) establish partnerships, engagement, and communication between water utilities and public health partners; (2) identify sources of data to characterize baseline public health conditions and track trends over time; and (3) help determine if transient treatment failures and contamination events lead to adverse health outcomes.

For IPR, local public health departments are informed when IPR projects are being considered.

Existing drinking water regulations require immediate reporting of waterborne microbial disease outbreak or other waterborne emergency, failure of treatment, and other events that have the potential for adverse effects on human health as a result of short term exposure. The California

Surface Water Treatment Rule also requires public water systems to receive water quality complaints and reports of gastrointestinal illness from customers, and provide a report to the State Water Board on a monthly basis.

For DPR, the State Water Board will consider whether additional strategies for public health surveillance should be adopted. The current DPR research on the feasibility of collecting raw wastewater pathogen concentration data associated with community outbreaks of disease can help identify sources of data to characterize baseline public health conditions.

8. Research Status

In the Report to Legislature, the State Water Board determined that the research recommended by the SB 918 Expert Panel should be conducted concurrently with the development of DPR criteria. The five research projects are summarized as follows:

1. Implement a probabilistic method (Quantitative Microbial Risk Assessment) to confirm the necessary removal values for pathogens, and apply this method to evaluate the performance and reliability of DPR treatment trains;
2. Monitor pathogens in raw wastewater to develop better empirical data on concentrations and variability;
3. Investigate the feasibility of collecting raw wastewater pathogen concentration data associated with community outbreaks of disease;
4. Identify suitable options for final treatment processes that can provide some “averaging” with respect to potential chemical peaks, particularly for chemicals that have the potential to persist through advanced water treatment.
5. Develop more comprehensive analytical methods to identify unknown contaminants, particularly low molecular weight compounds potentially in wastewater that may not be removed by advanced treatment and is not presently detectable by current regulatory monitoring approaches.

> *“The use of recycled water for DPR has great potential but it presents very real scientific and technical challenges that must be addressed to ensure the public’s health is reliably protected at all times.” [2016 Report to Legislature on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse, State Water Board]*

The State Water Board developed scopes of work for these five research projects in 2017, as well as a scope of work for an additional research project to investigate effective source control strategies that can be optimized to address chemical concerns specific to DPR. The State Water Board also initiated work to document the internal process to review the literature on chemicals, with an added focus on new compounds that may pose health risks to the developing young from short-term exposures.

The State Water Board is providing grant funding to The Water Research Foundation (TWRF) to support the completion of the five research projects recommended by the SB-918 Expert Panel. TWRF will be responsible for further developing the scope of the research, developing a detailed schedule for completion of the five research projects based on the scope of work that the State Water Board has outlined in the grant agreement, and managing the completion of the research. At the same time, the State Water Board is processing a contract with the National Water Research Institute (NWRI) to administer the source control research project. The research projects are expected to be completed in the 2020-2021 time frame.

Detailed schedules will be provided by TWRF and NWRI when the research is funded and these independent organizations begin work to manage the completion of the research projects.

9. AB 574: Revising SWA Regulations

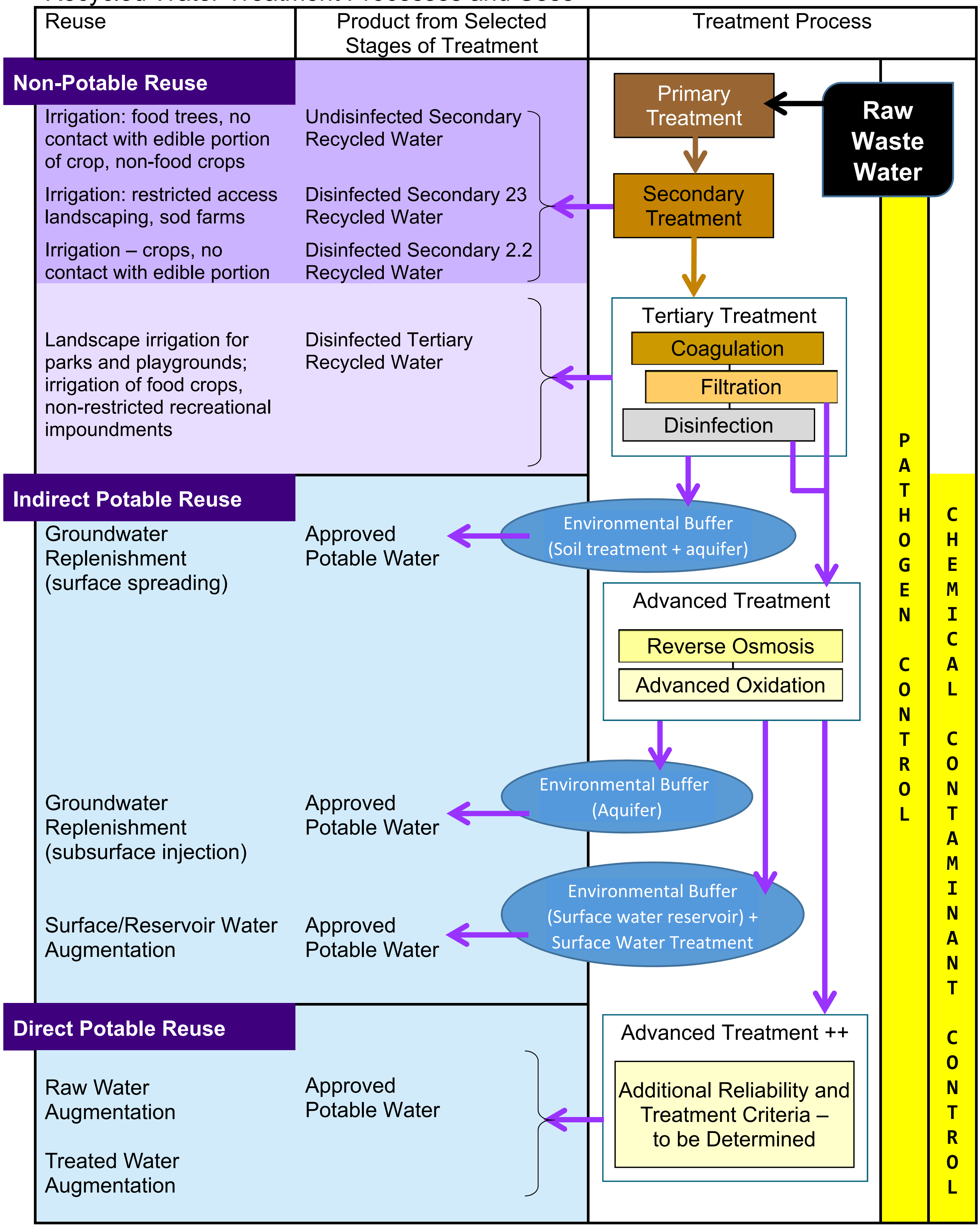
Prior to the passage of AB 574, Water Code section 13561(d) defined "surface water augmentation" as "the planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply." AB 574 subsequently repealed the definition, with the understanding that the State Water Board would be adopting the subject surface water augmentation regulations pursuant to Water Code 13562. Effective January 1, 2018, the revised Water Code section 13561(d) provides a definition for "reservoir water augmentation," which means "the planned placement of recycled water into a raw surface water reservoir used as a source of domestic drinking water supply for a public water system, as defined in Section 116275 of the Health and Safety Code, or into a constructed system conveying water to such a reservoir." [Emphasis added]

The SWA regulations adopted in April 2018 do not address circumstances where recycled water would be added to a constructed conveyance. Therefore, in AB 574, the legislature specified that the State Water Board should include in this framework a process and timeline for updating the SWA regulations to accommodate reservoir water augmentation. Because the revisions are not expected to impact the public health component of the SWA regulations that was reviewed by the Expert Panel for the SWA regulations, and AB 574 did not include a mandate for the reservoir augmentation regulations to be reviewed by an expert panel, the State Water Board does not envision that an expert review panel will be needed to adopt the reservoir water augmentation regulations. The State Water Board intends to revise the SWA regulations accordingly. Completing the revisions (i.e., adoption of reservoir water augmentation regulations) is expected to take one to two years.

Acronyms and Abbreviations

AB	Assembly Bill
AWWA	American Water Works Association
AOP	Advanced Oxidation Process
BAC	Biological Activated Carbon
CA-NV AWWA	California-Nevada Section of AWWA
CCP	Critical Control Point
CDPH	California Department of Public Health
DPR	Direct Potable Reuse
IPR	Indirect Potable Reuse
LRV	Log Removal Value, a LRV of 1 equals a 10-fold removal, a LRV of 2 equals a 100-fold removal, a LRV of 6 equals a 10^6-fold removal, etc.
MCL	Maximum Contaminant Level
MRA	Microbial Risk Assessment
NL	Notification Level
O&M	Operations and Maintenance
PATTP	Probabilistic Analysis of Treatment Train Performance
RWQCB	Regional Water Quality Control Boards (Regional Boards)
RO	Reverse Osmosis filtration
QMRA	Quantitative Microbial Risk Assessment
SB	Senate Bill
SWRCB	State Water Resources Control Board (State Water Board)
SWA	Surface Water Augmentation
SWTP	Surface Water Treatment Plant
TMF	Technical, managerial and financial
TOC	Total Organic Carbon

Recycled Water Treatment Processes and Uses



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