Enhanced Source Control Recommendations for Direct Potable Reuse in California

Prepared for:
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Foreword

The California State Water Resources Control Board (Water Board) is developing regulations for potable reuse application that do not include environmental buffers in their treatment trains, referred to as direct potable reuse (DPR). The Water Board recognized that to maximize the safety of DPR projects and to reduce the risk of consumers being exposed to chemicals of concern (COCs) in drinking water supplies, utilities with DPR projects must implement an enhanced industrial source control program that is protective of public health. The Water Board is taking action following a report to the Legislature investigating the feasibility of developing uniform water recycling criteria for DPR that is required by Water Code Division 7, Chapter 7.3 (SB 918 and 322).

The Water Board contracted with NWRI to convene an independent expert advisory panel (panel) and to examine existing research and case studies on enhanced source control programs designed for potable reuse projects. The result of NWRI's work is this panel consensus report (report), which is meant to inform the Water Board during the process of writing regulations for DPR.

Source control programs are used to control toxic chemicals from entering the wastewater collection system. Historically, these programs were designed by wastewater utilities to comply with the Clean Water Act (CWA). The main purpose of source control was to prevent chemicals that may interfere with or pass through the wastewater treatment system from entering the wastewater stream because they can pollute the environment and affect aquatic ecosystems.

Both DPR and indirect potable reuse (IPR) treat municipal wastewater to meet drinking water quality standards. In DPR, high-quality recycled drinking water is introduced into the drinking water system either just before the drinking water treatment plant or directly into the distribution system. In IPR, the high-quality recycled drinking water goes into a groundwater basin or surface water reservoir before it is treated in a drinking water treatment plant. This environmental buffer provides dilution, mixing, and contaminant attenuation, and gives water treatment utilities time to respond to potential chemical peaks caused by spills or unauthorized discharges into the wastewater collection system.

Because the response time between treatment and distribution to consumers may be shorter in the case of DPR projects than for IPR projects, utilities that plan to add DPR to their water supply portfolio need to ensure that their industrial source control program is sufficiently rigorous to safeguard the quality of water it distributes to customers.

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- Chair: Jeff Neemann, Black & Veatch
- James Colston, Irvine Ranch Water District
- Stuart Krasner, Independent Consultant
- Ian Law, IBL Solutions and University of Queensland
- Amelia Whitson, EPA Region 9

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- Mark Bartson
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- Sherly Rosilela

Invited Experts

The panel also thanks the following invited experts for presenting case studies of existing source control programs, describing new research and pilot studies on state-of-the-art monitoring systems, and providing peer review of this report.

- Ari Goldfarb, Kando

- Linda Schadler, Los Angeles County Sanitation Districts
- Eva Steinle-Darling, Carollo Engineers
- Shane Trussell, Trussell Technologies
- James Crook, Environmental Engineering Consultant
- Adam Olivieri, EOA, Inc.

Disclaimer

This report was prepared by an Independent Expert Advisory Panel (Panel), which is administered by National Water Research Institute. Any opinions, findings, conclusions, or recommendations expressed in this report were prepared by the Panel. This report was published for informational purposes.

About NWRI

A 501c3 nonprofit organization and Joint Powers authority, the National Water Research Institute (NWRI) was founded in 1991 by a group of California water agencies in partnership with the Joan Irvine Smith and Athalie R. Clarke Foundation to promote the protection, maintenance, and restoration of water supplies and to protect public health and improve the environment. NWRI's member agencies include Inland Empire Utilities Agency, Irvine Ranch Water District, Los Angeles Department of Water and Power, Orange County Sanitation District, Orange County Water District, and West Basin Municipal Water District.

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Acronyms

AWTP	Advanced water treatment plant
CalEPA	California Environmental Protection Agency
CCP	Critical Control Point
CECs	Constituents of emerging concern
CIU	Categorical Industrial User
COCs	Chemicals of concern
CWA	Clean Water Act
DO	Dissolved oxygen
DPR	Direct potable reuse
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
GIS	Geographic Information System
HACCP	Hazard Analysis and Critical Control Point
IPR	Indirect potable reuse
ISO	International Organization for Standardization
ISQMS	Integrated Sewage Quality Management System
IU	Industrial User
JWPCP	Joint Water Pollution Control Plant
MF	Microfiltration
NPDES	National Pollutant Discharge Elimination System

NPP	National Pretreatment Program
NRP	National Residue Program
ORP	Oxidation reduction potential
PDCA	Plan, do, check, act, part of a quality management program
PDSA	Plan, do, study, act, part of a quality management program
PFAS	Per- and poly-fluoroalkyl substances
POTW	Publicly Owned Treatment Works
QRA	Quantitative Risk Assessment
RCRA	Resource Conservation and Recovery Act
RO	Reverse osmosis
SCADA	Supervisory Control and Data Acquisition
SDCP	Slug Discharge Control Plan
SIU	Significant Industrial User
SQRAT	Sewage Quality Risk Assessment Toolbox
SWDA	Solid Waste Disposal Act
TMF	Technical, managerial, financial
TOC	Total organic carbon
UF	Ultrafiltration
UV	Ultraviolet
VOC	Volatile organic compound
WDR	Waste discharge requirement
WE&RF	Water Environment & Reuse Foundation

WHO	World Health Organization
WWTP	Wastewater treatment plant

Executive Summary

In California, utilities are discharging less municipal wastewater to the environment and reclaiming more of it for potable reuse. As more wastewater is purified and introduced into the drinking water supply, either directly or indirectly, utilities need to exclude more chemicals from the wastewater collection system; this chemical exclusion should occur at the source.

Instead of narrowly focusing on chemicals of concern (COCs) for the protection of environmental health, an enhanced source control program that supports potable reuse must also target chemicals that are a threat to public health if they cannot be removed by advanced water treatment processes.

The California State Water Resources Control Board (Water Board) is developing regulations for direct potable reuse (DPR) following completion of a report to the Legislature (Olivieri et al., 2016) investigating the feasibility of developing uniform water recycling criteria for DPR that is required by Water Code Division 7, Chapter 7.3 (SB 918 and 322). The Water Board determined that key knowledge gaps and research recommendations must be addressed before uniform water recycling criteria for DPR can be adopted. The Water Board also recognized that to maximize safety, utilities with DPR projects must implement an enhanced source control program that is protective of public health.

The Water Board engaged the National Water Research Institute (NWRI) to convene an independent panel of experienced water industry practitioners to evaluate the existing research and state of practice of source control for potable reuse. NWRI organized the panel, planned and facilitated the meetings, and helped develop this panel consensus report. The panel reviewed literature and case studies on source control programs that are used in California, nationally, and internationally to protect and support potable reuse projects. This report is the product of the panel's meetings and work sessions. It contains the panel's findings and recommendations on what should be considered for enhanced source control for DPR projects.

During their meetings and discussions, panel members agreed that many of the concepts and recommendations are best practice for ALL forms of potable reuse, whether or not an environmental buffer is included in the treatment train. To be consistent with the panel's charge, this report focuses on DPR; however, in many cases, the recommendations also apply to indirect potable reuse (IPR) that includes treatment schemes with an environmental buffer.

The National Pretreatment Program

Source control programs manage any type of wastewater that is discharged to the wastewater collection system and conveyed to a wastewater treatment plant (WWTP). Pretreatment, a component of a source control program, regulates what nondomestic (industrial and commercial) dischargers can release into the wastewater collection system. The National Pretreatment Program (NPP) is the set of federal regulations that define pretreatment.

Source control programs prevent chemical interference with the treatment process, prevent pollutants from passing through the WWTP, protect the collection system and the WWTP from damage, protect the health of the collection system and WWTP workers, and improve the ability to reclaim and reuse water and biosolids. Most importantly, though, source control programs protect public health and the environment by safeguarding the integrity of the WWTP.

Agencies or utilities that operate WWTPs with approved pretreatment programs are responsible for surveying and inspecting Industrial Users (IUs), controlling and monitoring IU discharges, receiving and reviewing IU reports, enforcing pretreatment standards and requirements, and preparing annual reports for the State of California and the US Environmental Protection Agency (EPA). IUs are responsible for complying with permit requirements, which includes self-monitoring, reporting, and the proper operation of on-site treatment systems, when applicable.

Source Control for Potable Reuse

Potable reuse regulations should provide a framework for source control program and also allow innovation on a project-by-project basis. A research project by the Water Environment and Reuse Foundation (WE&RF 2017) identified key considerations when developing a source control program for potable reuse and, in particular, for systems that do not include an environmental buffer such as a surface water reservoir or a groundwater aquifer.

Source control programs for potable reuse must appropriately address industrial and commercial discharges to protect public health, water treatment infrastructure, and the environment. A source control program designed for potable reuse differs from source control for environmental discharge because source control is a component of an integrated water supply program. Source control for potable reuse should focus on providing a consistent quality of wastewater, which in turn improves operation of the WWTP and the advanced water treatment plant (AWTP). Enhanced source control will help ensure the quality and reliability of treated finished water that flows either to a drinking water treatment plant or finished water that flows directly into the drinking water supply distribution network.

The source control program should be tailored to the size of the community, the number of industrial and commercial dischargers, the managerial, operational, and technical barriers selected for the project, and the type of potable reuse project. One important element of an effective source control program is the IU inventory; in other words, it’s important to identify the types of industries, their locations within the wastewater collection system (for example, using geographic information system [GIS] mapping), the volumes of wastewater discharged, and the concentrations and mass loadings of chemicals/pollutants discharged into the wastewater collection system.

Chemicals listed in source control programs may not reflect all the COCs that are relevant to potable reuse projects today. Water agencies with potable reuse programs should also develop local limits that include chemicals that are detected in the AWTP finished water at concentrations that could affect human health.

Quantitative Risk Assessment and Management

Risk assessment and risk management are essential in any potable reuse program to protect public health. A comprehensive risk assessment should include a thorough evaluation of the local source control program, which is an important barrier to protect the treatment system.

Effective source control requires a complete inventory of all industries that have the potential to impact the wastewater collection system, the contaminants being discharged, and a plan to safely manage them. Typical source control practices such as concentration and mass loading limits, chemical substitution, discharge prohibition, on-site monitoring, and other measures, should be in place before any potable reuse program is implemented, regardless of the treatment configuration adopted.

Any potable reuse scheme, and in particular those planning for DPR should also incorporate a risk-based approach to identify and set limits for water quality constituents that could be present in industrial waste discharges. Including risk assessment and management procedures to establish local acceptance limits will be an enhancement of the NPP for DPR applications.

Sampling and Monitoring

Monitoring is critical to verify that the enhanced source control program is working and to determine areas to focus on in the future. Monitoring can include routine and non-routine sampling to verify that a discharger is meeting its permit requirements.

Two of the most significant risks in source control for potable reuse programs are noncompliant discharges and illegal dumping. Noncompliant discharges can be detected by enhanced monitoring at the discharge point at the IU; illegal dumping can be detected by monitoring systems at nodal points installed in the wastewater collection system and at the WWTP headworks. These monitoring processes help to establish risk management procedures that safeguard the quality of water produced by the AWTP.

Sensors for real-time data acquisition within a wastewater collection system are emerging as important tools to consider for any enhanced source control program, according to a report that includes case studies from Singapore, Denmark, Australia, and Israel (WateReuse 2017). Sensors can be located at significant industrial user (SIU) discharge sites, strategic locations in the wastewater collection network, such as at pump stations or nodal points that serve clusters of industries, and at WWTP headworks. Sensors can monitor various water quality parameters, such as temperature, pH, conductivity, turbidity, dissolved oxygen (DO), and oxidation reduction potential (ORP), and can detect pollutants, such as volatile organic compounds (VOCs), total organic carbon (TOC), heavy metals, cyanide, and other toxic substances. In addition to using sensors, enhanced monitoring could include collecting unscheduled samples during off-hours.

As utilities implement potable reuse and especially DPR, some form of an early warning system in the wastewater collection system or WWTP could help utilities initiate a remedial action plan. The goal of the action plan is to quickly resolve problems as they happen and to prevent adverse water quality excursions from occurring at the WWTP or the AWTP and in the product water.

Technical, Managerial, and Financial Capacity

The concept of technical, managerial, and financial (TMF) capacity has been applied to drinking water systems to ensure the system is sustainable and can consistently comply with regulations.

TMF (or institutional) capacity should be part of the initial design and long-term operations of a DPR program. Utilities should use this concept to assess and allocate the resources needed to launch and sustain the program. Enhanced training and high-level certification for operators of wastewater and drinking water treatment plants should be included in the development of TMF capacity for DPR projects. Two elements—continuous improvement and a source control committee—should be used to improve the TMF capacity of an enhanced source control program.

Recommendations for an Enhanced Source Control Program

Table 1 summarizes the key elements and recommendations for an enhanced source control program.

Table 1. Key Elements of an Enhanced Source Control Program

Key Program Element	Recommendations/Enhancements	Metrics
Federal National Pretreatment Program (NPP)	The NPP is a solid foundation for enhanced source control for a DPR program. • Use Waste Discharge Requirements (WDR) and NPDES permits to require pretreatment programs for all potable reuse systems with significant industrial users, regardless of size. • Establish source control as a component of an integrated water supply program. • Provide adequate resources within Water Board/DDW to have a consistent programmatic approach to enhanced source control for DPR.	Water Board/Division of Drinking Water (DDW) annual inspection/audit. Water Board/DDW to review annual reports from potable reuse utilities.
Enhanced Local Limits	Add explicit language to indicate that local limits must be designed to protect the wastewater collection system, the operation of the treatment plants, public health, and water quality for potable reuse. Use quantitative risk assessment for local limits to identify the constituents discharged, and in particular, concentrations of COCs.	Require development of local limits or discharge prohibitions for high-risk COCs. Have a continuous improvement plan to periodically reassess local limits.

Key Program Element	Recommendations/Enhancements	Metrics
Enhanced Discharger Evaluation	Use risk assessment to screen business applications and permits for COCs and inclusion in DPR source control program. • Based on list of COCs and quantity used on site, establish risk category for inclusion in the DPR source control program. • Use risk assessment to evaluate discharge of concentrated waste (brine) to the DPR program or to require a different discharge route. Expand industrial users/significant industrial users NPP database to include businesses within the source control service area with the potential to impact the WWTP/AWTP. • Require a business permit database and GIS map that is updated annually.	Business license application includes a list of chemicals stored or used on site. Include database/map as part of annual report and audit of DPR program by Water Board/DDW.
Enhance Collection System Monitoring	Evaluate the potential to establish a sensor/software monitoring system in the collection system or at the WWTP to provide early warning of source control issues (such as illegal or accidental discharges). • Require evaluation for all DPR projects with SIU contribution. • Project sponsor can defer this requirement if the SIU contribution is low, or if the project employs other adequate means such as additional treatment barriers, blending, effluent monitoring, and diversion. • Determine the value of enhanced monitoring for noncompliant discharge and illegal dumping using sensors at IU/SIU dischargers, which may be possible depending on the chemical of interest. • Recommend data collection and research to identify more sensor types and feasibility of long-term performance.	An early warning system has been deployed to address critical SIU discharges and has established response guidelines. System and performance is reviewed as part of annual report. Number of source control-related events detected by the early warning system compared to the number of events detected through routine monitoring at the WWTP or AWTP.
Enhance Education/Outreach	Establish a public education and public outreach program regarding control and disposal of hazardous constituents for industrial, commercial, and domestic dischargers. Coordinate education and outreach program with utilities treating wastewater for potable reuse and regulators and others having expertise in monitoring, treatment technology, and health risk assessment.	Develop handouts to businesses to reduce use of COCs. Educate residents about proper disposal of medications. Include regular information with monthly sewer bill.

Key Program Element	Recommendations/Enhancements	Metrics
Technical/ Managerial/ Financial Capacity	Ensure that the Safe Drinking Water Act Requirements for TMF capacity apply to DPR projects. • Require each DPR program to implement a continuous improvement plan as part of the enhanced source control program. • Require each DPR program to form and maintain a source control steering committee. • Develop guidance for resource requirements for staffing and budget to develop local DPR source control programs.	Have an active a source control steering committee and governance documentation. Maintain and follow a continuous improvement program.

Research Recommendations

Additional research should be conducted to further define an approach for enhanced source control for DPR. Some examples of additional research include:

- Develop a risk assessment and management framework for source control programs for any potable reuse project, building on what others have done.
- Identify and collaborate with utilities that have risk management frameworks in place that inform acceptance criteria for industrial discharges in their source control programs.
- Establish and continually update a comprehensive register of potentially toxic chemicals that are removed by WWTPs. The aim is to establish removal relationships with WWTP operating conditions, such as solids retention time (SRT) and the extent of biological nitrogen removal.
- Study operational reliability of in-sewer sensors for use in the collection system to alert on illegal or inadvertent discharges.
- Develop a database of analytes most pertinent to the detection of out-of-spec discharges. For example, pH, flow, conductivity, ORP, VOCs, and TOC are already in use, but research should focus on other analytes that could be more informative.
- Evaluate if on-premises, on-line monitoring stations achieve better results than irregular grab sampling and analysis.
- While some sensors and software are identified in the case studies, additional research should be conducted to identify if there are other sensors more suited for use in a wastewater collection system.

- Investigate surrogates for different groups of chemicals for wastewater collection system sampling and monitoring to expand the ability to detect unplanned chemical discharges.
- Conduct additional research to define detailed recommendations for the operating conditions and software configuration of an early warning system, preferably with insight from agencies that already have such systems in place.

1 · Introduction

1.1 Project Background

The California State Water Resources Control Board (Water Board) is developing regulations for DPR following completion of a report to the Legislature (Olivieri et al. 2016) investigating the feasibility of developing uniform water recycling criteria for DPR that is required by Water Code Division 7, Chapter 7.3 (SB 918 and 322).

The Water Board determined that key knowledge gaps and research recommendations must be addressed before uniform water recycling criteria for DPR can be adopted. The Water Board also recognized that to maximize the safety of DPR projects and to reduce the risk of consumers being exposed to chemicals of concern (COCs) in recycled drinking water produced from wastewater, utilities with DPR projects must implement an enhanced source control program that is protective of public health. The Water Board, therefore, sought independent expert advice on what an enhanced source control program for DPR should include.

1.2 Panel Review Process

The Water Board engaged the National Water Research Institute (NWRI) to convene an independent panel of experts to evaluate the existing research and state of practice of source control for potable reuse. NWRI organized the panel, planned and facilitated the meetings, and helped develop this report. Profiles of the panel members are included in Appendix A. Information about NWRI and the Independent Advisory Panel process is in Appendix B.

The panel reviewed literature and case studies on source control programs that are used in California, in the United States, and around the world to protect and support potable reuse projects. It discussed what elements the enhanced source control program should contain, how to implement the program, and how to quantify the program's effectiveness in controlling COCs in recycled water. The panel reviewed relevant state-of-the-industry literature before their first meeting. See Appendix C for more information on the literature that was reviewed, and Appendix D for the works cited in this document. Case studies of potable reuse projects around the world are described in Appendix

E. Appendix F contains an overview of quality management programs that may be adapted to DPR projects.

This consensus report is the product of the panel's meetings and work sessions. It contains the panel's findings and recommendations for enhanced source control for DPR projects. The panel also made suggestions for further research.

1.3 Panel Charge from the Water Board

To develop this consensus report, the Water Board charged the Independent Advisory Panel with: researching the key elements of an enhanced source control program for DPR, establishing realistic objectives that can be achieved by enhanced source control, and defining metrics that can be used by the Water Board to judge when an enhanced source control program is optimized for DPR.

The panel charge from the Water Board was:

1. ***Literature Review.*** *Review the scientific literature, published technical reports, guidance documents, and engineering reports in its evaluation of source control programs and strategies used for IPR. The panel will consider the literature on source control, source control programs targeting industrial, commercial, and residential contributors of COCs and unknown chemicals, and novel applications of source control, such as continuous on-line monitoring in the sewer collection system and/or wastewater treatment plant (e.g., Singapore PUB) as a strategy in enhanced source control programs to detect chemical spills.*
2. ***Develop case studies.*** *Contact agencies that presently have potable reuse projects such as, but not limited to, Orange County Water District, West Basin Municipal Water District, and Singapore PUB, to discuss the elements of their source control programs, determine those elements that are most critical and identify those areas where, because of legal or technical issues (such as multiple agency involvement), their source control programs could have limitations.*
3. ***Make findings and recommendations on the key elements of an enhanced source control program for DPR that*** *are effective for reducing the chemical mass loading into the sewer system and for reducing the frequency and magnitude of chemical spikes observed at municipal wastewater treatment plants; the realistic objectives that can be achieved by an enhanced source control program; methods to quantify the effectiveness of various source control strategies; metrics*

that can be used to judge when an enhanced source control program is optimized for DPR; and metrics that can be used to judge the equivalency of different source control programs.

4. ***Address the following five questions*** *provided by the State Water Board:*

   What metrics can be used to objectively evaluate source control programs as a chemical control barrier, especially for chemicals relevant to DPR?

   What methods can be used to quantify the effectiveness of various source control strategies, such as public education, routine inspection, sampling, etc., to control chemicals relevant to DPR?

   What are the metrics by which source control programs from different potable reuse projects can be objectively compared, or compared to a standard?

   What guidelines can be used to design and implement monitoring options in the sewer collection system (e.g., Singapore PUB collection system VOC monitoring network)?

   What is the feasibility of developing an early-warning system of increased chemical loading based on high-frequency monitoring in the sewer collection system or municipal WWTP influent?

5. ***Make recommendations on sewer collection system monitoring options*** *for DPR, including a framework for sewer collection system monitoring program (strategy for selecting monitoring locations, example monitoring plans, sampling protocols, sample collection methods, a cost estimate for example programs, and identifying wastewater agency partnerships to pilot such program[s]).*

6. ***Identify additional research needs pertaining to the potential health risks*** *associated with the use of treated municipal wastewater from various sewer collection systems as source water for potable reuse.*

1.4 Important Terminology Notes

The panel’s charge was to evaluate and recommend enhanced source control methodologies for DPR. California assembly bill (AB) 574, which was signed into law in 2017, amended the Water Code to include definitions for four potable reuse configurations: groundwater augmentation, reservoir water augmentation, raw water augmentation, and treated drinking water augmentation.

The configurations for raw water augmentation (putting 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) and treated drinking water augmentation (putting recycled water into the water distribution system of a public water system, as defined in Section 116275 of the Health and Safety Code) fall under the definition of DPR.

The other two methods of potable reuse, groundwater augmentation and reservoir water augmentation, fall under the definition of IPR. Authors of this report use the term DPR to be consistent with the panel charge and because the term DPR represents both the raw water and treated drinking water augmentation configurations, which do not include an environmental buffer.

During their meetings and discussions, panel members agreed that many of the concepts and recommendations are best practice for ALL forms of potable reuse, whether or not an environmental buffer is included in the treatment train. Thus, to be consistent with the panel's charge, this report focuses on DPR—but in many cases, the recommendations also apply to IPR, which includes treatment schemes with an environmental buffer.

1.5 Foundational Assumptions

The panel first met in September 2018 to review the charge from the Water Board. By the end of Meeting 1, the panel developed the following foundational statements, which it used as the basis for its recommendations.

- The US Environmental Protection Agency (EPA) NPP is a good foundation for enhanced source control programs for DPR.
- Utilities must demonstrate commitment to the DPR project and sufficient technical, managerial, and financial capacity early in the planning process.
- Quantitative risk assessment can lead to better characterization, mitigation, and management of locally relevant COCs.
- Results of the quantitative risk assessment will determine whether DPR is feasible for the AWTP.
- The quantitative risk assessment is useful to identify opportunities to improve source water quality through creative system management and improvement.
- Establishing requirements using a quantitative, risk-based, tiered approach may especially help small communities to develop enhanced source control for DPR.

- Early monitoring at WWTP headworks, influent junction structures, or upstream nodal points is useful to locate water quality excursions and to detect targeted chemicals.
- To ensure compliance, an AWTP should use targeted outreach to educate the public, industrial, and commercial users.
- Case studies indicate that sensors can operate reliably in a wastewater collection system; therefore, an early warning system may be feasible. However there are additional research needs to further develop this concept.
- Source control monitoring should be coordinated between the WWTP and AWTP and should inform all response and action plans.
- Cooperation between the WWTP and the AWTP is essential and must include seamless communication and data sharing.
- Continuous improvement processes used in the food and pharmaceutical industries can be adapted to create a source control protocol for DPR.
- Continuous improvement should be embedded in the recommendations for enhanced source control for DPR.
- Any entity that implements an enhanced source control program for a DPR project must coordinate enforcement of the source control requirements with the holder of the water recycling permit. At a minimum, there must be a formal written agreement.

2 · The National Pretreatment Program as a Basis for Enhanced Source Control

The Federal Water Pollution Control Act of 1948 was the first major law in the United States to address water pollution (EPA 2017). In 1969, Ohio's Cuyahoga River was so contaminated with industrial pollutants that the river caught on fire. This event galvanized the public's burgeoning environmental awareness and concern about water pollution. As amended in 1972, the law became known as the Clean Water Act (CWA). The CWA was designed to eliminate the discharge of pollutants into the nation's waters and to achieve fishable and swimmable water quality limits.

One of the act's key components, the National Pollutant Discharge Elimination System (NPDES), requires that all direct discharges to the nation's waters comply with an NPDES permit that is administered in California by the California State Water Resources Control Boards and nine regional boards. However, since many industries discharge to municipal wastewater treatment plants, EPA established the National Pretreatment Program (NPP), which requires nondomestic (industrial and commercial) dischargers to treat or control pollutants in their wastewater before discharging it to municipal wastewater treatment plants.

2.1 The National Pretreatment Program

The NPP is a proven, effective, and cooperative effort of federal, state, and local environmental regulatory agencies, established by the CWA, that can:

- Protect wastewater collection, treatment, and potable reuse infrastructure, as well as the people who work and/or live near such infrastructure.
- Reduce conventional and toxic pollutant levels discharged by industries and other nondomestic sources into municipal wastewater collection systems, into the environment, or into DPR project source waters.

The NPP requires nondomestic dischargers to comply with pretreatment standards to prevent the introduction of pollutants into a WWTP that will interfere with its operation or pass through the treatment works or otherwise be incompatible with it. The NPP is one of the foundations of source control and, when enhanced as recommended in Table 2, represents one of the most important, effective, and reliable barriers to the protection of drinking water quality.

2.2 Key Terms, Roles, and Responsibilities

The following key terms, roles, and responsibilities are integral to understanding the NPP and enhanced source control.

Pretreatment is the treatment of nondomestic wastewater in compliance with NPP standards before it is discharged to the local wastewater collection and treatment system. Pretreatment programs support communities and their wastewater infrastructure investments across California. However, given the variation in local conditions, developing a new DPR project may require some communities without an existing pretreatment program to launch one for the first time. The objective of a pretreatment program for a DPR project is to minimize the amount of industrial and commercial pollutants that interfere with the AWTP or otherwise affect the community's source of drinking water.

Source control is a set of strategies and a programmatic approach to ensuring that wastewater consistently meets stringent specifications established through a continuously improving, locally relevant, public-health focused, risk-based process. Source control is the natural progression of pretreatment beyond industrial control to protect water for recycling. Examples of source control include assessing industrial, commercial, and domestic pollution sources and emerging pollutants. Controlling pollutants at their source saves the public from subsidizing environmentally harmful businesses, protects the wastewater infrastructure efficiently and effectively, and supports resource recovery initiatives. In the case of a DPR project, the objective of source control is to reduce chemical/pollutant discharges to ensure that WWTPs and AWTPs can consistently meet all drinking water and other required standards.

An **Approval Authority** ensures that all approved source control programs continuously comply with the NPP. California's Environmental Protection Agency (CalEPA) has achieved and maintained EPA authorization to implement the NPP in California and does so via the State Water Board and Regional Water Quality Control Boards. The Approval Authority's key roles and responsibilities are to:

- Determine when and where source control and pretreatment programs must be implemented.
- Approve source control and pretreatment programs, and establish appropriate statewide regulatory controls on these programs, as authorized by EPA.
- Approve local permitting, administrative processes, and enforcement procedures for discharges into the local wastewater collection and treatment infrastructure.
- Evaluate source control and pretreatment program efficacy and compliance through audits and inspections.
- Enforce applicable pretreatment requirements.
- Provide technical guidance to control authorities.

The **Control Authority** administers and enforces source control and pretreatment programs locally under the combined authorization of the CWA, Approval Authority, and other locally relevant discharge limits set forth in a wastewater collection system use ordinance. WWTPs act as the Control Authority where they have an approved pretreatment program. The Control Authority's key roles and responsibilities include:

- Develop legal authority for their jurisdiction, set technically based local limits, establish standard operating procedures, secure funding, and develop an enforcement response plan to establish and maintain an approved pretreatment and/or source control program.
- Regulate dischargers by issuing control mechanisms, conducting monitoring and inspections, receiving and reviewing reports and notifications, reviewing requests for variances, evaluating discharger compliance, and taking appropriate enforcement action.
- Submit regular reports to the Approval Authority on implementation of the source control and/or pretreatment program.

The NPP distinguishes industrial users into significant industrial users and all other industrial users (IUs). **Significant Industrial Users** (SIUs) are large-volume or high-strength dischargers. A discharger is classified as an SIU based on the character, volume, or inherently offensive or harmful nature of its discharge. SIUs are subject to rigorous, risk-based permitting, control, inspection, monitoring, and enforcement requirements.

Categorical Industrial Users (CIUs) are a subset of SIUs that are subject to specific, technology-based standards or effluent limitation guidelines that use uniform national standards developed by EPA for specific categories of industrial dischargers. Examples of these categories are metal finishing (40 CFR §433), centralized waste treatment (40 CFR §437), pharmaceutical manufacturing (40 CFR §439), and electrical and electronic components manufacturing (40 CFR §469). All properly categorized CIUs discharge pursuant to the EPA's effluent limitation guidelines or an approved alternative upstream of the discharger's connection to the wastewater collection system.

NPP objectives are achieved by applying and enforcing three types of pretreatment standards to industrial users. The **general discharge prohibitions** as set forth in 40 CFR §403.5(a) state, "*A User may not introduce … any pollutant(s) which cause Pass Through or Interference.*" **The specific discharge prohibitions** as set forth in 40 CFR §403.5(b) state that the following pollutants shall not be discharged:

1. *Pollutants which create a fire or explosion hazard in the POTW*[1]*, including, but not limited to, wastestreams with a closed cup flashpoint of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21;*

2. *Pollutants which will cause corrosive structural damage to the POTW, but in no case Discharges with pH lower than 5.0, unless the works is specifically designed to accommodate such Discharges;*

3. *Solid or viscous pollutants in amounts which will cause obstruction to the flow in the POTW resulting in Interference;*

4. *Any pollutant, including oxygen demanding pollutants (BOD, etc.) released in a Discharge at a flow rate and/or pollutant concentration which will cause Interference with the POTW;*

5. *Heat in amounts which will inhibit biological activity in the POTW resulting in Interference, but in no case heat in such quantities that the temperature at the POTW Treatment Plant exceeds*

[1] The EPA uses the term publicly owned treatment works (POTW) to refer to water treatment plants.

40 °C (104 °F) unless the Approval Authority, upon request of the POTW, approves alternate temperature limits;

6. *Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin in amounts that will cause interference or pass through;*
7. *Pollutants which result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that may cause acute worker health and safety problems;*
8. *Any trucked or hauled pollutants, except at discharge points designated by the POTW.*

These general and specific prohibitions apply to each discharger, whether or not the discharger is subject to other NPP standards or any national, state, or local pretreatment requirements.

Local limits developed by Control Authorities enable communities to customize discharge limits to enhance water recycling and help meet regional water resource management goals. The adoption of local limits, pursuant to the processes set forth in the NPP, extend CWA enforcement mechanisms and remedies to the violation of local limits. In addition, local limits are site-specific, can address unique considerations of the built and natural environment, can be numeric or narrative pollutant discharge limits, and can include alternative discharge practices. Local limits are powerful because they can be customized to address specific, locally relevant risks. Local limits are a key regulatory tool for optimizing enhanced source control in support of DPR on a community-specific basis across the state of California.

2.3 Recommendations and Selected Enhancements to NPP

For DPR projects, traditional source control programs must be enhanced to provide additional protection, because the WWTP treats water that will be purified for use as drinking water. Source control for DPR projects must be designed to prevent or minimize specific COCs from entering the wastewater collection system.

Municipal wastewater contains discharges from homes, businesses, industries, hospitals, and other public and private institutions. Because every community's wastewater is different, the organic and inorganic constituents contained in its wastewater are also different. It is a best practice for DPR to conduct a risk assessment of source waters as part of the potable reuse project review. With proper source control and treatment, these projects can reclaim wastewater that contains acceptable levels of commercial and industrial discharges.

Because of the importance of enhanced source control for DPR, the Water Board/DDW should ensure there are adequate resources for a consistent and programmatic approach to enhanced source control and for annual reviews and audits of all DPR programs.

The top operational priority for enhanced source control programs that serve a DPR project is to prevent concentrations of COCs—from any source—from entering the wastewater collection system at levels that can prevent the project from meeting water quality requirements. Preventing these contaminants from entering a DPR project's source water provides an additional barrier of protection. Therefore, policy or guidance should support enhanced source control that protects public health and DPR project source waters by:

- Focusing on contaminants that are relevant to drinking water as the ultimate product of a DPR project, especially to the extent that the AWTP may not reduce the contaminant to acceptable levels.
- Using risk assessment to screen business license applications and permits for COCs. Based on the list of COCs and the quantity used at the site, a risk category can be assigned for inclusion in the enhanced source control program.
- Minimizing or eliminating the discharge of potentially harmful or difficult-to-treat chemical constituents to the wastewater collection system from homes, businesses, industries, hospitals, health- and aged-care facilities, and other types of industries.
- Developing a discharger inventory that is a database and GIS map of IUs and SIUs that can be updated frequently to screen for COCs.
- Developing a program to reduce or eliminate concentrated waste streams as a source water for DPR programs. The local limits can be used to identify COCs and a risk assessment framework can be used to evaluate the discharge or diversion to an environmental discharge.
- Enhancing education and public outreach could reduce COCs coming from domestic wastewater. The AWTP should develop communication materials, establish outreach programs like "No drugs down the drain," and coordinate with other utilities to share common and consistent messages.

- Assuring the quality of AWTP source water through improved primary, secondary, and (if applicable) tertiary wastewater treatment.

Table 2 provides a detailed summary of key sections of the NPP, plus recommended enhancements to support safe DPR in California. These recommendations constitute enhancements that California could incorporate to augment the NPP regulations it has already incorporated by reference into State regulations 23 CCR 2235.2.

Table 2. Summary of National Pretreatment Program Requirements and Recommended Enhancements for DPR

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
PROGRAM PURPOSE AND APPLICABILITY **40 CFR 403.1**	Regulation applies to (1) Any indirect discharges or pollutants "otherwise introduced into POTWs"; (2) POTWs receiving "wastewater from sources subject to NPP standards"; (3) States which have or are applying for approved and delegated NPDES Programs; and, (4) To any new or existing source subject to Pretreatment Standards. NPP Standards do not apply to sources which are not connected to a POTW Treatment Plant	Expand the use of "POTW" throughout these requirements to also apply to DPR projects or any other local wastewater entity that is part of a DPR project (for example, privately-owned treatment works).
PROGRAM OBJECTIVES **40 CFR 403.2**	a) To prevent the introduction of pollutants into POTWs which will interfere with the operation of a POTW, including interference with its use or disposal of municipal sludge; (b) To prevent the introduction of pollutants into POTWs which will pass through the treatment works or otherwise be incompatible with such works; and, (c) To improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.	No enhancement needed.
DEFINITIONS: **INTERFERENCE** **40 CFR 403.3(K)**	A discharge which, alone or in conjunction with a discharge or discharges from other sources, both (1) Inhibits or disrupts the POTW, its treatment processes or operations, or its sludge processes, use or disposal; and (2) Therefore is a cause of a violation of any requirement of the POTW's NPDES permit or an increase in the magnitude or duration of a violation or of the prevention of sewage sludge use or disposal in compliance with the following statutory provisions and regulations or permits issued thereunder: Section 405 of the Clean Water Act,	Add explicit language to extend the definition of interference to include violations of DPR regulatory requirements, in addition to violations of NPDES and waste discharge requirements (WDRs).

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
	The Solid Waste Disposal Act (SWDA) including the Resource Conservation and Recovery Act (RCRA), and State regulations contained in any State sludge management plan prepared pursuant to subtitle D of the SWDA, the Clean Air Act, the Toxic Substances Control Act, and the Marine Protection, Research and Sanctuaries Act.	
DEFINITIONS: **PASS THROUGH** **40 CFR 403.3(P)**	A discharge which exits the POTW into waters of the United States in quantities or concentrations which, alone or in conjunction with a discharge or discharges from other sources, is a cause of a violation of any requirement of the POTW's NPDES permit.	Add explicit language to extend the definition of pass-through to include violations of DPR regulatory requirements, in addition to violations of NPDES and waste discharge requirements (WDRs).
SIGNIFICANT INDUSTRIAL USER **40 CFR 403.3(V)**	The term Significant Industrial User means: all Industrial Users subject to (1) Categorical Pretreatment Standards and (2) Any other Industrial User that: Discharges an average of 25,000 gallons per day or more; Contributes a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW Treatment plant; Or is designated as such by the Control Authority on the basis that the Industrial User has a reasonable potential for adversely affecting the POTW's operation or for violating any Pretreatment Standard. The Control Authority may determine that an Industrial User otherwise subject to categorical Pretreatment Standards is “Non-Significant” upon a finding that the Industrial User has no reasonable potential for adversely affecting operation or for violating any Pretreatment Standards or requirements.	Add explicit language to support and complement changes to definitions of "pass through" or "interference." Require Control Authorities to designate any IU with a reasonable potential for adversely affecting the DPR project’s operation or for violating any Pretreatment Standard, including the above enhancements to the definitions of “pass through” and “interference.”
GENERAL PROHIBITIONS **40 CFR 403.5(A)(1)**	A User may not introduce any pollutant(s) which cause Pass Through or Interference. These general prohibitions and the specific prohibitions in paragraph (b) of this section apply to each User introducing pollutants into a POTW whether or not the User is subject to other National Pretreatment Standards or any national, State, or local Pretreatment Requirements.	Enhancement is probably not needed, but be aware that the definitions of "pass through" or "interference" could change.
SPECIFIC PROHIBITIONS **40 CFR 403.5(B)**	(1) Pollutants which create a fire or explosion hazard as defined; (2) Pollutants which will cause corrosive structural damage or have a pH lower than 5.0 without specific design accommodation;	Enhancement is probably not needed, but be aware that the definitions of "pass through" or "interference" could change.

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
	(3) Solid or viscous pollutants in amounts which will cause obstruction to the flow resulting in Interference; (4) Any pollutant released in a Discharge at a flow rate and/or pollutant concentration which will cause Interference; (5) Heat in amounts which will inhibit biological activity or result in POTW water temperatures higher than 40°C (104°F) without Control Authority authorization; (6) Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin in amounts that will cause interference or pass through; (7) Pollutants which result in the presence of toxic gases, vapors, or fumes that may cause acute worker health and safety problems; and, (8) Any trucked or hauled pollutants, except at designated discharge points.	
LOCAL LIMITS **40 CFR 403.5(C)** **40 CFR 403.8(F)(4)**	Each Control Authority must develop and enforce specific, locally relevant discharge limits to implement the General and Specific prohibitions. These limits are known as local limits. The development of local limits requires substantial administrative process, including individual notice to persons or groups who have requested such notice and an opportunity to respond, that must be carefully followed to ensure local limits are enforceable through the Clean Water Act. Local limits can include Best Management Practices (BMPs). Such BMPs are considered local limits and Pretreatment Standards. The POTW shall develop local limits as required in §403.5(c)(1) or demonstrate that they are not necessary.	When specific limits must be developed by the POTW, expand the definition to include the requirement that DPR projects include local limits. Refer to the EPA web site for guidance on local limits (EPA 2004a) and the appendices (EPA 2004b). Add explicit language to indicate that pretreatment standards must support applicable local limits designed to protect public health if DPR is the end use. See recommendations for considering Risk Assessments to establish Local Limits in Chapter 3 of this report.
PUBLICLY OWNED TREATMENT WORKS REQUIRED TO DEVELOP A PRETREATMENT PROGRAM **40 CFR 403.8(A)**	Any POTW (or combination of POTWs operated by the same authority) with (a) a total design flow greater than 5 million gallons per day and (b) receiving from Industrial Users pollutants which Pass Through or Interfere with the operation of the POTW or are otherwise subject to Pretreatment Standards is required to establish a Pretreatment Program *unless the NPDES State exercises its option to assume local responsibilities*. The Approval Authority may require that any POTW develop a POTW Pretreatment Program to prevent Interference or	Recommend that any DPR project, of any design flow, that accepts waste from significant industrial users be required to develop and implement a pretreatment program. As mentioned under "Program Purpose and Applicability" above, this can include a POTW that is part of a DPR project, or any other

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
	Pass Through upon a finding that (1) the nature or volume of the industrial influent, (2) treatment process upsets, (3) violations of POTW effluent limitations, (4) contamination of municipal sludge, or (5) other circumstances warrant.	local wastewater entity that is part of a DPR project (for example, privately owned treatment works).
DEADLINE FOR PRETREATMENT PROGRAM APPROVAL **40 CFR 403.8(B)**	A POTW which meets the criteria of paragraph (a) of this section must receive approval of a POTW Pretreatment Program no later than 3 years after the reissuance or modification of its existing NPDES permit. POTWs identified after July 1, 1983 as being required to develop a POTW Pretreatment Program under paragraph (a) of this section shall develop and submit such a program for approval as soon as possible, but in no case later than one year after written notification from the Approval Authority of such identification.	Under current California requirements, submittal of the pretreatment program is required as part of the Title 22 Engineering Report review and approval process, which is before issuance of the WDRs.
LEGAL AUTHORITY **40 CFR 403.8(F)(1)** **PRETREATMENT PROGRAM LEGAL AUTHORITY REVIEW CHECKLIST** **DELINEATES ALL LEGAL AUTHORITY REQUIREMENTS FOR PRETREATMENT PROGRAMS (INCLUDING OVERLAP WITH OTHER REQUIREMENTS LISTED HERE).**	A POTW pretreatment program must be based on the specific legal authority and includes specific procedures to ensure Clean Water Act compliance and enforceability. At minimum, this legal authority shall enable the POTW to: Require IUs to comply with applicable NPP standards; Control the contribution of each IU and SIU by specified control mechanisms; Require (A) the development of a compliance schedule by each Industrial User for the installation of technology required to meet applicable Pretreatment Standards and Requirements and (B) the submission of all notices and self-monitoring reports from Industrial Users as are necessary to assess and assure compliance; Carry out all inspection, surveillance and monitoring procedures; Obtain remedies for noncompliance; and, Comply with the applicable confidentiality requirements.	No enhancement needed. Link to: [EPA's Pretreatment Program Legal Authority Review Checklist]
PROCEDURES **40 CFR 403.8(F)(2)** **(V) SAMPLE AND ANALYZE IU EFFLUENT, AND CONDUCT INDEPENDENT SURVEILLANCE, AS NECESSARY TO DETERMINE IU NONCOMPLIANCE; INSPECT AND SAMPLE EACH SIU AT LEAST ONCE PER YEAR** **(VI) WHETHER EACH SIU NEEDS A SLUG**	The POTW shall develop and implement procedures to ensure compliance with the requirements of a Pretreatment Program. At a minimum, these procedures shall enable the POTW to: • Identify and locate all possible Industrial Users which might be subject to the POTW Pretreatment Program. • Identify the character and volume of pollutants contributed to the POTW by the Industrial Users. • Notify Industrial Users identified, of applicable Pretreatment Standards and any applicable requirements under sections 204(b) and 405 of the Act and subtitles C and D of the Resource Conservation and Recovery Act.	Require all SIUs contributing to the collection system of a DPR project to develop a slug discharge control program. See recommendations for Enhanced Monitoring and Early Warning System in Chapter 4 of this report.

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
DISCHARGE CONTROL PLAN, AND REQUIRED CONTENTS OF SUCH A PLAN	• Receive and analyze self-monitoring reports and other notices submitted by Industrial Users in accordance with the self-monitoring requirements.	
ENFORCEMENT RESPONSE PLAN **40 CFR 403.8(F)(5)**	The POTW shall develop and implement an enforcement response plan to respond to instances of industrial user noncompliance. The plan shall, at a minimum: (i) Describe how the POTW will investigate instances of noncompliance; (ii) Describe the types of escalating enforcement responses the POTW will take in response to all anticipated types of industrial user violations and the time periods within which responses will take place; (iii) Identify (by title) the official(s) responsible for each type of response; (iv) Adequately reflect the POTW's primary responsibility to enforce all applicable pretreatment requirements and standards.	Enhancements may be needed to address a suite of potential programs depending upon the needs of the utilities. Recommend following the EPA guidance for developing control authority enforcement response plans (EPA 1989).
INVENTORY OF IUS **40 CFR 403.8(F)(6)**	The POTW shall prepare and maintain a list of its Industrial Users. The list shall identify the criteria in §403.3(v)(1) applicable to each Industrial User. The initial list shall be submitted to the Approval Authority pursuant to §403.9 or as a non-substantial modification pursuant to §403.18(d). Modifications to the list shall be submitted to the Approval Authority pursuant to §403.12(i)(1).	No enhancement needed.
REPORTING FOR CATEGORICAL SIGNIFICANT INDUSTRIAL USERS **40 CFR 403.12**	Baseline monitoring report New sources reporting Compliance schedule for meeting categorical Pretreatment Standards Report on compliance with categorical pretreatment standard deadline Periodic compliance report from CIUs Annual certification by Non-Significant CIUs	No enhancement needed.
REPORTING FOR NON-CATEGORICAL SIGNIFICANT INDUSTRIAL USERS **40 CFR 403.12**	Periodic compliance report from non-categorical SIUs	No enhancement needed.

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
REPORTING FOR ALL INDUSTRIAL USERS **40 CFR 403.12**	Notification of potential problems (including slug loads) Notification of changed discharge Hazardous waste reporting	No enhancement needed.
POTW REPORTING **40 CFR 403.12**	Annual Pretreatment Program Reports Pretreatment Program Compliance Schedule Electronic Reporting Requirements	Require the pretreatment program manager to report whether or not the facility complied with all DPR requirements, and if not, whether any noncompliance was a result of non-domestic discharges. Require the pretreatment program manager to report a summary of any triggers of early warning systems and consequent responses.
UPSETS **40 CFR 403.16**	Upset means an exceptional incident in which there is unintentional and temporary noncompliance with categorical Pretreatment Standards because of factors beyond the reasonable control of the Industrial User. (a) An Upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation. (b) Effect of an upset. An Upset shall constitute an affirmative defense to an action brought for noncompliance with categorical Pretreatment Standards if the requirements of paragraph (c) are met. (c) Conditions necessary for a demonstration of upset. An Industrial User who wishes to establish the affirmative defense of Upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that: (1) An Upset occurred, and the Industrial User can identify the cause(s) of the Upset; (2) The facility was at the time being operated in a prudent and workman-like manner and in compliance with applicable operation and maintenance procedures;	No enhancement needed.

SECTION	NATIONAL PRETREATMENT PROGRAM REQUIREMENT	DPR ENHANCEMENT
	(3) The Industrial User has submitted the following information to the POTW and Control Authority within 24 hours of becoming aware of the Upset (if this information is provided orally, a written submission must be provided within five days): (i) A description of the Indirect Discharge and cause of noncompliance; (ii) The period of noncompliance, including exact dates and times or, if not corrected, the anticipated time the noncompliance is expected to continue; (iii) Steps being taken and/or planned to reduce, eliminate and prevent recurrence of the noncompliance. (d) Burden of proof. In any enforcement proceeding the Industrial User seeking to establish the occurrence of an Upset shall have the burden of proof.	
BYPASS **40 CFR 403.17**	(a) Definitions. (1) Bypass means the intentional diversion of wastestreams from any portion of an Industrial User's treatment facility; (d) Prohibition of bypass. (1) Bypass is prohibited, and the Control Authority may take enforcement action against an Industrial User for a bypass, unless; (i) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage; (ii) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance; and (iii) The Industrial User submitted notices as required under paragraph (c) of this section.	No enhancement needed.
PROGRAM MODIFICATIONS **40 CFR 403.17**	Either the Approval Authority or a POTW with an approved POTW Pretreatment Program may initiate program modification at any time to reflect changing conditions at the POTW. Program modification is necessary whenever there is a significant change in the operation of a POTW Pretreatment Program that differs from the information in the POTW's submission, as approved under §403.11.	No enhancement needed.

3 · Assessing and Managing Risk in Potable Reuse

Risk assessment is essential in any potable reuse program to protect public health and prevent damage to the water treatment system. A comprehensive risk assessment should include a thorough evaluation of the local source control program. Risk assessment and management procedures to establish local acceptance limits are enhancements that are included in the NPP for DPR applications as shown in Table 2 (Chapter 2).

Effective source control requires a complete inventory of all industries that discharge to the wastewater collection system, the contaminants being discharged, and a plan to safely manage them. Typical source control practices such as concentration and mass loading limits, chemical substitution, discharge prohibition, on-site monitoring, and other measures, should be in place before **any** potable reuse program is implemented.

Any potable reuse scheme, and in particular those planned for DPR, should incorporate a risk-based approach to identify and set limits for water quality constituents that could be in commercial waste discharges. Examples of comprehensive health risk assessments are the technical support documents for public health goals by CalEPA’s Office of Environmental Health Hazard Assessment. The Office of Environmental Health Hazard Assessment sets health-protective levels for drinking water contaminants and assesses for chemicals and contaminants in the environment and workplace.

This chapter includes examples of risk assessment protocols, case studies, and broader frameworks that have been adopted internationally to manage risk for potable reuse projects. More research should be conducted to further define a risk assessment approach and develop specific recommendations for enhanced source control for DPR. The research should build upon what others have done in their source control programs to identify and inform acceptance criteria for industrial dischargers.

3.1 Risk Categories

Any potable reuse application must manage two risk categories: Acute risk, which is generally caused by pathogenic microorganisms—though some chemicals may pose acute risks—and chronic risk, which is generally caused by organic and inorganic chemical contaminants. Evaluating both acute and chronic risks is important, because both have the potential to affect public health; however, acute risk from pathogens is considered less of a source control issue except in the case of dischargers such as hospitals and healthcare facilities.

The increasing global problem of antibiotic-resistant microbes and genes in wastewater is causing greater scrutiny of hospital discharges. Many hospitals segregate biohazard and blood waste for disposal by incineration. Waste from isolation and infectious disease wards is often disinfected separately before being discharged to the sewer. Nevertheless, hospitals should be classed as SIUs as described in Table 2 (Chapter 2). Collection system utilities need to assess the risks posed by medical waste and identify the best management options, which may include not allowing discharge to any wastewater collection system that provides water for a DPR program.

Industrial discharges usually contain chemicals and, therefore, generally—but not always—contribute to chronic risks. Examples of chemical risks are documented in the EPA National Pretreatment Program and in California source control programs, including those by the Orange County Sanitation District and the Sanitation Districts of Los Angeles County. For example, Orange County Sanitation District has established a local limit for 1,4-dioxane of 1.0 mg/L for the protection of water reclamation. They also added a prohibition to the Wastewater Ordinance on wastewater discharges that "Causes the Orange County Water District Groundwater Replenishment System product water to exceed its TOC limit of 0.5 mg/L."

In addition to managing the risks from known chemical contaminants, it is important for collection system utilities to stay up to date with emerging industries and the risks they pose. For example, the global nanotechnology market is expected to exceed $125 billion by 2024 (Research and Markets 2018). Waste effluent containing engineered nanoparticles ranging from 1 to 100 nm in diameter could present challenges to AWTPs (Law and Davison 2017). And concerns about potential health risks from per- and poly-fluoroalkyl substances (PFAS) in drinking water have emerged recently, even though PFAS have had widespread use in industry and commerce for some time.

Overall, a source control risk assessment is important for potable reuse applications that do not include environmental buffers. Several approaches to continually identify and manage risk are described in the following section. Regardless of the approach, it is important for senior management at the AWTP to commit the necessary staff and technical, managerial, and financial resources to support an enhanced source control program.

3.2 Managing Risk in an Enhanced Source Control Program

Local limits for concentration and mass loading of constituents should be set after the risk assessment process, regardless of the WWTP/AWTP plant configuration or size. Collection system utilities should focus on the decision to adopt potable reuse and not on whether environmental buffers are included in the treatment train. For potable reuse projects that do not include environmental buffers, the risks posed by illegal discharges should be managed by monitoring for COCs or their surrogates at nodal points in the wastewater collection system.

Further, the risk management process should be applied from source water to tap. The process should include representatives from:

- Operations—Collection system, WWTP, AWTP and distribution system.
- Industrial waste officers.
- Industrial users.
- Laboratory services.
- Health Department.
- External advisors.
- Risk assessment facilitators.

The overall risk management process includes:

- Define the approach to hazard identification and risk assessment.
- Identify and document hazards and hazardous events for each system component.
- Estimate risk level for each hazard and hazardous event.
- Determine significant risks and document priorities for risk management.

- Evaluate major uncertainties and create a strategy to reduce uncertainty.
- Identify existing preventive measures and estimate remaining risk.
- Identify alternative preventive measures to reduce risk to acceptable levels.
- Document preventive measures and strategies to address each significant risk.
- Assess preventive measures to identify Critical Control Points (CCPs) that align with Hazard Analysis and Critical Control Point (HACCP) procedures.
- Establish mechanisms for operational control.
- Document CCPs, critical limits, and target criteria.

The Water Safety Plan Manual developed by the World Health Organization (WHO) and the International Water Association includes case studies and a process to manage risk for drinking water that could be used as a model for DPR (Bartram et al. 2009).

3.3 Risk Assessment and Management Methodology

Many industries, including water utilities, already have risk assessment and management procedures in place. However, the procedures are often limited to high-level concept documents that are linked to other corporate strategies. Because of the complexity and high stakeholder involvement with public water supply issues, the risk assessment process for DPR projects must be comprehensive and targeted to specific technical and managerial practices.

Everyone involved in the risk assessment process must understand the methods and the desired outcomes. Assessing the magnitude of risk without any controls (inherent risk) helps to identify baseline risk and understand the rationale for a risk management system. Assessing the magnitude of risk that remains after controls are implemented (residual risk) confirms how well the control measures have mitigated the inherent risk.

Figure 1 shows a general approach to the risk management process. Components of the process are described in the following subsections.

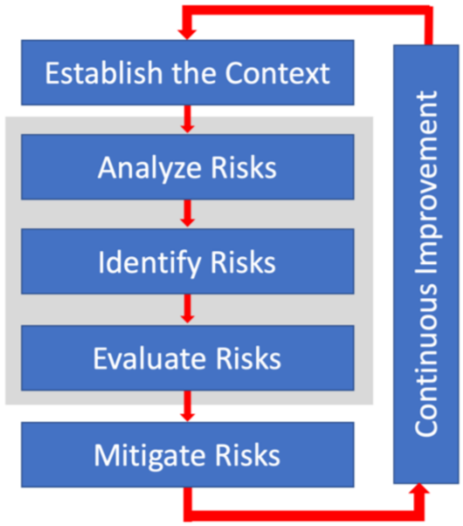

Figure 1: General Approach to the risk management process

3.3.1 Establish context

The first step is to establish the context for the risk assessment. Context is specific to each project and may include technical, managerial, and financial aspects of the treatment facilities along with social and political conditions surrounding the utility's staff, appointed and elected officials, and community stakeholders. For a DPR project, the most important risks are related to source control, influent water quality parameters, treatment reliability, monitoring, and regulatory oversight.

3.3.2 Analyze risk

After the context for the risk assessment has been established, the next step is to analyze the potential risks.

3.3.3 Identify risk

After analyzing the potential risks for potable reuse, the next step is to identify the actual risks in the wastewater collection system and service area. This step includes reviewing the existing source control program (if there is one) and conducting a survey of the wastewater collection system to identify all commercial discharges.

3.3.4 Evaluate risk

Both qualitative and quantitative measures are useful to evaluate risk. Risks should be evaluated in a matrix that describes the likelihood of an event and the consequences of the event. One water-industry-specific example is from the Australian Sewage Quality Management Guidelines (WSAA 2012), which defines the likelihood of an event (Table 3), and the significance of the financial and health/safety damage caused by the event (Table 4).

Table 3. Qualitative Measures of Likelihood of Event Occurring

Level	Descriptor	Example Description
A	Almost Certain	Event occurs daily
B	Likely	Event occurs weekly
C	Possible	Event occurs monthly
D	Unlikely	Event occurs yearly
E	Rare	Event occurs every 5 years or more

Source: (WSAA 2012)

Table 4. Qualitative Measures of Consequence or Impact of Event

Level	Descriptor	Example Description
1	Insignificant	Insignificant impact or non-detectable
2	Minor	Minor impact, small increase in op costs
3	Moderate	Moderate impact, operational costs increased, increased monitoring
4	Major	Major impact, system compromised, increased monitoring
5	Catastrophic	Major impact, system failure, causes death or permanent disability

Source: (WSAA 2012)

Combining the likelihood and consequences into a matrix (Table 5) can help to assess severity and assign a numerical score to the risk level. Higher values indicate more severe and certain consequences, while lower values indicate less severe and certain consequences. For example, a catastrophic event that is likely to occur scores high, while an insignificant event that probably won't happen scores low.

Table 5. Qualitative and Quantitative Risk Analysis Matrix – Level of Risk

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium (5)	High (10)	High (15)	Extreme (20)	Extreme (25)
Likely	Medium (4)	Medium (8)	High (12)	High (16)	Extreme (20)
Possible	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare	Low (1)	Low (2)	Low (3)	Medium (4)	Medium (5)

Other quantitative values can be developed from the qualitative risk measurements in Tables 3 and 4. For example, assign scores to the potential frequency of an event, with the most frequent events scoring the highest. To quantify the consequences of an event, it is necessary to evaluate several outcomes, such as increased operational costs, increased public outreach, and lost productivity.

The WSAA 2012 guidelines referenced above are one example approach; the collection system utility should use an approach that best meets their needs in identifying and scoring risk.

3.3.5 Mitigate risk

After evaluating risks, the next step is to develop risk mitigation strategies. Some risks may be eliminated or reduced with mitigation; however, many mitigation methods will just reduce the likelihood or consequences of a risk by a small amount.

3.3.6 Continuous improvement

A key concept around risk assessment and management is that, over time, risks will change for many reasons; for example, new industries open while others close down, existing industries expand, or new chemicals are used. Therefore, it is important to regularly review how often the collection system utility conducts a risk assessment.

3.3.7 Risk acceptability and management

Once the risk levels have been assessed for each process step, we must evaluate their acceptability and, where necessary, establish mitigation measures. A qualitative risk acceptability matrix is shown in Table 6.

Table 6. Qualitative Risk Acceptability Matrix

Inherent Risk Rating (Score)	Risk Level	Action
High (10) to Extreme (25)	Intolerable	Do not operate the process until the risk is reduced to tolerable
Medium (4-9)	Tolerable	Operate the process using added safeguards to reduce risks to acceptable
Low (1-4)	Acceptable	Operate the process with existing controls

Source: (WSAA 2012)

The results of the assessment should be summarized in a risk register (list of risks) that shows the process steps with intolerable risk levels. If no intolerable risks emerge from the analysis, then we must address those with a tolerable risk ranking and attempt to reduce them to acceptable levels by implementing preventative actions as part of a continuous improvement program.

3.4 Example of a Risk Management Framework

Water industry and public health officials worldwide have long recognized the importance of a rigorous source control program to protect the wastewater collection system, the wastewater treatment plant (physical and biological treatment), and the resulting water quality. The exact framework used for assessing risk in a source control program is not critical; what is important is adopting a defensible framework and including a continuous improvement program.

Australian guidelines could provide a good example framework for utilities that are considering enhanced source control. Originally developed in 2008 and updated in 2012, the WSAA 2012 guidelines recommend a 12-element risk management framework to help utilities protect wastewater collection system assets and treatment processes, comply with environmental legislation, reduce hazards and odors for workers and the community, and control the quality of recycled water and biosolids.

The 12-element risk framework includes:

Element 1 – Commitment to Sewage Quality Management

Element 2 – Assessment of the Hazards

Element 3 – Risk Assessment and Control

Element 4 – Operational Monitoring and Control Points

Element 5 – Verification and Monitoring

Element 6 – Management of Incidences and Emergencies

Element 7 – Employee Awareness and Training

Element 8 – Stakeholder Management

Element 9 – Research and Development

Element 10 – Documentation and Reporting

Element 11 – Evaluation and Audit

Element 12 – Review and Continual Improvement

The WSAA (2012) guidelines, in Appendix E, summarizes how a collection system utility can demonstrate compliance with the 12-element risk framework. The guidelines identify each of the 12 elements, the measures that the utility can use to show compliance, and the supporting records that are required.

The Australian framework is similar to the HACCP and ISO 22000 (International Organization for Standardization) requirements: HACCP is recognized internationally as a tool for proactive management of food safety issues, and ISO 22000 incorporates HACCP principles into a broader framework that is aligned with recognized principles of management systems that drive continuous performance improvement.

Adoption of the 12-element risk framework for source control aligns this guidance with both the Australian Drinking Water Guidelines (NRMMC & NHMRC 2011) and the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) – Augmentation of Drinking Water Supplies (EPHC, NHMRC & NRMMC 2008).

The panel suggests that a similar approach—linking a risk framework with relevant California regulations—should be considered.

3.5 Examples of Risk Assessment in the Water Industry

This section summarizes examples of how risk assessment has been applied in three Australian cities: Canberra, Perth, and Melbourne.

3.5.1 Canberra, Australian Capital Territory

In September 2007, the local water utility conducted a risk assessment of industrial and commercial waste inputs to Canberra's wastewater collection system. The topics they evaluated included:

- Canberra suburbs and their regulated inputs.
- Main industries discharging to the wastewater collection system.
- Process flow diagrams.
- Microbial and chemical hazards.
- Existing controls.
- Risk assessment and risk management frameworks.
- Risk assessment and risk ranking methodologies.

Summaries of analytical results for pesticides, inorganic chemicals, heavy metals, organic chemicals, radionuclides, pharmaceuticals, and fragrances in WWTP effluent were compared with relevant guidelines. This process identified chemicals that required further consideration through the risk assessment and risk management process.

From the risk assessment worksheets, the utility identified 21 separate hazards and categorized 4 as high-risk and 17 as moderate-risk items. Follow-up actions to achieve acceptable risk levels were then developed and summarized.

3.5.2 Perth, Western Australia

A groundwater replenishment potable reuse project has been operating in Perth since 2015, and a detailed risk assessment was carried out to identify not only the operational risks but also those that could adversely affect water production by the AWTP, which incorporates microfiltration, RO, and UV treatment.

The assessment showed that there were 11 high-risk, 7 moderate-risk, and 13 low-risk items. Of the 11 high-risk items, 8 were related to commercial waste. Management took steps to address the high and moderate risks and was able to recharacterize them in the low-risk category before the project was commissioned and built.

In addition, the Water Corporation of Western Australia carried out a Human Health Hazard Assessment on a range of chemicals that were monitored in water coming from the WWTP and feeding into the AWTP. The goal was to identify chemicals or chemical groups that could pose an unacceptable risk to the quality of water produced by the AWTP. The result was that the risks identified as moderate and high were reduced to low. As with the operational risks, this exercise was carried out before the project was commissioned and involved Water Corporation design and operations staff as well as external consultants. The assessment identified measures that would reduce risk levels to acceptable and manageable levels.

3.5.3 Melbourne, Victoria

Melbourne Water also applied a risk assessment approach to managing the quality of industrial waste discharged into its wastewater collection system but used a different approach than Canberra or Perth. The Melbourne Water Sewage Quality Management System includes a quantitative risk assessment that provides a toolbox of models to help the utility understand pollutants of interest (POIs) in its raw wastewater. These models enable Melbourne Water to understand the impact of POIs on the wastewater treatment processes, treatment plant operations, the beneficial uses of recycled water and biosolids, and the marine systems where these products enter the environment (Melbourne Water Corporation 2018).

The utility has carried out quantitative risk assessments (QRAs) since 2008, which identify and prioritize POIs to create a list of potential priority pollutants. The list is used to manage and inform commercial waste acceptance levels. Recent stages of the QRA have focused on developing a framework for an Integrated Sewage Quality Management System (ISQMS) and supporting databases and software tools, known as the Sewage Quality Risk Assessment Toolbox (SQRAT).

The QRA and SQRAT use five models developed specifically for Melbourne Water's Eastern Treatment Plant and Western Treatment Plant, which treat about 800 ML/d (211 mgd).

The five models are:

- WERT. Weight of Evidence Ranking Tool. Used to prioritize POIs for further assessment and provide a database of POIs for SQRAT.
- AQUAWEB. A food web bioaccumulation model.
- SOILX. A model to determine the fate of organic chemicals in soil.
- CHEM-Rox. A fugacity model to assess fate of POIs through the WWTP plus an oxidation model for POI removal through oxidative processes such as ozonation or chlorination.
- TRET. Trade-waste Risk Evaluation Tool. Used to derive influent guideline values and to assess the risk of accepting trade-waste (industrial waste) variation requests.

A conceptual overview of the wastewater quality management system logic, model, and guidelines is presented in Figure 2, with the five models highlighted in orange.

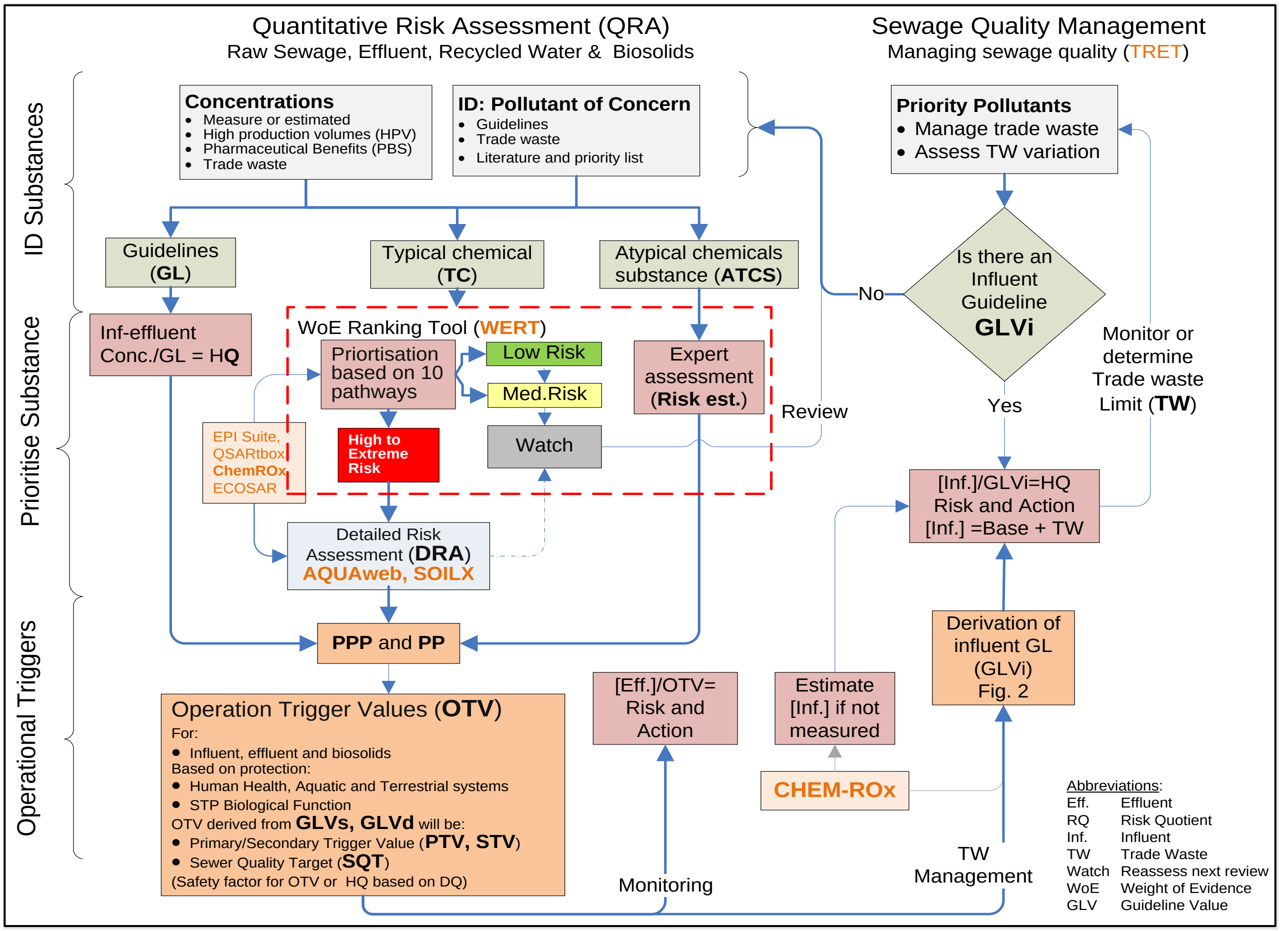

Figure 2: Conceptual Overview of Melbourne Water's Sewage Quality Management process (Melbourne Water Corporation 2018)

The final stage in developing the ISQMS is to digitize SQRAT to help operators assess the effects of contaminants in wastewater on treatment plant operations. It informs the licensing of commercial waste and management of wastewater quality by setting appropriate acceptance criteria.

3.6 Recommendations

Enhanced source control programs for all potable reuse applications, and particularly those that do not include environmental buffers, should follow a quantitative risk assessment and management process that identifies and ranks all risks and proposes measures to manage them.

- Enhanced source control programs should include the principles of risk assessment and risk management and should either be based on one of the example frameworks or be developed in their own right and be suitable for California.
- Risk assessment should be used to identify shortcomings in the Source Control Program, and risk management should be used to address shortcomings and to develop appropriate concentrations for local limits.
- Risk assessment and management should be used to evaluate sampling (frequency and range of analytes) and real-time monitoring at the dischargers' premises as well as within the wastewater collection system.
- Enhanced source control programs should have a continuous improvement process where risks and mitigations are reevaluated at regular, predetermined intervals.

Metrics

Metrics to assess the risk management recommendation include:

Pass/Fail

- Did the utility perform an initial risk assessment of the enhanced source control program in setting local limits for acceptance of wastes?
- Did the utility implement and follow the mitigation measures of the plan?
- Does the risk assessment have a continuous improvement process?

4 · Enhanced Monitoring and Early Warning Systems

Monitoring an enhanced source control program is critical to verify that the program is working and to help plan future efforts. Monitoring for industrial user permit compliance can include routine and non-routine sampling to verify that a discharger is meeting the permit requirements. However, one of the most significant risks in source control programs for DPR is caused by occasional noncompliant and illegal discharges.

Noncompliant discharges can be detected by enhancing monitoring at the industrial discharge point, while illegal discharges can be detected by installing monitoring systems at nodal points in the wastewater collection system and in the headworks at the WWTP. These two types of monitoring help to establish risk management procedures to safeguard the AWTP product water quality.

Enhanced monitoring also provides data for continuous program improvement. Dischargers and the nature of discharges can vary over time, and there will be known and unknown events that could cause chemical peaks. Enhanced monitoring continuously refines the program to decrease the mass loading and number of chemical peaks in the wastewater collection system.

4.1 Traditional Monitoring

For utilities that are *not* practicing potable reuse, traditional source control program monitoring focuses on compliance and identifying illegal discharges. Wastewater treatment plants remove conventional pollutants, such as biochemical oxygen demand and total suspended solids, but the NPP regulates the input of toxic pollutants, such as heavy metals and volatile organic compounds, from industries that discharge into the wastewater collection system. The NPP protects the wastewater collection system, WWTPs, and, ultimately, receiving waters. NPP requirements are used to establish routine monitoring for permitted dischargers. NPDES permits under the CWA also typically require WWTPs to monitor influent and effluent for both conventional and toxic pollutants.

Under the traditional NPP approach, the WWTP and individual industrial users provide the backbone of the monitoring programs. Since the NPP was established, wastewater utilities have developed specialty monitoring to meet site-specific needs. These include primary pipeline (trunk line) monitoring to assess wastewater, downstream and upstream monitoring targeted to catch illegal discharges, and other special studies. More sophisticated real-time and near-real-time monitoring equipment is now available to detect and respond to illegal or unexpected discharges more rapidly. This includes equipment that is deployed within the wastewater collection system at selected nodes to help isolate the source of the discharge.

4.1.1 Sampling

The NPP has many specific requirements for sampling and reporting; the basic premise is that the location and frequency should be established to ensure compliance. For SIUs, this means at least annual monitoring by the WWTP and semiannual monitoring by the SIU. For middle-tier CIUs, the NPP requires monitoring once every two years by the WWTP; non-significant categorical users should be evaluated every two years to make sure they still meet the criteria. Depending on the constituent being measured, there are requirements for grab samples or for 24-hour composite monitoring. In general, the minimum requirements are focused on long-term issues and not real-time discharge monitoring.

WWTPs are also often required to monitor influent, effluent, and receiving waters, such as rivers, lakes, or the ocean. The NPP requires WWTPs to establish local discharge limits to protect the wastewater collection system, treatment facility, and receiving waters. Typically, this includes an influent/effluent mass balance with an assignment of loading to all industrial dischargers. WWTPs are also required to maintain their facilities in proper operating condition. This can include additional maintenance and/or monitoring of wastewater collection facilities.

4.1.2 Enforcement

The NPP requires enforcement against industries that violate the NPP under the CWA or Local Authority discharge requirements. Traditional monitoring includes enforcing permits and finding illegal dischargers. While scheduled sampling will identify some issues, there is a time lag between sampling events and not all issues will be caught. Therefore, WWTPs should perform random or targeted system sampling to find noncompliant discharges for permit enforcement. Depending on the results of this monitoring, the collection system staff may need to investigate the source of the discharges. These evaluations can take weeks or months and, in some cases, the noncompliant discharge stops before the source can be identified.

4.2 Enhanced Monitoring Systems

One way to enhance monitoring for DPR is to use on-line sensors and software that evaluate sensor data in real time. While some source control programs use such sensors, their application is limited because of the increased maintenance and cost.

Sensors can relay data back to a supervisory control and data acquisition (SCADA) system; however, because of concerns about data reliability, many utilities don't rely on sensors for real-time decision making but use them as an alert to deploy traditional monitoring. In a potable reuse system, time is critical, so an enhanced source control program should integrate sensors and software to monitor the status of the wastewater collection system and to develop an early warning system.

4.2.1 Sensors

The number and variety of commercial sensors that can be used in a wastewater collection system is increasing. Wastewater collection systems are a challenging environment for most sensors because of the water quality matrix, solids and trash, variable flows, open channel flow, and the corrosive environment. Water industry literature is filled with case studies on tests of different kinds of sensors—some are successful, but most are not. In many cases, while data from the sensor was seen as beneficial, the cost and maintenance of sensors was deemed to outweigh the benefit.

Sensor technology is advancing, however, and some utilities use sensors in wastewater collection systems with very encouraging results. Case studies identified some sensors and software that may apply to source control to monitor flow, pH, conductivity, temperature, hydrogen sulfide, and VOCs. Real-time monitoring has a definite role in enhanced source control programs for potable reuse applications. However, more research is needed to identify and test other sensors that could work in a wastewater collection system.

4.2.1.1 Direct Sensors

The number of sensors that directly measure parameters of concern, such as a water quality constituent or flow, is increasing. There are sensors on the market that DPR project managers should consider for real-time monitoring, such as pH, conductivity, flow, or ORP.

A collection system utility should assess the risks and, if warranted for risk mitigation, deploy sensors on a discharger's premises and at nodal points in the wastewater collection system. The collection system utility should examine what others are doing in the United States and internationally to match the sensor with the type of waste discharged.

4.2.1.2 On-Premises Monitoring

SIU dischargers should, as a condition of their waste discharge permits, be required to continuously monitor their waste discharge. The monitoring point must be free of domestic wastewater and the parameters that could be typically monitored, depending upon the nature of the commercial discharge, include:

- Flow rate and daily volume
- pH
- Conductivity
- Oxidation reduction potential
- Temperature
- Turbidity
- Hydrogen sulfide
- Volatile organic compounds

The collection system utility should establish requirements for calibrating sensors and verifying sensor performance. This will enable the collection system utility to meet acceptance limits.

Such monitoring systems do not preclude both the discharger and the collection system utility from taking regular grab and composite samples and analyzing for specific chemicals that are relevant to the type of industry. If necessary, changes to local limits, both in terms of concentration and mass loading, will need to be implemented by the collection system utility. Examples of COCs to monitor include acetone, PFAS, and 1,4-dioxane.

Equipment failure can cause noncompliant discharges, so there must be a rapid response contingency plan in place that has been developed and agreed to by both the discharger and the collection system utility receiving the wastewater. The rapid response contingency plan, when applied, will bring the discharge back into compliance within an agreed-upon time. This plan could also be part of an Enhanced Inspection Program that uses sensors to detect noncompliant discharges and illegal dumping.

4.2.1.3 Nodal Monitoring

Nodal monitoring can occur in the wastewater collection system at nodal points in the system and in the headworks at the WWTP. Headworks monitoring is more standard for constituents such as pH, conductivity, flow, and ORP because the analyzers are located at the WWTP where staff can check and maintain them. Data from headworks monitors can also be compared to daily grab or composite samples that are part of regulatory or process monitoring for the WWTP utility. Monitoring at the headworks does not, however, give the utility much time to react to problems. Monitoring at nodal points is gaining traction as companies develop new sensors that are adapted to the challenges of the wastewater collection system; two key challenges are the corrosive environment and remote nature of monitoring locations.

Wastewater collection system monitoring to deter illegal discharges and detect the effects of infiltration has been tested in Australia, the United States, Israel, Greece, and Singapore.

Technology developed in Israel monitors conductivity, ORP, temperature, pH, and H_2S, and was tested over nine months (July 2018 through March 2019) by Unity Water, a Utility in Queensland, Australia. The technology was tested for:

- Sulfide monitoring for optimized network odor management.
- Peak pollution sampling to facilitate compliance with commercial waste admission limits.
- Pollution monitoring to better inform WWTPs of incoming volumes and constituents.
- Inflow and infiltration monitoring to identify seawater intrusion.

Results were very encouraging. Similar technology is being tested in Ventura, California, as part of The Water Research Foundation Project 17-30 on Real-Time Collection System Monitoring for Enhanced Source Control.

One advantage of real-time monitoring is that the resulting data can be used to refine the wastewater collection system sampling program and manage costs.

Singapore Public Utilities Board (PUB) is committed to protecting the operation of its WWTPs and NEWater Plants and has successfully installed 40 VOC analyzers at nodal points in its wastewater collection system to track and deter illegal discharges. It has recently added 42 microbial electrochemical sensors (MES)—a form of microbial fuel cell—which provide real-time monitoring for heavy metals and cyanide and, when used with sensors for pH, temperature, chemical oxygen demand, ORP, nitrate, and sulfate, contribute significantly to the value of real-time monitoring. These MES units are installed at selected dischargers along with pH meters. Autosamplers are installed when a noncompliant discharge is detected.

Parameters that are monitored with real-time monitoring equipment at the WWTP headworks are similar to those listed for on-premises discharger monitoring with the possible addition of total organic carbon and ammonia.

4.2.1.4 Surrogate Sensors

Because of the high number of chemicals found in wastewater, it is not cost-effective to routinely monitor for each one, and sensors do not exist to measure them all. Therefore, surrogates for different groups of chemicals should be investigated for wastewater collection system sampling and monitoring. Considerable work has been done to establish surrogates for groups of chemicals in product water. For example, Diclofenac has been used to represent pharmaceuticals and personal care products, Chlorate has been used to represent inorganic disinfection byproducts, and Boron has been used to represent inorganic chemicals, to name a few. Little research has gone into investigating surrogates for source control programs other than the proven sensors for pH, hydrogen sulfide, conductivity, turbidity, ORP, and flow.

Monitoring the wastewater collection system can provide an early warning that an actionable event has happened in the system. Knowing the exact chemical and concentration is beneficial but not practical in all cases, so using surrogates could be a viable option. This concept is like the event warning systems that alert if a dangerous chemical is discharged into the drinking water distribution system. Some sensors are set up to monitor typical water quality parameters—pH, temperature, conductivity, chlorine residual—and when a change is detected, it triggers an alert. Utilities looking to implement potable reuse should evaluate their system and potential risks and then evaluate surrogate sensors that could trigger an alert when potential problems occur in the wastewater collection system.

4.2.1.5 Future Sensors

Sensor technology and innovation are accelerating across the water industry, and it is likely that the numbers of sensors will increase, their functionality and reliability will increase, and their cost will decrease. Because of the importance of monitoring and early warning for potable reuse projects, utilities should always be looking for new and better sensors to add to their monitoring program.

4.2.2 Software

Using software to monitor performance is common in power and nuclear plants but is just beginning to be more prevalent in the water industry. The water industry has traditional Supervisory Control and Data Acquisition (SCADA) systems, but the software performance monitoring systems envisioned for source control go beyond these and will aggregate data from several systems and analyze it for complex patterns. Performance monitoring software might use artificial intelligence or machine learning to analyze wastewater collection systems and trigger an alert.

4.2.2.1 Industrial User Sensor Data Sources

Real-time water quality and flow sensors in the collection system are obvious data sources for monitoring software. They represent many of the typical parameters that have historically been collected and can be correlated to upstream changes based on institutional experience. A potential benefit of monitoring software is the ability to look at additional data from the IUs.

Additional data could be collected from operating systems of the dischargers, as they typically have their own SCADA system with real-time sensors. With advancing technology and the internet of things, it is becoming easier to collect and share data through public, private, and cloud-based systems. Utilities should assess all available sensor data in their wastewater collection system and consider including real-time data transfer requirements for IUs into their discharge permits. Such data sharing increases transparency to ensure minimal interference with the collection system and treatment plant.

4.2.2.2 Nontraditional Data Sources

The advantage of newer software systems is the ability to handle diverse types of data (structured and unstructured), generate insights from data, and use data from nontraditional sources. Some nontraditional data sources could be potable water or power use data from advanced metering infrastructure at discharger sites, which could be used to predict discharge quality or quantity. Other nontraditional data could be inventory or delivery data from discharger sites to track chemical use and predict potential impacts on discharge quality.

With more data transparency, monitoring software could use data from a variety of sources to help a collection system utility understand when potential risks in the system are elevated. While a collection system utility might not monitor all dischargers this way, it might be appropriate to implement a data monitoring system for SIUs because of the time-critical need to respond to an unauthorized or accidental discharge that could affect the potable reuse project.

4.2.2.3 Trends for the Future

In the future, software monitoring is likely to have a greater role in finding and predicting problems in wastewater collection systems. While these are just a few software solutions for specific problems, the potential for water industry software is attracting interest from major software companies. Utilities that are considering potable reuse today can expect to use software more in the future.

4.3 Early Warning System

As utilities implement potable reuse—especially DPR—an early warning system in the wastewater collection system could help launch remedial actions to quickly respond to a problem and prevent adverse water quality excursions at the WWTP, the AWTP, or in the product water. Early warning systems are a viable option for potable reuse applications and can be invaluable for protecting the collection system and WWTP.

4.3.1 What is it?

Early warning systems identify water quality excursions in the wastewater collection system and trigger response actions. The system uses a series of detectors that can trigger alerts and feed information into a decision hierarchy so that either an automated system or a human operator can make decisions and act. Once an alert is triggered and sent to the decision hierarchy with some contextual data, a decision tree or set of rules is applied to help classify the alert and determine the necessary response. The primary objective of the early warning system is to use technology to identify, classify, and select actions that will help a human operator respond.

4.3.2 How is it done now?

Currently, early warning systems in the water industry are quite simple. A few water quality sensors may be programmed with a specific algorithm or an if/then statement to recognize an event. A set of rules may be triggered, but in many cases, the alert is raised to a human operator who will interpret the data and decide what actions are needed.

Often, these systems respond to very specific scenarios, such as an unauthorized discharge into a pipeline, an increase in the amount of permitted discharge, or other specific water quality scenarios such as an unexpected increase in chemical oxygen demand or a decrease in dissolved oxygen.

Hundreds—if not thousands—of disruptive scenarios are possible in a wastewater collection system. There are commercially available sensor systems and software that find scenarios of concern or can be set up to learn scenarios of concern. The case studies in this report include programs in Singapore and Israel where such systems were tested and are now in operation. Over time, sensor and software systems will be able to find and react to a broader range of scenarios.

The cost and scale of an early warning system can be tailored to the DPR program size and the risk assessment performed for the enhanced source control program. For smaller programs with less contribution from IUs or SIUs, the early warning system could be more focused or may not be needed if other risk mitigation measures, such as additional treatment, blending, effluent monitoring, or diversion are viable. The cost of the program will vary, but if collection system utilities take advantages of real-time data from the IUs and SIUs and other non-traditional data sources, the early warning system could have a more robust view of the collection system for a lower cost, other than connecting to those data sources through cloud-based technologies.

4.3.3 Is an Early Warning System Viable Today?

While it would take effort, technology is available to support such an early warning system. If a collection system utility has the interest, it can develop its own early warning system by systematically deploying the required sensors, configuring software to detect events, and then creating the response rules.

While a collection system utility could plan out their scenarios and the data they needed to detect adverse events, there still could be limits on the availability of applicable sensors. However, the inability to detect all possible scenarios should not prevent implementing a system that can detect some scenarios such as acid or alkali discharges, heavy metal discharges, saline discharges, volatile organic compound discharges, and others. As a collection system utility assesses the nature of its discharges and its wastewater collection system and looks at its risks, it could develop an early warning system that would alert WWTP and AWTP operations that an adverse event has happened and that they should consider action. Given the importance of source control in potable reuse applications, and particularly in those applications that do not include an environmental buffer, some type of early warning system is a valid expectation for an enhanced source control program.

4.4 Recommendations

Enhanced source control programs for all DPR applications should include enhanced monitoring that includes real-time sensors, software, and some form of early warning system. Enhanced source control programs should:

- Perform a risk assessment to identify the constituents and locations where real-time monitoring would be best applied. WWTPs can defer this requirement if the SIU contribution is low or by using other mitigation measures, including additional treatment barriers, blending, effluent monitoring, and diversion.
- Consider the different scenarios they are trying to detect and use a combination of real-time sensors and software to detect and alert when a potential issue is occurring.
- Implement enhanced monitoring at some nodal points within the collections system.
- Consider sensors for surrogate parameters or software detectors in addition to traditional real-time water quality sensors.
- Utilities should assess all available sensor data in their wastewater collection system and consider including real-time data transfer requirements for IUs into their discharge permits—all with the aim of increasing transparency to ensure minimal interference with the functioning of the collection system and associated treatment plants.
- Consider other sources of data, such as water use or energy use of SIUs, and consider partnering with specific SIUs to get a real-time transfer of their operational data.

- Implement an early warning system that has elements of real-time sensors/data, event detection, and a decision hierarchy that can inform needed actions.
- Implement a continuous improvement plan for the real-time monitoring and the early warning system and reevaluate it regularly for enhancements.

Metrics

Metrics to assess the enhanced monitoring recommendation include:

Pass/Fail

- Did the collection system utility perform an initial risk assessment?
- Did the collection system utility implement and follow the mitigation measures of the risk assessment?
- Does the collection system utility have some real-time sensors deployed?
- Does the collection system utility have an early warning system deployed?

Quantitative Metrics

- Number of source control related events detected by the early warning system compared to the number of events detected at the WWTP or AWTP.
- Number of IU events detected by the early warning system compared to the number of IU events that are reported by the IU.

5 · Technical/Managerial/Financial Capacity

The concept of technical/managerial/financial (TMF) capacity is the ability of a utility to provide safe and dependable water to its customers. TMF capacity has been applied to drinking water systems to ensure the system is sustainable and can consistently comply with regulations. TMF should be part of the initial design and long-term operations of any potable reuse program, and the managers should use this concept to assess and allocate the resources needed to launch and sustain the program.

The Safe Drinking Water Act requires state regulators to incorporate TMF capacity into public drinking water systems operations (Olivieri, et al. 2016).

The elements of TMF are:

- Technical. Addresses performance, operation and maintenance.
- Managerial. Addresses governance of the involved organizations.
- Financial. Addresses the financial ability to operate and maintain existing AWTP infrastructure and financial planning for future needs. It is assessed through budgets, asset management practices, and regular independent audits.

In California, source control programs are authorized and enforced through NPDES (for ocean discharge) and waste discharge requirement (WDR) permits issued by regional water quality control boards.

NPDES and WDR permits are issued to a specific wastewater treatment plant, an entity operating multiple treatment plants or, in some cases, a combination of both agency and treatment-plant-specific permit requirements. Across California, communities large and small served by wastewater utilities that span a range of sophistication may view potable reuse as a viable option to diversify their water supply. Because treatment processes are more sophisticated than traditional wastewater treatment in such applications, and because they require a consistent and safe supply of source water to the AWTP, the source control programs that serve potable reuse projects must demonstrate continuous improvement to comply with the Safe Drinking Water Act responsibilities to assess and build its TMF capacity.

A continuous improvement program will provide objective evidence to help ensure that public water systems of all sizes earn and maintain public trust through the consistent production and delivery of safe drinking water sourced from potable reuse projects.

5.1 Continuous Improvement: Quality Management

The overarching goal of any continuous improvement plan is to formalize the process of pursuing and investing in more efficient and effective management of the project. For a DPR program, the more specific goals include to protect public health and to assure the community that the drinking water supply is as safe as possible.

5.1.1 Source Control Steering Committee

To ensure that any potable reuse program is successful and safe, a high level of commitment is required from all utilities and dischargers in the wastewater collection system. Because the industries, businesses, and households contributing to the wastewater collection system are providing the source water for the drinking water supply, it is important to engage with these dischargers through a source control steering committee. The goal of the committee will be to support the continued success of the DPR program.

The committee should include representatives from all the utilities that supply wastewater to the program as well as the utilities that operate the WWTP and AWTP. In addition, the committee should include representatives of significant industrial users and others that discharge COCs to the wastewater collection system. The source control steering committee should proactively identify issues that could compromise the potable reuse program, should participate in the risk assessment and management deliberations and should also suggest ways to improve their own contributions to support the project.

5.2 Recommendations

Two important elements are necessary to enhance the TMF capacity of a DPR program.

1. Require each program to implement a continuous improvement plan as part of the enhanced source control program.

The program proposer must allocate the resources needed to develop, approve, and maintain the plan.

The continuous improvement plan should address all aspects of the enhanced source control program.

The program proposer should adopt an existing continuous improvement framework (such as ISO 9001) or develop their own that is consistent with industry best practices.

2. Require each DPR program to form and maintain a source control steering committee.

The committee should include representatives of all the utilities in the wastewater collection system that supply water to the program, as well as the utilities that operate and monitor the performance of the WWTP and the AWTP.

The committee should include representatives of significant industrial users and other dischargers that contribute COCs to the wastewater collection system.

The committee should meet periodically and share information that is important for the health and safety of the watershed/wastewater collection system.

The successful adoption, implementation, and long-term commitment to a quality management and continuous improvement program is a critical expression of TMF capacity for any wastewater agency providing source control services to a potable reuse project in California. The PDSA/PDCA program required of DPR Source Control Programs should include the elements derived from the ISO 9001:2015 Enterprise Quality Management System, described in Appendix F.

Metrics

Metrics to assess the TMF capacity include:

Pass/Fail

- Does the DPR proposer have a continuous improvement plan?
- Does the DPR proposer follow the planned activities in the plan?
- Does the DPR proposer have a source control steering committee?
- Does the committee have representatives of the SIUs?

- Does the committee meet periodically and improve the enhanced source control program?

Appendix A · Independent Advisory Panel Members

Jeff J. Neemann, D. Eng., PE (Chair)
Client Director, Black & Veatch (Irvine, California)

Jeff Neemann has experience with innovative water, wastewater, and reuse projects around the world. His expertise is in the development and application of advanced treatment technologies, including evaluation, pilot testing, design, and operation of ozone, chlorine dioxide, ultraviolet light (UV), granular activated carbon, and membrane technologies. He has developed and applied big data and technology solutions for the water industry and is an inventor on two patents for limiting bromate formation during ozonation. Dr. Neemann holds a BS in Civil Engineering and an MS in Environmental Engineering from Missouri University of Science and Technology, and a Doctorate in Civil Engineering from University of Kansas.

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Director of Water Quality and Regulatory Compliance,
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James (Jim) Colston has more than 30 years of experience in source control, environmental compliance, and regulation of wastewater. At Irvine Ranch Water District, he manages a team that implements the pretreatment program under the federal Clean Water Act along with state and local regulations. He has chaired many technical and legislative advisory committees that represent the water and wastewater community and is a recognized expert in source control strategies that protect public health. Mr. Colston worked at the Orange County Sanitation District (OCSD) in a number of capacities to protect the wastewater collection system and the watershed of the Orange County Water District (OCWD). He contributed to the 2002 decision to voluntarily upgrade OCSD to full secondary treatment and to the 2008 launch of the OCWD Groundwater Replenishment System, which is the world’s largest water purification system for IPR. He holds a JD from Western State University College of Law and a BS in Biochemistry from University of California, Riverside.

Stuart Krasner
Independent Consultant, formerly with Metropolitan Water District of Southern California (La Verne, California)

Stuart Krasner's expertise includes the occurrence, formation, and control of disinfection byproducts (DBPs) of health and regulatory concern, including those associated with chlorine, chloramines, ozone, chlorine dioxide, and bromide/iodide-containing waters and wastewaters. He also evaluates the occurrence and watershed sources of pharmaceuticals and personal care products (PPCPs) and their effects on drinking water supplies. He is active in developing analytical methods, occurrence information, and regulations for disinfection byproducts (DBPs), and facilitates technical exchanges with the toxicology and epidemiology community. He also has expertise in taste and odor control evaluation of drinking water—including sensory analysis, and sources and treatment of off-flavors. Mr. Krasner holds a BS in Chemistry and an MS in Analytical Chemistry from University of California, Los Angeles.

Ian Law
Principal, IBL Solutions and Adjunct Professor, University of Queensland (Brisbane, Australia)

Ian Law has more than 30 years of experience in advanced wastewater and reuse projects in Southern Africa, Southeast Asia, and Australia. He was, until March 2003, CH2M HILL's Technology Director for Southeast Asia, Australia, and New Zealand, and has since run his own business, *IBL Solutions*. Mr. Law is also an Adjunct Professor at the University of Queensland and a Fellow of the Singapore Water Academy and has published widely on the application of advanced reuse systems and the concept of "Total Water Management" for all future water resource and wastewater planning, which he is actively promoting in Australia. Mr. Law served on the Research Advisory Committees for the Australian Water Recycling Centre of Excellence (AWRCE) and the Urban Water Security Research Alliance (UWSRA). He is a Chemical Engineer and holds a Master of Public Health Engineering from University of Cape Town in South Africa.

Amelia Whitson
Pretreatment Coordinator, EPA Region 9 (San Francisco, California)

Amelia Whitson is a Physical Scientist in the US Environmental Protection Agency's Pacific Southwest Regional Office (Region 9) in San Francisco. She has worked in the NPDES Permit Office for nine years. In addition to writing NPDES permits, Ms. Whitson provides technical support to state environmental agencies and manages EPA's oversight of industrial wastewater pretreatment in Arizona, California, Hawaii, Nevada, and the Pacific Island Territories. She holds a BA in Environmental Earth Science from University of California, Berkeley.

Appendix B · About NWRI

For more than 20 years, the National Water Research Institute (NWRI)—a science-based 501c3 nonprofit and Joint Powers Authority located in Fountain Valley, California—has collaborated with water utilities, regulators, and researchers in innovative ways to help develop new, healthy sources of drinking water.

We NWRI assembles teams of scientific and technical experts that provide credible independent review of water projects, develop recommendations that support investment in water infrastructure and public health, and enable water resource management decisions grounded in science and best practices.

Learn more at the NWRI website.

About NWRI Independent Advisory Panels

NWRI specializes in facilitating Independent Expert Advisory Panels on behalf of water and wastewater utilities, as well as local, county, and state government agencies to provide credible, objective review of scientific studies and water infrastructure projects. NWRI panels consist of academics, industry professionals, government representatives, and independent consultants who are experts in their fields. The NWRI panel process provides numerous benefits, including:

- Third-party review and evaluation.
- Scientific and technical advice by leading experts.
- Assistance with challenging scientific questions and regulatory requirements.
- Validation of proposed project objectives.
- Increased credibility with stakeholders and the public.
- Support of sound public-policy decisions.

NWRI has extensive experience in developing, coordinating, facilitating, and managing expert panels. Efforts include:

- Selecting individuals with the appropriate expertise, background, credibility, and level of commitment to serve as panel members.
- Facilitating hands-on panel meetings held at the project's site or location.
- Providing written report(s) prepared by the panel that focus on findings and recommendations of various technical, scientific, and public health aspects of the project or study.

NWRI has coordinated the efforts of more than 40 panels for water and wastewater utilities, city and state agencies, and consulting firms. Many of these panels have focused on projects or policies involving groundwater replenishment and potable (indirect and direct) reuse. Specifically, these panels have provided peer review of a wide range of scientific and technical areas related to water quality and monitoring, constituents of emerging concern, treatment technologies and operations, public health, hydrogeology, water reuse criteria and regulatory requirements, and outreach, among others.

More information about the NWRI Independent Advisory Panel Program can be found on the NWRI website, nwri-usa.org.

Appendix C · Literature Review and Conclusions

Enhanced industrial source control is the first barrier in a multi-barrier approach intended to ensure that the wastewater management agency serving a potable reuse project protects source water from chemicals that may endanger public health or interfere with treatment operations. In all currently understood potable reuse scenarios, the quality of water produced by the wastewater treatment plant has direct bearing on the operations and performance of the advanced water treatment plant (AWTP). Although the wastewater treatment plant (WWTP) can remove a wide range of COCs, source control is needed to ensure that a feasible and economically viable operation can be achieved. Traditional source control criteria for wastewater are designed to protect the health of people who work in and around wastewater operations and to minimize negative effects on the environment

A comprehensive approach to source control or enhanced source control is necessary to ensure compliance with accepted public health standards applicable to drinking water. In recognition of this need, the Water Board charged the panel with considering scientific literature, published technical reports, guidance documents, and engineering reports to evaluate existing source control programs that support operating potable reuse projects. Specifically, the Water Board asked the panel to propose strategies that target all sources contributing COCs and unknown chemicals and aid in the implementation of novel applications of source control regulation, including continuous monitoring of DPR project flows, water quality, and treatment efficacy.

Literature Reviewed

To support their deliberations and develop recommendations on source control concepts for DPR, the Independent Advisory Panel reviewed the following scientific literature, technical reports, regulatory guidance documents, and engineering reports:

- EPA (2011). Introduction to the National Pretreatment Program.
- EPA (2017). Potable Reuse Compendium.

- Water Environment & Research Foundation (2017). Guidelines for Source Water Control Options for Direct Potable Reuse. Reuse Project 13-12.
- Water Research Foundation (2019). Sensors and Monitoring for Direct Potable Reuse. Project 14-01.
- US Department of Agriculture (2018). Blue Book: Residue Sampling Plan.
- Water Services Association of Australia (WSAA) 2012. Australian Sewage Quality Management Guidelines. ISBN: 1 920760 50 4, June, Sydney
- Water Futures (2007). Risk assessment of inputs to Canberra's sewerage system – summary of 10th September workshop for ACTEW, Actew/AGL and key stakeholders, September.

Complementing this effort is a review of case studies related to potable reuse projects, which are discussed in greater detail in the case studies in Appendix E. The literature revealed that traditional source control programs typically consists of:

- Regulations governing both volume and mass discharges of selected pollutants, the latter being dependent upon the type and nature of the discharge.
- Regulations governed by legal statutes and policed/monitored by the wastewater management agency.
- Concentration limits for selected contaminants assessed through risk assessment.
- Cost structures based on volume and mass loadings discharged, the latter linked to WWTP costs.
- Planning powers in some countries to control the location of certain industries in selected wastewater collection systems. Industrial waste regulations are also used to promote industry relocation.
- Regular surveillance of housekeeping practices within industries and monitoring of all discharges.
- Regular monitoring of nodal points in the wastewater collection system.
- Regular discussions with all industries to engage in waste-minimization practices and control of inadvertent discharges.

Conclusions

Based on its review and consideration of the cited sources, the panel finds the following elements most critical to safe and effective enhanced source control in support of potable reuse.

- Pretreatment programs are an established requirement of the EPA for compliance by a WWTP. In addition, IPR projects are typically supported by additional community-based source control programming. Additional considerations are needed for DPR. Local Limits are a valuable tool to address some of these issues.
- It is clear that traditional source control programming, designed solely for wastewater agencies discharging to ambient waters, is not appropriate for potable reuse facilities (for example, for IPR), and there is a need for enhanced source control programs to be established for DPR schemes.
- In potable reuse scenarios, source control is part of a multi-barrier approach, where the source control program works in tandem with treatment.
- Source control programs for potable reuse must appropriately address all discharges to protect the public health, downstream WWTPs and AWTPs and collection infrastructure, and the environment.
- The DPR source water from the wastewater collection system is treated by a WWTP, and then enters an AWTP. The water produced by the AWTP can then undergo different blending strategies. Therefore, the source control program, the treatment facilities, and the blending strategy need to be optimized to ensure a reliable and efficient potable reuse program.
- Wastewater collection system monitoring and sensors are being used for regulatory and operational parameters, as well as for measuring COCs.
- Case studies in the United States and abroad, as well as in other industries (for example, food) can provide insights into source control. For example, Orange County Sanitation District and Orange County Water District have demonstrated how local limits for health significant constituents (e.g., 1,4-dioxane and NDMA) can address issues as they arise. Singapore's source control program incorporates VOC monitoring. In Australia the risk management process includes a source control risk assessment. As part of the National Residue Program for meat, poultry, and egg products, a surveillance advisory team decides which compounds (for example,

pesticides and environmental contaminants) represent a public health concern (risk assessment) and warrant inclusion in the scheduled sampling plans.

- Reuse Project 13-12 developed a set of guidelines for the following items: integration of DPR into the overall integrated reuse recovery facility, source control strategies for DPR, WWTP operations and optimization for potable reuse, WWTP process monitoring and control, and WWTP risk management. Reuse Project 14-01 explored the use of sensors and monitoring for DPR, where scenarios could be created specific to source control. The EPA 2017 Potable Reuse Compendium discussed various possible DPR source control program elements: regulatory authority; monitoring and assessment of commercial and industrial dischargers to the wastewater collection system within the service area; investigation of chemical and other constituent sources; maintenance of the current inventory of chemical constituents; preparation of a public outreach and participation program; and preparation of a response plan for water quality deviations.

Overview of Key Literature Considered

EPA (2011). Introduction to the National Pretreatment Program

Pretreatment programs regulate nondomestic discharges to WWTPs to prevent interference, prevent pass-through, protect WWTP workers, and improve opportunities to reclaim/reuse wastewater and sludge. The basis for discharge limitations include general and specific prohibitions in 40 Code of Federal Regulations (CFR) § 403.5, EPA-developed categorical standards, and local limits. Federal pretreatment regulations include requirements for WWTPs and nondomestic dischargers to those WWTPs.

The WWTPs are responsible for surveying and inspecting Industrial Users (IUs), controlling significant IUs, monitoring discharges to the wastewater collection system and treatment plant, receiving and reviewing IU reports, enforcing violations of pretreatment standards and requirements, and preparing annual reports to the state and EPA. IUs are responsible for complying with permit requirements, self-monitoring, and reporting.

This EPA guidance manual provides (1) an overview on the National Pretreatment Program (NPP) requirements and (2) a road map to additional and more detailed resources for those trying to implement specific elements of the National Pretreatment Program. The manual refers to more detailed EPA guidance on specific program elements. Details on this document and the NPP in general are discussed in Chapter 2.

EPA (2017). Potable Reuse Compendium

This document was produced by the EPA and CDM Smith. This document notes current practices and approaches in potable reuse, including the existing technical and policy knowledge base. It represents the current state of practice in the United States to assist planners and decision-makers considering potable reuse approaches.

Chapter 8 addresses source control. Source control programs for potable reuse must appropriately address industrial and commercial discharges to protect the treatment processes, public health, and downstream infrastructure and the environment. An important question to consider for a potable reuse project is whether existing source control measures, designed solely for wastewater agencies discharging to ambient waters, are appropriately designed for facilities with a direct or indirect connection to a public drinking water system. Therefore, there is a need for source control programs for potable reuse, and potentially a need for "enhanced" source control programs when DPR is employed.

Critical components of a source control program for potable reuse include an evaluation of the wastewater collection system service area, a discharge characteristics assessment, an educational awareness and public outreach program, wastewater collection system-use by-laws and best management practices, and enforcement and response. Moreover, the document discusses California's IPR source control program requirements. This document includes a fate assessment of specific wastewater and recycled municipal wastewater chemicals and contaminants; specific chemical and contaminant source identification and monitoring; an industrial, commercial, and residential outreach program; and an inventory of specific chemicals and contaminants. Furthermore, the document includes recommended DPR source control program elements. "(1) regulatory authority; (2) monitoring and assessment of commercial and industrial dischargers to the wastewater collection system within the service area; (3) investigation of chemical and other constituent sources; (4) maintenance of the current inventory of chemical constituents; (5) preparation of a public outreach and participation program; and (6) preparation of a response plan for water quality deviations" (NWRI, 2015).

National Water Research Institute (NWRI). 2015. Framework for Direct Potable Reuse

Sponsored by the American Water Works Association (AWWA), Water Environment Foundation (WEF), and WateReuse Research Foundation (WRRF). Alexandria, VA.

Other considerations include an adequate and approved pretreatment program, a pollution prevention program, and the use of chemicals and materials at a WWTP that may impact the suitability of the water for potable reuse. Although beneficial, the NPP has not eliminated pollution loadings from industrial sources, thus implementation of a rigorous source control program in conjunction with the NPP is needed for DPR. In developing a source control program, it is important to understand the sources of toxic compounds in the wastewater collection system. A multi-barrier approach to DPR needs to include source control. Keeping COCs out of the WWTP system is an effective strategy for managing industrial contributions to the wastewater supply. The source control program should begin with the regulatory authority to establish the program. The source control program is a critical element in creating a safe water supply and is not focused solely on wastewater compliance. Other elements include monitoring and assessment, investigation of chemical sources, inventory of chemical constituents, public outreach, and response plan.

Water Environment & Research Foundation (2017). Guidelines for Source Water Control Options for Direct Potable Reuse. WE&RF Project 13-12

This document summarizes upstream wastewater treatment impacts (for example, industrial source control) on DPR source water quality and DPR processes, and the impact of hydraulic control mechanisms (for example, source water storage buffers) on influent water quality and flow variations that “stress” the DPR process. Four case studies provide a comprehensive summary of the design, operation, and performance of the WWTPs and AWTPs at participating utilities and inform the discussion on the wastewater collection system management and source control programs. The benefits of this project included information that facilities could use to implement their own source control programs, design considerations related to AWTPs and WWTPs and operational issues that impact IPR/DPR systems, and considerations that will allow for savings in capital and operations and maintenance costs.

The guidelines include the following:

- **Integration of DPR into the overall integrated reuse recovery facility.** This facility receives source water from a municipal wastewater collection system and is comprised of the WWTP and AWTP. The purified water can then be used in several different blending scenarios.
- **Source Control Strategies for DPR.** Source control issues looked at how to establish the differences between "pretreatment" programs and "source control" programs, develop the key elements of source control programs for DPR, understand the effectiveness of source control, and determine how a source control program may or may not differ from a program implemented for an IPR project.
- **WWTP operations and optimization for potable reuse.** Some of the principal objectives include production of a consistently high quality supply water suitable for further treatment in the AWTP, the ability to detect poor-quality supply water and divert the flow away from the AWTP process and produce a steady consistent flow.
- **WWTP process monitoring and control.** The objective of this guideline is to review strategies and options to monitor and control WWTPs to manage, minimize, and mitigate the risks associated with WWTP process upsets and/or deviations, which would have a detrimental impact on the supply water quality or production consistency.
- **WWTP risk management.** The key components to the overall risk analysis include identification and assessment of hazards and risks, and development of a mitigation and management plan for process control and actions when undesirable events occur.

The Water Research Foundation (2019). Sensors and Monitoring for DPR.
WRF Project 14-01.

The project objectives include developing an operational decision support tool and integrating existing sensors into a network that can act as an early warning system. The project builds on previous projects that defined CCPs within a DPR treatment process and develop a framework for sensor data integration. There are real-time water quality analyzers that can be used to verify performance. A wide view of data can be taken and performance can be verified from different types of data. The issues include scenarios (what am I monitoring), the math detector (how do I detect it), the monitoring class (how does it relate), actions to take (what do I do), and priority/importance (is it important).

Monitoring should include critical operating parameters (for example, regulatory requirements), and things that are "important" (for example, water quality, performance). There are different types of math (for example, regression) to detect anomalies. Monitoring classifications framework include regulatory/critical, operation integrity and performance, water quality, events, and maintenance. Actions should be appropriate for what you are monitoring, Importance is based on your situation and risks. We could create scenarios specific to source control.

As an example, for a microfiltration (MF)/ultrafiltration (UF) system, regulatory/critical monitoring could include total chlorine and pressure decay test, and operational integrity could include rate of pressure decay. In addition, regulatory/critical could include total chlorine and free ammonia online, and operational integrity could include operational data. Regulatory/critical results less than the target or a critical level could trigger a "yellow" or "red" condition, respectively, whereas operational integrity results greater than the target via a clustering algorithm could indicate a yellow condition. Finally, a facility dashboard could summarize the condition of each process.

USDA (2018) Blue Book: Residue Sampling Plan

This plan documents food industry standards. Although the food processors don’t have stringent controls on the quality of water used, they do have strict limits on the amount of chemicals and pathogens that may be present in foods. The potable reuse industry are interested in their methods for preventing contamination of food products and their protocols for sample collection and monitoring.

The National Residue Program (NRP) for meat, poultry, and egg products provides information on the process of sampling for chemical compounds of public health concern. The Food and Drug Administration (FDA) establishes tolerances for veterinary drugs and action levels for food additives and environmental contaminants, the EPA establishes tolerances for registered pesticides, and the surveillance advisory team meets annually to evaluate chemical compounds for inclusion in the scheduled sampling plan. The annual sampling plan is based on prior NRP findings, FDA veterinary drug inventories compiled during on-farm visits and investigation information, and pesticides and environmental contaminants of current interest to the EPA. The surveillance advisory team ranked pesticides and environmental contaminants based on relative public health concern (relative public health risk = exposure x toxicity).

The program implemented the HACCP inspection system in all federally inspected establishments. Multi-residue methods for the detection and verification of veterinary drugs (more than 80), pesticides (more than 100), and environmental contaminants are used. Carcasses are randomly selected for sampling, where the number of samples scheduled each year is based on the probability of detecting at least one violation. Additional sampling is conducted when it is suspected that animals may have violative levels of chemical residues (for example, evidence of a disease that may have been treated or suspect the administration of a drug).

In terms of how this industry relates to or differs from water reuse, veterinary drugs and pesticides are of major concern in animal husbandry, where some pharmaceuticals (for example, certain antibiotics) are used by humans and animals. The food industry needs to prevent contamination of products, as there is no process for removing contaminants. Water reuse can effectively remove certain contaminants (for example, pharmaceuticals) with advanced water treatment such as reverse osmosis.

Additional Reading

Other foundational documents that complement those discussed in the literature review include:

- **Evaluation of the Feasibility of Developing Uniform Watering Recycling Criteria for Direct Potable Reuse (2016).** This document noted that because of the diversity of sources, the organic and inorganic constituents contained in wastewater can vary. When planning a DPR project, communities should strive to look for the best available wastewater stream with the lowest fraction of nondomestic flow. The panel that prepared this report believes that the comprehensive source control program required by the State Water Board for IPR may be effective in minimizing the frequency with which pulses of hazardous chemicals are likely to enter AWTPs used for DPR projects but are unlikely to eliminate them. Hence, the panel suggested that research on online continuous monitoring of selected constituents and/or parameters in the wastewater collection system is needed to identify the presence of hazardous constituents in wastewater. Also, the potential for spills and other sources of chemicals that may enter the wastewater collection system episodically must be identified and action response plans are needed for spills. In addition, source control criteria will need to be established for new industries or businesses that move into the area. Moreover, source control should be enhanced to control for COCs from the perspective of drinking water; these enhancements should go beyond requirements in the pretreatment regulations.

- **Monitoring Strategies for constituents of emerging concern (CECs) in Recycled Water (2018).** This document included the development of a list of monitoring parameters, including four health-relevant and four performance-based (indicator) CECs to demonstrate a consistent capacity for reduction of CECs by recycled water treatment processes. This document focused on what can be achieved at the AWTP and not on source control.
- **Framework for Direct Potable Reuse (2015).** Although not all WWTPs are required to implement federal pretreatment programs, any municipality, utility, or agency pursuing a DPR project, regardless of size, should consider the impacts of industrial and commercial contributions on the wastewater supply. In some cases, to minimize the impact from large industrial dischargers, it may be appropriate to consider diverting highly industrialized discharges to alternative treatment facilities. Source control programs are most effective when the constituent is consistently found at measurable levels in the wastewater influent or wastewater collection system. If a constituent is found sporadically, it is often difficult to identify the source. For agencies with large service areas, multiple communities, or industrial flows coming from other wastewater entities, it may be desirable to link the inventory to a service area mapping tool such as a geographic information system network. The success of a source control program will depend on strong interagency cooperation and responsiveness between the WWTP and AWTP.
- **Potable Reuse Research Compilation: Synthesis of Findings (2016).** In addition to observations like that of the other reports, it is noted in this document that the most advantageous and cost effective methods should be considered to eliminate contaminants. It may be more advantageous and cost effective to prevent the introduction of or treat specific contaminants at the source rather than dilute those contaminants through discharge into a wastewater collection system. Conversely, it might be more cost effective to construct more robust treatment at a downstream or down gradient central location, taking advantage of economies of scale.
- **National Research Council Handbook on Potable Reuse (1998).** Although this document does not address source control programs, it does mention the National Pretreatment Program. The latter has led to significant reductions in the concentrations of toxic chemicals in wastewater and the environment. However, the list of priority pollutants regulated at the time of this handbook by the Program had not been updated since its development. The handbook

indicates that EPA guidance on priority chemicals to include in local pretreatment programs would assist utilities implementing potable reuse.

- **Guidance Framework for Direct Potable Reuse in Arizona (2018).** As part of Arizona's guidance for DPR, a source control program will require interagency cooperation between the entities operating the WWTP, AWTP, and drinking water treatment plant. In addition, the program will involve coordination with the community through permitting (for example, for industries) or voluntary action (for example, for residents). Additional measures can include online monitoring of WWTP influent and effluent to detect illicit discharges to the wastewater collection system.
- **Texas Water Development Board: DPR Resource Document (2015).** The Texas guidelines on source control programs are like that those discussed in the other documents in the literature search.
- DPR Guidelines and Operational Requirements for New Mexico (2016). The New Mexico guidelines on source control programs are like that those discussed in the other documents in the literature search.
- **WHO Potable Reuse Guidance Document (2017).** In many cases, potable reuse schemes are developed as extensions of established municipal WWTPs. In these circumstances changing collection areas to reduce or eliminate industrial discharges may not be possible. However, control measures can be applied to reduce impacts of industrial discharges on wastewater quality. Waste discharge restrictions and pre-treatment requirements can significantly reduce the presence of chemical contaminants. Organizations responsible for treating wastewater for subsequent potable reuse should undertake risk assessments to determine the range of contaminants that may be found in wastewater used as a source for potable reuse schemes. Such risk assessments should consider the sources of wastewater, including the range and number of industrial and commercial premises providing discharges. These risk assessments should inform the design of treatment/management plans.
- **Australian Guidelines for Water Recycling: Managing Health and Environmental Risks, Augmentation of Drinking Water Supplies (2008).** These Guidelines identify that management of industrial discharges to wastewater collection system is one of the key principles that are fundamental to the safe application of potable reuse. The Guidelines stress that source control programs must be established and maintained and that some contaminants

should be precluded from discharge (for example, contrast media, radionuclides and medical, veterinary and laboratory wastes). Further, source control plans must include site monitoring and audit inspections of significant industrial dischargers.

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Appendix E · Case Studies

Need for Enhanced Source Control for Potable Reuse Projects

Potable reuse is an emerging practice for communities seeking solutions to their regional water supply and water quality risks. Source waters influent to potable reuse projects include wastewaters generated in residences and by industrial, institutional, commercial, and public facilities, as well as stormwater capture and infiltration. Such source diversity results in wide variations in the organic and inorganic constituents entering the advanced treatment facility.

In the United States, all wastewater agencies with a design capacity of 5 mgd or higher must implement the NPP as a source control measure. The NPP includes elements of permitting, inspection, monitoring, enforcement, and reporting for industries that discharge to the wastewater collection system in order to prevent damage to the wastewater treatment plant and to protect the people who work with the plant and the wastewater collection system, and the environment. Under the NPP, source control programs have been implemented across the nation to reduce the discharge of many harmful or recalcitrant constituents to waters of the United States.

The risk profile associated with augmenting drinking water supplies with recycled water is different from the risk profile arising from the environmental discharge of highly treated wastewaters in compliance with the NPDES. In recognizing the different risks, the Water Board charged the panel to review the source control programs currently in place for operating potable reuse projects. In its review, the panel focused on determining the most critical elements of these programs and identifying where, because of legal or technical issues, their source control programs may have limitations.

Case Study Review Approach

To address the scope of work for this effort, the panel reviewed eight potable reuse projects:

- California: Orange County Water District and Orange County Sanitation District, Ground Water Replenishment System
- California: County Sanitation Districts of Los Angeles, Satellite Water Recycling Facilities

- California: City of Oxnard, Aquifer Storage and Recovery Project
- Texas: Wichita Falls, Reservoir Augmentation Project
- Virginia: Hampton Roads Sanitation District, Sustainable Water Initiative for Tomorrow
- Western Australia: Water Corporation's Beenyup Advanced Water Recycling Plant
- Singapore PUB: NEWater
- South Africa: Beaufort West

In its review, the panel identified both common and innovative approaches used to prevent COCs from entering the wastewater collection system and treatment works, with a focus on the following concepts:

- Key elements of the source control program
- Elements critical for success of the program
- Limitations of the source control program due to legal and technical issues

The panel then developed a one-page summary for each case study highlighting the concepts listed above along with essential information including the type of project, treatment train components, agency contact point.

Panel Findings and Recommendations Based on the Case Studies

Although the NPP is an effective tool, it alone is not enough for managing the risk posed in DPR schemes. In cases where a wastewater treatment plant is a source for a potable reuse project, the panel recommends additional source control measures to prevent COCs from entering the wastewater collection system and treatment works or reducing their concentrations to acceptable levels in the wastewater. These additional measures are considered enhancements to the NPP and will ensure that water produced for potable reuse applications meets the specifications needed to protect public health and the environment.

The panel finds the following elements most critical for safe and effective source control in support of potable reuse:

- Proactive and continuous hazard analysis.

- Advanced, risk-relevant pretreatment and discharge control at critical control points.
- Creative, ongoing community and industrial education and engagement.
- The sharing of insightful operational data among partner organizations.
- Augmented monitoring of discharges including enforcement surveillance.
- Accelerated enforcement and enforcement monitoring.
- Expanded use of hazard-based constituent discharge prohibitions to prevent the introduction of low-molecular weight or otherwise recalcitrant pollutants and disinfection byproducts into a community's drinking water supply.
- Enhancement to specific NPP elements including: discharger identification; discharge limitations and controls; discharge and compliance schedule reporting requirements; and doctrines related to discharger pretreatment system upsets, bypasses, slug loads and emergencies.

The panel concluded that these case studies indicate that at least some of the scenarios that will arise in local programs will require a certain degree of flexibility and not be subjected to overly prescriptive regulatory oversight.

Finally, the panel is sensitive to the fact that enhancing source control regulations to support safe and effective potable reuse will require an investment in public agency staffing, tools, and systems, and will require long-term financial support.

Case Studies Analysis

Orange County Water District and Orange County Sanitation District, Fountain Valley, California: Groundwater Replenishment System

Technical details of project

Type of Reuse: Groundwater replenishment via subsurface injection and surface spreading
Treatment Train: secondary treatment, microfiltration, reverse osmosis, UV/advanced oxidation process (AOP)
Flow: 100 mgd (expanding to 130 mgd in 2023)

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Critical elements of success

- Pretreatment program recognized by both EPA and California Water Environment Association (CWEA), including 33 dedicated staff, and more than 350 permitted industrial dischargers, including 190 federal categorical industrial dischargers.
- Frequent monitoring and inspection of industrial facilities beyond the requirements of the NPP.
- Discharge surveillance, including covert and downstream monitoring.
- Non-industrial (community-based) source control program including commercial and residential programs.
- Modification of legal authority to protect potable reuse. Wastewater agencies with federally approved pretreatment programs must have adopted legal authority to implement the program. This is usually accomplished through a wastewater ordinance adopted by the jurisdictional authority. In the case of OCSD, its wastewater ordinance was amended to include protection for

the GWRS including a narrative limitation on Total Organic Carbon and a local limit for the discharge of 1,4-dioxane. Additionally, the Purpose and Policy section of the wastewater ordinance recognizes that "OCSD is committed to: 1) a policy of Wastewater reclamation and reuse…" See Ordinance N. OCSD-53 – Wastewater Discharge Regulations.

- Targeted emergency response plan.

Unique program elements

- Formal, jointly exercised bilateral agreement that describes roles and responsibilities for each partner agency. One party (Orange County Water District) holds the recycling permit while the other (Orange County Sanitation District) implements the source control program.
- Initially OCWD and OCSD conducted routine meetings between Operations staff of both agencies to exchange information and enhance coordination. After the start-up of Phase II, the two agencies added a new form of coordination between laboratory, pretreatment, and regulatory compliance staff. They meet quarterly to discuss issues of mutual interest such as water quality, emerging constituents, and reporting.

Limitations and challenges

- Large, geologically complex, highly urbanized, and densely populated wastewater collection system with significant industrial discharges.
- Illegal dumping requires an affirmative control mechanism (such as monitoring).

Under federal and state laws and regulations, local wastewater agencies have limited authority over the discharge of radioactive materials into the sewer system. OCWD staff has worked with the Radiologic Health Branch of the California Department of Public Health to better manage the discharge of radioactive materials into the sewer system.

Sanitation Districts of Los Angeles County (LACSD), California

Technical details of project

Type of Reuse: Title 22 partnering with Metropolitan Water District of Southern California on study for potable reuse for groundwater recharge
Treatment Train at 10 WWTPs: Variety of traditional and innovative secondary and tertiary treatment
Flow: treats 510mgd, 165mgd available for reuse

Contact

Linda Shadler; lshadler@lacsd.org

Critical elements of success

- Industrial Waste Pretreatment Program. LACSD has 66 people that work solely on the pretreatment program. LACSD has over 2,500 regulated sampling locations, with about 950 of those considered significant. Of the significant, 380 are subject to federal categorical regulations.
- Rigorous up-front permitting and pretreatment requirements.
- Intensive and extensive field presence by inspection staff and monitoring crews.
- Aggressive enforcement actions for significant violations.
- Outreach.
- Held workshops for IUs that were in significant noncompliance and proposed steps IUs could take to reduce significant noncompliance.
- Sponsor Industry Advisory Council to bring together industry, utilities and regulators.
- Certificates of recognition for fully compliant significant industrial users.
- Local limits have been fully protective of the collection and treatment systems.

- Spill containment: any IU with significant potential to discharge restricted materials required to install and maintain spill containment (for example, cyanide, heavy metals, toxic organics).
- Toxic organic management plan option instead of monitoring (electroplating, electronics, etc.).
- Wastewater collection system monitoring: Special studies/surveillance monitoring.
- Influent Monitoring: pH, Priority Pollutants, CECs, and Observations.

Unique program elements

- Large industrial base including multiple refineries.
- Surveillance sampling continues thru service area focusing primarily on companies of interest.

Selected significant achievements

- Detailed investigation into sources and amounts of air toxics.
- Benzene program: carbon adsorption installed centrally at Joint Water Pollution Control Plant (JWPCP) instead of at individual IUs.
- Appropriate industries are billed in proportion to amount discharged.

Limitations and challenges

- Organizational, geographical, operational, and technical complexity.
- Partnership of 24 independent special districts; 78 cities and unincorporated areas. The cities and the county own and maintain the local lines, which discharge to LASCD's trunk lines and wastewater treatment plants. To ensure that the requirements of LACSD and the local cities and county are met, the industrial wastewater discharge permits are issued jointly by LACSD and the city or county. It should be noted that if a facility discharges to LACSD, LACSD will always permit, inspect, and sample that facility regardless of location. There are some facilities that reside outside of the service area boundaries, like in the Inland Empire (San Bernardino County) that are permitted, inspected, and sampled by the LACSD, along with the Inland Empire Utilities Agency, to ensure that both agencies' requirements are met. This coordinated effort is agreed to in a contract.
- 820 square miles; varying topographical features and land use categories.
- 10 WWTPs and one ocean discharge facility (JWPCP).

- Differ in treatment, capacity, quality of raw wastewater, end use (discharge vs. reuse).
- Industrial flow at 10 WWTPs = 0.8-15% (does not go to JWPCP); Industrial flow at JWPCP: 17%.
- 2,100 industrial users from a broad range of industry: petroleum refineries, centralized waste treatment facilities, food manufacturing, textile manufacturing, and electroplating and metal finishing facilities.
- Challenging industrial users.
- Oil fields.
- Membrane manufacturers.

Wichita Falls, Texas

Technical details of project

Type of Reuse: DPR changed to IPR blended with 50 percent lake water

Treatment Train: Secondary treatment, chlorination, advanced filtration, reverse osmosis

Flow: 5 mgd

Contact

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Critical elements to success

- Does not accept hauled waste.
- Does not accept underground storage tank (UST) clean-up waste.
- Provide additional industrial monitoring.
- Baseline monitoring for all new industrial facilities.
- Required notification before change at industrial facilities.

Unique program elements

- Prohibition on certain types of dischargers.
- Critical initial evaluation of industrial dischargers beyond federal pretreatment requirements.

Limitations and challenges

- Wichita Falls has a pretreatment program that is responsible for monitoring the large industries, which is a two-person function. In addition, they have a grease trap program that falls to the Health Department, which is a one-person function. Wichita Falls has laboratories at both the water and wastewater facilities that perform different analyses on the collected sewer water that isn't shipped to other laboratories. Accounting for that percentage of their work, it is probably a one-person function. Finally, there is a Water Utilities Manager that manages all of the sewer programs.

- Variability and unpredictability of certain industrial dischargers.
- Centralized waste treatment facility and sources.

Hampton Roads, Virginia: SWIFT (Sustainable Water Initiative for Tomorrow)

Technical details of project

Type of Reuse: IPR for subsurface injection/groundwater replenishment.
Treatment Train: Secondary treatment, tertiary treatment, eight step carbon filtration system, disinfection with chlorine or UV.
Flow: 1 mgd demonstration; planning for full-scale 100 mgd.

Contact

Visit the SWIFT website or email swift@hrsd.com or Jamie Mitchell at JMITCHELL@hrsd.com

Critical elements to success

- Residential outreach program
- Industrial permitting
- Zero discharge pollutant list
- Toxic organics List
- Identify key contaminants and trigger levels for action.

HRSD has not hired any additional support staff within their pretreatment program, but they envision that they may need to do so as they move to full-scale implementation. At this point, they are operating a 1 mgd demonstration facility, but at full-scale, they will have five Sustainable Water Initiative for Tomorrow (SWIFT) facilities that serve virtually all of Hampton Roads. They have been doing service area monitoring in a phased approach, focusing on the HRSD wastewater facilities that are next in line for full-scale SWIFT. For their current activities, consulting support has been vital in data management for their service area monitoring.

They will likely need to add an additional staff member to the pretreatment team to manage the source control program at full scale. Before they decide to hire this staff member, they will carefully evaluate current activities and look for ways to streamline workflows or eliminate work that is no longer needed. This process is part of an ongoing evaluation of resource utilization and is always incorporated into their decisions about hiring additional staff.

Their laboratory activities include analytical services to support their source control program.

Unique program elements

- Eight-step carbon filtration system (no reverse osmosis).

Limitations and challenges

- Investigating use of online analyzers for both WWTP and AWTP.
- Increased monitoring of individual permits not successful to detect events.

City of Oxnard, California: Advanced Water Purification Facility

Technical details of project

Type of Reuse: IPR for aquifer storage and recovery

Treatment Train: Secondary, microfiltration, RO, UV/AOP

Flow: 6.25mgd; final design to 25mgd

Contact

Water Service Center (805) 385-8136; Andrew Salveson, ASalveson@carollo.com

Critical elements to success

More staffing for pretreatment program. Oxnard has not implemented their enhanced source control program as they have also not started running their existing (and soon to be permitted) potable reuse program. Their consultant's (Carollo) general view on the economics of an enhanced source control program versus a conventional local limits program is:

- Substantial increase in chemical testing over the baseline. Could be $25k per year for a very small system to more than $50k per year for a large collection system. The enhanced source control program has extensive MCL and priority toxic pollutant testing at the AWPF, the WWTP, and in the collection system, depending upon results.
- Increased staffing; could be a 50 percent increase to a local limits program.
- For a small community, with less than 5 mgd, in which they must implement an enhanced source control program without ever having a local limits program, they anticipate 1.5 to 2.5 full time staff equivalents.
- More frequent monitoring.
- Use of online monitoring in wastewater treatment plant.
- Mapping of the wastewater collection system to trace contaminants of health concern.
- More frequent review of slug control plans from significant industrial users.

Unique program elements

- Online monitoring in the wastewater treatment plant.

Perth, Australia: Groundwater Replenishment System

Technical details of project

Type of Reuse: IPR/groundwater injection into deep aquifer
Treatment Train: Secondary, UF (0.1 micron), RO, UV
Flow: 20 mgd (77 ML/d) with plans to expand

Contact

groundwater.replenishment@watercorporation.com.au

Critical elements to success

Number of staff involved in industrial waste management:

- The C&IS team carries out a couple of other functions beside industrial waste (such as backflow prevention), and some staff work across these functions. The allocation of C&IS staff time to the industrial waste function statewide was estimated at about 24 full-time equivalents (FTE). This includes technical and administrative staff.
- While staff are not specifically allocated to an individual catchment, about 5 FTE could be considered to be working on Beenyup, including sampling and inspecting businesses, assessing applications from proposed new dischargers, reviewing information from monitoring programs, and modifying as appropriate.

Number of regulated sampling points in the Beenyup catchment:

- There are several thousand commercial and industrial customers with permits to discharge waste in the catchment. These vary from small retail food outlets to large food processors, industrial laundries, metal finishers, laboratories, and chemical manufacturers. They don't have regulated sampling points, but nearly all industrial waste customers have an identified location for sampling discharged waste. The large and/or high-risk customers are typically required to have a waste monitoring point that includes an industrial waste meter, a facility to enable flow-proportional samples to be collected using an automatic sampler and, in some cases, continuous monitoring of water quality parameters such as pH, conductivity, and temperature.
- Compared to the other large metropolitan catchments, Beenyup has a relatively smaller proportion of large or high-risk industrial customers.
- Critical control points and multiple barrier approach.
- Extensive monitoring of operations and groundwater quality.
- Developing in-sewer sensor system.

Unique program elements

- Risk-based approach to evaluating program with regular updates on risk components and methods to manage the identified risk, if warranted.

Singapore Public Utilities Board: NEWater Project

Technical details of project

Type of reuse: Industrial use and surface water augmentation

Treatment train: Secondary, MF, RO, UV, pH adjustment

Flow: 175mgd (795ML/d) from 5 NEWater Factories

Contact

pub_qsm@pub.gov.sg

Critical elements to success

- Discharge regulations.
- Regular monitoring and industry inspections.
- Use of analyzers to monitor volatile organic chemicals (VOCs). There are 40 analyzers in the wastewater collection system and 25 at industrial premises.
- Use of 375 pH analyzers installed at industrial premises and connected to lockable valves that are activated if pH is outside the regulated range.
- Use of 42 microbial fuel cells for 24/7 measurement of heavy metals, cyanide, pH, and ORP. Deployment of 100 units at permitted industry sites , with plans to install 100 units in the wastewater collection system by Q4 2020 and a further 115 units at industrial premises by Q1 2020.
- Use of robotics to enter and sample from wastewater collection system when illegal discharges are detected.
- Drone surveillance.
- Ongoing research and development on the use of fluorescence analyzers at nodal points to monitor organics like those used at the Tsinghua Industrial Park in China.

Unique program elements

- Large industrial base with VOC discharges.
- Use of in-sewer monitoring system, microbial fuel cell and shut-down procedures at significant industrial user premises.
- Use of advanced analytics to monitor and predict unusual situations in the wastewater collection system and send advanced warning to the relevant WWTP.

Limitations and challenges

- Additional monitoring is needed in the wastewater collection system to detect and reduce the frequency of illicit VOC discharges.
- The VOC monitoring system cannot detect methylene chloride, which is used in some industries and is a threat to water quality.

Beaufort West, South Africa

Technical details of project

Type of Reuse: Treated Water Augmentation
Treatment Train: Secondary & Tertiary, UF, RO, UV/AOP, final chlorination
Flow: 1 ML/d product water

Contact

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Critical elements to success

- Bans release of medical waste into wastewater collection system.
- Requires unused medications to be returned to supplier.
- Sends medical wastes to incinerator.

Unique program elements

- Focus on the issue of medical wastes

Appendix F · Quality Management Programs

Using groundbreaking work done by Walter A. Shewhart at Bell Labs in the 1920s, Edward C. Deming advocated the importance of seeing improvement, product design, and manufacturing as never-ending processes. He also introduced an early version of what has become widely known as the “plan, do, study, act” (PDSA or sometimes PDCA, for “plan, do, check and act”).

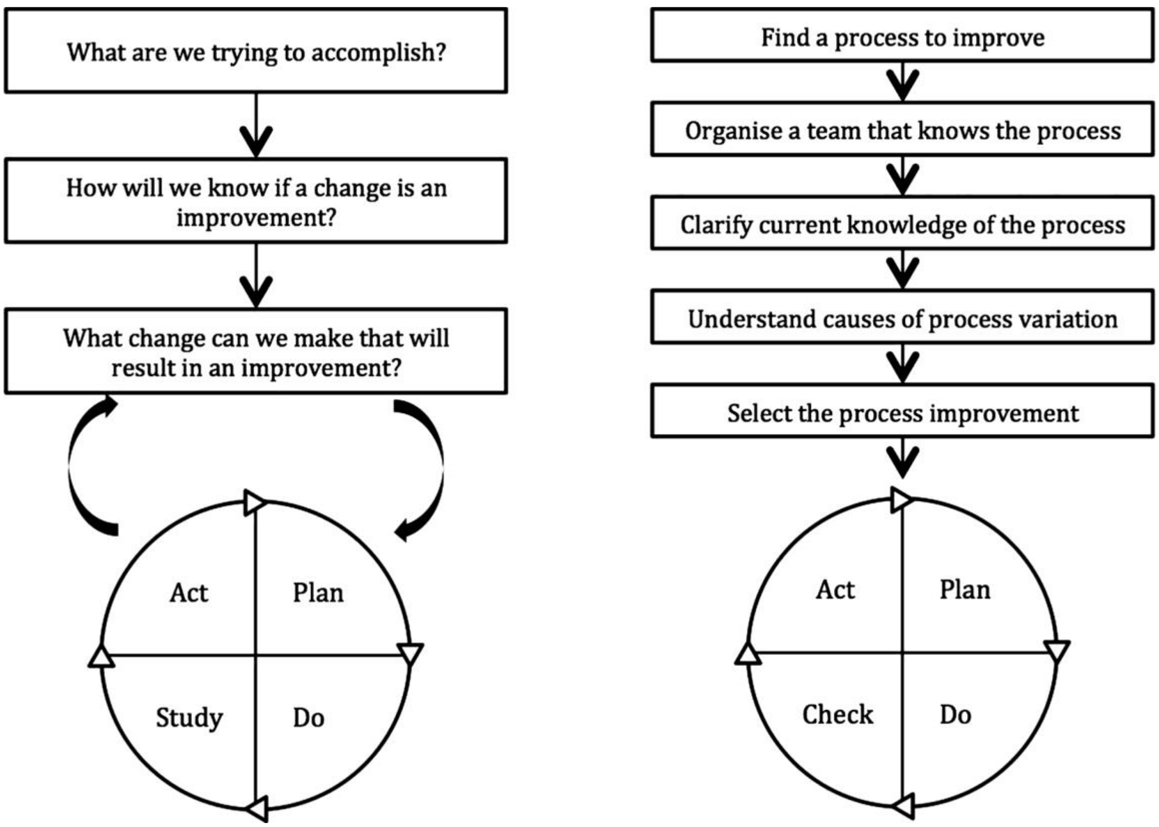

Figure F-1. PDSA and PDCA Quality Improvement Cycles

Japanese businesses adopted Deming’s quality management framework, which gave rise to a variety of PDSA/PDCA-based programs and standards that support product quality and encourage continuous improvement including:

- The National Institute of Standards and Technology sponsors the Baldrige Performance Excellence Program, which grants presidential recognition for performance excellence.

- The European Foundation for Quality Management supports the EFQM Excellence Model, which includes an award scheme similar to the Baldrige Award for European companies.
- The Toyota Way system of continuing improvement and lean manufacturing successfully applied in a variety of organizational contexts is one icon of *kaizen*, a Japanese term for improvement
- Six Sigma is a data-driven approach to eliminate defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process.
- International Standards Organization (ISO) develops and publishes international standards that provide specifications to ensure that products and services are fit for their purpose. The American National Standards Institute (ANSI) is the ISO member body in the United States.
- Total Quality management (TQM) is an approach that seeks to improve quality and performance that will meet or exceed customer expectations and is achieved by integrating all quality-related functions and processes throughout the company.
- Industry- or product-specific hybrid PDCA/PDSA-based standards, like the National Biosolids Partnership's Biosolids Management Program, is based on ISO Standard 14001.

Developing and implementing a quality management program will present challenges to any water treatment utility. However, organizations that invest in quality management initiatives can expect the following general benefits:

- Better product at lower cost.
- Less waste and increased time savings, leading to reduced expenses that can be passed along in the form of lower prices.
- Increased consistency.
- Improved employee engagement, which reduces turnover and saves money on training and mistakes.

Some disadvantages of quality management programs need to be recognized in developing and implementing regulations, including:

- The organization must commit completely to quality improvement, which can be difficult. All levels of management must be on board for the program to be successful.

- Any lack of effort or resources will undermine the success of a quality improvement program, causing negative ripples throughout the company.
- If management fails to fully implement a quality management program, its partial efforts are bound to fail. For example, just limiting the initiative to personnel training without making use of statistical tools to measure and evaluate process changes will create frustration and inadequate results.

ISO 9001:2015

The ISO 9001:2015 standards are aimed at embedding risk-based thinking into the overall quality management framework, thereby building a stable foundation for the future. The revised standard emphasizes the need for program leadership to establish a quality management system based on their understanding of their external environment and third parties, as well as their internal culture, values, and performance.

None of the US case studies have an ISO-like program. Carollo’s (Oxnard's consultant) source control expert has not heard of an ISO standard being applied to DPR in the United States. This does not mean that ISO has not been applied to DPR, but it is rare. Alternatively, Perth's industrial waste function, along with a number of other technical functions in the Water Corporation, held ISO 9002 certification for a number of years around 2000. However, a corporate decision was made to discontinue certification of these groups.

ISO 9001:2015 is based on seven principles, described in the following paragraphs: Customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision-making, and relationship management.

- Improve Customer Focus. According to the new standard, the primary focus of an organization’s quality management program is to meet customer requirements and exceed expectations for products and services. DPR program leadership teams would do well to comprehensively research, analyze, and understand both the current and future needs of the organization and adjust their programs and processes to deliver these goals. Before that, however, it is important to align organizational objectives to market trends and communicate them across the organization. It is also essential to implement programs and processes to measure customer satisfaction and act on the results.

- Enhance Leadership Involvement. Unlike the earlier ISO 9001 standard, the revised version emphasizes leadership involvement in quality management. The leadership team is expected to be highly committed to the quality management program. They need to ensure that every business unit understands and accepts the changes brought about by the new standard to ensure a unified commitment to quality. The leadership team also needs to understand the expectations of customers, end-users, regulators, suppliers, distributors, retailers, and any other stakeholders affected by quality management. Leaders should inspire, encourage, and recognize people's contributions and provide the required resources and training to improve quality management.
- Improve Engagement of People. ISO 9001 states the need for all people to be competent, empowered, and engaged in delivering value. Leadership teams are expected to enhance employee communication, provide better clarity on job expectations, find ways to motivate employees to contribute to organizational success, capture regular feedback, and facilitate a dialog with supervisors to help employees achieve their growth plan.
- Adopt a Process-Based Approach. ISO 9001 requires organizations to adopt a process-based approach to quality management that involves documenting and implementing processes, resources, methods, and controls to demonstrate compliance. The process-based approach also includes defining quality objectives at the relevant function and process levels and integrating quality management requirements into business processes. Leadership teams should have defined processes and guidelines to perform any quality management task and keep track of ongoing activities.
- Enable People and Process Improvement. ISO 9001 demands organizations maintain a persistent focus on improvement, both in terms of organizational efficiency and effectiveness. Leadership teams are expected to implement a consistent, enterprise-wide approach to training people to effectively use quality management methods and tools. Organizations should also focus on the improvement of products, processes, and management systems, with the goal of enabling the growth of every individual in the organization.
- Facilitate Evidence-Based Decision-Making. ISO 9001 emphasizes evidence-based decision-making, indicating that decisions based on the analysis and evaluation of data and information are more likely to produce the desired results. Organizations are expected to revamp their quality management systems to support effective evidence gathering through observations, measurements, and tests, or by using any other suitable method like audits and inspections. The

evidence collected should be accurate, reliable, and easily accessible to those who need it for decision-making.

- Ensure Relationship Management. ISO 9001 ensures organizations effectively manage relationships with third parties such as suppliers and partners to enable sustained growth. The key is to identify and select the right suppliers, establish joint development plans, and establish improvement activities, including training. Scorecards and metrics are also important to measure supplier performance, recognize improvement, and benchmark achievements.
- Establish a Systematic Approach to Risk Management. A key focus area of the new ISO 9001 standards is to inculcate risk management into an organization's day-to-day activities. Risk has always been implicit in the ISO 9001 standards, but risk-based thinking is now explicitly defined, making preventive actions part of daily routines. The new standard requires leadership teams to create and implement corrective actions to manage incorrectly qualified risks, as well as preventive actions to address potential risks and non-compliance violations.
- Conduct Regular Program Audits. The standards do not include auditing. To ensure that consumers can have confidence that water sourced from DPR projects is safe, conduct regular internal and external/independent auditing of the required quality improvement program by certified auditors.