Thematic Topic #2: Performance Reliability (Treatment, Operations, and Training)

**Definition of the Topic:**

Fundamental to potable reuse is the reliability of treatment performance, which is needed to ensure the protection of public health. Reliability is built upon effective treatment, along with appropriate operations, monitoring, and trained staff. Underlying performance is a multiple barrier concept, which has been the cornerstone of the drinking water programs. It consists of coordinated technical, operational, and managerial barriers that help prevent contaminants at the source, enhance treatment, and ensure a safe supply of potable water. Significant protection is provided when a diversity of independent barriers are combined in series. This configuration provides two critical elements: redundancy (which prevents the failure of a single barrier from causing a failure of the entire system) and robustness (or the use of a diversity of barriers to address the diversity of potential contaminants). The use of multiple and diverse barriers results in a high overall level of reliability. In addition, appropriate monitoring and sound operations, including trained and knowledgeable operators, ensures treatment performance and water quality.

**State of the Knowledge:**

In California, two types of indirect potable reuse (IPR) are possible for groundwater recharge: (1) spreading of tertiary treated wastewater, and (2) spreading or injection of full advanced treated (FAT) waters that have been further treated via reverse osmosis and advanced oxidation. A third option is IPR via reservoir augmentation. All IPR systems must meet stringent chemical and pathogen criteria. The key difference between direct potable reuse (DPR) and IPR is that DPR eliminates the use of an environmental buffer (i.e., aquifer or reservoir). Removing the environmental buffer raises three important questions:

1) Is an engineered storage buffer needed?
2) What treatment performance monitoring requirements are needed to evaluate quality assurance?
3) What is the role of redundancy and robustness in a treatment train without an environmental buffer?

To ensure a significant level of protection for potable reuse systems, the following management, operational, and technological barriers are employed:

- Source control, including industrial source control, monitoring, and consumer, business and industrial sector education.
- Wastewater treatment, equalization, and monitoring.
• Advanced treatment and monitoring (reverse osmosis, advanced oxidation, disinfection).
• Optional drinking water treatment.
• Engineered buffer and/or monitoring.

A consistent potable water reuse quality should be achieved through appropriate and proven treatment strategies (e.g., FAT), technical controls (e.g., alarms, inspections, standard procedures), online monitoring devices (e.g., turbidity, total organic carbon [TOC], residual chlorine), and operational controls to react to upsets and variability. Similar to drinking water systems, quality control in potable reuse projects is provided by monitoring and operational response plans. Quality assurance is provided through multiple barriers and an assessment of treatment reliability. Established design and operational principles are used to ensure water quality.

As with drinking water facilities, water quality monitoring for potable water reuse involves the monitoring of bulk parameters (surrogates) and indicators to ensure the proper performance of unit processes. Monitoring consists of: 1) on-line monitoring devices (turbidity, chlorine residual, pH, and TOC), and 2) measurements using grab or composite samples (ammonia, nitrate, TOC, and \textit{E. coli}) to ensure the quality of the finished water. These practices follow standards and protocols similar to those applied in drinking water treatment.

Current wastewater and drinking water operator certification programs define criteria and provide the minimum qualifications for certification. However, these two programs do not address advanced treatments used in FAT systems. At present, utilities and agencies with these needs provide the appropriate training and experience. Treatment performance, monitoring, and operational requirements are documented in Operation, Monitoring, and Maintenance Plans for potable reuse systems.

**Summary of the Issues:**

DPR can be protective of human health if adequate protection through \textit{treatment, monitoring, and operations} is engineered within the system. Specific areas include the following:

• **Source control programs** for the wastewater collection systems are needed to address the control of substances not compatible with potable water reuse systems.

• **Other design features** should be evaluated, including: optimization of wastewater treatment; elimination of return flows; denitrification; flow equalization; and improved performance monitoring.

• **Strategies for incorporating reliability and resilience** into system design and operations are needed. Strategies should address the variability of processes, treatment lapses, and operator error. One approach for operational reliability is the use of Critical Control Points (CCPs), which involves operating processes under specific conditions to ensure a certain level of treatment is achieved.

• **Currently, a “4R” approach** has been proposed for DPR that defines the \textit{reliability} of the system in terms of \textit{resilience, robustness, and redundancy}. Applying this concept has the potential to ensure public health protection through the proper design and operation of DPR systems.
• In the future, **new technologies** may improve capabilities for both monitoring and treatment. These innovations will increase performance reliability for potable reuse.

• An appropriate online monitoring scheme is not feasible to provide real-time monitoring of all constituents of concern. However, **surrogate and indicator constituents** can be used to assess performance reliability of key unit process in place of direct measurements for all constituents of interest.

• **Monitoring and operation plans** are needed to address variability, equipment lapses, and operator error.

• Robust **operator training** is needed for DPR facilities to address advanced treatments and monitoring schemes, as well as meet appropriate response times in case of failures.

**Research Needs:**

• Assess the resiliency and interdependency of unit treatment processes (i.e., trace the failure and impacts).
  - Evaluate the removal efficiency of trace organic compounds of potential public health concern through FAT.
  - Predict the removal of compounds that may be precursors of disinfection byproducts.
  - A key component of defining the “consistency of treatment” is to understand the variability occurring within each unit process. More understanding is needed of what makes a barrier redundant or independent.
  - Use CCP assessments to quantify the robustness and reliability of multiple treatment barriers of DPR.

• Develop a process to evaluate and validate new and innovative technologies.
  - What treatment trains are considered equivalent to FAT?
  - More information is needed on the potential of non-reverse osmosis treatment options to eliminate the need for brine disposal.

• Document and quantify the removal of pathogens.
  - Limited information exists on pathogen levels in raw wastewater.
  - Evaluate the removal of pathogens in different biological wastewater treatment processes.
  - Better understand microbial communities that exist in treated water facilities.

• Regardless of how effective, reliable, robust, and redundant the system is, the treatment plant and delivery system must be prepared for circumstances where it fails (this is described as resiliency).
  - Evaluate information on out-of-spec behavior for IPR projects in the U.S. and the impact on water quality.

• A plan is needed to transition the results of research to application.

• Develop training for operators for DPR facilities.