Executive Summary

Enhancing resilience for potable reuse at every step

From Collection Systems to Tap: Resilience of Treatment Processes for Direct Potable Reuse (Reuse-14-13/4766)

The Central Issue

The objective of this research was to establish resilience guidelines for direct potable reuse (DPR) process trains from wastewater source through wastewater treatment and advanced water treatment. Supporting objectives included identification of failure modes for unit treatment processes commonly considered for DPR applications, along with associated monitoring for failure detection, consequences, and response. The researchers addressed previous information gaps including consideration of granular and biologically activated carbon and membrane bioreactors; dependencies such as power and data communication; and inter-agency communication.

Context and Background

Resilience is defined as the ability of a treatment train to successfully adapt to failure through rapid recovery. For utility operators, this means the ability to 1) adapt successfully or 2) restore performance rapidly in the face of treatment failures and threats. Resilience is also a commonly used metric for assessing water system performance – usually defined as the probability that a time period of unsatisfactory system state is followed by a time period of satisfactory system state.

Operational resilience is a key consideration for water security, independent of source, but especially for DPR systems. DPR operation requires planning and design for resilience due to variable water quality and flow rate associated with wastewater sources. Outage severity and recovery time can be decreased by optimizing reliability and resilience principals to address common failure modes identified through risk assessment and hazard analysis and critical control point (HACCP) assessment methods.

Findings and Conclusions

The risk of treatment failure can never be eliminated completely. Therefore, process monitoring is critical since response depends on detection. Hazardous events including process malfunction, wastewater source variability, natural disasters, malevolent attacks, and dependency on third-party providers such as power suppliers can lead to consequences that affect a utility's mission objectives associated with both water quality and quantity.

Outline of the Resilience Guidelines Explored in this Report.

Resilience is enhanced by reducing outage severity (duration and percent of service area) by providing process redundancy, source redundancy (which provides opportunities for blending), storage, real-time monitoring, and automated response to decrease response time. Response time may be shortened through improved communication (both inter- and intra-agency communication) and faster response time afforded by integrating standard operating procedures and Emergency Response Plan practice as regular staff training sessions. Specialized training is recommended for operators due to the increased complexity of monitoring, interpretation of data and alarms, and decisions required for response and recovery. Process robustness depends on removal of key pathogens and emerging contaminants and may be enhanced by establishing and monitoring utility-specific intermediate treatment goals for each DPR water cycle stage. Additionally, extreme weather events are likely to increase in frequency due to climate change. Therefore, special consideration should be given to natural disaster dependencies associated with flooding and drought.

Management and Policy Implications

The advancement of water reuse addresses water security, public health, and environmental protection. This report presents risk assessment methods that can aid utility managers and others in evaluating resilience-enhancing alternatives and identifying alternatives associated with the maximum risk reduction per triple bottom cost (people, plant, profit). Risk assessment methods such as the HAACP approach for DPR may be the best approach in some circumstances, but would mark a significant departure from current regulatory practices in the U.S. that typically rely of multiple barriers, best available technology, and risk-based drinking water quality objectives. When implemented properly, incorporating HAACP or other similar approaches with the existing regulatory framework may lead to a more holistic approach in system operations and public health protection.

Related WRF Research

Project Title	Research Focus
Evaluation of Risk Reduction Principles for Direct Potable Reuse (Reuse-11-10)	Identifies how risk reduction and response concepts developed in other industries can be applied to DPR. Provide new perspectives on how to consider risk management and an understanding of what engineering practices could be incorporated into the design, control, operation, and maintenance of advanced treatment systems.
Critical Control Point Assessment to Quantify Robustness and Reliability of Multiple Treatment Barriers of a DPR Scheme (Reuse-13-03)	Develops best design, monitoring, and operational practices by evaluating critical process control points in various DPR treatment trains that were evaluated to meet overall system robustness and reliability.
Guidelines for Source Water Control Options and the Impact of Selected Strategies on direct Potable Reuse (Reuse-13-12)	Provides information that facilities can use to implement source control programs and objectives for the development of these programs, as well as design considerations related to advanced water purification and source water treatment facility operational issues that impact IPR/DPR systems.
Development of Operation and Maintenance Plan and Training and Certification Framework for Direct Potable Reuse Systems (Reuse-13-13)	Develops a standard operations and maintenance plan for various DPR treatment processes, including appropriate portions of the upstream secondary wastewater treatment processes providing feedwater to the DPR processes.
Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse (Reuse-14-12)	Presents the results of a reliability analysis and challenge tests, and shows how a combination of redundancy, robustness, and resilience can ensure that direct potable reuse is protective of human health.
Operational, Monitoring, & Response Data from Unit Processes in Full-Scale Water Treatment, IPR, and DPR (Reuse-14-16)	Assesses the failure mechanisms of potential DPR processes that could impact water quality/health risk and the range of times to a failure event associated with specific unit processes.

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