THE Water Research FOUNDATION

FACT SHEET

November 2024

Project 5040

Successful Implementation of Onsite and Distributed Water Reuse Systems

Partners: Columbia University, Pacific Institute, and Water Environment Federation

Introduction

The One Water paradigm promotes a holistic approach to managing all urban water flows as interconnected systems, emphasizing sustainable and regenerative development. Onsite and distributed water reuse systems (ODWRS) are emerging as feasible alternatives to centralized systems, treating water closer to the point of use and tailored to specific end uses. ODWRS collect water sources close to where they were generated and/or used, treating these sources to a quality deemed safe for a specific end use application (see Figure 1). The global market for decentralized packaged or containerized water and wastewater systems has experienced growth in the last decade and is projected to continue growing as communities look to sustainable alternatives for its water systems (Frost & Sullivan 2017). This document summarizes motivations for communities to consider ODWRS, key success factors for implementation, case studies in the North America, and future research needs.

WATER SOURCE	END USE	CONFIGURATION
• Municipal Wastewater • Stormwater • Industrial Wastewater • Process Water • Greywater • Rainwater • Condensate • Other Sources (e.g., foundation drainage, splashpad runoff, and bay water)	• Landscape Irrigation • Other Outdoor Non-potable (e.g., water features, fire protection, green roof irrigation, street cleaning) • Toilet Flushing • Heating or Cooling • Other Indoor Non-Potable (e.g., laundry, cleaning, indoor irrigation) • Industrial Processes • Habitat or Natural System Restoration • Groundwater Recharge • Agriculture • Drinking Water (sinks and dishwashers)	• Cluster ○ District-scale ○ Community-scale • Single Building ○ Small Residential ○ Multifamily Residential ○ Mixed Use ○ Office ○ Other Commercial ○ Industrial ○ K-12 School ○ University ○ Visitor Attraction ○ Other

Figure 1. Overview of Different Sources, End Uses, and Configurations for ODWRS.
Source: Hayek et al. 2024.

Drivers and Co-Benefits of ODWRS Implementation

The drivers for ODWRS are varied and depend on local conditions. For example, some projects may be driven by water scarcity and the need to augment and diversify water supplies. Other projects may be driven by the need to reduce pressure on strained sewer systems or to reduce the discharge of stormwater or treated wastewater into sensitive water bodies. This may be especially attractive for communities with combined sewer systems. Still other projects may be driven by a desire to meet sustainability goals or earn a higher rating for LEED or other certification programs. Research has shown that ODWRS in municipal settings are installed in places where centralized wastewater options are too expensive, water supplies are constrained, or effluent discharge options are limited (Hayek et al. 2024). For specific types of sources, it was found that ODWRS systems that use stormwater are typically installed in places with combined sewers, polluted runoff, high flood risk, or constrained water supplies. Greywater systems are implemented to meet local water reuse mandates, green building goals (e.g. LEED), or out of a sense of environmental stewardship (Hayek et al. 2024).

Just as drivers are diverse, so too are the potential co-benefits. Buildings equipped with an ODWRS, for example, may face fewer or reduced water-related risks, such as water shortages that threaten to disrupt building operations. ODWRS are perceived as innovative and leading edge, and as a result, they can improve brand reputation and support employee recruitment and retention. Furthermore, a growing number of companies are adopting water sustainability goals to reduce their water use and/or increase onsite water reuse, and ODWRS can support achievement of those goals (Cooley et al. 2021).

ODWRS can also provide co-benefits for natural and manmade water systems and the larger community. They can, for example, increase water supply reliability, improve water quality, and reduce local flooding. When integrated into the centralized system, they can also enhance water resilience by diversifying water sources and providing operational flexibility and redundancy. Finally, ODWRS can provide non-water benefits, such as supporting more green space in urban areas and community cooling through reductions in the urban heat island effect. Importantly, the realization and magnitude of these benefits vary with the type of system adopted, scale of implementation, and other context-specific factors (Cooley et al. 2021).

Current Status of ODWRS Implementation and Case Studies in the North America

In 2024, researchers from Columbia University, funded by The Water Research Foundation, undertook a study to document and compile a database of existing ODWRS in North America (Hayek et al. 2024). The database includes 310 systems across 262 projects, with 270 systems in the United States and 26 in Canada, covering various water sources, end uses, and configurations. Of the different types of source water, rainwater is the most common source (50%), followed by municipal wastewater (24%) and stormwater (17%). Of the different end uses, landscape irrigation is the most common end use (56%), followed by toilet flushing (25%), and heating or cooling (12%).

Figure 2. Locations for 270 ODWRS Systems in the U.S. as of 2024.
Source: Hayek et al. 2024.

Case Study: City of Vancouver, British Columbia, Canada

- Drivers: Combined sewer overflow (CSO) volume reduction, runoff quality control
- Sources: Stormwater, rainwater, wastewater
- End Uses: Toilet flushing, landscape irrigation

The City of Vancouver's interest in ODWRS is rooted in concerns about the quality of surrounding water bodies. In 2018 alone, more than 8.7 billion gallons of combined sewage were discharged into nearby waters from CSOs. Vancouver began developing a citywide integrated rainwater management plan (IRMP) in 2013. In April 2016, the City Council supported using green infrastructure and stormwater and rainwater ODWRS to meet the IRMP target of capturing and treating 90% of average annual rainfall volume by 2050. Another team was created to engage experts and the public in defining interim targets and milestones, which are summarized in Vancouver's Rain City Strategy (Conger et al. 2019). Since January 2019, operating permits are required for all alternate water source systems. Later amendments to the by-laws in June 2020 included codification of additional rainwater ODWRS end uses and required operator certification for at least one individual listed on a system's operating permit after January 1, 2022.

Case Study: The Twin Cities Region, Minnesota

- Drivers: Runoff quality control, aquifer recharge
- Sources: Stormwater, rainwater
- End Uses: Landscape irrigation, toilet flushing, habitat restoration

The Metropolitan City Council, the regional planning organization for the seven-county Twin Cities area, developed one of the first guidance documents for stormwater reuse in the state back in 2011. The Stormwater Reuse Guide includes case studies, detailed considerations during different phases of stormwater ODWRS implementation, and worksheets to help implementers work through the process. In 2015, the Metropolitan City Council adopted the 2040 Water Resources Policy Plan that includes a commitment to support stormwater and wastewater reuse (with amendments in 2018 to expand on strategies for wastewater reuse). They also joined the Minnesota Department of Health's Interagency Workgroup on water reuse that same year. A report released by the Interagency Workgroup in 2018 laid out recommendations for state and local governments in developing regulations and guidance for water reuse within their jurisdictions.

Tips for Successful Implementation

Integrated efforts are needed to support successful adoption of ODWRS in local contexts. Based on the experiences of extensive case studies in North America, there are six major recommendations for advancing ODWRS:

1. Engage a multidisciplinary team in an integrated, collaborative design process. Involvement and participation from individuals and/or organizations familiar with water reuse applications during early civil and structural design can ensure that developers and owners understand all their options and what they entail for construction, operation and maintenance.
2. Approach regulators as allies in ODWRS implementation and work with them to address regulatory barriers. In some cases, regulations may not currently exist for your jurisdiction, which will require thoughtful and extensive coordination with local, regional, and state regulatory agencies to ensure that your system is protective of human and environmental health.
3. Clearly communicate the impacts and benefits of ODWRS implementation to stakeholders throughout the project. Across various projects, stakeholders may include the building owners, developers, design firms, local utilities, regulators, and general public. It is important to develop the narrative for how ODWRS addresses existing drivers and maximizes co-benefits to help others understand the "why."
4. Consider the use of water submetering and the appropriate online monitoring systems during initial installation to improve stakeholder engagement, system performance and diagnostic capabilities.
5. Consider the operational support needed to ensure that ODWRS systems are adequately maintained once online. Prior to installing systems, jurisdictions should consider the certification needed by ODWRS operators.

Future Research Needs

While communities in North America are starting to see the emergence of ODWRS, additional effort is needed to support broader uptake of these systems. Areas for additional research include the following:

- Identifying effective models for management and ownership of ODWRS.
- Optimizing the integration of centralized, onsite, distributed and decentralized reuse systems to maximize community co-benefits.
- Assessing the economic impact and cost effectiveness of ODWRS.
- Education and certification requirements for supporting operator development.

Sources and Related Materials

- Conger, T. A. Couillard, W. de Hoog, C. Despins, T. Douglas, Y. Gram, J. Javison, R. Lukes, C. Owen, M. Pollard, J. Satzewich, and M. Scholefield. 2019. Rain City Strategy: A Green Rainwater Infrastructure and Rainwater Management Initiative. Accessed November 12, 2024. https://vancouver.ca/files/cov/rain-city-strategy.pdf.
- Cooley, H., A. Thebo, C. Kammeyer, and D. Bostic. 2021. The Role of Onsite Water Systems in Advancing Water Resilience in Silicon Valley. Oakland, CA: Pacific Institute. https://pacinst.org/wp-content/uploads/2021/01/Role-of-Onsite-Water-in-Silicon-Valley-Jan-2021.pdf.
- Frost & Sullivan. 2017. "Global Decentralized Packaged/Containerized Water and Wastewater Treatment Systems Market, Forecast to 2023." Accessed November 19, 2024. https://store.frost.com/global-decentralized-packaged-containerized-water-and-wastewater-treatment-w-wwt-systems-market.html.
- Hayek, C., U. Lall, W. Becker, P. Knowles, L. Faber, S. Teevan. 2024. *Successful Implementation of Onsite and Distributed Water Reuse Systems.* Project 5040A. Denver, CO: The Water Research Foundation.
- Snyder, C., H. Cooley, and A. Thebo. 2023. "Guide for Developing Onsite Water Systems to Support Regional Water Resilience." Oakland, CA: Pacific Institute. https://pacinst.org/wp-content/uploads/2023/01/OnsiteGuide_FINAL-1.pdf.