

ONSITE NON-POTABLE WATER REUSE

PRACTICE GUIDE



CHARLES PANKOW
FOUNDATION



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CRESCENT HEIGHTS



WILLIAM J WORTHEN
FOUNDATION

DEDICATION



WILLIAM J WORTHEN FOUNDATION

William Worthen, co-founder and CEO of Urban Fabrick, Inc. and co-founder of The Urban Fabrick Collaborative, now the William J. Worthen Foundation, until his death in 2017, was a nationally recognized sustainability and collaborative design leader. Over his twenty-year career, Bill balanced policy development with professional and public advocacy, practice experience, industry research, and peer-to-peer education. Bill served as the sustainability consultant for many high-visibility projects exploring the practical application of cutting-edge sustainability strategies, energy performance and high-level LEED certifications for clients all over the world.

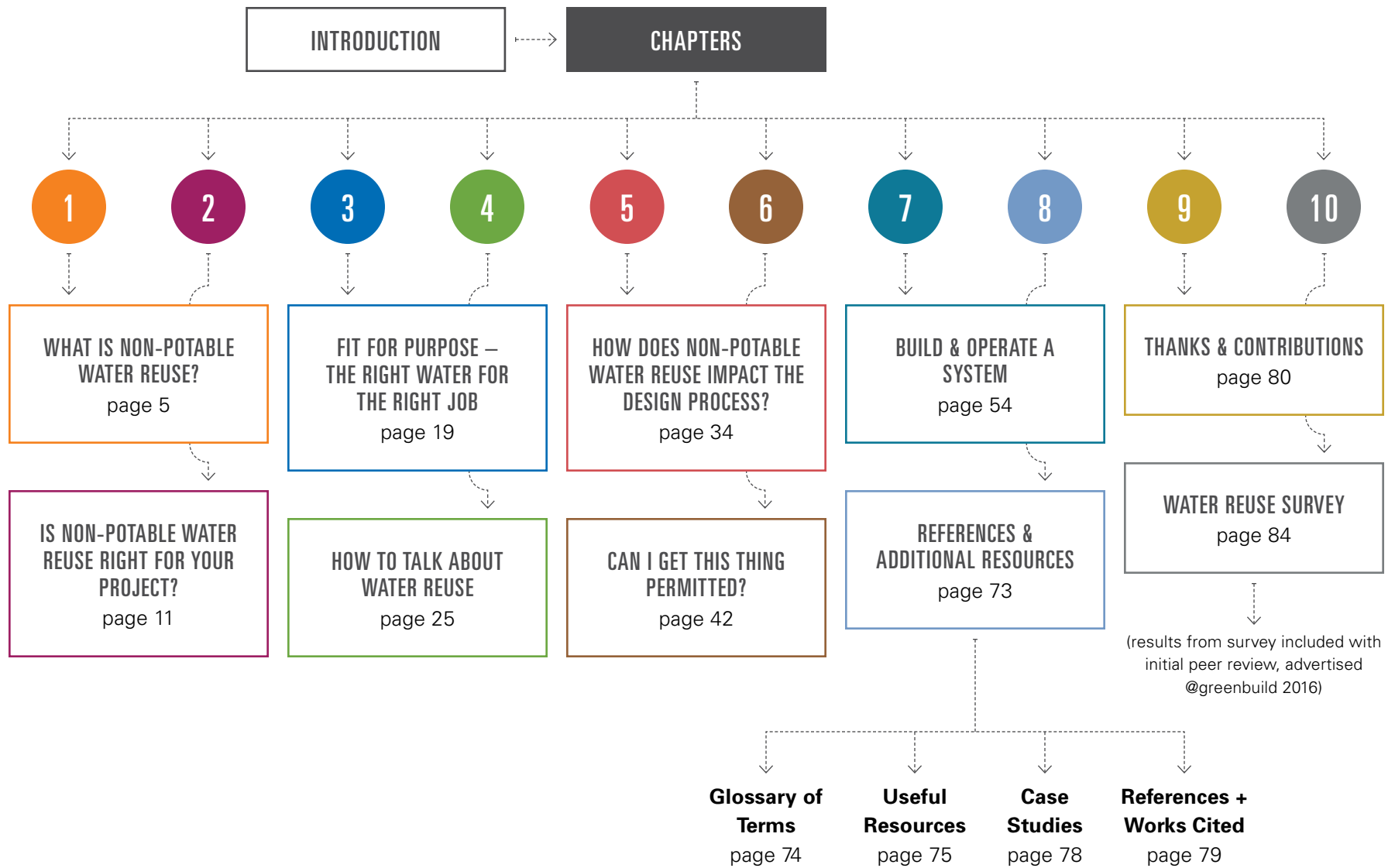
In addition to his professional practice, Bill was a leading advocate for green building and sustainability policy. He served as a member of San Francisco Mayor Gavin Newsom’s Green Building Task Force, resulting in the city’s pioneering Green Building Ordinance which won the first World Green Building Council Government Leadership Award in 2011. Bill also represented his profession as the AIA National Director and Resource Architect for Sustainability from 2010 to 2012, spearheading several cross-industry collaborative sustainability initiatives—most notably overseeing the development of the AIA Energy Modeling Practice Guide which ultimately served as the model for this Water Reuse Practice Guide.

Bill’s leadership in water reuse strategies resulted in some of the first onsite residential systems in the City and County San Francisco. He helped craft San Francisco’s water reuse ordinance requiring new large developments of 250,000 or more square feet located within the city’s “purple pipe” reclaimed water zone to install onsite water reuse systems for non-potable uses, while also requiring all developments citywide 40,000 square feet and above to go through an onsite water reuse analysis by the Public Utilities Commission. He brought a passion for sustainability that moved and motivated the industry. We at the William J. Worthen Foundation and Urban Fabrick Inc. are committed to carrying on his legacy of collaborative leadership and to advance a climate positive future through policy, practice, design, and innovation. This project would not have occurred without Bill’s commitment, tenacity, and charm. He is greatly missed.

Kyle Pickett

Co-Founder and Executive Director
Co-Founder and COO, Urban Fabrick Inc.

CONTENTS



INTRODUCTION



WELCOME TO THE ONSITE NON-POTABLE WATER REUSE PRACTICE GUIDE.

The Non-Potable Water Reuse Practice Guide is written with practicing architects and other building design professionals in mind. It provides simple and powerful explanations of why you may want to consider whether non-potable water reuse makes sense for your commercial or residential project. It also offers easily accessible information and next steps for how to incorporate systems in project design and maximize their value.

TOP TEN REASONS WHY THE A/E/C COMMUNITY SHOULD CARE ABOUT ONSITE NON-POTABLE WATER REUSE:

1. It reduces a building's need for potable water.
2. It extends our water supply.
3. It increases the resiliency of our cities and urban neighborhoods.
4. It can reduce the costs of expanding and upgrading water and sewage infrastructure.
5. It can allow projects to better achieve green building certifications without altering the architectural design.
6. When done right, it is safe, cost-effective, and publicly acceptable.
7. It can be a cost-effective strategy to move your project closer to net-zero energy and water use.
8. It can be used as a tool to shorten planning and entitlement reviews.
9. Understanding how to address the water-energy nexus in practice is a great way to demonstrate professional leadership and environmental stewardship.
10. Eventually, onsite non-potable water reuse will be allowed and may be required in your jurisdiction. Are you ready?

Onsite non-potable water systems are systems that “collect wastewater, stormwater, rainwater, and more, and treat it so that it can be reused in a building, or at the local scale for non-potable needs such as irrigation, toilet flushing, and cooling. These systems are usually integrated into the city’s larger water and wastewater system and contribute to a more resilient and sustainable water management by using alternate water sources, reducing valuable potable water used for non-potable purposes, and minimizing strain on wastewater systems” (US Water Alliance, 2017). While many refer to these systems as “onsite reuse,” the water/wastewater sector is increasingly moving towards terminology “onsite water systems,” both to distinguish from municipal-scale water reuse and to highlight that some alternative water sources that are captured, treated, and used onsite, such as rainwater, are in fact being used by humans for the first time.

Disclaimer: In this guide, “onsite reuse,” “onsite water,” and similar terms are shorthand for “onsite non-potable water systems.” This guide does not cover treatment or reuse for potable purposes.

This guide is for educational purposes only. It is not intended to imply that water reuse is appropriate for all jurisdictions or building types. The William J. Worthen Foundation, the Onsite Non-Potable Water Reuse Guide Working Group, and project sponsors cannot be held liable for damages of any kind arising from the use of, reference to, or reliance on the Guide’s contents.

CHAPTER 1

WHAT IS NON-POTABLE WATER REUSE?

CHAPTER LEARNING OBJECTIVES

- ◆ Learn what onsite non-potable water is and why it matters to architects, engineers, and other design professionals.
- ◆ Understand how onsite non-potable water reuse fits within the hydrologic cycle.
- ◆ Get to know “One Water”—a paradigm shift—and why onsite reuse is key to making it work.

1. WHAT IS NON-POTABLE WATER REUSE?

KEY DEFINITIONS

Water Reuse: Treatment and use of impaired water source before putting it back into the natural environment. Water can be reused for potable or non-potable purposes (irrigation, toilet flushing, laundry, etc.).

Non-Potable Water: Water that is not of a quality suitable for human consumption, but can be used for other purposes.

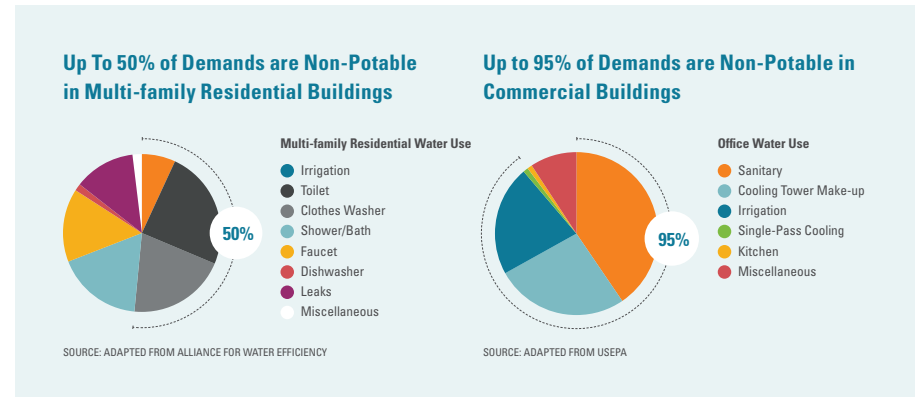
Onsite Treatment: Capturing and treating water in close proximity to its collection and next use, for instance in a building or within a district, rather than sending water to the utility plant for treatment.

“Fit-for-Purpose” Use: Matches the quality of a particular water source to an end-use for which that water quality is sufficient.

What is Non-Potable Water Reuse?

“Potable” means “drinkable.” Non-potable water is water that does not meet the standards for human consumption but is suitable for other purposes, depending on the water quality of a given non-potable water source and its intended end-use. Most people do not realize that most of the water used in buildings does not need to be potable. For instance, many would say flushing our toilets with drinking water is a “waste.”

In fact, 95% of water used in commercial buildings and 50% of water used in multi-family residential buildings is for non-drinking water needs.



The non-potable water associated with buildings—rainwater, stormwater, and wastewater—has traditionally been considered either too expensive or too dirty to reuse, but that is not necessarily the case. This water, which is typically collected and carried away from the buildings we design, can be treated onsite to a level of quality that makes it safe to use again immediately for specific, dedicated purposes. Onsite treatment is cost-effective and safe and has proven effective in meeting water quality standards while reducing the need for potable water and the energy consumed in its delivery. Onsite treatment uses similar principles and technologies that have been used to treat water/wastewater in our municipal systems for decades.

In many cases, the processes used to treat non-potable water mimic the way that nature itself cleanses water.

1. WHAT IS NON-POTABLE WATER REUSE? (continued)



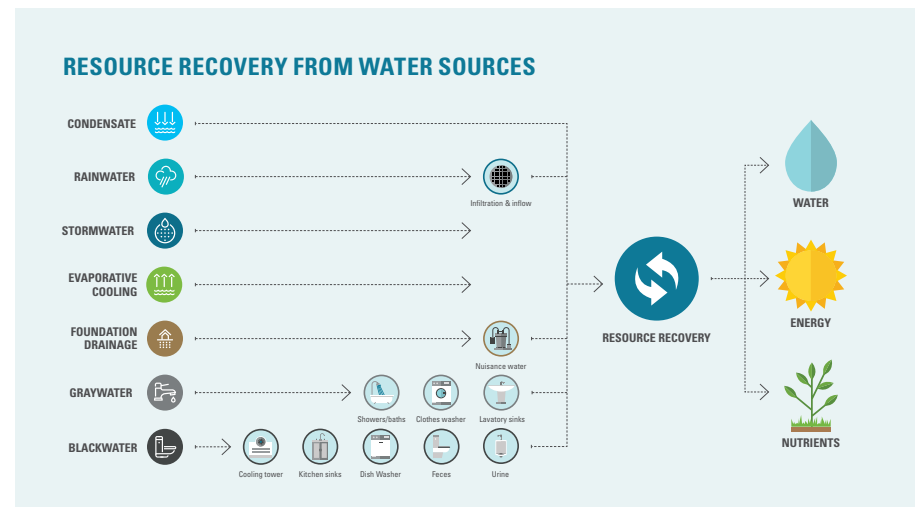
The Hydrologic Cycle

To fully grasp the value of non-potable water reuse, it is helpful first to understand the natural hydrologic cycle and its relationship to water infrastructure.

Water is one of the most common substances on Earth. It covers more than 70 percent of Earth's surface and is a necessity for life, yet less than one percent is accessible and of a sufficient quality to be treated and used for human consumption. Where water of sufficient quality and quantity exists, human activities can be found. Cities, countries, and cultures have risen and fallen based on its changing availability. Many of the social and economic conflicts we see today are rooted in or exacerbated by a lack of access to clean water in a changing climate.

All water is a resource. No matter where it comes from or what quality it is, it is still H₂O—two hydrogen atoms bonded to a single oxygen atom. But it is more than that: it carries potential energy, and it often contains nutrients and other valuable substances. Water and the resources held within it can be used for many purposes.

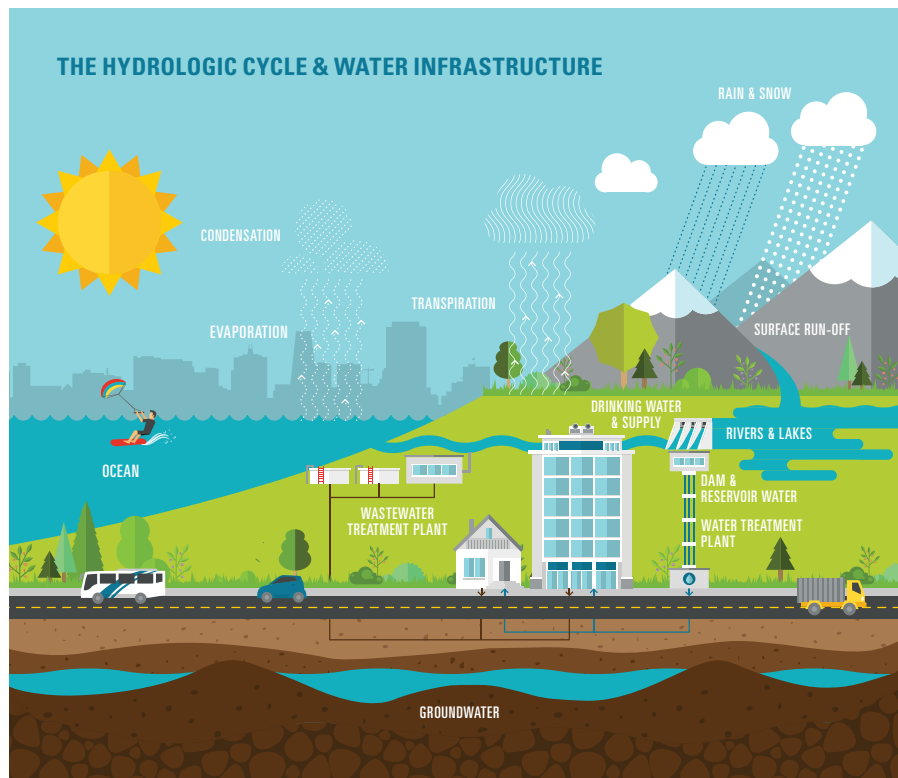
Water reuse treats and recycles water faster than nature, on a scale that our centralized infrastructure is not currently designed for, in a cost-effective way, and closer to the building or site where that water can be used again. Water reuse matches appropriately treated water with appropriate uses. We call this “fit-for-purpose” water use. Fit-for-purpose water allows us to save high quality drinking water for just that: drinking. Instead of flushing drinking water down the toilet, we can treat water to a quality not on par with drinking water standards, but still sufficient to protect public health and meet the non-potable demands of a project: toilet/urinal flushing, landscape irrigation, cooling towers, etc. This approach saves precious drinking water by reducing the amount of potable water required in a building, while also decreasing the amount of wastewater discharged to the municipal system.



1. WHAT IS NON-POTABLE WATER REUSE? (continued)

Recognizing that all water is a resource, the wastewater sector has begun to refer to wastewater treatment plants as “Water Resource Recovery Facilities.” They—and we—are beginning to understand that there is no such thing as “waste” water.

The hydrologic cycle is the system through which water naturally circulates on our planet. Heat from the sun causes surface water to evaporate and form water vapor in the atmosphere. As the water vapor cools, clouds form that transport moisture around the globe. Eventually the moisture becomes too saturated to remain in vapor form, condenses, and returns to the surface as precipitation—rain or snow.



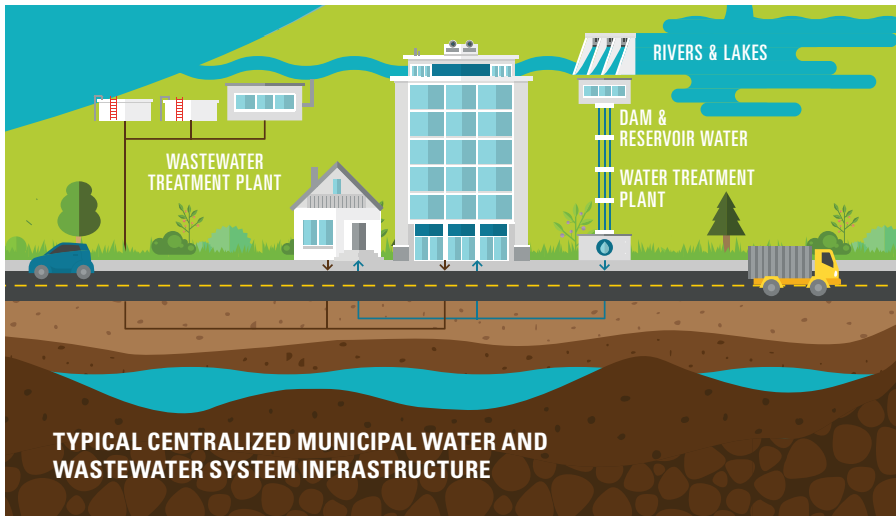
Some precipitation evaporates back into the atmosphere. But most of it ends up on land as surface water—runoff, rivers, streams, and lakes. From here, it replenishes groundwater in aquifers or flows back to the oceans, where it eventually heats up and evaporates, starting the cycle again. Nature treats water during this process, filtering away many contaminants and pollutants. This cycle has occurred for millennia.

The hydrologic cycle shows us that all water is already recycled water. It re-circulates throughout our planet, changing form and location. But the amount of water on Earth has not and will not change.

Every drop of the water we drink, every drop we flush down our toilets, every drop we use to shower, wash our clothes, irrigate our lawns, and grow our food—all water on the planet—has been used and treated and recycled, countless times.

Our centralized water and wastewater treatment systems speed up this cycle, and many treatment systems mimic natural processes in increasingly innovative ways. Water sources that are of sufficiently high quality need minimal filtration or treatment. Other water sources require much more treatment, due to contamination from a variety of sources. After people use water, it must typically be processed to regulated standards of cleanliness, to protect downstream human and environmental health, before it can be returned to the environment. Traditional water management approaches evolved and built water infrastructure to address water needs as they developed over time—providing clean drinking water, developing storage for water supplies, carrying away our wastewater to protect public health, draining our cities during storms for flood protection, and, finally, treating our wastewater to protect the environment.

1. WHAT IS NON-POTABLE WATER REUSE? (continued)



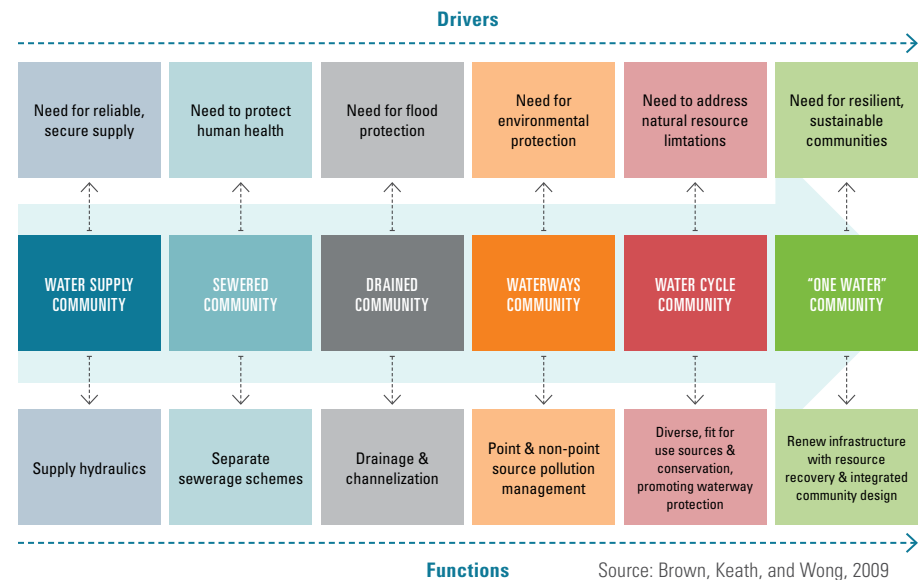
“One Water” Management

One Water management seeks to take this evolution a step further, by integrating conservation, sustainability, and environmental protection with innovative solutions. The Water Environment & Reuse Foundation (WE&RF) defines One Water as an *“integration in the planning and management of water supply, wastewater, and stormwater systems in a way that minimizes the impact on the environment and maximizes the contribution to social and economic vitality.”* (Mukheibir et al., 2015)

It mirrors the natural hydrologic cycle by bringing together the different ways in which entities deal with water, wastewater, and stormwater. Though the specifics may differ from place to place, One Water reaches beyond the “do no harm” principle to create regenerative systems that support healthy, sustainable cities by recognizing that all water flows offer potential resources and seeking to integrate and optimize these resources (Howe & Mukheibir, 2015).

The future of our cities and communities will not rely solely on traditional, centralized infrastructure, but rather on an integration of centralized and decentralized approaches that maximizes the advantages of different systems to make our water supplies reliable and adaptable.

EVOLUTION OF WATER MANAGEMENT AND THE FUTURE OF ONE WATER COMMUNITIES



Onsite non-potable treatment and reuse play an important role in this approach. Incorporating decentralized treatment systems into buildings can increase the efficient use and reuse of water, reducing the amount of potable water used unnecessarily. In turn, recycling water onsite decreases the significant energy consumption needed to pump water long distances between treatment plants and users and may also offer heat recovery opportunities.

1. WHAT IS NON-POTABLE WATER REUSE? (continued)



Furthermore, onsite systems can help alleviate stress on existing, burdened infrastructure. By diverting flows, the lifespan of pump stations and treatment facilities can be extended, maintenance and municipal energy costs can be reduced, and capacity can be utilized elsewhere. When considering an onsite solution, it is important to recognize that project savings are often greater than the impacts of lost revenue related to the diverted flows.

Water Reuse is a Design Opportunity

By designing buildings with non-potable onsite water reuse, architects and other building design professionals, developers, and others in the industry can support a larger shift toward One Water within our communities to build and manage a more resilient, equitable system. Thinking holistically about a project provides the opportunity to develop a strategy that utilizes alternative water sources available to the project in innovative, cost-effective ways to meet non-potable demands.

Non-potable onsite water reuse is a new way of thinking based on established, proven technologies and treatment processes. It is an important component of a larger, One Water approach to managing, treating, and maintaining our precious water resources. As an innovative approach to One Water and resource conservation, onsite water reuse is indeed a design opportunity.

CHAPTER 2

IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT?

CHAPTER LEARNING OBJECTIVES

- 💧 Assess the regulatory requirements.
- 💧 Identify questions that validate the viability of reuse.
- 💧 Understand when non-potable reuse makes sense.

2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT?

The suitability of non-potable water reuse varies according to many factors, such as project type, scale, and location. Each project should be independently assessed to determine the viability of water reuse. This chapter outlines the high-level questions to ask before making a final decision.

Is It Required by Code?

Reuse facilities operate within a framework of regulations that must be understood in early planning. A thorough understanding of applicable regulations is required to plan an effective water reuse program.

Water reuse is regulated or guided in more than 40 states and territories in the US; some require it, some encourage it, some allow it, and some prohibit it. Currently, there are no federal regulations directly governing water reuse practices in the United States. The EPA surveyed the 50 states, tribal communities, and US territories to inventory reuse regulations and guidelines, which are summarized in Table 4-5 of the [EPA 2012 Guidelines for Water Reuse](#).

Possible regulatory considerations include:

- Water availability or discharge restrictions (water quality, storm/sewer tie-ins, Combined Sewer Overflow mitigation, MS4 compliance, stormwater runoff requirements of Section 438 of the federal Energy Independence and Security Act.

- Sensitive area avoidance (FEMA floodplains, wildlife corridors, archaeological finds, etc.).
- Authorities potentially having jurisdiction, including local, regional, or state public health agencies as well as building departments, water resources control boards, local water and/or sewer utilities, et al.
- Policy, development agreements, or conditions of approval (e.g., US Army Corp of Engineers “Waters of the US”).

The [Regulatory Pathways to Net Zero Water Phase II](#) report summarizes a yearlong effort by the Cascadia Green Building Council and the City of Seattle to identify regulatory pathways for Seattle-area projects pursuing net zero water strategies.

Is the Site Susceptible to Water Stress?

“Water stress” occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saltwater intrusion, etc.). As awareness regarding “water stress” increases, use restrictions continue to spread.

2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)

You will want to consider:

- The project site's current water stress.
- The site's projected water stress with and without climate change.
- How governing authorities are managing water stress. For example, San Antonio Water System (SAWS) uses drought restrictions, established by city ordinance, to proactively manage the region's water resources. The restrictions limit water use based on the level of the Edwards Aquifer.

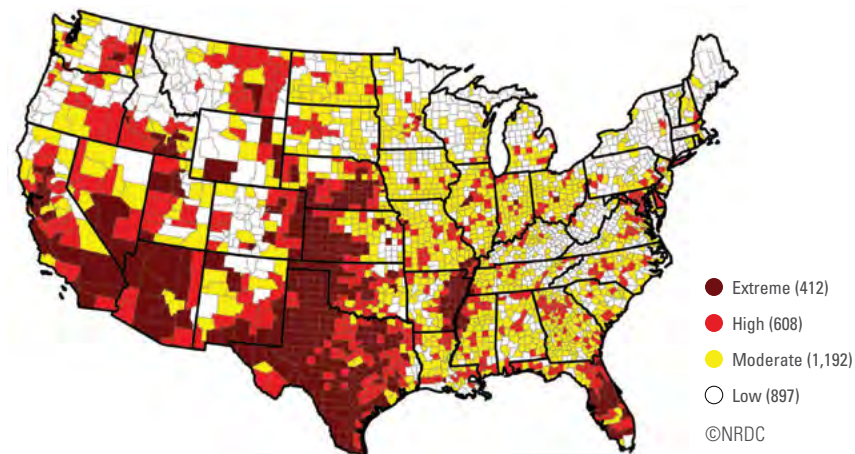
CURRENT WATER STRESS

Find the project's location in the [Aqueduct Water Risk Atlas](#). This tool allows you to visualize the extent and severity of current water stress in and around the area in question.

PROJECTED WATER STRESS

What is water stress projected to look like in the future? Regardless of the site's current water stress, look toward the future with the Natural Resources Defense Council's [Water Supply Sustainability Index](#) map and supporting data.

WATER SUPPLY SUSTAINABILITY INDEX (2050)



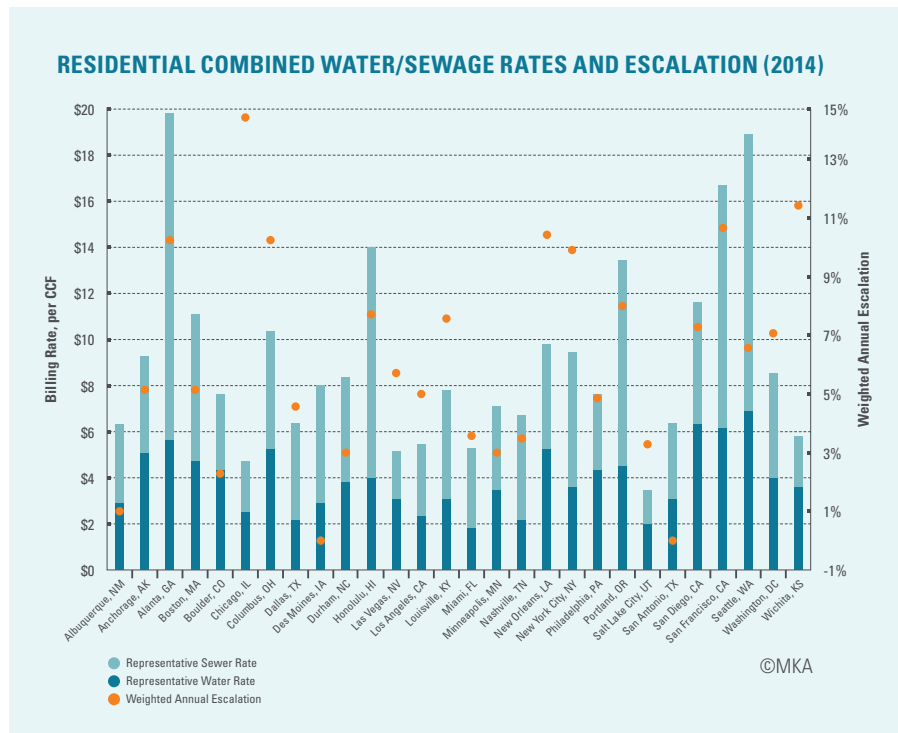
Does it Make Financial Sense?

The amount that Americans pay for water resources is rising faster than US inflation and faster than the amount paid to any other utility service—be it gas, electricity, or telephone—according to the Institute of Public Utilities.

You will want to consider:

- Current utility rate environment.
- Existing infrastructure capacity and projected population growth vs. cost of water purchase agreements.
- At what utility rate would it make sense to reuse water? Is that rate far off?

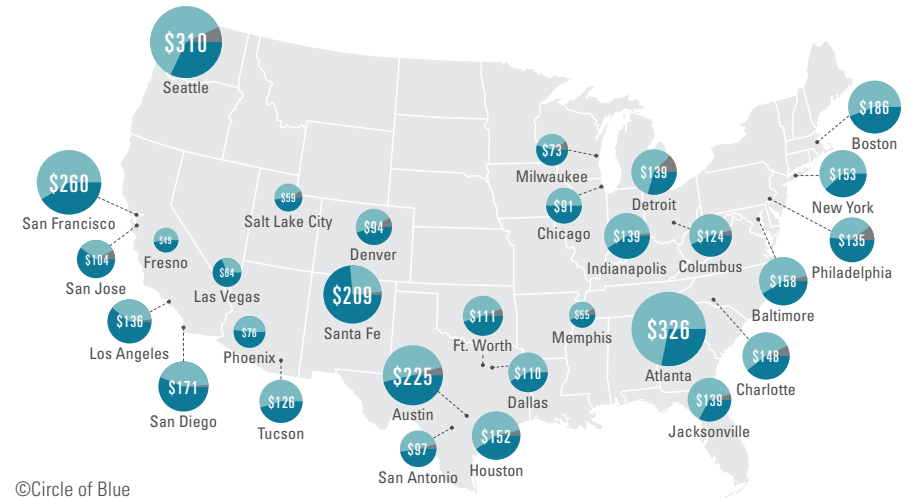
2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)



Across the country, water rates are rising at a surprisingly rapid pace. A recent article on 2016 water rates observed, “The price of water rose 5 percent last year, according to Circle of Blue’s annual survey of 30 major US cities. The median increase was 3.5 percent. The increase continues a steady upward climb in water prices that reflects investment in new infrastructure and a response to declining water sales. The average price climbed 48 percent since 2010.” There are a number of reasons why rates are increasing. Chief among them is aging water infrastructure in need of constant maintenance and repairs. The cost of updating water systems in various cities is overwhelming some utilities, which have resorted to raising money through new billing systems and fee structures.

Ask yourself why rates are rising and whether your project may be affected by those increases now and in the future.

THE PRICE OF WATER (2015)



- WATER** prices for treating, pumping and delivering water, while sewer prices cover the cost of cleansing the water that goes down the drain.
- SEWER** prices are often higher than water prices because more energy and chemicals are required for treatment. Following the Clean Water Act, the federal government gave grants for new treatment plants during the 1970s and 1980s. Over the past three decades, however, new spending has been cut for local sewer infrastructure.
- STORMWATER** fees are not included in every city’s monthly bill. Some cities use general tax revenues to pay for projects to reduce polluted runoff from streets and parking lots. However, these projects must then compete for funds with other departments like police and schools.

Combined water, sewer and stormwater prices for households in 30 major cities.

Seattle and Atlanta have the highest total monthly bills. Each is building costly underground storage facilities and treatment plants to comply with federal requirements to reduce raw sewage that is dumped into lakes and rivers.

Santa Fe has the highest water prices in the survey. The small city of 70,000 recently completed a \$US 187 million pipeline from the Rio Grande.

Baltimore has stormwater fees that are mandated by state law as part of a program to keep polluted runoff from entering the Chesapeake Bay.

2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)



GET GUIDANCE ON HOW TO PREPARE AN ECONOMIC ANALYSIS FOR WATER RECYCLING PROJECTS

An economic analysis is used to determine whether a proposed project will be a worthwhile investment. The analysis takes a perspective beyond that of the proponent and accounts for all benefits and costs regardless of who is affected.

Is the Market Demanding It?

In 2015, the USGBC published [“The Business Case for Green Building,”](#) which outlines market factors affecting green building. Among them are the following:

- The top two reasons for building green: client demand (35%) and market demand (33%).
- The global green building market grew in 2013 to \$260 billion, including an estimated 20 percent of all new US commercial real estate construction. This trend is expected to intensify in the coming years, both in the US and internationally.
- LEED-certified buildings with lower operating costs and better indoor environmental quality are more attractive to a growing group of corporate, public, and individual buyers. High performing building features will increasingly enter into tenants’ decisions about leasing space and into buyers’ decisions about purchasing properties and homes.
- Today’s tenants understand and are looking for the benefits that LEED-certified spaces have to offer. The new Class A office space is green; lease-up rates for green buildings typically range from average to 20 percent above average.

- Owners of green buildings reported that their ROI improved by 19.2% on average for existing building green projects and 9.9% on average for new building projects.
- A business case study examining the San Diego real estate market showed that the overall vacancy rate for green buildings was 4 percent lower than for non-green properties—11.7 percent, compared to 15.7 percent—and that LEED-certified buildings routinely commanded the highest rents.

Much as the energy crisis of the 1970s spurred innovation and led to projects developing an energy strategy, the global water crisis will lead to the need for projects to develop a holistic, sustainable water strategy. As awareness grows around the preciousness of water, the market will demand that spaces not only be energy conscious, but also water conscious.

Would It Minimize or Eliminate Expensive Infrastructure Improvements?

In some cases, a new development may require a sewer main extension or upsizing of a water distribution main. These can be significant capital outlays that may be avoided by implementing a water reuse program to reduce the amount of wastewater sent downstream or the amount of potable water required to serve the proposed development. The Water Environment & Reuse Foundation (WE&RF) offers many tools to help you, your team, and your client evaluate the cost effectiveness of decentralized wastewater treatment.

In addition, decentralized systems can be recognized as “green” and thus may be eligible for special funding opportunities, such as the green project reserve under the Clean Water State Revolving Fund (CWSRF).

2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)

The EPA promotes use of the CWSRF as a means for states to implement comprehensive wastewater system management programs and has been encouraging states to re-evaluate their CWSRF programs to ensure decentralized needs are adequately determined and sufficiently funded. WE&RF has prepared several comprehensive case studies focused on a variety of decentralized systems, including onsite reuse systems driven primarily by the green building and sustainable design movements.

Are There Development Incentives?

Properly researching incentives and funding opportunities in your region can substantially inform you and your clients' decisions during the vetting process. Some development incentives offered in the marketplace include:

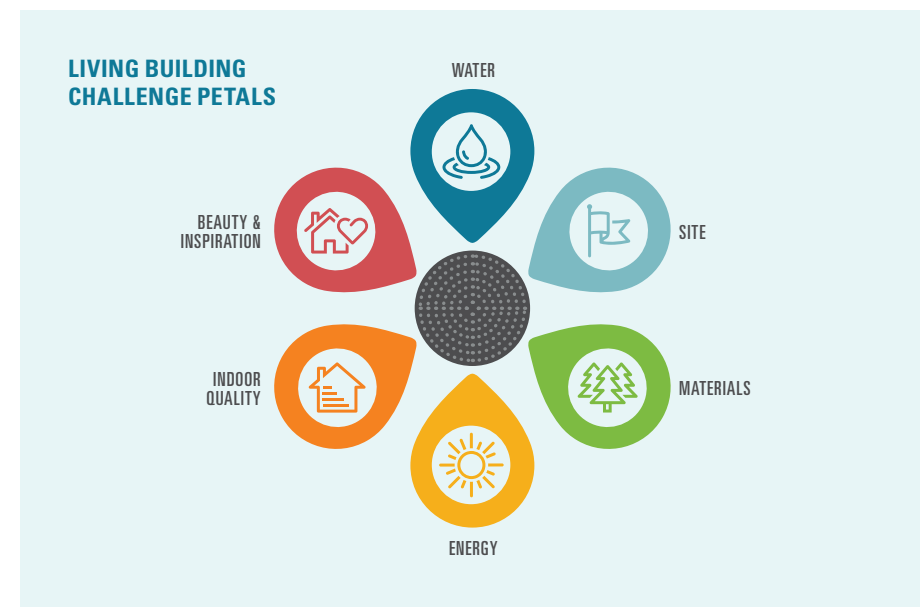
- Chicago's Green Permit Program expedites permit reviews for projects that meet certain LEED criteria.
- Portland's Floor Area Ratio (FAR) bonus increases a building's allowable area in exchange for adding an ecoroof/greenroof, which has resulted in over \$225 million in additional private development, with more than 120 ecoroofs in the center city district.
- New Jersey adopted business tax credits and sales tax refunds as incentives to support reuse in industrial processes.
- The City of Seattle launched The Living Building Pilot Program in 2011 to encourage innovative green buildings.
- Cincinnati offers financial grants and low-interest loans for innovative projects.
- The City and County of San Francisco offers capacity charge adjustments for new buildings installing onsite non-potable water systems to ensure projects are only charged for the demand placed on the municipal water and sewer systems. San Francisco also

offers grants for onsite non-potable water projects that meet eligibility criteria.

- The City of Santa Monica waives building permit fees for projects and properties that include reuse systems.
- New York City charges discounted service rates for projects and properties that include reuse systems.

Are Water-Related Sustainability Credits Desired or Needed?

Rewarding developers or homeowners who practice green building techniques spurs innovation and demand for green building technologies. Green building certifications can be a significant incentive. Consider both the type of certification and the number of credits possible through LEED, the Sustainable Sites Initiative, or the Living Building Challenge.

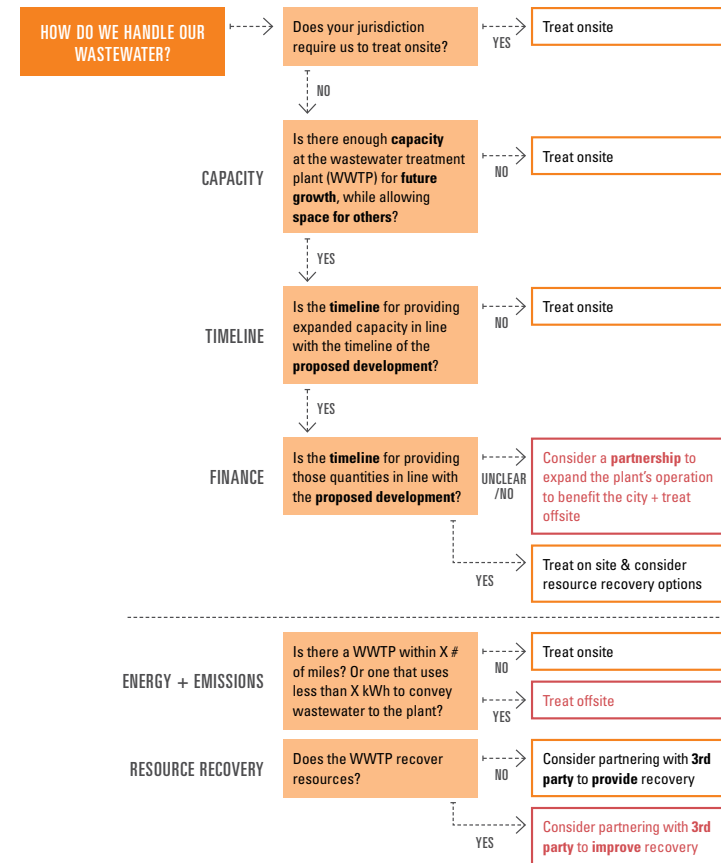
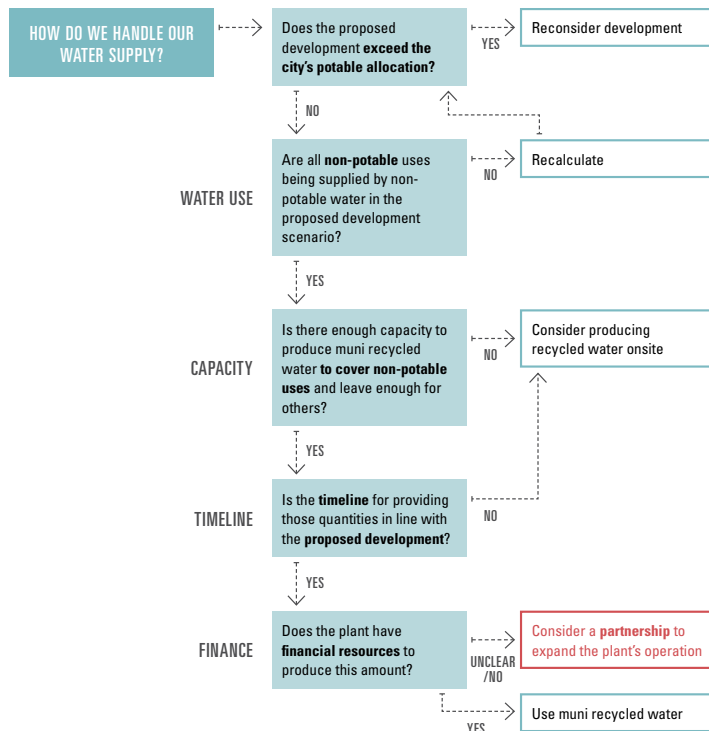


2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)

Is There an Interest in Making the Project Resilient?

Water reuse systems reduce reliance on municipal water systems and thereby improve the resiliency of the project; i.e., the ability to adapt successfully or restore performance rapidly in the face of treatment failures and threats. Asking questions like “How do we handle our water supply?” and “How do we handle our wastewater?” prompts a discussion of topics like water use, capacity, timelines, financing, partnerships, energy and emissions consequences, and resource recovery, as demonstrated in the adjacent flowcharts. Each project is unique and the decision tree produced should reflect that.

WATER DRIVER FLOWCHARTS



Is There an Interest in Being a Community Steward?

Non-potable water reuse reduces the amount of potable water a project consumes, which allows another user access to that portion of high-quality drinking water. It also frees up capacity at the local wastewater treatment plant, thereby reducing the occurrence of combined sewer overflows. A project may produce more recycled water than it uses,

2. IS NON-POTABLE WATER REUSE RIGHT FOR YOUR PROJECT? (continued)

thus giving rise to an opportunity to create a non-potable water district with the project's neighbors. These are a few of the ways that a project may enable its owner to become a community water steward.

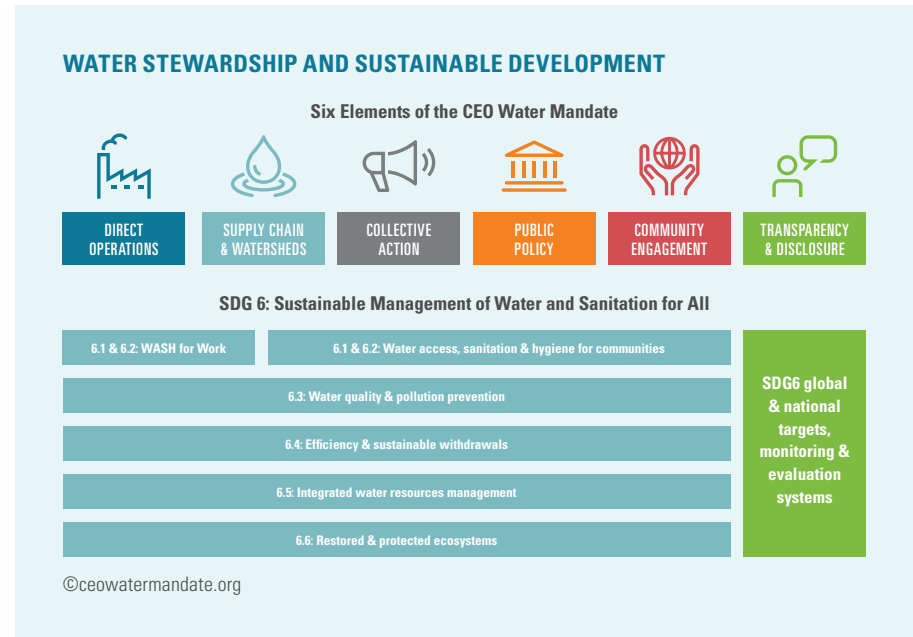
Water stewardship can be good not only for the community, but also for the owner. As the CEO of Water Mandate puts it, "Water stewardship empowers businesses to identify and manage the many water risks threatening their growth and viability. It also enables them to seize the ever-growing list of water opportunities available to their companies. Ultimately stewardship helps companies make invaluable contributions to solving the world's water crises, achieving the [United Nations'] Sustainable Development Goals, and supporting human rights."

By implementing water sustainability practices, companies can:

- Reduce costs—stewardship pays for itself through efficient practices.
- Protect themselves from operational disruptions due to insufficient water supplies.
- Maintain and strengthen their license to operate.
- Gain a competitive advantage and boost brand value.
- Assure investors that the business is viable for the long term.
- Drive improved productivity and talent recruitment.

Are the Risks Worth It?

When you propose water reuse solutions for a project, the client, public agencies, planning commissions, community members, and other stakeholders will want assurance that you have comprehensively considered the risks involved. Community stakeholders will look for assurance on public health, while the client will want to understand not only the health risks, but also the economic, permitting, and operational risks. They may cite such risks without articulating the source of their fear.



PARTING THOUGHTS

In order to determine whether non-potable reuse is right for your project, you need to understand whether it is allowed, if it makes economic sense now or in the future, or if there are other compelling reasons to undertake it. Given that reuse is not currently the norm, it is imperative to do your homework before engaging in a reuse conversation with the client. Of course, if the client wants to include onsite water reuse from the beginning, by all means, go with it, assuming it's feasible for your project.

CHAPTER 3

FIT FOR PURPOSE - THE RIGHT WATER FOR THE RIGHT JOB

CHAPTER LEARNING OBJECTIVES

- Identify types of water sources available in your project (water inputs).
- Match potential water sources (inputs) to the appropriate end-uses (outputs) in your project.
- Learn calculations to match supply with non-potable demands.

3. FIT FOR PURPOSE – THE RIGHT WATER FOR THE RIGHT JOB

KEY DEFINITIONS

Potable: drinking water

Non-Potable: water source not appropriate for drinking

Blackwater: wastewater from kitchen and utility sinks, urinals, and toilets

Graywater: wastewater including all sources except kitchen and sewage

Wastewater: umbrella term for blackwater + graywater

Foundation Drainage Water: groundwater that intercepts a foundation

Stormwater: surface water from rainfall events

Rainwater: water collected from rooftop runoff only

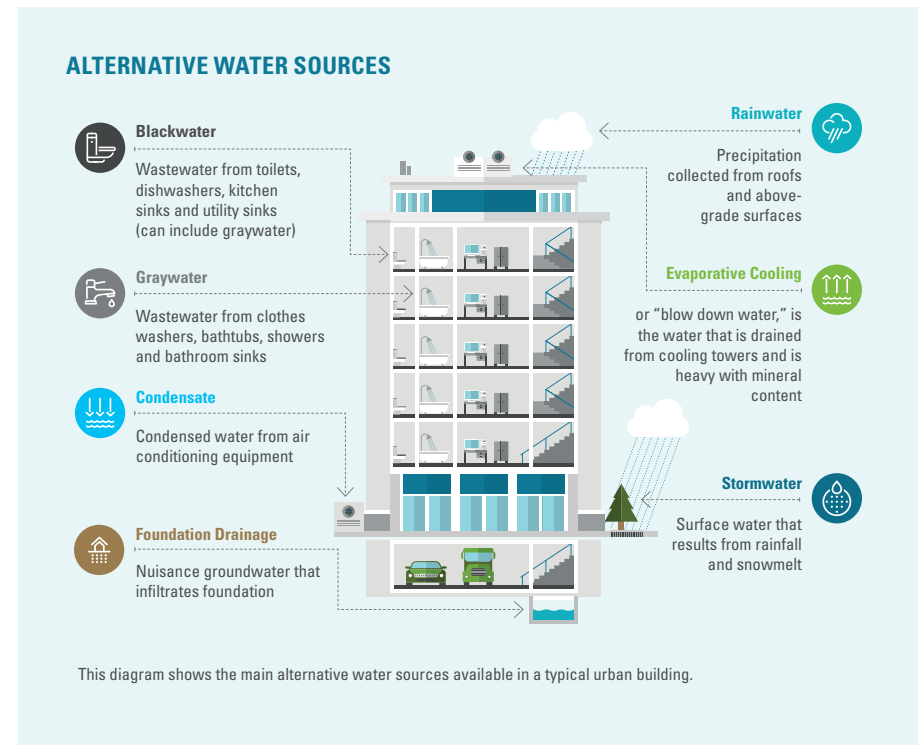
Condensate: condensed water from air conditioning equipment and cooling towers

Recycled Water / Reclaimed Water / Purple Pipe: treated wastewater for reuse (non-potable; in CA governed by Title 22)

As the hydrologic cycle illustration in Chapter 1 suggests, not all water is created equal, in terms of quality and availability. Just as water quality varies throughout natural systems, so too does it vary in the built and designed environment. Generally speaking, water in the fountain in front of city hall is cleaner than it was before it entered the municipal water treatment system. Similarly, water is not always easily or cheaply available when and where it's wanted. For instance, fresh water is more readily available in Chicago, on the shore of Lake Michigan, than in arid Las Vegas. Understanding the quality and availability of water is key to developing a strategy for integrating an onsite water reuse system in the design process.

What Alternate Water Sources Are Available for Use in a Building?

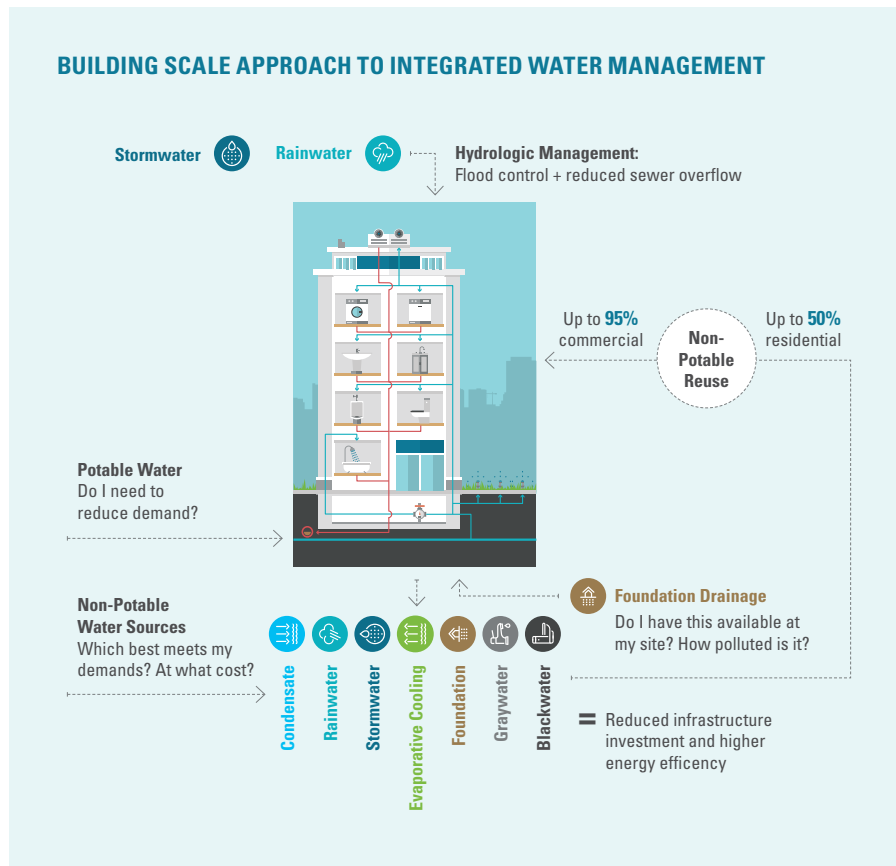
Water generally enters a conventional building via a few different means: as fresh, potable water arriving from a municipal source or well; as rainwater or stormwater; or as foundation drainage. Once on site, water can be consumed or used for various building system functions. Rainwater, stormwater, foundation drainage, and reused water are alternatives to the municipal water supply.



3. FIT FOR PURPOSE – THE RIGHT WATER FOR THE RIGHT JOB (continued)

Integrated Water Management

It is important to take some time to analyze how water impacts your project, taking into account all needs, risks, and opportunities present. The first step in designing for water reuse includes assessing all sources and demands in an integrated approach that supports your region’s water management goals. This will ensure that you use the **right water for the right job**.



How Do I Match Water Source to End-use?

Once you have identified the different non-potable uses of water in your project, you can then consider where this water will come from. To do this, you will need to understand what the water demands are in the building, as well as what water quality is necessary—to protect public health, code compliance, and to promote cost-effectiveness and energy efficiency. Remember, 50% of water in multi-residential units and up to 95% of water in commercial buildings can be safely supplied through non-potable water supplies. Allowable end-uses will vary by jurisdiction, and may include toilet flushing, landscape irrigation, cooling towers, water for clothes washing, and other demands.

The quality of a particular water source coupled with its end-use will determine what level of treatment is necessary, as detailed in Chapter 7. In some jurisdictions, such as California, sources such as rainwater and graywater can be used for subsurface irrigation without required treatment. Treatment may still be necessary for technical and operational reasons, such as clogging of irrigation nozzles. It is critical to confer with consultants versed in more specialized uses, such as plumbing engineers to determine water quality requirements for such end uses as cooling towers and agronomists for irrigation.

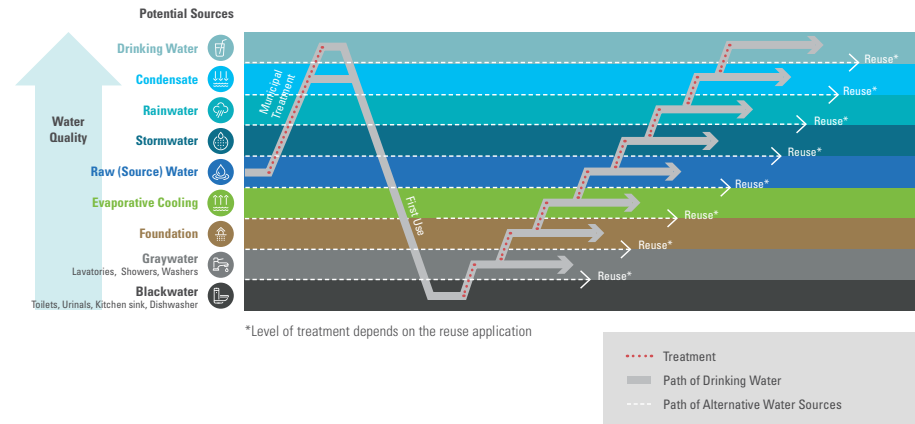
3. FIT FOR PURPOSE – THE RIGHT WATER FOR THE RIGHT JOB (continued)



How do I Conduct a Water Balance?

Among the more critical elements of the analysis of your project water impacts is the water balance. The water balance, sometimes called a water budget, should account for the volume of water you anticipate each potential source to supply in your building, so that you can plan the appropriate reuse or recycling strategy. The figure at the end of this chapter presents a simplified project modeled after the San Francisco Public Utilities Commission’s Non-potable Water Program and its water budget spreadsheets, which are available online.

ATTRIBUTING YOUR WATER SOURCES CORRECTLY



Steps to a Water Balance

1. Assess your area’s water inputs and outputs, in terms of volume of water, the costs of water supply rates, sewerage rates, and associated taxes and related fees.
 - Consider local and regional potable water supply, its associated fees, and whether there is water scarcity in the area. Do the current and estimated future fees reflect anticipated constraints due to climate change and population growth?
 - Is there need for flood control due to stormwater/sewer overflow episodes?
 - Does the local jurisdiction permit alternate water source recycling and reuse?

3. FIT FOR PURPOSE – THE RIGHT WATER FOR THE RIGHT JOB (continued)

2. Consider onsite sources of water. Typical examples include:

Rainwater

- Annual rainfall data from National Weather Service or the US Geological Survey (see note).

Stormwater

- Runoff calculator (e.g. EPA National Stormwater Calculator).

Blackwater/Graywater

- Modeled data in water balance calculator or metered data from building.
- LEED fixture estimates (from USGBC tools).


Nuisance Water (Foundation Drainage)


Condensate from air conditioning equipment

- Consult with MEP for volume and quality

3. Collect information on building program and occupancy to determine demands.

4. Consider demands that can be met with non-potable water. Typical examples include:

 **Toilet flushing:** Use low flow fixtures for unit demand assumptions to calculate gallons used per person per day (e.g. LEED estimates).

 **Irrigation:** Estimate irrigation demand based on landscape need (e.g. California Department of Water Resources online calculator).








 **Cooling tower makeup:** consult with MEP.

NOTE ON RAINWATER/STORMWATER AS A WATER SOURCE:

Due to changing precipitation patterns and more frequent, prolonged drought, it may not be advisable to depend solely on rainwater/stormwater for non-potable reuse in dry and drought prone areas. Non-potable demands in most buildings/sites are constant; precipitation is not. Sources other than rainwater or stormwater should be considered for seasonally dry or unpredictable climates. Regardless of the climate, having a backup water supply, such as a municipal utility tie-in, is a must.

3. FIT FOR PURPOSE – THE RIGHT WATER FOR THE RIGHT JOB (continued)

SUPPLY MEETS DEMAND: THE WATER BALANCE

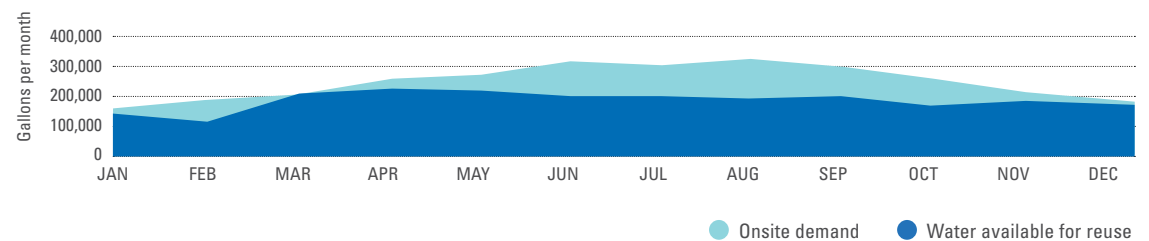
Alternate Water Sources Estimates		
Onsite Alternate Water Source Supplies	Water Quantity (gpy)	Notes
 Condensate	1,500,000	
 Rainwater	140,000	
 Stormwater	50,000	
 Evaporative Cooling	250,000	
 Foundation Drainage	0	No Foundation Drainage supply available
 Graywater	144,000	
 Blackwater	1,488,000	Blackwater is not allowed to be reused here; so it's not part of the water balance
Total:	3,572,000	w/o blackwater: 2,084,000

Non-Potable Applications Estimates		
Onsite Non-potable Application Demands	Water Quantity (gpy)	Notes
Toilets/Urinals	1,278,000	
Irrigation	550,000	
Decorative Fountains	225,000	
Cooling Tower	750,000	
Other	3,750	
Total:	2,806,750	

Make-up Water Requirements	
Month	Make-up Water Required (gal)
January	18,000
February	75,000
March	0
April	27,250
May	45,500
June	105,000
July	95,000
August	125,000
September	85,000
October	75,000
November	28,000
December	18,000
Total	696,750

These tables and graph represent the summary water balance calculations for a hypothetical 30-story commercial building in a semi-arid climate zone, 455,000sf of gross area (19,000sf of roof area) and 252 days/year of operation.

Make-up water demand is often high, meaning that onsite water demand exceeds the supply available for reuse; therefore, the building would have to continue to rely on utility supply, or go for a sewer mining strategy. (Format based on [SF Water's Single-building Water Use Calculator](#))



CHAPTER 4

HOW TO TALK ABOUT WATER REUSE

CHAPTER LEARNING OBJECTIVES

- ◆ Address the “Yuck” Factor.
- ◆ Understand who project stakeholders might be and what motivations drive their decisions.
- ◆ Learn how the regulatory environment will affect your water reuse project.
- ◆ Determine who you need to speak to, when, and about what.

4. HOW TO TALK ABOUT WATER REUSE

Introduction: What Conversations Should You Have?

Once you have concluded that water reuse has a place in your project, you will need to make some decisions about the nature of your water reuse system that will be formed through conversations with project stakeholders. As you embark on the onsite water reuse journey, there are several initial considerations:

- A clear understanding of project goals.
- Regulations that govern the system.
- How you will get from concept to design.
- What the impact will be on the community-scale water supply and wastewater systems.

This chapter will guide you through the conversations with stakeholders that drive project development decisions.

FROM YUCK TO YAY

As you read through this document and begin to navigate the world of onsite water reuse, you may still have reservations about the very concept. It's not difficult to imagine that other stakeholders may be even more reluctant to embrace onsite reuse, due in part to the Yuck Factor—the sense that there is inherently something unpleasant and unsanitary about reusing water from any source for any application.

Many people do not have direct conscious experience with water reuse and will understandably feel some level of discomfort with the idea of reusing wastewater. To build a mindset of acceptance, it is important to remind stakeholders that it is the quality of the water and the end use that determine its fitness. Explain that water does not change its chemical nature when we put our waste into it, so it can be filtered to remove all the substances that it has conveyed and can be purified to the extent appropriate for its next use.

Treating water onsite for non-potable reuse is accomplished by adapting existing processes that have kept our water safe for human use for a long time and supplementing them with innovative technologies. In many ways, onsite systems are comparable to other wastewater treatment technologies in municipal systems that are then scaled down to new technologies that can efficiently treat smaller amounts of water at the building scale. Today, the technology for eliminating undesirable substances from water is so advanced that there is really no question that it can be done effectively.







Also, highlighting the benefits of recycled water and the problems of demand that alternative water sources can address can soften opposition and lead to a more positive reception.

Understanding Project Stakeholders

Water reuse project stakeholders are the various individuals and entities who determine whether onsite non-potable water reuse is feasible for your project, what the potential treatment processes are, and what you will do with the products of your treatment system. There are two types of stakeholders with whom you will have important conversations: internal and external. Internal stakeholders are those who have a direct interest in the project itself, while external stakeholders are those who have an interest in the larger community. All stakeholders will realize risks and rewards from your project, so your objective for communicating with them is to understand their concerns and take those into account in your design.

Internal stakeholders include owner or developer, design team, builder, end user, and facility manager. External stakeholders can include regulators, water and sewer utilities, and financial institutions.

4. HOW TO TALK ABOUT WATER REUSE (continued)

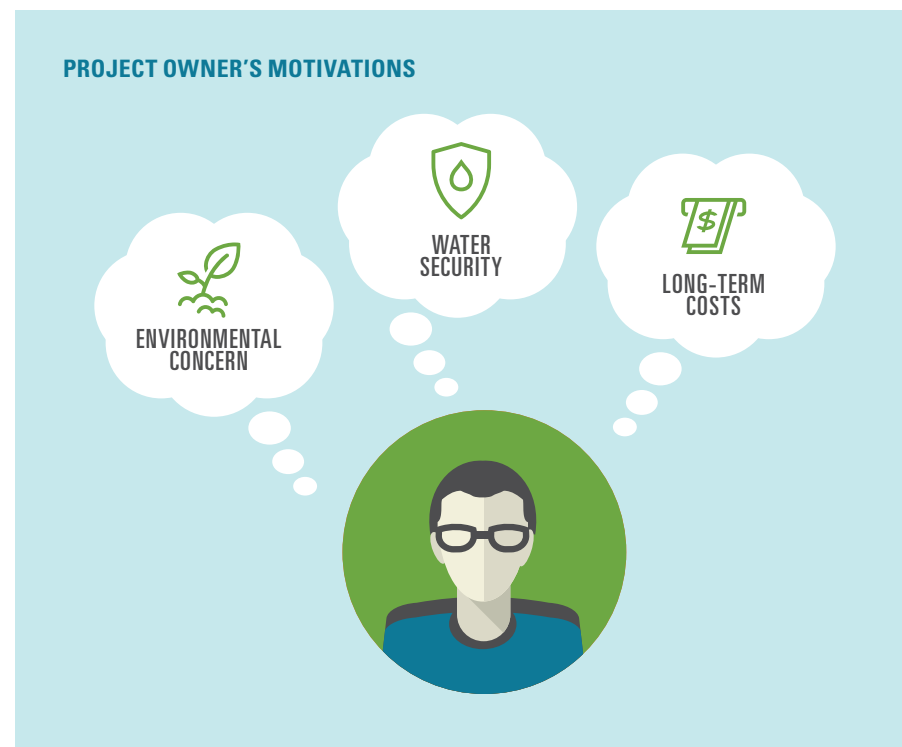
Internal Stakeholders		
	Developer/Owner	<ul style="list-style-type: none"> • Cost efficiency • Regulatory compliance • Brand enhancement
	Design Team/Builder	<ul style="list-style-type: none"> • Positive industry reputation • New expertise
	Occupants	<ul style="list-style-type: none"> • Ease of use • Control over rate increases
	Facility Manager	<ul style="list-style-type: none"> • Seamless, cost effective, reliable operations
External Stakeholders		
	Regulators	<ul style="list-style-type: none"> • Protect public health and water quality • Conserve scarce resource • Enforce code compliance
	Utilities	<ul style="list-style-type: none"> • Guarantee water supply • Maintain revenue
	Financial Institutions	<ul style="list-style-type: none"> • Avoid risk • Maintain long-term value of investment

Conversations with the Owner

An initial look at the potential to reuse water at your project site should be a discussion with the owner and design team early in the design process to understand the goals for the project.

There are a variety of reasons for including water reuse in a construction project. Some reasons may overlap, and a comprehensive solution can meet multiple objectives, while other reasons may require a separate or

unique approach. The project's owner will be most satisfied if the scope of the solution fits the desired initiative and motivation. The following are typical goals and approaches held by project owners to help target suitable solutions.



4. HOW TO TALK ABOUT WATER REUSE (continued)

HIGHLIGHT OPPORTUNITY FOR BRAND ENHANCEMENT

- **Provide a public perception of environmental responsibility.** This type of owner will want to make a visible public statement about environmental concern, but cost will be the bottom line. The most simple, efficient, and cost effective solution will probably be the most tolerable.
- **Provide solutions that are authentically environmentally responsible.** An owner with this goal will seek a long-term solution that provides the most benefit, to both the project stakeholders and the environment, to the fullest extent of financial and physical feasibility. Cost may not be an obstacle.

ADDRESS REGULATORY COMPLIANCE AND CONCERN FOR SUFFICIENT WATER QUALITY AND QUANTITY

- **Regulatory responsibility.** At times, an owner's concern may be based simply on achieving compliance with local water conservation or reuse regulations.
- **Create long-term water resource security.** This goal will seek to improve adequacy and flexibility of long-term supply that accounts for periods of prolonged drought or contaminated water supplies. Treating and reusing water onsite for non-potable applications can provide a secure water source for the project. Incorporating additional storage and access to backup water supplies in case of system failures further ensures a secure water source.
- **Ensure a resilient and adaptable design.** Solutions to meet this goal will achieve a system that maximizes self-sufficiency and operational viability with onsite resiliency during periods when public supply is unavailable. Infrastructure that provides for a self-sufficient water supply on site could be costlier and require more space.

The proposed design should also have the ability to adapt to permanent change, including climate change and sea level rise.

CONCERN FOR COST-EFFICIENCY: UPFRONT COSTS AND LONG-TERM COSTS

- **Provide a financial advantage over rising water/sewer costs.** Long-term cost savings will be the main focus of this solution. Projecting likely rate increases over time and understanding the time frame for return on investment are key metrics.



KEY TALKING POINTS WITH BUILDING OWNERS

- Non-potable onsite reuse is safe and feasible in your building.
- It can reduce long-term water/sewer costs for your building.
- It contributes to water and energy savings in a community.
- It promotes environmental responsibility and sustainability.
- It enhances your company's or building's brand as a leader.



Conversations with the Design Team

As with any successfully executed project, the first conversations with the design team require matching the client's goals with potential solutions. Once a rough idea of the desirable type of system is established, a review of case studies and visits to operating projects with similar systems can answer many questions that the design team may have. Chapters Six and Eight include case studies of a variety of successful projects.

4. HOW TO TALK ABOUT WATER REUSE (continued)

Your design team may not have familiarity with water reuse projects, in which case it will be critical to include a specialist. There are pitfalls in the planning, permitting, and implementation of water reuse systems, because it is an emerging industry, and professional experience with navigating those challenges is critical and worth the cost of an additional expert. Early in the design process, it may be especially beneficial to bring on a professional engineer with expertise in water treatment system design.

Once the project goals are understood, you have a rough understanding of the source and quantity of your wastewater supply and non-potable water demand, and the system type is established, it will be important to conduct feasibility studies and water use calculations to validate early assumptions about reuse potential for your project. The feasibility process should include discussions with installation contractors to further validate assumptions. At this point, a rough order of magnitude cost analysis should be conducted to affirm the project owner's continuing commitment to water reuse.

KEY TALKING POINTS WITH DESIGN TEAMS

- Non-potable onsite reuse is safe and feasible.
- Existing alternative water sources can be utilized onsite.
- Done correctly, it can be a cost-effective option.
- Potential LEED and other certification credits and community amenities—such as additional green space (if a natural treatment system is selected for the onsite treatment), a sustainable branding for the building, etc.—make this an attractive option for your clients.
- Experts can help navigate the permitting and operations processes.



Conversations with the Facility Managers

The facility manager should ensure that the operations staff or service contractors have the necessary breadth of capabilities. This includes preventive maintenance and repair, as well as system optimization. The responsible party must have the ability to analyze performance and adjust the controls and equipment in order to maintain optimal water quality and quantity produced over time. Your conversations with facilities managers should instill the idea that most water reuse treatment systems require specific expertise, which the vendors can confirm, and continual and ongoing monitoring and maintenance, which is also usually required for permitting the system. (See Chapters 6 and 7 for more information on parties responsible for managing these systems, also known as Responsible Management Entities or RMEs).



KEY TALKING POINTS WITH FACILITY MANAGERS

- Non-potable onsite reuse is safe and feasible for this building.
- All water reuse systems require ongoing monitoring and maintenance.



Conversations with Regulators

The first step in speaking with regulators is to understand who you will be dealing with. Identify the regulators for non-potable water in your jurisdiction and their roles and concerns.

At the state level, these will be agencies that regulate and/or permit water resources and water quality. In California, for example, it is the Regional Water Quality Control Board. The roles of such agencies are to

4. HOW TO TALK ABOUT WATER REUSE (continued)

set policies and requirements applicable throughout the state, and they may be the lead permitting agencies in your state. You will also work with the public or environmental health department and the wastewater treatment agency, which are addressed in the next section. These organizations provide requirements for processes and output. The agency and particular set of ordinances governing your project may depend on the size and complexity of the project.

At the local level, the regulators in question will likely be the agencies that deal with wastewater treatment/sewerage, planning, zoning, and building/plumbing permitting. Planning agencies for new development may impose water allocations on sizable projects. The building department, which may use the currently adopted Uniform Plumbing Code (UPC), will ensure that code requirements are met. The local environmental health department may be the lead agency that oversees certain types of reuse.

The most effective approach to a smooth regulatory and permitting process is to develop a collaborative relationship with the regulators and a clear understanding of their expectations and concerns. Costly delays caused by the permitting process can be avoided by following two key protocols: engage in early and continuous communication, and insure that all permitting agencies are included in your discussions.

In addition, emerging performance-based standards are in the process of being formalized and adopted. These standards seek to provide a nationally adopted framework for addressing water quality and health considerations that go beyond current references related to the treatment system (see Additional Resources in Chapter 8 for more information on these topics). It is important to understand the status of the adoption and implementation of these standards in the context of the objectives, specifications, and schedule for the project.

A few other key tips:

- Understand that the person you will be talking with at the permit desk is not going to be the highest level of authority.
- Learn the organizational structure of the agencies you are dealing with, so you can know how the decision-making flows.
- Understand how the various permitting agencies interact with each other.
- Know that regulators around the country are working to develop water quality guidelines and permitting procedures for onsite non-potable water systems. They have to work within a locality's or state's existing regulations until (and if) specific national regulations for these systems are developed.

Within the context of wastewater reuse regulation, it is important to develop trust with regulators and provide the appropriate level of detail and transparency throughout the project. This does not mean that you provide every detail; rather, understanding regulators' concerns will reveal what information is needed for appropriate collaboration. Do the design and submittals address their concerns? Does the design meet established codes? Are the submittals in the form and at the level of clarity that they want and expect? Do your treatment process and monitoring strategy adequately protect public health?

Be sensitive to the regulators' burden—the regulatory world is slow to react because of its responsibility and liability for public health and safety. Nevertheless, because of the growing awareness of issues with resource availability, regulators are beginning to realize and accommodate the fact that liability needs to be balanced with resource scarcity and increased demand.

4. HOW TO TALK ABOUT WATER REUSE (continued)



KEY TALKING POINTS WITH REGULATORS

- Non-potable onsite reuse is safe and feasible in this project. The reused water will not be used for drinking and will minimize public health risks.
- The project is using treatment technologies that are proven effective.
- The building will remain connected to centralized water/wastewater systems to continue providing drinking water and to serve as a backup in the unlikely event of system failure.
- The design meets all codes and regulations.
- The system will be regularly monitored and maintained.
- Appropriate signage and public education and outreach are integrated into the project.



Conversations with Utilities

All projects will deal with local utilities. These are the water retailers and sewerage and wastewater treatment agencies, which may or may not be the same entity. Water purveyors may be municipally owned or private, for-profit companies. Depending on the scale of your project, it could have a significant impact on the potable water delivery system or discharge into the wastewater system. In particular, the discharge to the sewer system, if any, will be different in character, and may be reclassified as industrial waste. This reclassification will mean that there could be a lower sewer cost and that the permitting will be different.

Additionally, water and wastewater providers may be concerned about revenue loss, regardless of the region you are in. Utilities' number one

goal is to provide reliable water and sanitation services while protecting public health. This comes at a very high cost. Though water/sewerage rates are high in some areas, they are a fraction of the true cost of extracting, treating, and delivering clean water and removing, treating, and discharging wastewater. Costs for utility providers have risen drastically over time, yet they are required to provide increasing levels of service to customers. They have to do more with fewer resources. Understand that this is where the concern over lost revenue is coming from. This is especially true in drought prone areas, where many utilities have developed robust programs to promote water conservation, a necessary endeavor, but have suffered financially because of it.

As mentioned in Chapter 1, onsite systems can help alleviate stress on existing, overburdened infrastructure. By diverting flows, capacity can be increased, the lifespan of existing pump stations and treatment

4. HOW TO TALK ABOUT WATER REUSE (continued)

facilities can be extended, and maintenance and energy costs can be reduced. When considering an onsite solution, it is important to approach conversations with utilities from a perspective that cost savings for operations, infrastructure, and bonds are often greater than the lost revenue. Some utilities have even introduced incentive programs for buildings to incorporate onsite reuse, such as the San Francisco Public Utilities Commission.

An additional consideration is whether the local utility or regional water authority is pursuing its own utility-scale reuse strategy. Such strategies are modeled and funded based on current revenue projections, which in turn are based on use, population growth, rate increases, etc. It is plausible that the sponsoring utility or agency may view an onsite reuse system as affecting their underwriting model. Accordingly, what is best for the owner's project may not be viewed as best for the regional plan. It is important to highlight that onsite non-potable water systems may contribute to broader local and regional strategies to enhance water reuse and generate significant water sources that will serve the community well; however, individual onsite water treatment and reuse systems in and of themselves do not necessarily address capacity and facility issues, maintenance, and pump station needs. In these environments, it will be important to focus conversations on resiliency and existing infrastructure stress, so that the project onsite reuse system is viewed favorably as augmenting the regional strategy.

Once all the other stakeholders have bought into the project, and initial conversations with the regulators have taken place, it will be time to initiate conversations with the utility. The conversation with the wastewater utility will identify the nature of discharges to the sewer with regard to acceptable flow volume and composition of effluent. In order for the utility to identify what permitting you will need, your project team will provide data to evaluate methods to eliminate the potential for sediment buildup and odors.



KEY TALKING POINTS WITH UTILITIES

- You have an interest in working with utilities, not against them.
- Non-potable onsite reuse can supplement local and regional efforts to build water security and promote environmental sustainability.
- It can reduce treatment costs by reducing unnecessary potable water consumption.
- It can delay or mitigate the need for expensive infrastructure expansion.
- It reduces energy consumption and system overflows.
- A blend of decentralized and centralized treatment boosts system reliability and resiliency.
- You understand that the building will still require connections to water and wastewater systems, regardless of the level of onsite non-potable water reuse.



Conversations with Water Reuse Equipment Manufacturers and Vendors

Water reuse system vendors and manufacturers want to sell you their products. Initially, a reputable vendor will likely ask you a series of questions to better understand your particular water reuse needs and expectations. Chapter 7 describes the various types of reuse systems, but it is incumbent upon you to have a clear sense of how you intend to integrate water reuse into your project. Much of this understanding will stem from conducting a water budget and working with the appropriate regulatory authorities, who should be able to describe the parameters of what is legally acceptable in your project's jurisdiction.

As you design your spaces and specify the products that may come into contact with recycled water, it is a good idea to discuss your intentions

4. HOW TO TALK ABOUT WATER REUSE (continued)

with manufacturers and vendors. Fixtures subjected to recycled water use need to be selected according to their expressed warranties of suitability for the purpose for which they will be used, i.e., the end-use. Water supply quality can limit a product manufacturer's warranty.

It is important to work with the manufacturer or vendor to ensure the right system is selected to protect users from these and other water quality concerns and with the attention to aesthetics desired by the building owner and residents. Refer to the Water Reuse Design Considerations section of Chapter 7 for further details.



Conversations with Builders

The builder must understand that they will not be allowed to value engineer the project in any way that will compromise the system's ability to perform properly. The builder must work closely with the engineer of record to ensure that the integrity of the system is maintained throughout any changes during bidding and construction.

Builders also must understand the disclosure and insurance implications of the onsite reuse system; special skill sets needed from their trade partners; and the need for timely scheduling of system rough-in and installation of large system components.



Conversations with Occupants

Educating the occupants about the water reuse system is an important element of a sound risk management program. This could include signage about the benefits of water reuse and savings, as well as assurance that their wellness is not compromised, because all the recycled water uses are non-potable, such as irrigation and flushing.



KEY TALKING POINTS WITH OCCUPANTS

- Non-potable onsite reuse is safe. All water is already recycled water.
- Effective treatment technologies ensure water is of a sufficient quality to use for non-drinking purposes.
- Regular monitoring and maintenance are conducted.
- Reuse saves energy, water, and costs—contributing to building and community sustainability.

CHAPTER 5

HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS?

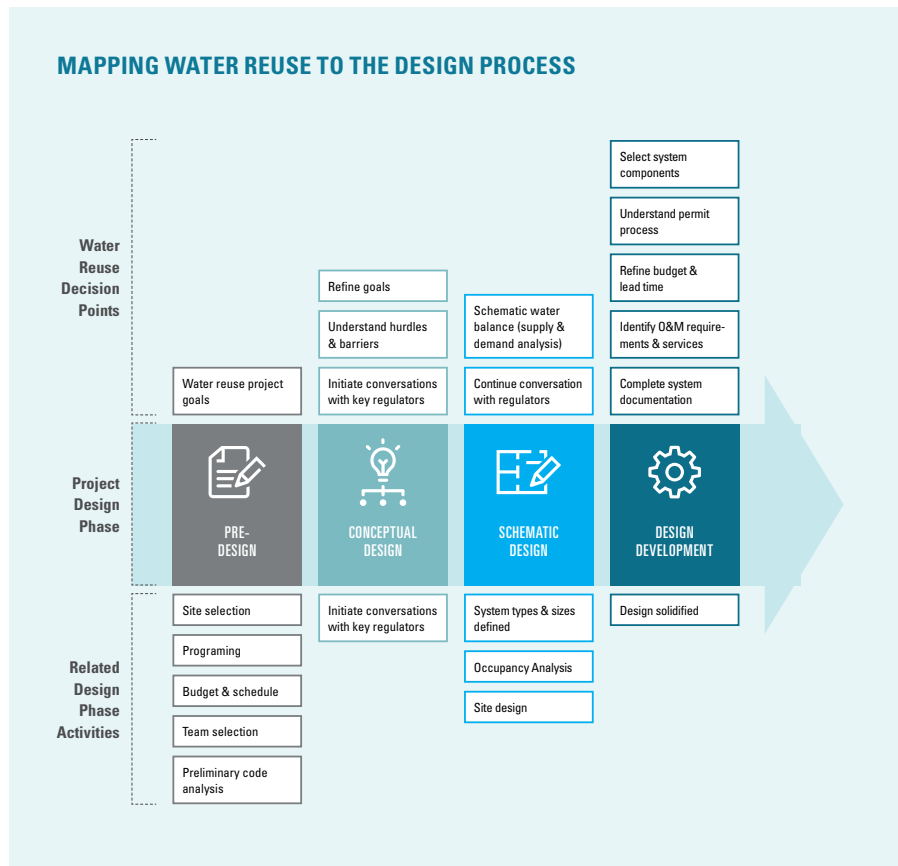
CHAPTER LEARNING OBJECTIVES

- ◆ Understand steps to integrating onsite reuse into the design process.
- ◆ Know what decisions to make and when.
- ◆ Utilize appropriate expertise at the appropriate time.
- ◆ Identify how and when other professionals should be engaged.

5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS?

Introduction: Mapping Water Reuse to the Design Process

This chapter identifies the factors that affect how a water reuse element is integrated into the design process once the decision is made to include it in the project (see Chapter 2). Specific actions for the successful integration of water reuse systems into a project begin at the earliest stage of the design process.



For the best outcome, onsite water reuse must be integrated into the project design from the outset of the process. Successful integration of non-potable reuse requires a similar approach to other essential building systems and can impact architecture, landscape, civil, MEP, and structural processes. Opportunities may arise during the design process that may not be available as an afterthought, potentially precluding preferred solutions. The diagram on the following page illustrates the steps and stakeholders in a project based on an integrated project delivery process—IPD—versus a more traditional design process. Onsite water reuse projects are the poster children for IPD.

Think of it as a series of decisions, as in structural engineering or energy analyses, in which iteration and feedback may affect adjacent design decisions such as fixture selection, cooling system approach, and landscape design. Engaging water reuse stakeholders from the outset, in such things as task and permit scheduling, project milestones, team communications, feedback, and coordination meetings, will avoid rework, save time and money, and ensure onsite water systems are optimized to meet project goals and targets.

Non-potable reuse requires space that may be difficult to identify if it is not integrated into the design process from the outset. Allocating space for treatment equipment, tanks, and piping is manageable and can be more cost effective if well-coordinated early on. If addressed late in the project, numerous iterations may require changes by the architect and consultants to modify plans and respond to unintended consequences. Common examples include late-design impact to structural requirements caused by the heavy weight of water tanks, impacts to landscape and street design, or unanticipated pipes and pumps where space is not available.

5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

Even if you have a preliminary cost analysis to guide the decision to include or reject non-potable reuse, you will want to update estimates of probable cost (capital expense and operating expense) as you refine and complete the water reuse systems design. Consulting with those who have expertise in non-potable water reuse systems is essential to the development of accurate technical guidance, creative, efficient solutions, and controlled costs. In addition to coordination with engineers on your design team, you might also employ specialized water reuse professionals. Oversimplified or prescriptive water reuse solutions often result in high first cost and operating expenses due to poor or late analysis of engineering values.

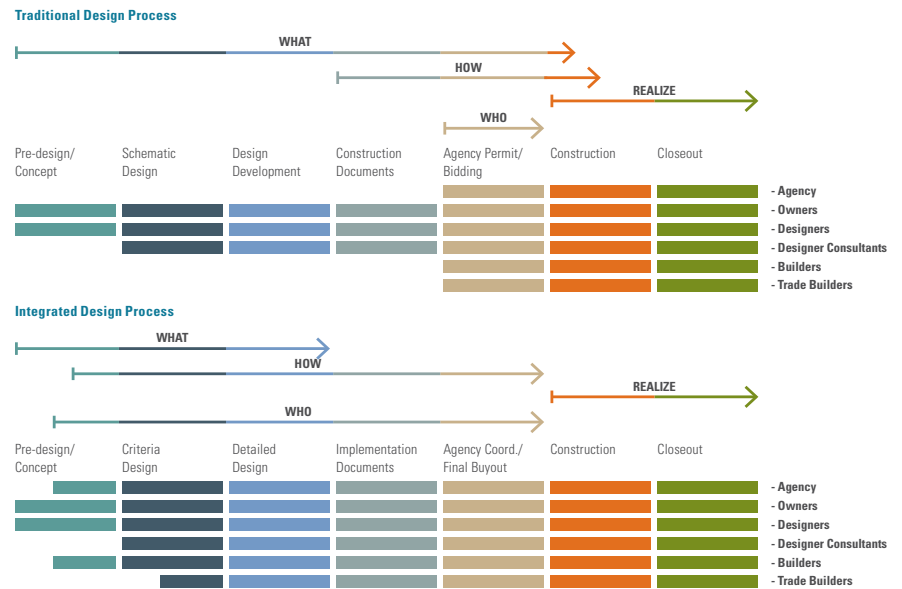
IPD—The Definition:

Integrated Project Delivery (IPD) integrates people, systems, business structures, and practices to collaboratively harness the talents and insights of all participants in order to reduce waste and optimize efficiency through all phases of design, fabrication, and construction. The Integrated Project Delivery method contains, at a minimum, the following elements:

- Continuous involvement of owner, key designers, and builders from early design through project completion.
- Business interests aligned through shared risk and reward, including financial gain dependent upon project outcomes.
- Joint project control by owner, key designers, and builders.
- A multi-party agreement or equal interlocking agreements.
- Limited liability among owner, key designers, and builders.

[courtesy of American Institute of Architects California Council: INTEGRATED PROJECT DELIVERY: AN UPDATED WORKING DEFINITION, v3, July, 2014.]

INTEGRATED PROJECT DELIVERY (IPD) ©AIACC



Pre-Design

At this early phase, the design team interprets and develops the goals for integrating water reuse into a project. Adjustment of goals would typically reflect site characteristics, available alternative water sources, programming, calculated demand models, and local code considerations.

Prior to contacting your engineer, you must establish criteria for the type of system and the project complexity. For example, a blackwater/sewer project for an existing residential building would be easier to implement than a graywater system, because the graywater system would require running purple pipe throughout the building.

5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

KEY CONSIDERATIONS

Type of project. The project type—residential, commercial, industrial—enables you to evaluate such variables as peak flows (by day of the week or time of day) and the likelihood of chemicals or other wastes in the flow.

Existing or new construction. Existing construction requires you to work with what is already there, whereas new construction may enable you to influence design. For example, you typically cannot supply toilets with onsite water in an existing construction that does not have purple pipe.

Existing data. A water bill will provide basic quantitative data.

Sources of wastewater. It is of course crucial to distinguish the different sources—rainwater, stormwater, graywater, blackwater, cooling tower blowdown, etc.

Site Population. Estimating necessary volume of water for reuse depends upon the number of people who will be reusing the water.

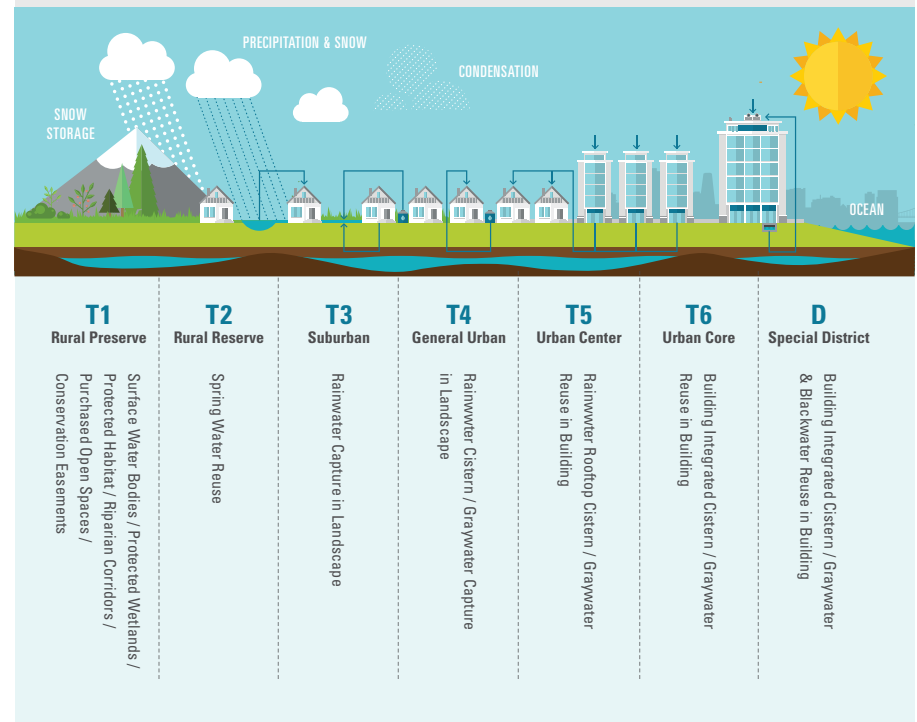
What would you like to do with the recycled water? To estimate the extent of treatment and volume necessary depends upon the intended use of the recycled water.

Will you have a connection to the city sewer? If the project does not have a sewer connection, then the design will need to incorporate considerable risk mitigation in the form of collection volume and emergency storage. In such a case, you would need to size the system to capture and treat peak flows of the source water, whereas a connection to sewer allows you to bypass to it.

Such considerations will help you to estimate the volume and type of wastewater available. In turn, these estimates will help you to determine whether you need to collect and treat the project's entire supply or only capture enough to fulfill the intended reuse application, such as toilet flushing, while allowing any excess to bypass to the sewer. It will also let you know what degree of water quality your treatment will require, a factor that may influence the system design.

THE WATER TRANSECT

The water transect describes how types of water systems mirror the urban transect. Sustainability goals such as walkability and energy reduction increase as the one moves toward the urban center. The difficulty of achieving water conservation goals typically increases, as well, because there is less surface area for rainwater collection, less permeable ground for infiltration, and less room for water treatment systems. Yet the availability of external alternate sources—rainwater, stormwater, and nuisance water—decreases. Urban centers therefore often require more tech-intensive approaches to water goals, while lower tech solutions can be implemented in buildings that have a smaller footprint on the land.



5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

STEPS: INFORMATION GATHERING AND PROJECT ASSESSMENT

1. Gather, organize, and make available to team members all your known information to date:
 - Project type (public vs. private, residential vs. commercial vs. institutional or industrial).
 - New construction, existing building, or building addition.
 - Geographic location with weather data. (In the future, predictive climate modeling may allow for estimation of expected future rainfall, given real-time climate data.)
 - Entitlements and code compliance checklists, including those from any state or local public health departments; green building requirements (for example, Title 24 or CALGreen in California); or special regulatory requirements or alternative compliance methods, making sure to flag any regulatory or code items about which you may still have questions.
 - Water agencies and sewer utilities, their regulations, and their connections (including municipal purple pipe) or district-scale sources available to serve your building site.
 - Location and extent of any building-level purple pipe.
 - Current water use data.
 - Any owner's project requirements (OPR) regarding water use goals, program, or systems performance.
 - Estimated onsite rainfall and stormwater available for catchment.
 - Any incentives, benefits, or potential finance mechanisms.
2. Evaluate the water balance to understand the feasibility and utility of onsite systems.
3. If water reuse is a "Go" for the project, be sure to consider including a qualified water reuse consultant on your design and engineering team, since plumbing engineers may not have specific expertise in water reuse systems.
 - If the project delivery method is design-build or negotiated bid, check to see that the general contractor's team also includes experienced, well-qualified water reuse sub-contractors.
 - Consultants may be found through the National Onsite Wastewater Recycling Association (NOWRA), the California Onsite Water Association, the WasteReuse Alliance for Water Efficiency, and other agencies.
4. Now is a good time to gently suggest to or remind the client or owner to:
 - Engage a third-party building commissioning provider.
 - Develop owner's project requirements, if not yet created.
 - Review timeline, design approach, outcomes/benefits, and budget expectations.

5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

Conceptual Design

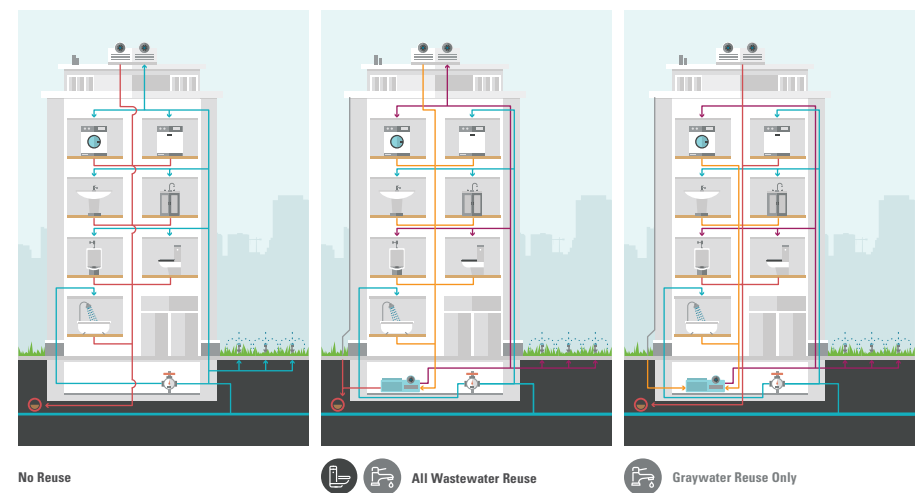
It is wise to do some preliminary conceptual design to test water reuse assumptions and strategies, to refine water reuse goals, and to begin to understand challenges, barriers, and any necessary trade-offs. If there is no formal conceptual design phase, then incorporate these steps at the front end of the schematic design phase. Keep in mind that, in addition to an onsite treatment system, the project will require non-traditional plumbing considerations.

1. Update your water balance, as presented in Chapter 3.
 - There are a number of templates available for this purpose, or you can have your plumbing engineer or other water reuse professional confirm it.
 - Understand the volume of water necessary to meet the projected demands, and make sure appropriate sources meet these demands.
2. Determine level of treatment and/or disinfection required and/or desired.
 - Identify strategies for collecting, filtering, treating, storing, and distributing water for reuse.
 - See Chapter 7 for natural biological strategies, treatment systems, and new technologies. Identify one or more technology approach.
 - Identify rough order of magnitude requirements for space, energy use, cost, regulatory or entitlement/permitting implications, and operations, including regular periodic water quality testing.
 - Plan for various overflow and back-up source scenarios.

Schematic Design

1. Diagram water balance, also called supply and demand (see Chapter 2); make design selections from systems design options identified in conceptual design.
2. Incorporate preferred system design into schematic plans and begin to outline specifications.
3. Engage with regulators, confirming that commissioning agent can begin reviewing design documents and proposed technology selections.
4. Develop owner's project requirements (OPR) set:
 - Design team to develop basis-of-design narrative, if called for.
 - Metrics and targets, such as green building or net zero goals.
 - Performance goals for the duration.

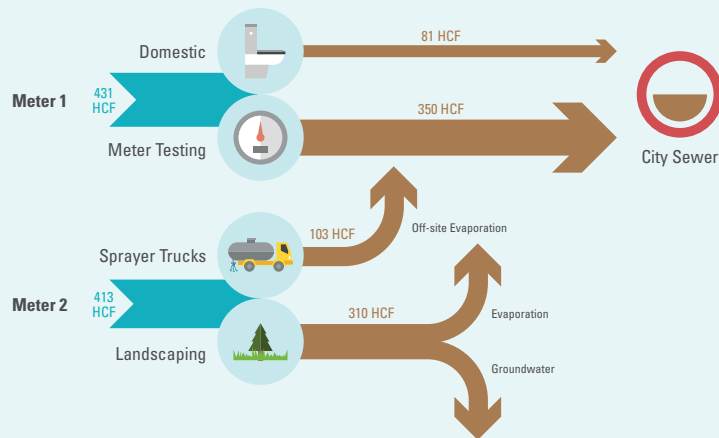
SINGLE BUILDING SCALE



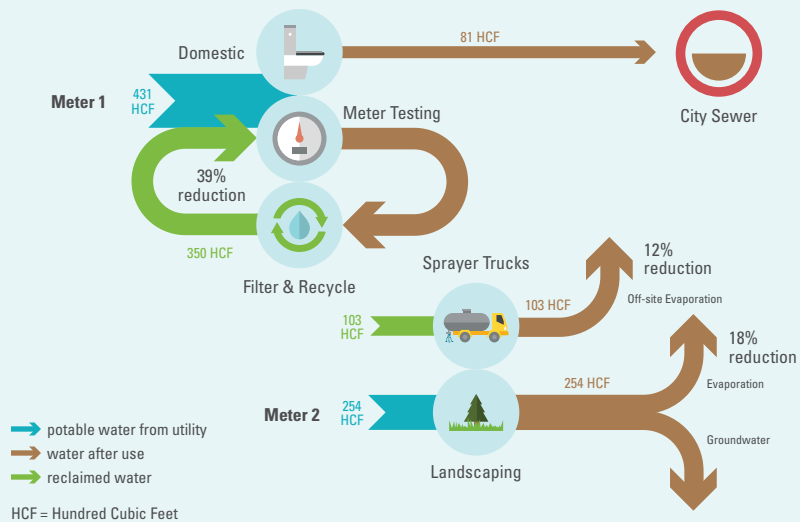
5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

WATER BALANCE IN SCHEMATIC DESIGN

Water Balance without Reuse



Water Balance with Reuse



This sample water balance diagram was constructed for the County of San Diego Agriculture, Weights, and Measures agency, which has the responsibility for using water for process activities, such as testing water meters and spraying fields to keep dust down. The “Water Balance without Reuse”, or before measures applied, diagram shows where water enters the site, how it is used by which systems, and how it all leaves the site. The “Water Balance with Reuse” diagram illustrates opportunities to capture and reuse the water, in this case by recycling meter testing water, by converting irrigation systems to drip, and by utilizing utility reclaimed water (purple pipe) for spraying. Diagramming a water balance during the schematic design phase is very helpful for water reuse planning and also for illustrating opportunities to project owners.

Design Development

1. Finalize decision to include onsite water infrastructure, based on cost and coordination validation from schematic design effort.
2. Finalize technology and design approach.
3. Select system components (see Chapter 7: Build & Operate a System for details on treatment options and selecting a technology).
4. Coordinate space requirements, water balance, and other areas of overlap with the full team.

5. HOW DOES NON-POTABLE WATER REUSE IMPACT THE DESIGN PROCESS? (continued)

Construction Documents

1. Achieve a firm and clear understanding of permitting process, submittals, and outcomes (for details, see Chapter 6: Can I Get this Thing Permitted?).
2. Refine budget and lead time for key components.
3. Identify operations and maintenance requirements and services.
4. Complete systems design and documentation.

Post-Design Processes

Perhaps more than with a typical design project, the design team will need to remain vigilant during the post-design process, from permitting through operations and maintenance, when there is a water reuse aspect to the project. This is due to the fact that this field is uncharted territory for most AEC professionals. An understanding borne from experience with an actual water reuse implementation project cannot be substituted by book learning or hearsay. Some of the post-design activities merit special note, as described in the paragraphs following.

PERMITTING

If the design team has done its homework with regulatory agencies, as outlined in Chapter 4, the permitting process will be pre-paved, but there will be additional agencies or familiar agencies with new review processes reviewing the submission. An experienced water reuse consultant will be useful during this phase to navigate those regulatory conditions that a more typical design project will never encounter. Chapter 6 covers permitting in depth.

COMMISSIONING

Although commissioning agents must have a general knowledge about various building systems to help the design team reach system optimization at the end of construction, water reuse technology is typically unfamiliar at the building scale. The design team or owner should not assume that the commissioning will have such expertise, and should expect to supplement that service with a water reuse commissioning expert.

OPERATIONS AND MAINTENANCE

Most facility managers will not have experience with the operations and maintenance activities required for operating an onsite water reuse system. The design process should have taken into account the complexity of the treatment processes and sought to produce an overall system that will minimize operator interface. The controls should be sufficiently sophisticated to provide actionable information to the operator for a correct and timely response. To develop expertise in the facility management staff, it is advisable to have the design consultant participate in the system startup along with the key equipment suppliers, contractor, and contracted operator, if any, to allow the staff to acquire the experience through observation and hands-on training.

CHAPTER 6

CAN I GET THIS THING PERMITTED?

CHAPTER LEARNING OBJECTIVES

- Understand stakeholders' interests that will enable or inhibit permit issuance.
- Navigate regulations and code resources that guide the permit process.
- Review the economic, health and historical design factors that may impact system permit attainment—even after design approvals have been received.

6. CAN I GET THIS THING PERMITTED?

Introduction: Permitting

As you have become familiar with this guide, you have gained an understanding of emerging strategies that will redefine infrastructure and building design for the foreseeable future. It has touched on the One Water concept; provided guidance in understanding water sources, uses, and related design opportunities; explained how to assess whether water reuse is a good idea for your project; and discussed the importance of engaging with stakeholders and approving agencies. It has also suggested design resources that will ensure the project benefits your client and integrates with the broader community. Understanding these factors is critical to assessing and communicating whether the onsite reuse design can be permitted.

Two things must be kept in mind when navigating the permitting process. First, it is important to recognize that there currently are no national water quality standards or guidelines for onsite non-potable water systems. This means that regulations vary across states and that numerous plumbing codes, guidance documents, and policies exist but are inconsistent. Second, the regulatory landscape for onsite systems is evolving, as it is with municipal-scale potable reuse, and many agencies are interested in developing permitting programs that are consistent from state-to-state.

Understanding Interests of Permit Stakeholders

Part of a successful permitting process is managing the competing interests of stakeholders. This requires an understanding that, even if the proposed project is practical, feasible, within guidelines and using proven technology, permitting may rest on other factors. Some of these factors are:

Economic Interests. Perceived loss of revenue may be an initial obstacle. Refocusing the permitting agency on reducing capital costs and creating capacity within existing systems can open dialogue and lead to opportunities to:

- provide for projected growth—especially in urban areas;
- create resiliency to future droughts or water constraints;
- support regional strategies to slow the increasing strain on watershed resources, reduce groundwater depletion, reduce the burden on infrastructure; and eliminate the need for capital expansion.

Agency / Utility Control and Centralized System Thinking. Local and regional water initiatives and infrastructure programs may be based on system-wide models of volume. The diversion of wastewater for onsite or localized reuse may reduce that volume, calling the program into question. In such cases, it will be critical to have agency engagement early and often, to support its broader objectives through successful integration of the project. This may be difficult for an agency focused on its own billion-dollar solution. Many times, these solutions are committed to without regard to smaller, decentralized strategies.

The key is to remember that receptivity enables change. Engaged stakeholder interest is not adversarial—it is collaborative. The frame and context of the discussion often make a difference in success. Therefore, it is important to demonstrate that decentralized water systems can be a tool for optimizing centralized infrastructure, reducing strains, and potentially reducing capacity upgrades.

6. CAN I GET THIS THING PERMITTED? (continued)

Understanding Standards and the Regulatory Landscape

Due to the lack of federal standards, water reuse regulations are not uniform across the United States. Individual states, municipalities, and local jurisdictions have independently developed water reuse regulations, where they exist. Most states still lack water reuse regulations, and some only have regulations for certain water sources, such as rainwater or graywater but not blackwater. In other areas, regulations only apply to water reuse at a certain scale, such as residential graywater reuse, or on a municipal level. Some places have based guidance for onsite systems on regulations developed for centralized systems. Many are working to develop more specific guidance for onsite systems, as existing regulations fall short in some cases. Water quality criteria, testing requirements, monitoring strategies, and management plans developed for larger systems are not always appropriate for smaller systems, in terms of feasibility, cost-effectiveness, and protecting public health.

In addition, approving-agency structures and permit pathways vary dramatically by location, and different permit pathways may be required for different types of systems. The permit pathway in an area where planning, permitting, health, and water agencies are under one jurisdiction (e.g., San Francisco) is vastly different from areas where county, city, regional authority, health and utility are all separate entities.

In some cases, standards and regulations have developed solely through public health agencies that are concerned with human health risks associated with water reuse. In other areas, regulations have been developed by environmental agencies that are primarily concerned with protecting environmental health. In some areas, both environmental and public health regulations may be applicable, depending on water source and reuse application.

For a given project, the design team needs to determine what regulations apply and how to navigate the permitting process as efficiently as possible. The following section will clarify the relationships among potentially applicable regulations and the roles that different agencies typically play in the permitting process.

6. CAN I GET THIS THING PERMITTED? (continued)

1. BUILDING + PLUMBING CODES

Generally speaking, building codes dictate how non-potable onsite water reuse systems are built and utilized. Rainwater and graywater reuse is frequently regulated through state or local plumbing codes. Each state or locality develops its own plumbing code but generally adopts, in part or whole, either the International Plumbing Code (IPC) or the Uniform Plumbing Code (UPC). The IPC and UPC typically go through a revision every three years. At the time this manual was written, the latest revision for both was 2015. Revisions over the last ten years have greatly expanded the graywater and non-potable water sections. States, however, do not necessarily adopt the newest version of UPC or IPC right away.

- **IPC.** Addresses the materials, design, construction, and installation of graywater systems for flushing of toilets and urinals and for subsurface landscape irrigation. The IPC also establishes the minimum acceptable level of safety to protect life and property from the potential dangers associated with supplying non-potable water and the conveyance of wastewater. (See Chapter 13, IPC 2015).
- **UPC.** States that alternate water sources, including graywater, and onsite-treated non-potable water (e.g., rainwater and stormwater), are permitted to be used in lieu of potable water for identified applications. The UPC indicates that water quality standards should meet the applicable water quality requirements for the intended applications as determined by the Public Health Authority Having Jurisdiction. (See Chapters 16 and 17, UPC 2015).

The IPC and UPC have been amended by some states (such as California and Wisconsin) and local municipalities to establish their own codes and guidelines to further refine water quality numerical limits and standards.

A given state plumbing code version can be a number of revision cycles behind current versions. The building code may defer to water quality requirements established either by the authority having jurisdiction or through a separate framework such as that of the National Sanitation Foundation; see State and Municipal Regulations section, below. Existing plumbing codes provide a context for a local program and identify the current requirements that can be built upon or expanded.

2. STATE + MUNICIPAL REGULATIONS




States and municipalities may regulate water quality; consequently, there is great variation in water quality criteria, particularly for fecal indicator organisms. Requirements are often based on municipal-scale reclamation and/or surface water body contact. Many states already allow single-residence reuse of roof runoff and graywater and are exploring other onsite permits and regulations.

Increasingly, cities are developing standards and guidelines to help foster water reuse while assuring that public and environmental health objectives are being met. Where they exist, these standards help streamline the permitting process.

In the absence of state or national standards, some jurisdictions use standards set by the National Sanitation Foundation (NSF). NSF is an independent, nongovernmental organization that certifies decentralized graywater and wastewater reuse treatment systems through a 26-week testing process using synthetic graywater. Standards are performance-based and were developed from a non-scientific survey of national and international reuse standards.

6. CAN I GET THIS THING PERMITTED? (continued)

WATER REUSE DESIGN STANDARDS AND REGULATIONS

Water Source		Reuse Application	Building Codes (IPC 2015 / UPC 2015)	Municipal Regulations	Public Health Regulations ⁴ (State / Local)	Environmental Regulations ⁵ (State / Local)	3rd Party National Sanitation Foundation (NSF-350-1)	3rd Party National Sanitation Foundation (NSF-350)	3rd Party WE&RF Risk-Based
 Rainwater	Subsurface Irrigation	No ¹ / No ²	Select Cities	No	No	No	No	Yes	
	Indoor / Public Contact	IPC / UPC	Select Cities	Select Jurisdictions	No	No	No	Yes	
 Graywater	Subsurface Irrigation	No ¹ / No ²	Select Cities	No	No	Yes	No	Yes	
	Indoor / Public Contact	IPC / UPC	Select Cities	IPC / UPC	No	No	Yes	Yes	
 Wastewater	Subsurface Irrigation	No ³ / UPC	Select Cities	No ³ / UPC	Most Jurisdictions	Yes	No	Yes	
	Indoor / Public Contact	No / UPC	Select Cities	Most Jurisdictions	No	No	Yes	Yes	

This table indicates where standards and regulations may be found for the reuse of rainwater, graywater and wastewater.

- 1 IPC doesn't specifically require rainwater/graywater treatment, but it prescribes filtration/disinfection as required by end use. Chapter 14 also specifies subsurface irrigation design parameters.
- 2 UPC does not require graywater or rainwater treatment for subsurface irrigation, but irrigation fields must be designed in accordance with UPC guidelines.
- 3 IPC does not cover wastewater reuse but does specify subsurface irrigation system design requirements.
- 4 Public health standards typically cover water quality parameters that are indicative of potential health risks, such as total fecal coliforms, biochemical oxygen demand, total suspended solids, or turbidity.
- 5 Environmental regulations may cover discharge to the environment of nutrients such as nitrogen and phosphorus.

6. CAN I GET THIS THING PERMITTED? (continued)

The goal of the certification process is to establish minimum requirements in the design and construction of decentralized commercial and residential graywater and wastewater reuse systems. NSF independently developed its own standards for toilet flushing (NSF-350) and subsurface irrigation (NSF-350-1), also based on a nonscientific survey of national and international water reuse standards. NSF certification represents a logical step forward in the creation of uniform reuse standards; however, its approach has been criticized, because the water quality standards developed may not adequately protect public health, and the methodology for developing those standards is not well supported. Only graywater and wastewater are considered by this certification process, and beyond the delineation of commercial and residential systems, scale and reuse applications are not considered.

At this point, few manufacturers have gone through the NSF-350 or 350-1 certification process, so it is not widely required, but there are a number of states and localities, as well as the 2015 UPC, that require a system to meet the water quality requirements set by NSF-350 for toilet flushing or public contact reuse in the absence of any of other uniform standards. For example, some jurisdictions in California, Colorado, and Oregon use the NSF-350 standard.

The Water Environment & Reuse Foundation (WE&RF) and the National Water Research Institute (NWRI) released their “Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems” in 2017 to provide a framework for state and local health departments to develop requirements for non-potable water reuse systems.

The guidance document gives a scientific framework for evaluating the risk of exposure to pathogens in reclaimed water by creating performance-based reduction targets that are supported by extensive public health

research. It takes into account the reuse application and number of people served by the system to determine risk level and then provides guidance on what type of technologies can reduce that risk to an acceptable level. The document also provides recommendations on monitoring, system management, permitting strategies, and applications and end uses of treated alternate water sources.

The WE&RF/NWRI document is the first to provide a comprehensive and scientifically validated process for evaluating decentralized reuse systems. The study’s authors, a widely-respected group of scientists, public health experts, and water reuse practitioners, recognized that onsite or decentralized systems were significantly different in many respects from municipal scale projects, and project requirements needed to be tailored to the realities of decentralized deployment. This process builds on the strengths of the NSF-350 approach while overcoming its main limitations.

3. ENVIRONMENTAL REGULATIONS

In certain states, environmental agencies play the central role in permitting water reuse. The Georgia Environmental Protection Division, Virginia Department of Environmental Quality, and New Mexico Environment Department are examples of state environmental protection agencies that play a central role in permitting water reuse in their respective jurisdictions.

4. COMPLIANCE WITH FUTURE REGULATIONS

While a treatment system may be designed to meet current water quality regulations or safety standards, future regulations may become more stringent. This is a risk in the application of user-owned treatment systems, as they may need future upgrades or retrofitting. However, onsite treatment systems benefit from the value of small scale; upgrades

6. CAN I GET THIS THING PERMITTED? (continued)

to individual systems are typically less costly than upgrades to large central facilities. Furthermore, current onsite treatment technologies can be designed to produce effluent that exceeds common water quality standards. Thus, regulating bodies have the opportunity to collaborate with owners of onsite systems early in the process to design systems that are effectively “future-proof.”

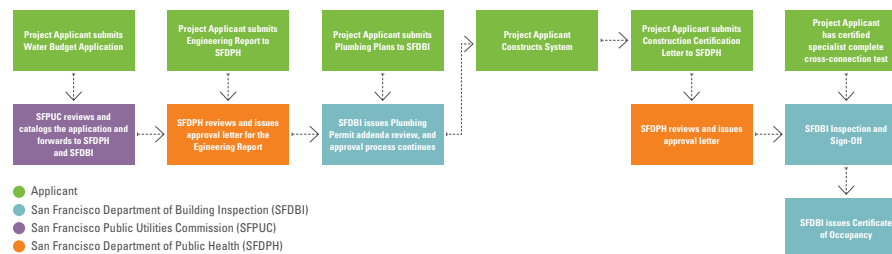
Permitting Case Studies

DEVELOPMENT OF A MUNICIPAL ONSITE REUSE PROGRAM

In September 2012, the City and County of San Francisco adopted the Onsite Water Reuse for Commercial, Multi-family, and Mixed Use Development Ordinance. Commonly known as the Non-potable Water Ordinance, it added Article 12C to the San Francisco Health Code, allowing the collection, treatment, and use of alternate water sources for non-potable applications in individual buildings. Since 2012, the Non-potable Water Ordinance has been amended to allow for district-scale projects, where two or more parcels can share alternate water sources. In 2015, Article 12C became a mandatory requirement for new development projects over 250,000 square feet of gross floor area to install and operate an onsite non-potable water system.

Article 12C became a mandatory requirement citywide in July 2015 for all new construction of 250,000 square feet or more of gross floor area. Projects that meet the criteria are required to install and operate an onsite non-potable water system to treat and reuse available alternate water sources for toilet and urinal flushing and irrigation.

SAN FRANCISCO APPROVAL PROCESS FOR ONSITE NON-POTABLE WATER TREATMENT SYSTEMS



San Francisco’s Non-potable Water Program was established to create a streamlined permitting process for onsite non-potable water systems. The program also provides oversight and management for the use of treated non-potable water by creating monitoring and reporting requirements to ensure systems are protective of public health. Development projects installing and operating onsite non-potable water systems in San Francisco are required to adhere to the following eight-step process:

- 1. Water Budget Application.** All projects must submit an SFPUC Water Budget Application, which includes a basic overview of the proposed project, including the alternate water source(s) and end use(s) proposed, as well as the estimated volumes.
- 2. Non-potable Implementation Plan.** Projects proposing district-scale non-potable water systems must submit to the SFPUC a Non-potable Implementation Plan, which includes details on the treatment system, sewer discharges, and other components related to implementation.
- 3. Engineering Report.** The Engineering Report details the design and technical aspects of the onsite water system and means for compliance with the San Francisco Department of Public Health (SFDPH) water quality and operating standards.

6. CAN I GET THIS THING PERMITTED? (continued)

4. **Plumbing Permit.** All projects are required to obtain a plumbing permit from the San Francisco Department of Building Inspection's Plumbing Inspection Division.
5. **Encroachment Permit.** Projects requiring infrastructure located under the sidewalk or roadway are required to obtain an Encroachment Permit from San Francisco Public Works.
6. **Cross-connection Test.** All projects are required to pass a cross-connection test prior to the operation of the onsite water system and issuance of the building's certificate of occupancy.
7. **Permit to Operate.** All projects must obtain a Permit to Operate from SFDPH, to ensure that SFDPH has oversight over the commissioning and operation of the onsite water system.
8. **Ongoing Monitoring and Reporting.** Frequent water quality monitoring and reporting are required, to ensure the onsite water system is in proper working order.

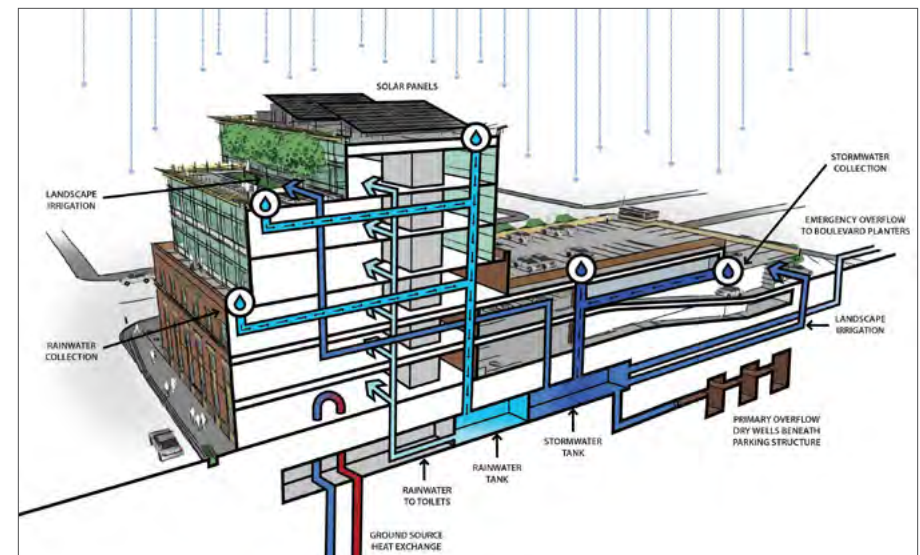
SOMETIMES, IT'S EASY: STOCKMAN BANK BUILDING, NEWLY COMPLETED. MISSOULA, MT

This project, a six-story commercial building in downtown Missoula, Montana, is slated to be the state's first LEED v4 certified building. An important aspect of the certification process involves harvesting onsite rainwater for use in toilets and urinals, as well as irrigation for the immediate landscape. While not terribly complex, it is an innovative approach for a region not well known for its green building initiatives.

The design team's plumbing engineer said the code approval process was surprisingly easy. The local plan reviewer initially questioned the system, so the engineer walked her through the collection system's axonometric drawing. She was concerned about interconnections between potable and harvested water. The plumbing engineer was able to demonstrate how

there were no such interconnections, which assuaged her concerns. As a follow-up, she questioned how water gets to the toilet flushing system if the building runs out of rainwater. The system includes a potable water fill line into the rainwater storage side of the storage tank. The fill line is above the overflow release elevation, so there is always an air gap between potable and harvested water. With those explanations, the system was approved.

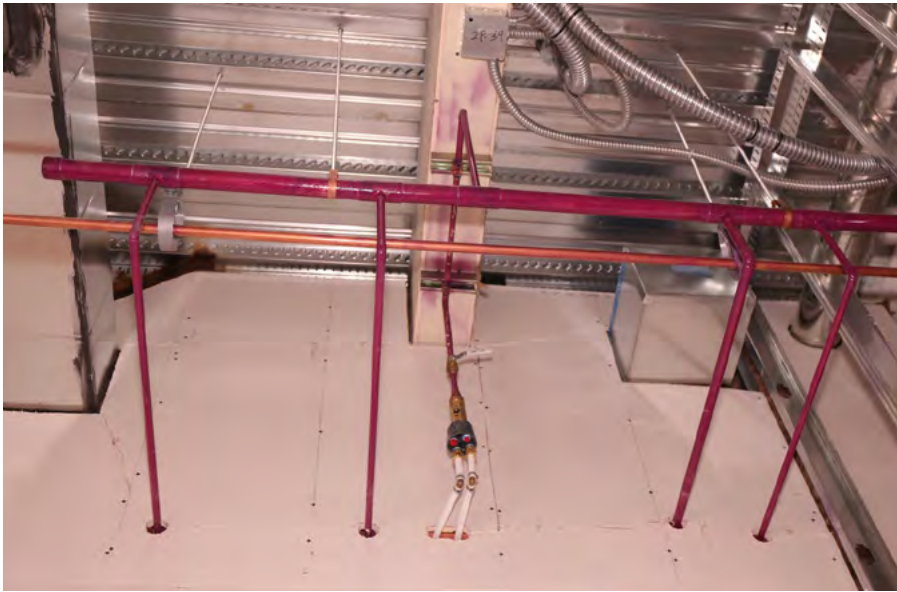
HARVESTING RAINWATER FOR TOILET FLUSHING | © CTA Architects Engineers



There were two snags. First, rather than installing purple pipe, as called for in the design drawings, the contractor installed copper. The design team then proposed using purple insulation on the pipe. The inspector instead insisted the pipe itself be painted purple, which they did.

6. CAN I GET THIS THING PERMITTED? (continued)

PAINTED PURPLE PIPES | Photo credit: ©David Loewenwarter



The second snag arose after the Missoula plumbing inspector attended a Uniform Plumbing Code seminar in which they talked about stormwater harvesting not being allowed in the 2012 UPC. Rainwater harvesting would be allowed, but the City immediately informed the design team that stormwater collected from the parking structure must be put into drywells. The design team asked local officials to reconsider based on this rationale:

1. There is an oil-sorbent pillow in the cistern which will remove vehicle contaminants.
2. The system is more environmentally friendly than putting contaminated water directly into groundwater, which happens to be the City's main drinking water source.

3. The stormwater is used for drip irrigation, it is not sprayed.
4. The 2015 UPC has a chapter devoted to the use guidelines and approval of stormwater harvesting.

Ultimately, the City allowed the use of the stormwater system. The design team was required to submit a maintenance schedule showing regular inspections of the system and yearly replacement of the oil sorbent pillow.

SOMETIMES, IT'S NOT SO EASY: MALIBU BLACKWATER RECYCLING PROJECT

A private beach resort in Southern California has 275 privately owned residences and a bustling restaurant on property owned by a single party. The single owner committed to recycling blackwater (i.e., sewage) for irrigation. Three motivators drove the decision to recycle water:

- Reduce the cost of potable water.
- Maintain landscape aesthetics and slope stability with a year-round, attractive ground cover.
- Match the owner's ethic of environmental stewardship.

Numerous state and municipal agencies were responsible for permitting the project. Each of the state and municipal agencies had its own permitting responsibilities and processes. Additionally, the water purveyor and electric utility had roles for protecting the potable water source and providing power to the recycled water treatment plant. Each level of government participated for distinct reasons:

STATE AGENCIES

- **State Water Resources Control Board (SWRCB)**, for defining conditions for producing and using recycled water in accordance with Title 22 of the California Water Code.

6. CAN I GET THIS THING PERMITTED? (continued)

RESORT PHOTO | Photo credit: ©Barbara Bradley



- **Regional Water Quality Control Board**, for defining protections to surface and ground waters that could reasonably be affected, in accordance with regionally specific water quality conditions.
- **CalFire**, for defining conditions for fire suppression, i.e., building features and fire truck access.

COUNTY

- **Department of Public Health**, for reviewing plans and inspection of installed features, such as signage, backflow prevention, and other physical features in conformance with Title 22 requirements for recycled water.

RESORT PHOTO | Photo credit: ©Barbara Bradley



CITY AGENCIES

- **Planning Department**, for conformance to city planning policies, coordinating the permit application and distributing it to city departments, notifying nearby property owners of the proposed land use change, presenting the project to the Planning Commission, and ultimately to City Council for approval.
- **City Biologist**, for determination of protected species and habitat.
- **City Landscape Architect**, for conformance to city landscaping codes including water conservation.
- **City Geologist**, for geotechnical issues of slope stability and soil infiltration.

6. CAN I GET THIS THING PERMITTED? (continued)

- **Environmental Health Administrator**, for codes associated with onsite disposal of wastewater.
- **Public Works**, for cross-parcel transfer of wastewater to the new recycled water plant and for earth work.
- **Building and Safety**, for review of electrical, plumbing, mechanical, and structural aspects of the project.

Permitting was an iterative process, with major phases of review characterized by one to several rounds of reviews with agency comments and the consultant's responses. The difficulty with that process was the uncertainty associated with how the agencies would focus their comments. This is not a reflection on the consultant's experience or capacity to understand how to design or present the system. Rather, it reflects the numerous codes, ordinances, and policies that apply; how they are interpreted by regulators for this particular site and project; the individual personalities involved and staff workloads; and the number of internal reviews.

With three state agencies and seven city agencies, the process took a year and a half to complete, including preparation of the various submittals required by each agency or department. Yet this was an accelerated project. Other, less complicated projects in this jurisdiction have taken up to three years. The long timeline was driven by the city's two-phase permitting—conformance review and plan check with both Planning Commission and City Council approvals involved. While state agencies were expected to take the most time, due to staff workloads, the drought became the driver behind a relatively swift approval, to address the need for immediate and long lasting implementation of water conserving practices.

RESORT PHOTO | Photo credit: ©Barbara Bradley



6. CAN I GET THIS THING PERMITTED? (continued)

APPROVALS TIMELINE FOR ONSITE BLACKWATER RECYCLING IN SOUTHERN CALIFORNIA

State Agencies		City Agencies		County Agency		Utilities	
12 months (overall)		18 months (overall)		5 months (overall)		3 months (overall)	
Agency	Timeline	Agency	Timeline	Agency	Timeline	Agency	Timeline
Water Board staff reviews	9 months	Planning	8 months				
SWRCB staff reviews	4 months	Biologist	3 months				
WB Board Directors	3 months	Landscape Architect	3 months				
		Geologist	4 months				
		EHA	8 months				
		Public Works	2 months				
		Planning Commission	3 months			Water Purveyor	3 months
		Planning	5 months	Dept Public Health	5 months	Electric Utility	3 months
		Biologist	2 weeks				
		Landscape Architect	2 weeks				
		Geologist	1 month				
		EHA	5 months				
		Building & Safety	3 months				
		City Council	2 months				

CHAPTER 7

BUILD & OPERATE A SYSTEM

CHAPTER LEARNING OBJECTIVES

- Identify potential water sources.
- Understand the three steps of the water reuse process.
- Become familiar with some common treatment technologies used for water reuse.
- Understand how to evaluate treatment vendors.
- Understand how water reuse applications differ.

7. BUILD & OPERATE A SYSTEM

Water Treatment Steps

Successful water reuse systems include three basic steps: primary, secondary, and tertiary. The treatment steps for different water sources and end uses are presented in the tables on the following page.

PRIMARY TREATMENT

Potential alternate water sources from rainwater to wastewater all require a first step to remove non-biological material in the water, coarse biological material, or fatty biological material which may be difficult to remove in the subsequent treatment steps. This step might include fine and/or coarse screens, settling tanks, and grease traps.

As there is inherent flow variability in most alternate water sources, the primary treatment step often also includes some form of flow equalization to buffer diurnal, seasonal, or random variability. Flow equalization assures the effectiveness of the secondary biological treatment, as well as a more consistent supply for reuse applications.

SECONDARY TREATMENT

Most alternate water sources include at least some organic material that is dissolved or in particles too small to be removed in the primary step. Left in the water, this organic material will cause septic and/or odor-generating conditions. Suspended solids and dissolved organics will also cause discoloration of the water.

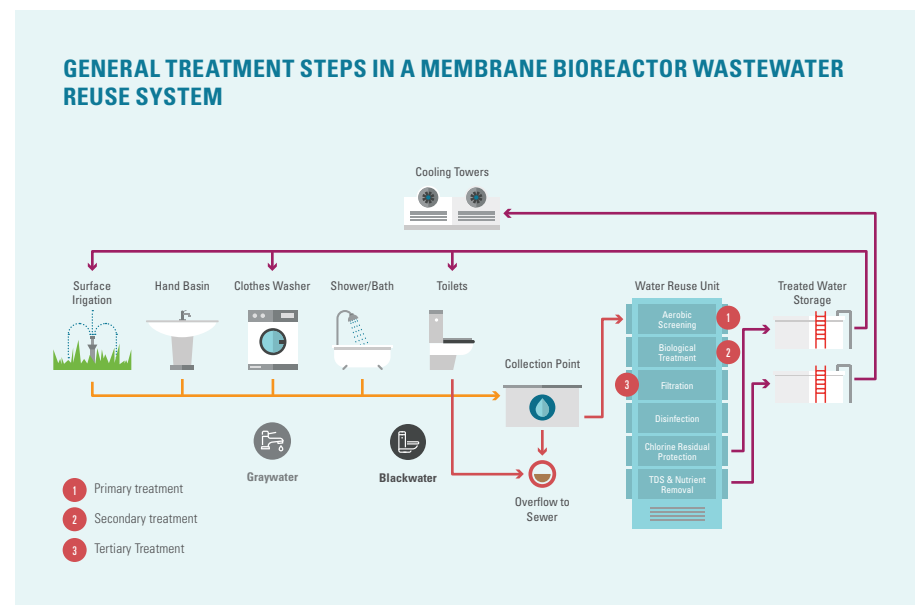
Microbiological processes will naturally consume the dissolved organic material. A wide variety of biological treatment processes exist that “turbo-charge” natural microbial processes by adding additional oxygen and by increasing the concentration of helpful microorganisms. These processes can also be utilized to remove nutrients in wastewater,

such as nitrogen and phosphorus, that might be detrimental to certain reuse applications. The most common biological treatment technologies on the market are discussed later in this chapter.

TERTIARY TREATMENT

While the first two steps are essential for most water reuse projects, the tertiary step is highly application specific, depending on water source, reuse applications, and regulatory requirements. Tertiary (also called polishing) steps can include additional filtration, deionization, and disinfection. Examples of each technology follow the secondary treatment discussion.

The adjacent schematic representation demonstrates a general onsite wastewater treatment and reuse system. Primary, secondary, and tertiary treatment take place in the “Water Reuse Unit,” several types of which are described in subsequent sections.



7. BUILD & OPERATE A SYSTEM (continued)

3-STEP WATER TREATMENT PROCESSES FOR DIFFERING END USES

○ Project Specific Requirements
● Typically Required

Water Source Type	TREATMENT						End Use
	Primary	Secondary	Tertiary				
	Screen	Flow Equalization	Bio Treatment or Chem Oxidation*	Filter	Disinfect	Reverse Osmosis	
Condensate							 Subsurface Irrigation
Rainwater	●	●					
Stormwater	●	●					
Foundation Drainage	○		○				
CT Blowdown	●	●	○				
Graywater	●	●		○			
Blackwater	●	●	●	●		○	

○ Project Specific Requirements
● Typically Required

Water Source Type	TREATMENT						End Use
	Primary	Secondary	Tertiary				
	Screen	Flow Equalization	Bio Treatment or Chem Oxidation*	Filter	Disinfect	Reverse Osmosis	
Condensate				●	○		 Toilet Flushing
Rainwater	●	●		●	○		
Stormwater	●	●		●	●		 Decorative Fountains
Foundation Drainage	○		○	●	●		
CT Blowdown	●	●	○	●	●		
Graywater	●	●	○	●	●		 Vehicle Washing
Blackwater	●	●	●	●	●	○	
							 Surface Irrigation

○ Project Specific Requirements
● Typically Required

Water Source Type	TREATMENT						End Use
	Primary	Secondary	Tertiary				
	Screen	Flow Equalization	Bio Treatment or Chem Oxidation*	Filter	Disinfect	Reverse Osmosis	
Condensate				●	●		 Cooling Towers
Rainwater	●	●		●	●		
Stormwater	●	●		●	●		 Boilers
Foundation Drainage	○		○	●	●		
Graywater	●	●	○	●	●	○	
Blackwater	●	●	●	●	●	●	





* Biological treatment processes and chemical oxidation processes can both be employed to degrade dissolved organic constituents. Chemical oxidation is rarely used for blackwater treatment or other water sources with high levels of nutrients or dissolved organics.

7. BUILD & OPERATE A SYSTEM (continued)

Example Treatment Systems

A wide variety of design approaches have been successfully employed to reuse wastewater. A few examples are provided here to illustrate typical design approaches for the most common alternate water sources, including rainwater and stormwater, graywater, and blackwater (combined wastewater). The benefits and challenges of incorporating alternate sources such as condensate, cooling tower blowdown, stormwater, and foundation drainage are considered in the following table.

BENEFITS AND CHALLENGES OF ALTERNATE WATER SOURCES

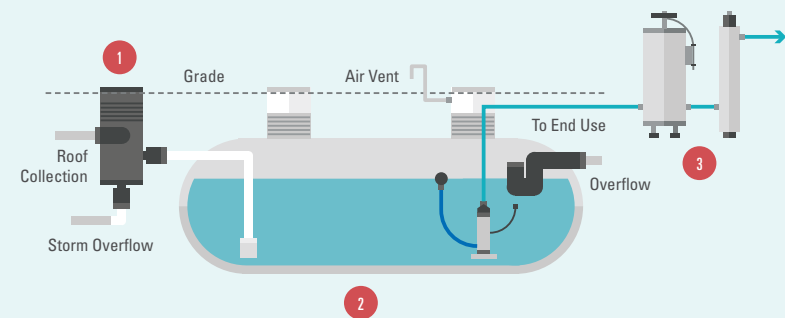
Water Source Type	Benefits	Challenges
 Condensate Condensation collected from air handling systems	<ul style="list-style-type: none"> Generally very pure source that requires little additional treatment Consistent source during the cooling season 	<ul style="list-style-type: none"> Potentially slightly acidic and may require buffering Significantly seasonal and regional supply variation depending on climate
 Stormwater Rainwater collected from landscape and hardscape	<ul style="list-style-type: none"> Large collection areas can yield large volumes during rain events 	<ul style="list-style-type: none"> Inconsistent water source; may require very large storage tanks May require screening to remove trash May be contaminated with clay, sediment, oils, or grease
 Foundation Drainage Groundwater collected from foundation dewatering	<ul style="list-style-type: none"> Consistent source that typically requires minimal additional treatment 	<ul style="list-style-type: none"> May have higher levels of dissolved salts and dissolved organics or other pollutants, requiring special biological and filtration systems
 CT Blowdown Salt build-up due to evaporation requires periodic discharge of cooling water	<ul style="list-style-type: none"> Consistent source during the cooling season 	<ul style="list-style-type: none"> Very high salt concentrations Potentially higher levels of organic materials, pathogens, or higher levels of chlorine or other biocides

Rainwater and Stormwater Treatment

Pretreatment of stormwater is usually significantly different from rainwater pretreatment, due to the potential presence of sediment, clay, zoonotic organisms and parasites, and hydrocarbons from landscape, roads, or parking lots.

Screening systems are typically required to handle trash, after which comes further treatment depending on the collection surface. In areas affected by snowfall, there is the added issue of salts used on roads and sidewalks.

TYPICAL RAINWATER/STORMWATER REUSE SYSTEM



1. Rainwater collected from roof surfaces flows through a mechanical filter with a screen to remove coarse debris.
2. Cistern volumes are sized for local rainfall patterns. Smoothing inlets, floating pump intakes and overflow skimmers reduce tank cleaning and increase water quality.
3. For toilet flushing reuse or surface irrigation, filtration and disinfection are frequently also required.

7. BUILD & OPERATE A SYSTEM (continued)

If rainwater is harvested through green roofs, the influent water may be brown in color, due to tannins leached from organic material or due to residual suspended solids. If this is the case, microfiltration or media filtration may be needed, coupled with chlorine.

Tertiary treatment required for rainwater/stormwater use is dependent on the reuse application and local regulations.

Appropriate sizing of the storage tank is critical*. Sizing calculations should be based on typical meteorological year rainfall data, roof catchment area, appropriate runoff factor, and non-potable demand. In general, tank sizing should be large enough to provide a reliable water source throughout the year. An example of a **tank size calculator** can be found [here](#).

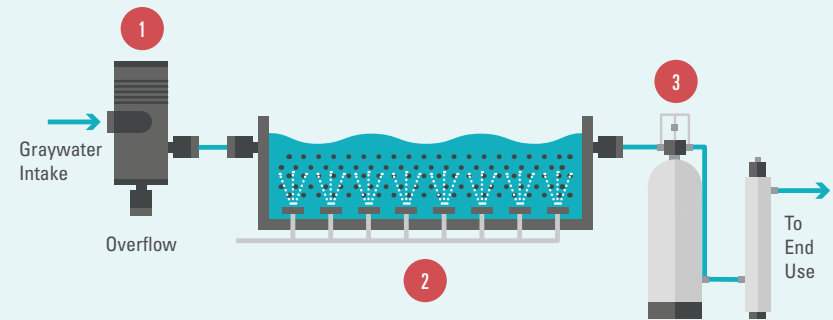
For a collection area greater than 2,000 square feet, filtering and first flush diversion are typically achieved with a vortex filter. (First flush diversion refers to sending an initial flow of rain- or stormwater away from the catchment system as a means allowing only cleaner water to enter the system). These filters utilize the centrifugal motion of water in the filter to scour the collection screen. This significantly increases the duration between manual cleaning events and is very effective for removing particles above 400 microns.

* Climate change has resulted in new patterns of rainfall in most parts of the world, often with short intense storm periods and much longer dry periods, and these patterns may not be reflected in historical data. This presents a challenge for rainwater harvesting, as larger tanks are necessary to hold the desired volume to supply your constant non-potable demand.

Graywater and Blackwater Treatment

Graywater doesn't necessarily always require secondary, or biological treatment; however, several onsite reuse systems have secondary treatment processes built in anyway. Blackwater reuse systems do require secondary treatment. Both graywater and blackwater will require tertiary treatment of some sort. Blackwater, due to its high biological content, requires considerably more treatment than other sources.

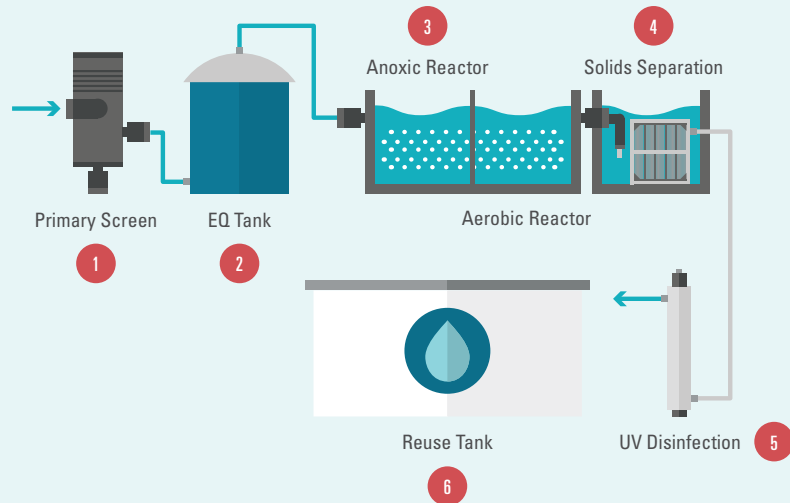
TYPICAL GRAYWATER REUSE SYSTEM



1. Graywater collected from building fixtures is screened to remove hair and lint.
2. Biological treatment or chemical oxidation (depending on anticipated water quality) degrades dissolved organics and detergents.
3. Filtration and disinfection remove residual solids and eliminate potential pathogens.

7. BUILD & OPERATE A SYSTEM (continued)

TYPICAL BLACKWATER REUSE SYSTEM



1. Wastewater screening or settling in a primary tank is used to remove nonbiological waste and coarse biological materials, as well as fats, oils, and grease. Screenings are removed as municipal solid waste, and primary tanks are periodically pumped out and the contents discharged to the sewer.
2. Variation in influent flow rate and concentrations can be buffered in a flow equalization (EQ) tank. Pumps in this tank normalize the flow into the biological system, increasing its efficiency and reliability.
3. Biological treatment typically occurs separately in anoxic (low oxygen) and aerobic (high oxygen) environments, where treatment microorganisms convert dissolved organics and nutrients into nitrogen and carbon dioxide gas. In the process, new microbial biomass is produced.
4. Microbial biomass is filtered with submerged membranes or is settled in a clarifier tank followed by filtration. Residual solids are typically discharged to the sewer or hauled from the site.
5. System effluent, termed filtrate or permeate, is disinfected before reuse, typically with UV or ozone as a primary disinfectant and chlorine as a secondary disinfectant.
6. Treated and disinfected effluent is stored in a reuse tank to meet instantaneous demand for reuse applications. Online instrumentation provides verification of specified water quality parameters.

Common Biological Treatment Technologies

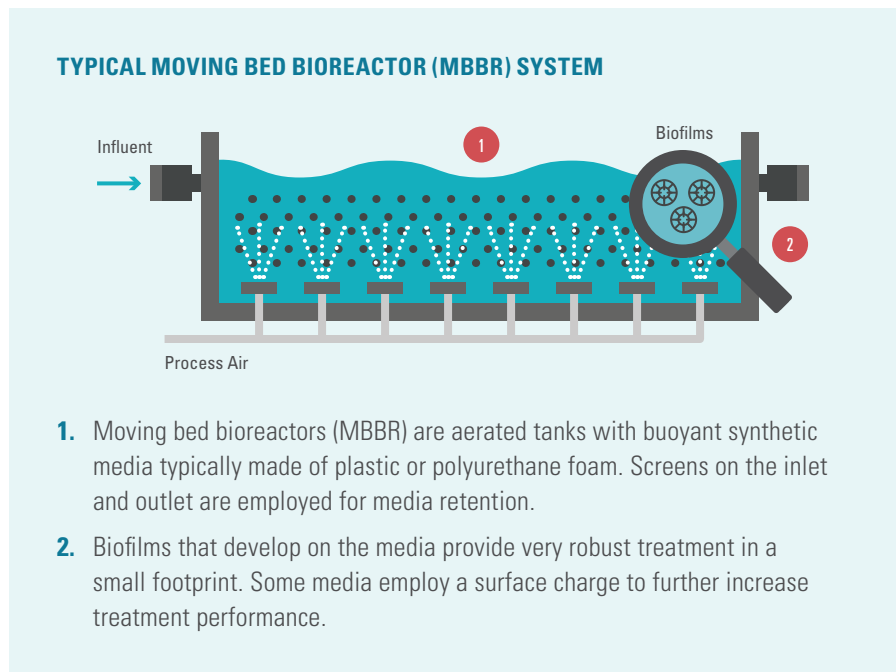
A wide variety of biological wastewater treatment technologies may be appropriate for reuse applications. All treatment systems seek to increase the availability of oxygen to microorganisms, to foster their accelerated growth. A few common treatment approaches are described below.

MOVING BED BIOREACTORS (MBBR)

Bacterial communities growing on surfaces, termed biofilms, are highly efficient and robust in variable waste streams. Synthetic treatment media, usually small pieces of plastic or polyurethane foam, can be added to aerated treatment reactors to create additional surface area for treatment microorganisms. These treatment media are continuously circulated, creating moving bed bioreactors (MBBRs). MBBRs require effective primary

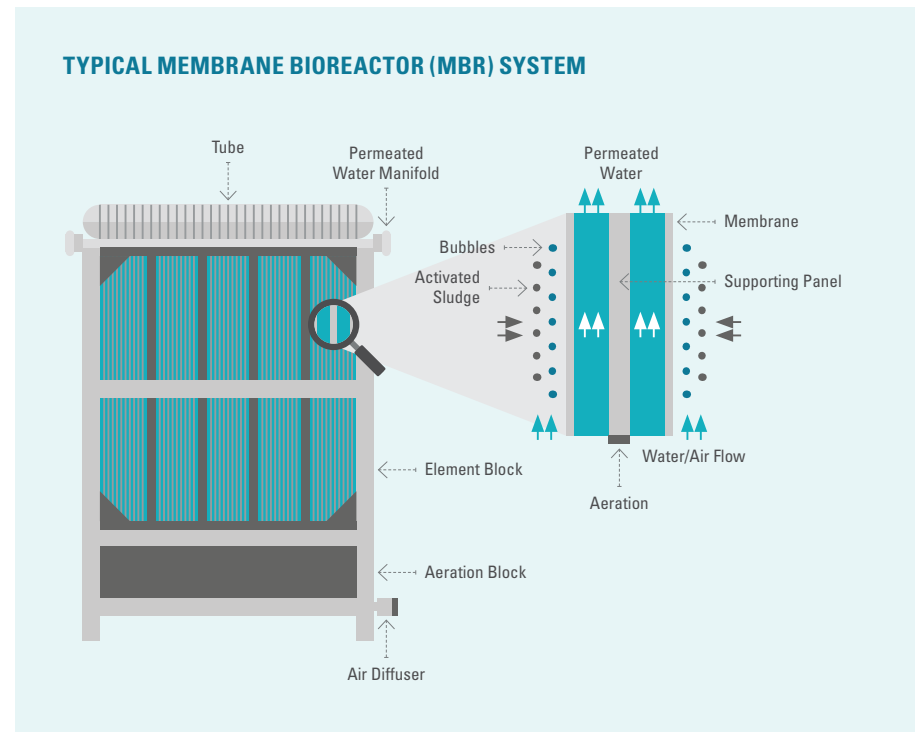
7. BUILD & OPERATE A SYSTEM (continued)

screening and can be paired with a variety of solids separation and filtration technologies, including clarifier and surface filters or media filters, or submerged membranes.



MEMBRANE BIOREACTORS (MBR)

A membrane bioreactor (MBR) is the combination of a membrane process such as microfiltration or ultrafiltration and a biological reactor. The biological reactor is typically aerated to promote aerobic digestion but can include anoxic processes to help promote nutrient removal and control pH in the final treated water. An MBR is an effective way to promote biological treatment and filtration in one system and produces very high quality treated water in a relatively small footprint.



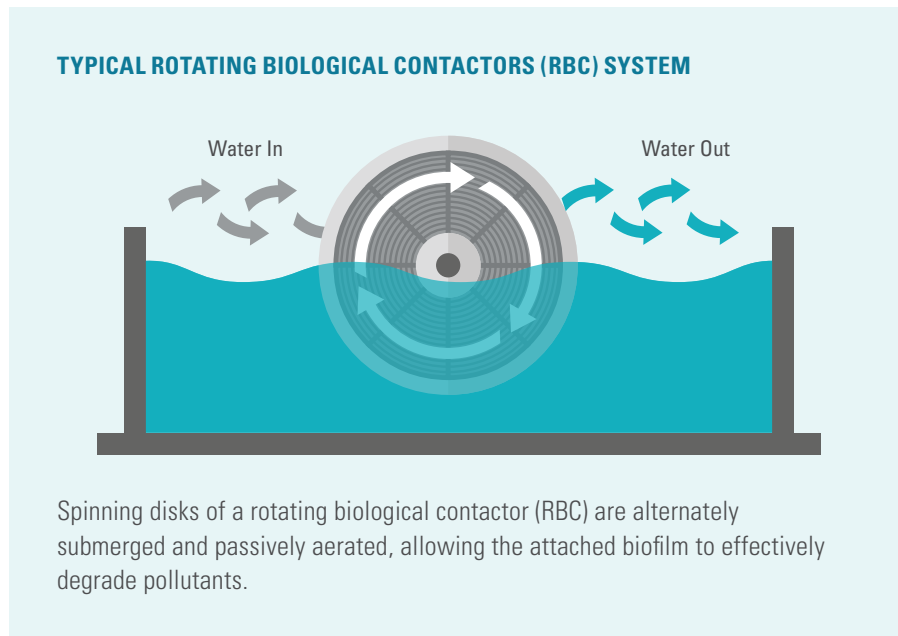
ROTATING BIOLOGICAL CONTACTORS (RBC)

Unlike most biological wastewater treatment processes, a rotating biological contactor (RBC) does not need diffused air to provide oxygen to treatment microorganisms. As a result, RBCs are among the most energy efficient systems available.

In an RBC, the biological contactors rotate slowly through a direct drive reduction gearbox and are arranged so that around 40% of their surface area is submerged in the effluent at any time. As the biological contactors rotate, surface media are subjected alternately to wastewater and air, encouraging an aerobic biofilm to become established on each side of

7. BUILD & OPERATE A SYSTEM (continued)

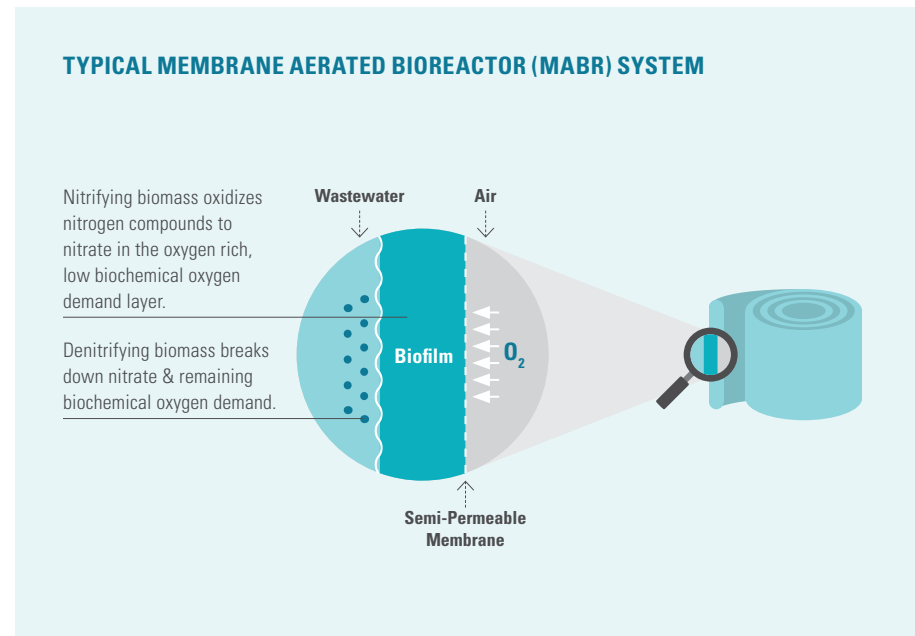
the media sheets. This biologically active film grows in size, is self-regulating, and oxidizes the pollutants in the wastewater. The microorganisms digest pollutants, measured as biological oxygen demand (BOD), as food and, as they do so, multiply in number, maintaining a specific biomass thickness to ensure optimum process efficiency.



MEMBRANE AERATED BIOREACTORS (MABR)

Instead of using submerged membranes for solids separation like MBRs, membrane aerated bioreactors (MABR) use submerged membranes that provide oxygen to treatment microorganisms. These membranes are located directly in the treatment reactors and provide significant surface area for biofilm growth. An air permeable (but not water permeable) membrane system allows low-pressure blowers to provide oxygen directly

to bacteria from one side of the membrane, while they consume nutrients and organics from the other side of the membrane. This emerging process significantly reduces energy requirements typical of aerated treatment processes. MABR systems require primary treatment, equalization, and typically clarification and filtration.



NATURAL TREATMENT SYSTEMS

Natural treatment systems combine plants and microbial communities to provide biological treatment. The two most common natural treatment systems utilized for water reuse are hydroponic systems and subsurface wetlands.

7. BUILD & OPERATE A SYSTEM (continued)

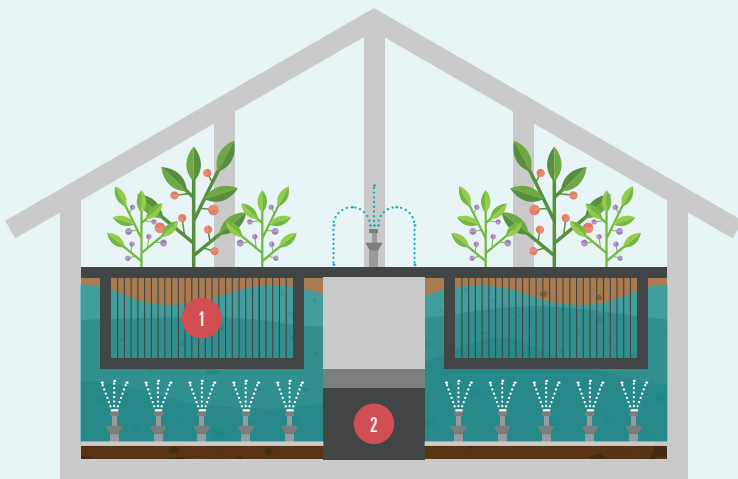
Hydroponic Systems. Hydroponic systems utilize plant racks suspended over aerated wastewater reactors. Certain plant species grow long roots in the wastewater environment. While the plants do remove a small amount of nutrients, their primary function in the wastewater process is to provide surface area for treatment bacteria and other microorganisms that live on the plant roots. Research has found that plant roots provide more surface area per cubic meter than synthetic media typically found in

MBBRs. Hydroponic treatment systems require primary screening and can utilize a variety of solids separation and filtration, including clarifier and disc filters or media filters, or submerged membranes. Certain hydroponic designs employ synthetic root media at depths below the plant roots.

Wetlands. In subsurface flow wetlands, wastewater is always below the surface of the wetland aggregate. Microbial communities develop on the pore areas of the aggregate and the plant roots. In these wetlands, plants play a number of important treatment roles, including increasing nutrient removal, increasing microbial biodiversity, and increasing long-term aggregate porosity. They also provide ancillary benefits, such as creating urban green space.

A variety of different subsurface flow process configurations have been developed to maximize the performance of wetlands. Tidal-flow or reciprocating wetlands (figure on next page) are among the most compact designs. These systems use pumps in coupled cells to alternately fill and drain subsurface flow wetland cells. The process of draining the cell passively provides oxygen to treatment microorganisms. This allows the wetlands to achieve high reuse standards and significantly reduce system footprint relative to other subsurface wetland designs.

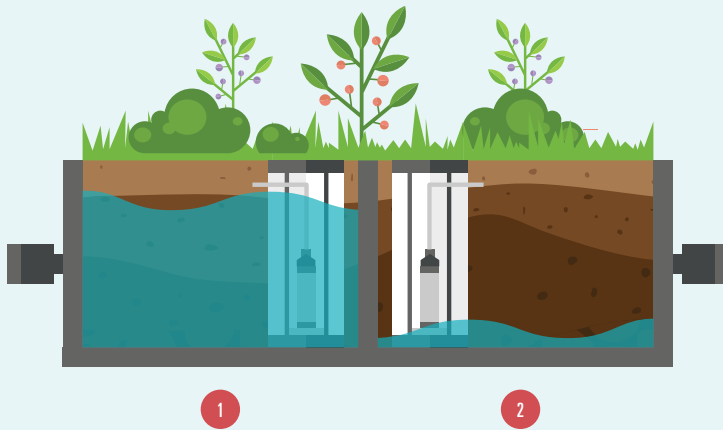
TYPICAL HYDROPONIC TREATMENT SYSTEM



1. Select plant species grown hydroponically in aerated reactors will produce dense root mats up to four feet in depth. The fractal structure of the roots provides greater surface area than synthetic media for biofilm development.
2. Hydroponic reactors generally have greater biodiversity of microorganisms that graze on bacteria, resulting in reduced sludge volumes.

7. BUILD & OPERATE A SYSTEM (continued)

TYPICAL RECIPROCATING OR TIDAL FLOW WETLANDS TREATMENT SYSTEM



1. After primary treatment, wastewater is pumped into subsurface wetland cells that are alternately filled and drained multiple times per day. During the fill phase, biofilm communities on plant roots and aggregate consume nutrients in the wastewater.
2. During the drain phase, atmospheric oxygen passively fills the void area, helping to “turbocharge” the microbial processes. Plants play an important role by increasing nutrient removal, microbial diversity, and long term aggregate porosity.

Common Tertiary Treatment Systems + Technologies

Filtration. Filtration is used to remove suspended solids. A wide variety of media and membrane filters exists to remove residual solids to required levels. Filtration can generally be classified as media, microfiltration (<10 microns) or ultrafiltration (<0.1 microns). Nanofiltration or reverse osmosis filtration is discussed below. The figure on the following page shows particle size removal range by filtration type. Note that the filtration that may take place during the tertiary phase removes much finer particles than primary phase filtration.

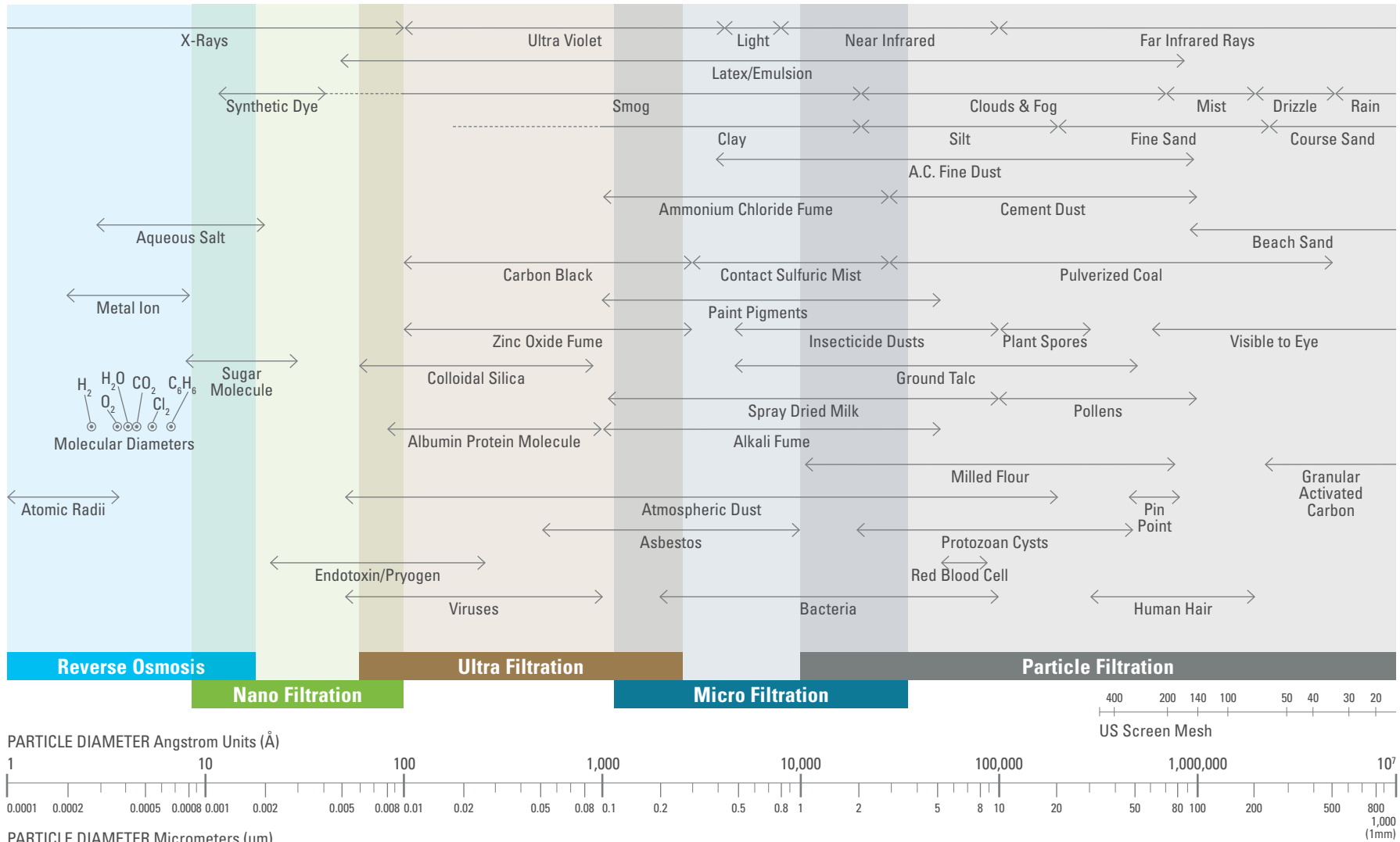
Deionization. Inorganic mineral constituents such as salts can also impact reuse. Soil structure, plant communities, plumbing fixtures, and heating and cooling systems can all be adversely affected by high salt concentrations. A variety of different technologies provide deionization or desalination of water. Reverse osmosis (RO) is the most common approach employed for decentralized systems. RO systems use a semipermeable membrane to remove ions (salts) from water. High pressure pumps are utilized to force water through the fine membrane pores. Typical recovery rates are between 75-80%, with the salt solution rejected as “brine.” It is worth noting that with RO, a brine management plan will be needed. It can be a difficult and costly process that needs to be fully considered.

Membrane capacitive deionization (CapDI) is an emerging technology with potential for decentralized reuse applications. CapDI utilizes an electric current and ion-selective membranes to preferentially remove salts from the water instead of forcing all flow through the membrane. Reversing the electric charge allows salts to be removed from the membranes and flushed out as brine. This process does not remove all of the salts, as does RO, but it uses significantly less energy. The figure on page 65 illustrates the deionization process.

7. BUILD & OPERATE A SYSTEM (continued)

PARTICLE SIZE REMOVAL RANGE BY FILTRATION TYPE

These sizes of well known objects and particles illustrate the size of the micrometer (or micron, μm)



7. BUILD & OPERATE A SYSTEM (continued)

CAPACITIVE DEIONIZATION

The diagram illustrates the two stages of capacitive deionization. In the **Purification** stage, saline water (represented by yellow and red dots) flows between two oppositely charged electrodes (top: +, bottom: -). The electric field attracts and removes dissolved ions from the water. The resulting water is labeled **PURE**. In the **Regeneration** stage, the electrode polarity is reversed (top: -, bottom: +). Feed water (yellow and red dots) is flushed through the cell at a lower flow rate. Ions are now repelled from the electrode surfaces and are concentrated in the flow channel, where they are flushed out of the cell. The remaining water is labeled **TDS**.

Saline water passes between oppositely charged electrodes that electrostatically remove dissolved ions.

Feed water flushes through the cell at a lower flow rate, while electrode polarity is reversed. Ions are rejected from the electrode surface, concentrated in the flow channel and flushed from the cell.

Capacitive deionization is an emerging, energy efficient technology for removing salts from reclaimed water.

Photo credit © Voltea

Disinfection. Biological treatment and filtration can significantly decrease the concentrations of potential pathogens in reuse water, but disinfection processes are necessary to assure the correct levels of pathogen removal required for certain applications.

Three main disinfection practices commonly employed are:

- **Ultraviolet disinfection.** Ultraviolet disinfection uses light of a specific spectrum to destroy the DNA of pathogenic organisms. UV systems are energy efficient and cost-effective but rely on adequate biological treatment and filtration to be effective, as suspended solids can block UV radiation and shield pathogens.
- **Ozone disinfection.** Ozone disinfection systems dissolve gaseous ozone into water to degrade pathogens. Ozone is less sensitive than UV to the breakthrough of solids and can also remove residual color and odor, but it needs to be combined with ozone destruct or “quenching” systems that remove any unused ozone gas that could be harmful or flammable.

- **Chlorine.** Neither UV nor ozone provides a disinfection residual that prevents the re-growth of pathogens in reuse storage tanks or reuse distribution systems. Chemical disinfectants such as chlorine are commonly combined with UV or ozone disinfection systems to provide the needed residual. Chlorine is typically used in conjunction with other disinfection technologies to reduce chemical requirements and improve overall disinfection reliability.

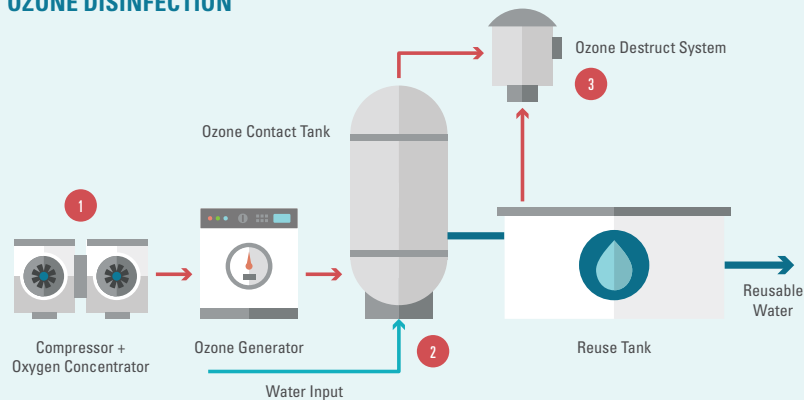
ULTRAVIOLET DISINFECTION

The diagram shows a cross-section of a UV disinfection system. It consists of a **Stainless Steel Vessel** with an **Inlet** on the left and an **Outlet** on the right. Inside the vessel is a **Reflective Reaction Chamber** containing **Ultraviolet Rays** (represented by wavy lines). A **Bulb Removal + Replacement** mechanism is shown at the inlet. The process is described in two steps:

1. Effluent flows into the reflective reaction chamber where ultraviolet bulbs generate light in the UVC spectrum.
2. UV light denatures the DNA of pathogenic organisms, sterilizing them. UV disinfection does not require a contact tank or increase conductivity but does not provide a disinfection residual.

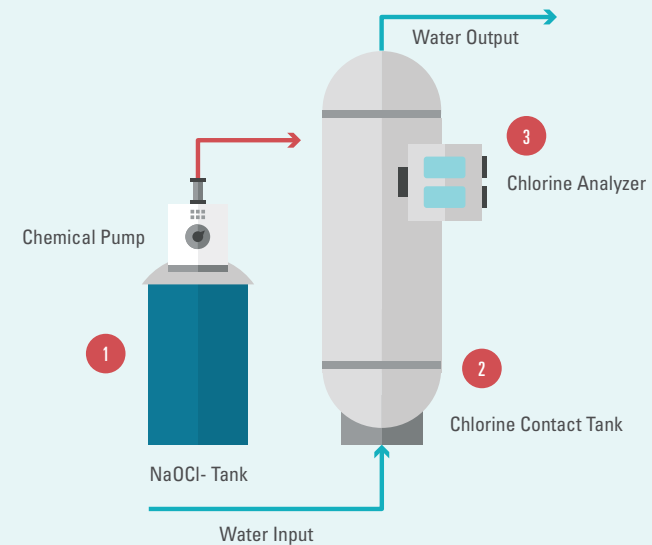
7. BUILD & OPERATE A SYSTEM (continued)

OZONE DISINFECTION



1. Oxygen is concentrated from ambient air and fed to an ozone generator. Ozone gas is injected into an ozone contact tank.
2. Effluent flows through the ozone contact tank, where it reacts with ozone gas. Ozone molecules kill pathogens by destroying their cell walls. Ozone does not provide a disinfection residual.
3. Ozone is a toxic and hazardous gas. Even at low concentrations, an ozone destruct system is required to remove any unreacted ozone.

CHLORINE DISINFECTION



1. Sodium hypochlorite (bleach) is one of the most common chemical disinfectants. It is pumped from drums, totes, or bulk tanks to the chlorine contact tank.
2. Effluent flows through the chlorine contact tank, where it mixes with the sodium hypochlorite solution, which kills pathogens by disrupting their protein structure.
3. Chlorine or ORP analyzers are used to detect chlorine residual levels, and assure disinfection is successful but that effluent levels are within safe boundaries because high free chlorine levels can damage piping and fixtures. Chlorine increases effluent salinity but provides a good disinfection residual.

Note: Chlorine can be used to chemically oxidize in the place of biological processes, but this requires twenty times the chlorine needed just for disinfection.

7. BUILD & OPERATE A SYSTEM (continued)

Evaluating Technologies & Vendors

A wide variety of vendors provides equipment for the water reuse market. Evaluating the equipment and the qualifications of vendors can be difficult. In general, three different approaches exist to evaluating technology vendors, and they are not necessarily mutually exclusive.

Reviewing previous project case histories, historical operating data, and project references and academic literature provides good insight into a potential technology or company. This approach is most useful for established technologies and for case histories of applications similar to your own. Engaging the expertise of a professional water treatment design to evaluate technologies can prove especially beneficial.

Third party verification can also be helpful to evaluate potential technology vendors. Historically, many new wastewater reuse technologies were developed and evaluated in commercial/academic partnership with universities, and data is available in peer-reviewed publications. Stanford University has recently constructed the William and Cloy Codiga Resource Recovery Center (CR2C). CR2C includes a test facility for demonstrating and evaluating water reuse technologies. Similarly, the WE&RF Leaders Innovation Forum for Technology (LIFT) program allows facility and industry end users to share the cost of conducting demonstrations to accelerate adoption of new technologies.

A number of software modeling tools can be used to empirically evaluate wastewater treatment system designs; they include BioWin by EnviroSim and GPSX by Hydromantis. Models may be particularly useful for evaluating new technologies or nontraditional designs. Technology providers should be able to provide model output to verify the function and sizing of the system upon request.

SAMPLE QUESTIONS FOR VENDORS

The following is a list of items that a vendor should be asked to provide as a statement of capabilities. It is important to evaluate whether the vendor has experience in wastewater reuse specific to your project.

Technology-specific questions should be asked to help compare options to find the most suitable technology proposed for your project. The following should be requested and assessed:

- Wastewater treatment process description and quality of treated water produced
- Integrated monitoring and controls system description
- Energy usage for technology provided (kWh/1,000 gallons produced)
- Anticipated annual maintenance cost, including asset replacements
- Footprint required for technology

A Statement of Qualifications can be requested from the vendor. It should include a list of in-building wastewater recycling installations. The following information should be requested of the technology being assessed:

- Designed treatment capacity (e.g., 15,000 gal/day)
- Reuse applications (e.g., toilet flushing and irrigation)
- Years projects were commissioned
- Third-party laboratory data from installations where the treated water performance requirements have been met or exceeded
- References for projects listed
- Standard terms and conditions of sale

7. BUILD & OPERATE A SYSTEM (continued)

Water Reuse Design Considerations

To design a successful water reuse system, it is essential to select knowledgeable designers and technology vendors and to work together in a collaborative manner. Engaging early with municipal utilities and permitting agencies helps assure that their input is integrated. A few other important items to consider are:

- Water sources should be appropriately matched to reuse, with respect to both flow and level of treatment required, to create the most cost effective reuse systems.
- Most water reuse systems require multiple treatment steps. The order of these steps is very important, and many failed systems included key treatment components but did not have them effectively sequenced.
- The challenge of graywater reuse is often underestimated. Graywater has dissolved organics as well as pathogens, and treatment processes need to consider both.
- All water reuse systems are managed systems—not set it and forget—and need to have designated staff and budgets to operate successfully. If not properly and continually managed, systems can fall into disrepair and potentially threaten public health and the acceptance of the system by building occupants.

It's worth repeating the point from Chapter 5 that, as you design your spaces and specify the products that may come into contact with recycled water, it's important to discuss your intentions with fixture manufacturers and vendors. Fixtures subjected to recycled water use need to be selected according to their expressed warranties of suitability for the purpose for which they will be used. Water quality can limit a product manufacturer's warranty.

IMPACT OF GRAYWATER ON TOILET TANKS

	18 DAYS	60 DAYS	90 DAYS	1 YEAR	WATER QUALITY/ USER COMPLAINTS
CONTROL CITY WATER					Good visual water quality. No user complaints.
SYSTEM 1 FILTRATION & CHLORINATION					Tank walls black when chlorine level is low. Complaints about odor.
SYSTEM 2 ADVANCED OXIDATION					Slimy appearing water in toilet bowls.
SYSTEM 3 MEMBRANE BIO-REACTOR (MBR)					Good visual water quality. No user complaints.
SYSTEM 4 MOVING BED BIOREACTOR WITH MEDIA FILTER					Good visual water quality. No user complaints.

One-year study by Kohler assessing effects of graywater treated by different methodologies on effluent water quality and user perception of reclaimed water quality. Biological treatment was found to be more reliable than chemical treatment in this study. Photo Credit © Kohler.

For instance, manufacturers may have concerns about aesthetics when their products, such as toilets and urinals, are supplied with water that has any color, whether or not the quality of the water harms the product in any way. Recycled water that contains even minute amounts of organisms that might colonize within a tank or supply pipe may cause unpleasant odors or discoloration. Either might be interpreted as reflecting on the quality or performance of the manufacturer's product.

Current concerns about airborne bacteria, such as legionella colonization in the biofilm on the inside of pipes supplying faucets and showers, are leading to new requirements. Very low flows from these fixtures, due to stringent regulations intended to protect supplies, can exacerbate

7. BUILD & OPERATE A SYSTEM (continued)

problems with colonization of bacteria, which can result in the release of airborne bacteria. It is important to work with the manufacturer or vendor to ensure the right system is selected to protect users from these and other water quality concerns and with the attention to aesthetics desired by the building owner and residents. Therefore, a quality standard such as California's Title 22 or EPA's standard for potable water should be referenced by the specifications for the treatment system supplying the recycled water.

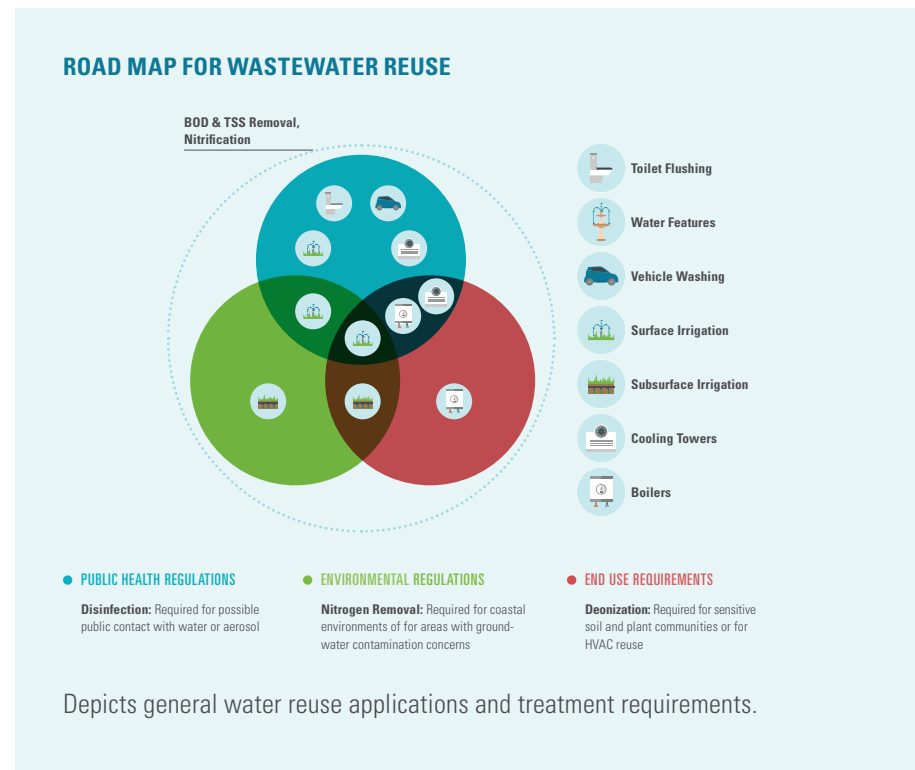
In addition, emerging performance-based standards are in the process of being formalized and adopted. These standards seek to provide a nationally adopted framework for addressing water quality and health considerations that go beyond current references (see Additional Resources in Chapter 8 for more information on these topics). It is important to understand the status of the adoption and implementation of these standards in the context of the objectives, specifications and schedule for the project.

Critical Considerations for Water Reuse Applications

Different water reuse applications require different levels of treatment. In general, there are three sets of requirements:

1. Public health requirements dictate levels of biological treatment and disinfection for water reuse as it relates to public contact. These regulations vary by state and sometimes by county or municipality, as well.
2. Environmental regulations dictate level of biological treatment, as well as degree of removal of nutrients—typically nitrogen, but near freshwater environments possibly phosphorus as well.
3. End use requirements are also important to consider. Fixtures such as toilets have reclaimed water standards recommended by manufacturers based on their own testing and validation. Cooling towers and boilers have reclaimed water requirements determined by manufacturers, utility staff, or by the third-party water treatment suppliers that manage these systems. Soil conditions or plant requirements are important to consider for irrigation reuse.

Successful reuse will meet public health and environmental regulations, as well end use requirements. Common requirements for different applications are presented in the adjacent figure.



7. BUILD & OPERATE A SYSTEM (continued)

Water Reuse Operations

All water reuse systems require ongoing operation and maintenance. The frequency of operational tasks is determined by the complexity of the treatment technology and reuse system, and by the level of health risk. Depending on state or local regulations a licensed operator may be required for some wastewater reuse systems but is generally not required for graywater or rainwater systems. Operational tasks can generally be divided into six categories:

- **Visual Inspection** (daily). Operators perform a walk-through inspection of system components, checking for leaks, noises, or other system abnormalities.
- **Water Quality Testing** (frequency varies, depending on local regulations). Laboratory testing is performed according to permit requirements to verify that all water is safe for reuse.
- **Servicing Instrumentation** (frequency based on regulation and system guidelines). Water reuse systems typically have a variety of online instrumentation. These components need to be calibrated and serviced at predetermined intervals to assure accuracy.
- **Replenishing Consumables**. Chemicals such as chlorine used in the disinfection process need to be continually replenished. Other consumables such as cartridge filters may also need to be regularly replaced.

- **Preventative Maintenance**. Mechanical components of the treatment process such as pumps, valves, or blowers may require preventative maintenance, such as changing oil, to maintain long, reliable service life. Microfilter and ultrafilter membranes require regular clean-in-place (CIP) procedures to maintain performance. UV bulbs need to be cleaned and replaced at regularly scheduled intervals. Membrane bioreactors must be periodically cleaned by physical (backflushing) and/or chemical means to recover permeability of the system.
- **Emergency Maintenance** (as needed). Preventative maintenance and mitigation of risk factors in the system design (e.g., duty/standby pumps) can reduce but not eliminate the need for emergency maintenance due to failure of mechanical components or biological upsets. Most water reuse systems have online control systems that respond automatically to emergency conditions, preventing the reuse of noncompliant water. These systems can quickly alert operators to address problems and restart reuse, while diverting source water to the sewer and switching over to city supplied mains water.

Water Quality Monitoring and Key Parameters

The following table lists the key water quality parameters that indicate overall water quality at a particular time. You must consult your county and state water regulations to learn what parameters need to be monitored and how often. Remember that, at the time of this publication, there are no national or consistent state guidelines for non-potable onsite water reuse.

7. BUILD & OPERATE A SYSTEM (continued)

KEY WATER QUALITY PARAMETERS ADD PH (FROM PG 73)

Parameter	Description	Unit
Total Suspended Solids (TSS)	is a measurement of total solid materials, both organic and inorganic, that are suspended in water and one of the main indicators of the quantity of pollutants present.	mg/L
Total Dissolved Solids (TDS)	is a measurement of total solid materials, both organic and inorganic, that are dissolved in water, and one of the main indicators of pollutants.	mg/L
Volatile Organic Compounds (VOCs)	are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects.	n/a
Total Coliform or E. Coli	are indicators of microbial contamination (bacteria and viruses). UV, chlorine, and ozone disinfection are highly effective at removing microbes and the associated public health risk.	CFU/ 100ml
Biochemical Oxygen Demand (BOD)	is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present. BOD can be used to gauge the effectiveness of biological wastewater treatment.	mg/L
Turbidity	is a measure of water clarity and is a useful indicator of the likelihood that the water may be contaminated with pathogens. Filtration processes are highly effective at removing turbidity.	NTU
Chlorine Residual	in the water indicates that: 1) a sufficient amount of chlorine was added to inactivate bacteria and some viruses; and, 2) water is protected from recontamination during storage.	mg/L

The table lists the key water quality parameters. You must consult your county and state water regulations to learn what parameters need to be monitored and how often.

NTU: nephelometric turbidity units | **CFU:** colony forming units

Equipment Replacement

Most onsite wastewater treatment systems are designed to function continuously for twenty years or more without down time, similar to other critical building systems. However, components will inevitably wear out over time. Replacement of components is typically a minimal expense; two case studies in Europe found that replacement costs amounted to 6-9% of system operation and maintenance costs. Replacements generally consist of the following:

- **Filters/Membranes.** Industrial/commercial grade filtration and membrane components are typically rated for effectiveness over a fifteen-year period or more. Tears or cracks in these components are uncommon with proper preliminary treatment.
- **Mechanical Components.** Pumps, valves and meters have typical service lives of twenty years or more. Failure of components is typically due to blockage from wastewater constituents.

7. BUILD & OPERATE A SYSTEM (continued)

Waste Removal

Most wastewater treatment systems are designed to process solids biologically and thus minimize the waste that is generated. However, due to the nature of separating contaminants from the effluent stream, all systems will accumulate waste that must be removed. Be sure to account for state and local waste disposal regulations.

- **Fats, Oils, and Grease (FOG).** Constituents that are screened and skimmed from the influent prior to entry into the treatment process are typically dewatered and disposed of in landfills or sent to a secondary facility for stabilization and reuse as soil amendment.
- **Sludge.** Sludge consists of settled solids from the primary and secondary treatment processes; it is often reused within the system for bacteria stabilization. Depending on the system, sludge may need to be periodically removed by a septage service, discharged to municipal treatment, or transported to a secondary facility for dewatering and stabilization for disposal or reuse as above.

Know Your Cost: System Operation Expenses

Expenses associated directly with system operation consist primarily of energy use and replacement of components. Energy use—though on average the second largest O&M expense—is extremely variable among system types. However, compared to base building HVAC systems, onsite wastewater systems are not significant power users. In a recent example, an MBR treatment system treats 30,000 gallons per day and draws on average 50kW of power. This includes full automation and monitoring

systems, as well as redundancy in pumps, tanks, screens, and other system components. A natural treatment system, by contrast, may have a much lower consumption profile, due to more passive means of treatment. Thus, energy use will vary significantly based on the number and type of components installed, such as:

- **Pumps.** Pumps are often the largest energy consumer of the system, depending on the length of pipe runs and the flow capacity required.
- **Treatment.** Energy is consumed to screen solids from influent, aerate tanks, and recirculate biologically activated solids.
- **Disinfection.** Components such as UV and ozonation require electricity for final sterilization of water. Post-treatment after water is stored may require additional energy.
- **Monitoring Equipment.** In-line meters, dedicated computer systems for control interface, and system alarms consume energy.

Conclusion

Proper operations and maintenance are key to ensuring a system's effectiveness. While you, as a design professional, can help promote onsite reuse in your project, it is important to ensure that a long-term management plan is also integrated from the outset. A sound management plan will demonstrate to regulators and other stakeholders the long-term viability and effectiveness of an onsite system, helping to ease conversations and permitting processes and successful ongoing operation of your onsite non-potable water reuse system.

CHAPTER 8

REFERENCES & ADDITIONAL RESOURCES

CHAPTER CONTENTS

- ◆ Glossary of Terms
- ◆ Useful Resources
- ◆ Case Studies
- ◆ References + Works Cited

8. REFERENCES & ADDITIONAL RESOURCES

Glossary of Terms

Blackwater: Wastewater that includes kitchen drains and sewage.

Condensate: Condensed water from air conditioning equipment and cooling towers.

“Fit-for-Purpose” Use: Matches the quality of a particular water source to an end-use for which that water quality is sufficient.

Foundation Drainage: Groundwater that intercepts a foundation.

Graywater: Wastewater including all sources except kitchen and sewage.

Make-up Water: Water from the utility that is necessary when the volume available from alternative sources is insufficient for a reuse application.

Non-Potable Water: Water that is not of a quality suitable for human consumption but can be used for other purposes.

Onsite Treatment: Capturing and treating water in close proximity to its collection and next use, for instance in a building or within a district, rather than sending water to the utility plant for treatment.

Potable Water: Drinking water.

Rainwater: Water collected from rooftop runoff only.

Recycled Water/Reclaimed Water: Treated wastewater for reuse (non-potable; in CA governed by Title 22).

Stormwater: Surface water from rainfall and snowmelt events.

Wastewater: Umbrella term for blackwater + graywater.

Water Reuse: Using water again before putting it back into the natural environment. Water can be reused for potable or non-potable purposes.

WATER QUALITY PARAMETERS

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen needed by an aerobic organism to break down organic material in water.

E. Coli: Indicator organisms for microbial contamination. UV, Chlorine, and ozone disinfection are highly effective at removing microbes and the associated public health risk.

pH: Measure of the acidic or basic nature of a solution. pH can be used to gauge wastewater treatment efficiency and the corrosion potential of the water in the distribution system.

Total Suspended Solids (TSS): The measurement of total solid material suspended in the water.

Total Coliform: Indicator organisms for microbial contamination. UV, Chlorine, and ozone disinfection are highly effective at removing microbes and the associated public health risk.

Total Dissolved Solids (TDS): A measurement of total solid materials, both organic and inorganic, that are suspended in water, and one of the main indicators of pollutants.

Turbidity: Measure of water clarity and a useful indicator of the likelihood that the water may be contaminated with pathogens. Filtration processes are highly effective at removing turbidity.

Volatile Organic Compounds (VOCs): Emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects.

8. REFERENCES & ADDITIONAL RESOURCES (continued)

Useful Resources

[Alliance for Water Efficiency](#)

AWI promotes the efficient and sustainable use of water. Its resource library covers many of the standards and codes germane to onsite non-potable water reuse.

ARCSA 63-2013: Rainwater Catchment Systems

American Rainwater Catchment System Association

Produced by a US organization with international reach, it is “designed to assist engineers, designers, plumbers, builders/developers, local government officials, and end users in safely implementing a rainwater catchment system using precipitation from rooftops and other hard, impervious surfaces for use for irrigation, laundry, hygiene, or even potable water applications if the appropriate treatment and materials have been certified for the specific end use.” Request access at the American Society of Plumbing Engineers.

Blueprint to Onsite Water Systems (2015)

[San Francisco Public Utilities Commission \(SFPUC\), Water Environment & Reuse Foundation \(WE&RF\), and Water Research Foundation \(WRF\)](#)

A useful guide for understanding how water and wastewater utilities are building onsite reuse programs in their localities. This ten-step guide walks utilities through the process of establishing and managing onsite water systems. Modeled after the San Francisco Public Utilities Commission’s, experience doing just that, the guide was jointly developed by SFPUC, the Water Environment & Reuse Foundation, and the Water Research Foundation. Available at SFPUC or WE&RF.

[International Living Future Institute](#)

The ILFI’s focus on water includes the results of several research efforts focused on net-zero water and onsite water reuse.

[Recode](#)

Recode’s mission is to ensure access to and acceleration of sustainable building and development practices. Recode collaborates with numerous partners to assist private and public-sector planners, architects, engineers, developers and owners through facilitation, training, and online resources like model codes and tools. The ReWater Program is dedicated to breaking down financial, social, and regulatory barriers to equitable potable and non-potable water reuse systems and closing the nutrient / food cycle for more resilient, sustainable communities.

Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems (2017)

[Water Environment & Reuse Foundation](#)

Questions about water quality and/or public health of non-potable onsite systems? This recently released report discusses a detailed framework to help guide the development of water quality criteria for decentralized non-potable water systems. This resource covers background, a quantitative microbial risk assessment, log reduction targets for many alternative water sources and end uses, responsible management entities, monitoring requirements, and more. Available at WE&RF.

Using Graywater and Stormwater to Enhance Local Water Supplies (2016)

[National Academies of Science, Engineering, and Medicine](#)

This research report covers the range of non-potable uses for graywater and stormwater, including irrigation, toilet flushing, washing, and cooling, although treatment may be needed. Discusses the many benefits, such

8. REFERENCES & ADDITIONAL RESOURCES (continued)

as providing additional sources of local water supply, energy savings, pollution prevention, reducing the impacts of urban development on urban streams, enhancing water supply reliability, and extending the capacity of existing wastewater systems in growing cities. Great talking points for discussions with multiple stakeholders. Available at NAS.

[US Water Alliance](#)

The US Water Alliance has several potentially useful resources available, including:

- *A Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems* December 2017
- *Model State Regulation for Onsite Non-potable Water Programs* December 2017
- *Model Local Ordinance for Onsite Non-potable Water Programs* December 2017

Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques (2004)

[Rocky Mountain Institute](#)

Report prepared for the USEPA that presents “the economic advantages and disadvantages of decentralized wastewater systems relative to larger scale solutions, in order to inform wastewater facility planning and assist communities in making better choices among their many technology options.” Summarizes “what is known about the comparative benefits and costs of various aspects of centralized and decentralized systems.” Available at RMI.

Water Reuse 101

Water Reuse Association

Your go-to guide for all questions related to reuse: non-potable, onsite, and otherwise. “Meeting the demand for water in the 21st Century requires a different way of thinking about water. Water Reuse 101 provides a variety of communication tools and products to help communities educate the public about reusing water.” Available at WRA or WE&RF.

When to Consider Distributed Systems in an Urban and Suburban Context

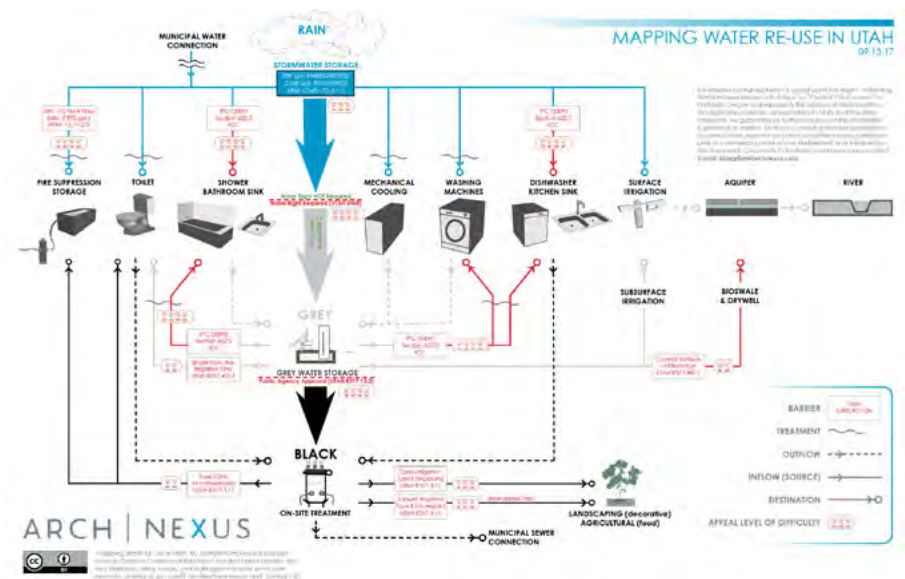
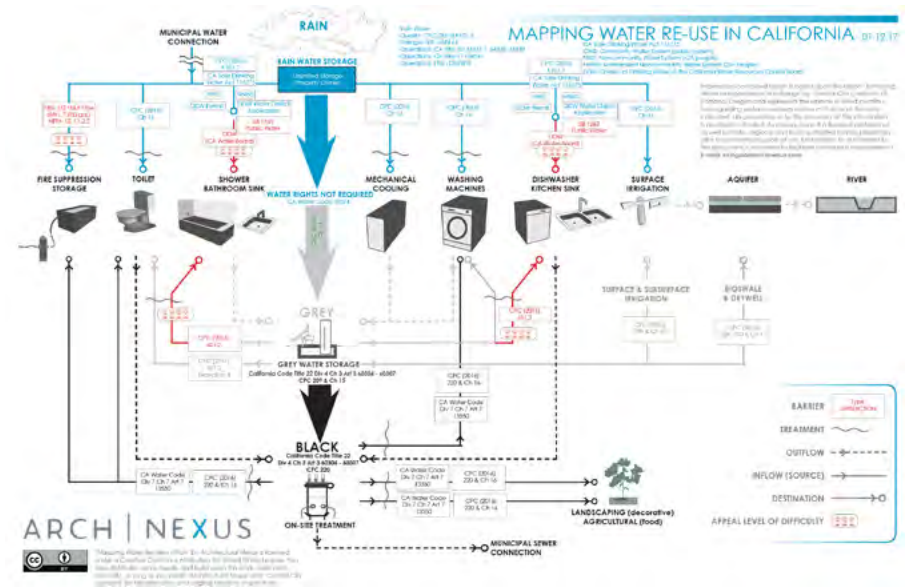
Water Environment & Reuse Foundation

Covers management approaches to “effectively deliver economical, flexible, and sustainable water services to communities” and how to convey these to a variety of stakeholders. It “provides examples showing where and why distributed approaches are being used to advance sustainability at the community level” (including twenty case study examples) “and provides tools that practitioners can use to make informed infrastructure decisions. The resources provided will assist planners, utility managers, engineers, developers, regulators and other decision-makers and stakeholders to better determine whether or not these approaches would be a viable solution in their community.” Access via WE&RF.

8. REFERENCES & ADDITIONAL RESOURCES (continued)

Water Reuse Mapping

Provided courtesy of [Arch Nexus](http://ArchNexus.com). To request a free editable file (uses Adobe INDesign), licensed through Creative Commons, to use as a starter template to map your own state or local water reuse process map, contact: Kenner Kingston, President, Arch Nexus, email: kkingston@archnexus.com. In return, we'd appreciate your sharing back your new water reuse design process maps with everyone for reference with this Water Reuse Guide. Please email your pdf to kyle@urbanfabrick.com, with any contact information instructions for editable file format retrieval, if you'd like to share it as another template. We hope to have all 50 states represented here as a shared clearinghouse for onsite water reuse.



8. REFERENCES & ADDITIONAL RESOURCES (continued)

Case Studies

[181 Fremont, San Francisco](#)

Recycles 5,000 gallons per day of graywater from luxury condos and commercial office floors, reusing the water for toilet and urinal flushing and irrigation, conserving annually up to 1.3 million gallons. The treatment process includes membrane bioreactor technology (MBR).

[Plumbers Local Union 130 Chicago Headquarters](#)

The headquarters of the Local 130 is home to 6,000 plumbers in the Chicago area and features hands-on educational and demonstration spaces for advanced plumbing systems, including rainwater harvesting and graywater treatment. The modular graywater treatment process includes automatic screening, biological treatment, and final filtration and disinfection of up to 1,000 gpd for irrigation reuse.

[Adam Joseph Lewis Center at Oberlin College, Ohio](#)

Completed in 2000, captures and treats all wastewater generated onsite to supply 100% of toilet flushing water with reused water. The treatment process includes a hydroponic system that is integrated into the building envelope. In addition, all stormwater is collected, treated, and infiltrated onsite.

[Bullitt Center, Seattle](#)

Reuses 500 gallons per day of graywater (from taps and showers) to recharge local aquifer. The treatment process includes constructed wetlands and a green roof.

[Hassalo On 8th, Portland](#)

One hundred percent of wastewater, up to 45,000 gallons per day, is treated from a four-block, mixed-use eco-district in Portland. The treatment process includes a trickling filter, reciprocating or tidal flow wetlands, a woodchip denitrification wetland, and final filtration and disinfection. Wastewater is reused for toilet flushing, irrigation, and aquifer recharge.

[SFPUC Headquarters, San Francisco](#)

All the wastewater from over 900 employees is collected and treated in San Francisco's first decentralized wastewater reuse system. The treatment process includes reciprocating or tidal flow wetlands, vertical flow wetlands, and final filtration and disinfection. The system also includes rainwater collection and reuse. Reclaimed water supplies 100% of toilet flushing and irrigation in the building.

[Solaire Building, Battery Park, New York City](#)

Recycles 25,000 gallons of wastewater from 700 residents for reuse in toilet flushing and cooling towers in a multi-residential building. This was New York's first onsite reuse project and was commissioned in 2013. The treatment process includes an MBR with UV and ozone disinfection. Find additional information here.

[WaterHub at Emory University, Atlanta, GA](#)

Mines up to 400,000 gallons of wastewater per day from campus sewers and provides reclaimed water through two miles of distribution piping to five campus cooling towers, the campus steam plant, and two campus dorms, saving over 80 million gallons of water per year. The treatment process includes moving bed bio-reactors, indoor and outdoor hydroponic reactors, and filtration and disinfection.

8. REFERENCES & ADDITIONAL RESOURCES (continued)

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[Water Environment & Reuse Foundation, When to Consider Distributed Systems in an Urban and Suburban Context](#)

[US Green Building Council, Good to Know: Green building incentive strategies](#)

[UN Global Compact, The CEO Water Mandate, Water Stewardship in 60 Seconds](#)

[Sustainable Development Goals \(SDGs\)](#)

Chapter 5

American Institute of Architects California Council. 2014. *Integrated Project Deliver: an Updated Working Definition*, v3.

Chapter 6

[San Francisco Public Utilities Commission](#)

On-site Non-potable Water Use Guide for the collection, treatment, and reuse of alternative water supplies in San Francisco.

CHAPTER 9

THANKS & CONTRIBUTIONS

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- ◆ Project Sponsors
- ◆ Additional Sponsors
- ◆ Contributors

9. THANKS & CONTRIBUTIONS

Project Sponsors



CHARLES PANKOW
FOUNDATION

THE CHARLES PANKOW FOUNDATION

The Charles Pankow Foundation was established to provide the AEC Industry with a better way to design and build. Established in 2002 by Charles Pankow, founder of Charles Pankow Builders, Ltd., a leading U.S. design-build constructor, the Foundation continues to advance his legacy of innovation. It was Charles Pankow's lifelong passion to lead and inspire new and better ways to build. He intended that this Foundation drive market-driven innovations in the building industry. The Foundation funds research, development and dissemination of new products and solutions that help the AEC Industry be more efficient and more cost competitive. The Foundation provides both resources and leadership to advance innovation in the design and construction of buildings. The Charles Pankow Foundation is incorporated as a nonprofit, public benefit, charitable foundation with 501(c)(3) status and operates independently of the Pankow Companies.



GOOGLE

At Google, sustainability is at the core of everything we do. We tackle environmental sustainability projects because they reduce our company's environmental impact, and also because they help our bottom line. But mostly we do it because it needs to be done and it's the right thing to do. And we're not just saying that. Google has been carbon neutral since 2007, and in 2017 we'll reach 100% renewable energy for all of our operations. We believe this Water Reuse Guide is a great tool that will help enable design and engineering teams everywhere to deliver water innovation for residential and office-space projects of all scales.



MAGNUSSON KLEMENCIC ASSOCIATES

Magnusson Klemencic Associates, Inc. provides structural and civil engineering services worldwide, with \$99 billion worth of projects in 46 states and 54 countries. The award-winning firm, headquartered in Seattle with a branch office in Chicago, was founded 97 years ago. MKA's mission, "Always Striving for Better," embodies our commitment to enriching society through the built environment, from enhanced communities to better buildings to efficient use of our most precious natural resource, water.

9. THANKS & CONTRIBUTIONS (continued)



AMERICAN INSTITUTE OF ARCHITECTS CALIFORNIA COUNCIL

The AIACC represents the interests of more than 11,000 architects and allied professionals in California. Founded in 1944, the AIACC's mission supports architects in their endeavors to improve the quality of life for all Californians by creating more livable communities, sustainable designs and quality work environments. For more information, visit www.aiacc.org.



WATER ENVIRONMENT & REUSE FOUNDATION

WE&RF's mission is to catalyze innovation through actionable research in water and the environment. WE&RF accomplishes this mission by seeking to achieve four principal goals:

- Establish water research and innovation priorities to address current and future needs.
- Initiate transformative, integrated, and collaborative research and demonstrations.
- Fund and conduct independent and unbiased, actionable water research.
- Effectively communicate the results and progress of our research and innovation activities in a timely manner.

ADDITIONAL SPONSORS



9. THANKS & CONTRIBUTIONS (continued)

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GRAPHIC DESIGN

- **Stoller Design Group**

CHAPTER 10

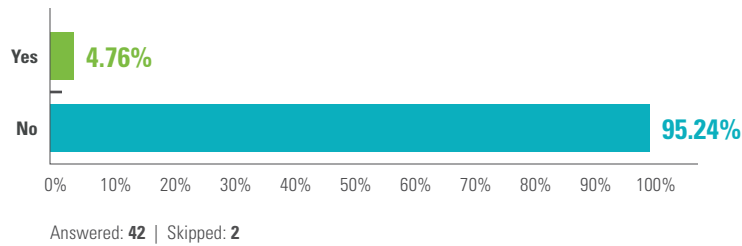
WATER REUSE SURVEY



From the lead-up to GreenBuild 2016 into early 2017, the Urban Fabrick Collaborative conducted an online survey regarding the general knowledge of onsite water reuse among industry stakeholders. 44 people responded to this very unscientific survey. Its results provide a snapshot of potential opportunities for design practitioners nationwide.

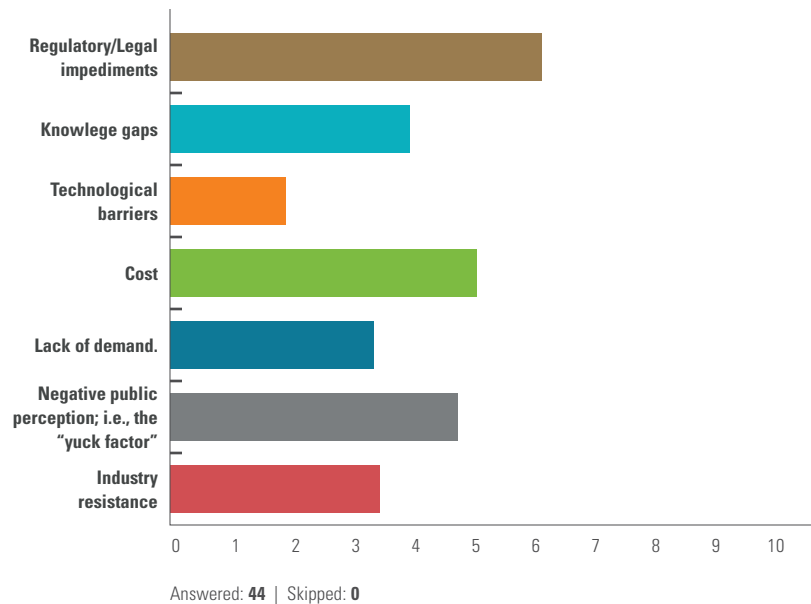
10. WATER REUSE SURVEY

Is non-potable water reuse the limit of onsite water reuse in the US?



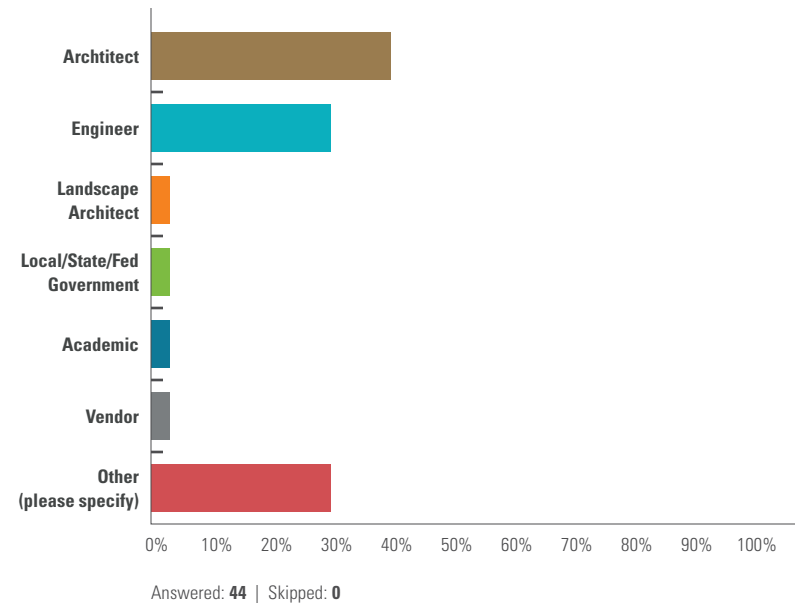
What are the biggest hurdles that prevent widespread adoption of onsite water reuse?

Please rank from most to least challenging (1 = the biggest hurdle)



What is your profession?

Please mark all that apply.

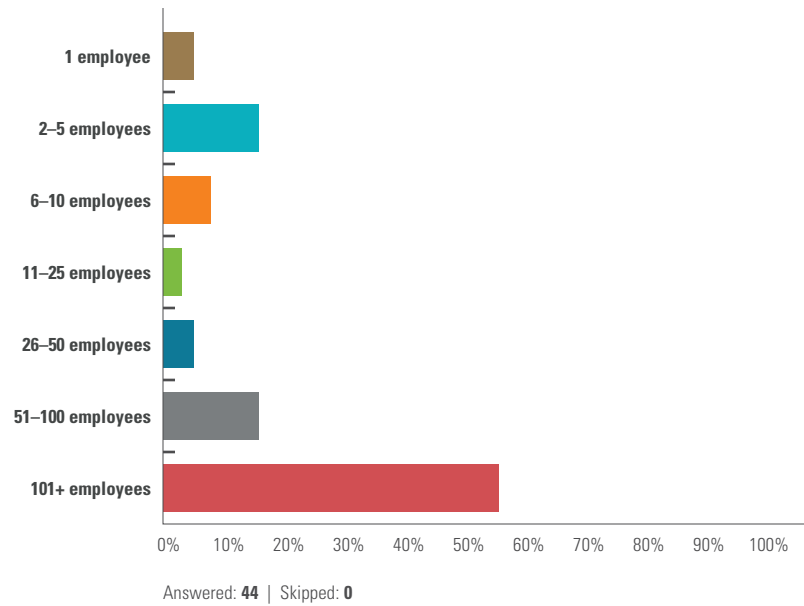


"OTHER" INCLUDES:

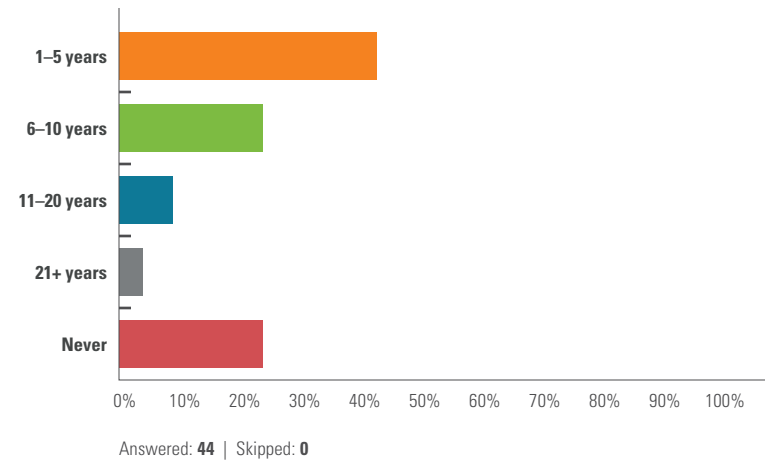
- Environmental Consultant/Engineer
- Sustainability Consultant
- Nonprofit/Advocacy
- Contractor
- Sustainability Specialist
- Affordable Housing Policy and Finance
- Sustainability / Energy Consultant
- LEED Consultant
- Green Building Consultant
- I am pursuing licensure as an architect, but am also wrapping up a thesis on water reuse for an MS in Architecture Sustainable Design.
- Urban Planner with technical background in landscape architecture
- I've been very interested, for over 50 years, in sustainability and self-sufficient living spaces.
- Educational Facility Planner, recovering architect

10. WATER REUSE SURVEY (continued)

How large is your organization?



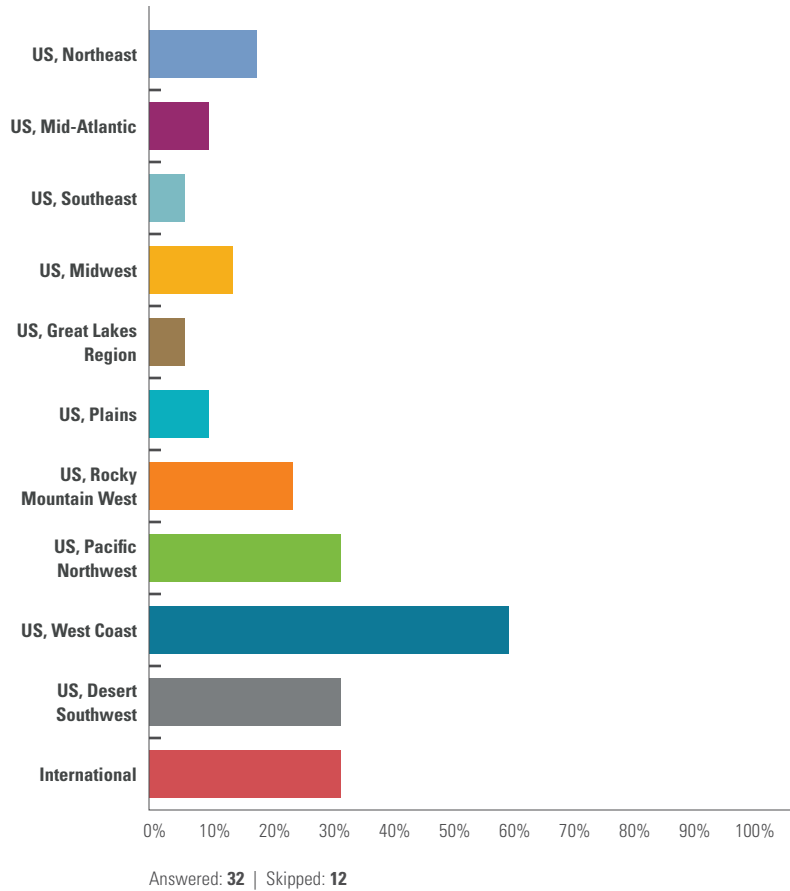
How long have you worked on onsite water reuse projects?



10. WATER REUSE SURVEY (continued)

Where are your onsite water reuse projects?

Please mark all that apply.



What sorts of water reuse projects have you worked on?

Please mark all that apply.

