

# **Onsite Wastewater Treatment Systems: A Technical Review**



**Seattle Public Utilities  
Utility Systems Management Branch**

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## **Acknowledgements**

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## Introduction

On November 1, 2007, Paladino and Company, Inc. met with representatives from Seattle Public Utilities (SPU), Department of Planning and Development (DPD), and other City of Seattle departments to discuss research into the application of onsite wastewater treatment systems. The issues discussed at this meeting served as a basis for this document. The objective was to provide a technical overview and address the specific concerns of both the utility and the project owner when considering the installation of an onsite wastewater treatment system. As such, this document is intended to serve as an internal resource for the Seattle Public Utilities (SPU) to use as a foundation for future research and collaboration with customers interested in installing onsite wastewater systems in the Seattle region.

The relevance of this research is particularly evident due to recent storm events. Over five inches of rain fell on western Washington on December 3, 2007, during which “more than 5.8 billion gallons of record rainfall, the equivalent of six Green Lakes full of water, [caused] neighborhood flooding and landslides throughout the city of Seattle.”<sup>1</sup> This storm overwhelmed local sewage treatment plants, resulting in raw sewage discharge to the Puget Sound.<sup>2</sup> Thus, as centralized facilities are increasingly taxed by storm events, investigation of new strategies to supplement or reduce our municipal treatment demands is critical to preserving our local natural resources.

## Overview

The following report presents an overview of the benefits, challenges, and opportunities of onsite wastewater treatment systems as a sustainable design strategy.

It is important to note that this document is not intended as a comprehensive overview of all onsite treatment technologies. The information provided is focused specifically on systems that have the potential to be installed within urban areas. Installations intended for large scale agricultural applications or remote residential applications are not included in this study. Within this context, the key points of this research include:

- Onsite wastewater treatment may reduce demands, mitigate peak conditions and save cost.
- Wastewater reuse has potential for non-potable applications in numerous building sectors.
- Onsite wastewater treatment systems provide preliminary, primary, secondary and tertiary treatment. Most technologies differ in their means of secondary treatment.
- Onsite wastewater treatment systems are designed to be reliable and self-sufficient. Labor is the largest expense, but is often integrated into standard facilities operation procedures.
- Health, safety, and liability issues can be resolved through early collaboration and design.
- Onsite treatment scales more directly with demand, which significantly reduces investment risk.
- Utilities and owners must balance the shifting of capitol costs, expenses, and revenue to validate onsite treatment.
- Project funding is available at the local, state and federal level for projects that align to water resource initiatives.

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<sup>1</sup> City of Seattle, Seattle Public Utilities, “City of Seattle Responds to Historic Rainfall Second-Wettest Day in City History,” Dec. 3, 2007, Dec. 10, 2007, [http://www.seattle.gov/util/About\\_SPU/News/News\\_Releases/SPU01\\_003293.asp](http://www.seattle.gov/util/About_SPU/News/News_Releases/SPU01_003293.asp).

<sup>2</sup> “5 Dead In Washington Storm,” Dec. 3, 2007, Dec. 10, 2007, <http://www.kirotv.com/weather/14758195/detail.html>.

## What is onsite wastewater treatment?

Onsite wastewater treatment is the collection, treatment and disposal or reuse of wastewater at or near the location in which the waste is generated.<sup>3</sup> The term “wastewater” is often associated with the waste discharge from human water use (sewage) on a site; however wastewater may also apply to other untreated water resources such as rainwater, stormwater, or groundwater.

## Why treat wastewater onsite?

The Pacific Northwest contains unique water resources. Each year, mountain snow melts to fill the rivers and lakes, providing vital support for habitat, wildlife, people and industry. This is a climatically dependent cycle, where water resources often vary by year. After increasing occurrences of water shortages and peaks in recent history, water resource management has become a priority initiative in the region.



Water resource management has traditionally occurred at the municipal level. As population increases, the water infrastructure must keep pace with the associated impacts of development. This creates the challenge of conserving water to meet demand. Additionally, bodies of water near urban areas are often exposed to pollutant discharge from infrastructures based on Combined Sewer Overflow (CSO); these centralized systems are highly susceptible to overloading during storm events. Thus, the decentralization of water treatment through the installation of onsite systems is one of many potential solutions under consideration by public water utilities. From a utility standpoint, onsite wastewater treatment has several primary benefits:

- **Demand reduction** through non-potable reuse and discharge avoidance
- **Peak condition mitigation** through dispersed storage capacity
- **Deferred costs and expenses** of expanding infrastructure to meet demand

The installation of these systems is an owner and developer driven process. While this may present challenges of simple payback, more systems have recently come online and demonstrated economic, social, and environmental benefit. This can make onsite treatment a compelling design approach for project developers based on several potential benefits:

- **Capital cost and expense reduction** from limited use of municipal treatment services
- **Receipt of grants and incentives** from government agencies
- **Increased market value** of building stock and property value<sup>4</sup>
- **Market distinction** resulting from third party certification (LEED) and environmental press

The realization of these mutual benefits has resulted in a noticeable increase in urban installations of onsite wastewater treatment, particularly in the last two decades. This has driven the development of new technologies and applications that make more opportunities available to project teams.

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<sup>3</sup> Ronald W. Crites and George Tchobanoglous, Small and Decentralized Wastewater Management Systems, (McGraw Hill, 1998): 1.

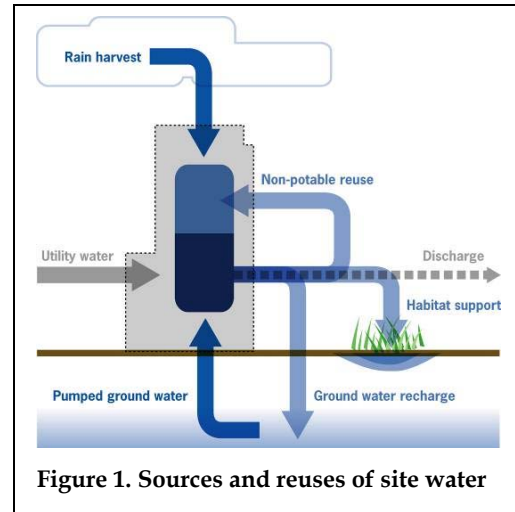
<sup>4</sup> Rocky Mountain Institute, “Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques,” November 2004, Nov. 30, 2007, <http://www.rmi.org/sitepages/pid172.php>.

## When is onsite wastewater treatment appropriate?

The feasible utilization of onsite wastewater treatment is not universal to every project. Onsite treatment is generally appropriate when a significant opportunity is identified; either functional, economical, or environmental. To identify where these opportunities exist, three fundamental questions may be posed:

- What water resources are available?
- What is the destination of effluent?
- What are the opportunities to reuse water?

Water resources may be available to a project in numerous forms. Rainwater, groundwater, greywater and sewage are all examples of resources that can be collected, treated, and reused on site. Clear opportunities exist when a balance is found between an available resource and a potential reuse. Benefits may manifest as potable water savings or capital cost avoidance. Low treatment requirements (e.g. for clean rainwater) may also influence feasibility, yet some opportunities may validate the cost of pollutant removal.



The effluent destination may also reveal opportunities for onsite treatment. For instance, treated wastewater may be an effective means to recharge groundwater or support local habitat. This could in turn generate revenue from utility fee savings and grants, as well as provide notoriety for the intangible environmental benefits. Thus, these opportunities can potentially be integrated into site design features that align with the project goals.

Reuse opportunities are unique to each project and building type. In the U.S., water reuse is conventionally limited to non-potable uses in order to reduce liability. While this prevents a fully closed loop water system, non-potable water reuse can avoid many demands to municipal water resources, as noted below.

Project Type	Water Reuse Opportunities	Comments
<b>Residential</b>  <i>See Case Study: The Solaire</i>	<ul style="list-style-type: none"> <li>• Sewage conveyance</li> <li>• Irrigation</li> <li>• Laundry</li> <li>• Multi-family HVAC</li> </ul>	On average, toilet flushing is the largest indoor domestic water use for U.S. residences. <sup>5</sup> Irrigation water use may also be significant depending on site landscaping. Individual residences do not typically generate enough wastewater to necessitate onsite treatment and reuse, so clustered developments or high-density residential projects are most appropriate.
<b>Commercial/Institutional</b>  <i>See Case Study: OHSU Center for Health and Healing</i>	<ul style="list-style-type: none"> <li>• Sewage conveyance</li> <li>• Irrigation</li> <li>• HVAC makeup</li> <li>• Fire suppression</li> </ul>	Domestic reuse potential is higher for sewage conveyance in commercial projects due to reduced cooking and bathing demands. If minimized, irrigation demand may also be entirely offset with water reuse. High volume HVAC and fire suppression systems can also take advantage of reused makeup water. Large commercial projects can sometimes validate individual onsite treatment systems, yet multi-building campus installations benefit from economy of scale.
<b>Industrial</b>	<ul style="list-style-type: none"> <li>• Process water</li> </ul>	Industrial onsite treatment is often tailored to specific reuse applications. Systems are designed to remove known contaminants in the effluent to meet specific reuse demands.

**Table 1. Typical water reuse opportunities per project type.**

<sup>5</sup> American Water Works Association, *Residential End Uses of Water*, (Denver: AWWARF, 1999).

## How do wastewater treatment systems function?

Wastewater treatment can be understood as a cascading process, where specific contaminants are removed at various stages or levels of treatment. While methods of treatment may differ, certain processes are universal to remove common constituents that affect water quality. Processes of treatment are traditionally grouped into four categories: Preliminary, Primary, Secondary, and Tertiary (as shown in *Table 2*).

Numerous components are available to accomplish these varying levels of treatment. In certain systems, several treatment processes may be integrated in a single unit, whereas other systems may have individual components for each task. Below is a breakdown of common components that are associated with each level of treatment. For more information, please see *Additional Resources*.

Treatment Level	Contaminants Removed	Treatment Processes
Preliminary	Bulk solids Oil & Grease	Screening
Primary	Organic Matter Suspended Solids	Flow Equalization Floation/Sedimentation
Secondary	Nutrients Biodegradables Suspended Solids Micro-organisms	Denitrification Aeration Biological Treatment Filtration
Tertiary	Pathogens Odor Dissolved Oxygen	Disinfection Odor Abatement Precipitation

**Table 2. Contaminants and processes per treatment level.**

**Preliminary treatment components** remove bulk constituents from the waste stream, thereby protecting components and preventing fouling of the system.

- **Screens:** Bars, plates or wire screens that range from course (2.0 mm) to fine (0.01 mm).

**Primary treatment components** support the consistent functionality of the treatment process by managing the consistent inflow to the system and allowing initial settling of suspended solids.

- **Flow equalization tank:** Storage tank used to buffer peaks and valleys of influent in order to provide a consistent flow rate to secondary treatment systems.
- **Sedimentation basin:** Tank with suspended flow where suspended solids are separated using gravity settlement and floatation.

**Secondary treatment components** facilitate the processes of biological treatment as well as the secondary settlement and removal of particulates.

- **Anoxic tank/reactor** – Tank with a low oxygen content that promotes the biological denitrification of wastewater.
- **Aeration tanks/Aerobic reactors** – Enclosed chambers where oxygen is added to the influent to promote bacterial digestion of biodegradable solids.
- **Filters** – Ranging from filtration media (e.g. sand) to porous membrane filters. Standard filters screen to 0.015 mm and micro-filters can remove micro-organisms to 1 micron.
- **Constructed Wetlands** – Engineered plant beds that use natural media as a means of treatment, sedimentation, and absorption of suspended solids and micro-organisms.
- **Final Clarifier** – Tanks that allow secondary separation of organic matter from effluent.

**Tertiary treatment components** provide the final treatment of system effluent before it is reused.

- **Disinfection Units** – Systems that use UV light, ozone gas, or chemicals such as chlorine to disinfect effluent from the treatment units.
- **Odor Abatement Systems** – Odorous gas filtration media such as activated carbon, chemical scrubbers, or bulk medium biofilters (e.g. soil, peat, compost).

## How do you choose the appropriate system?

In most urban installations, system size and wastewater source are typically the primary determining factors due to constraints of the site and infrastructure. This negates the use of lagoons, settling ponds, or other elements of large centralized treatment systems, as well as septic systems that are common to rural or suburban residential installations. This narrows the options to several system types that have been recognized as most adept to urban environments:

- **Membrane Bio-Reactor (MBR)** systems use an integrated biological treatment and micro-filtration membrane. Units are aerated for bacterial growth and cleansing.
- **Activated Sludge** systems use a mixing process to recirculate sludge in order to maintain active biological treatment.
- **Rotating Biological Contactor (RBC)** systems use partially submerged disks that are biologically activated to treat wastewater. Disks are rotated to promote aeration.
- **Living Machine** systems use an engineered wetland to naturally filter and treat water.

Certain components of these systems are universal. Any incoming wastewater – reclaimed, greywater or sewage – will require preliminary screening to remove constituents. Primary flow equalization is also critical to ensure that any system is not inundated or starved. Any system effluent intended for reuse will require tertiary disinfection to prevent the regrowth of bacteria. Thus, these systems principally differ in the means of secondary treatment, as shown in *Table 3* below.

	Membrane Bio-Reactor (MBR)	Activated Sludge	Rotating Biological Contactor (RBC)	Living Machine
Preliminary	Screening			
Primary	Flow equalization tank			
Secondary	Membrane Bio-Reactor	Sedimentation Basin		Biofilter
		Mixing Reactor & Reintegrated Sludge	Biological Contactor	Anoxic Reactor
		Final Clarifier	Final Clarifier	Aerobic Reactor
Tertiary	UV/Ozonation/Chlorination Disinfection			

**Table 3. Treatment processes of four onsite wastewater treatment technologies**

Each of these systems can be designed to effectively treat wastewater. However, certain system options may be more appropriate to a project based on the following considerations:

- Source and pollutant loading of wastewater influent
- Planned reuse for treated effluent
- Spatial constraints of system size and location
- Maintenance requirements and staff availability

Each of the four systems discussed above have strengths and weaknesses in different areas, as noted in *Table 4* below. Thus, these tradeoffs should be prioritized to make an appropriate selection.

System Type	Advantages	Disadvantages
Membrane Bio-Reactor	Most compact system Most scalable to future capacity Fully automated / Low maintenance	Higher level of operator training
Activated Sludge	Most common system type	Higher energy use for mixing
Rotating Biological Contactor	Accepts highest pollutant load	Higher energy use for treatment Potential for odor/noise
Living Machine	Visual amenity – can be showcased Quiet & low cost operation	High level of maintenance Larger footprint / system size

**Table 4. Advantages and disadvantages of treatment technologies**



## What is required to operate and maintain a treatment system?

Operation and maintenance (O&M) is critical to the proper functionality and longevity of any onsite wastewater system. In general, the O&M of these systems consists of operations labor, system operation expenses, equipment replacement, and waste disposal.

### Operations Labor

Although operations labor is the largest cost component of O&M<sup>6</sup>, it is generally perceived to be minimal. In many projects, operator tasks for onsite wastewater treatment systems are included in general facilities management. This is due to both minimal time commitment and integration of components with other building operations. The majority of onsite wastewater treatment systems are designed to be self sustaining and in continuous operation. More advanced technologies such as packaged MBR systems have sophisticated automation systems that allow comprehensive remote monitoring and control, as well as automatic shutoff in case of system failure. Thus, operator labor primarily consists of the following:

- **Visual Inspection (daily)** – Operators perform a walk-through inspection of system components, checking for leaks, sounds or other system abnormalities.
- **Water Sampling (daily)** – Samples are drawn from the system and tested for composition, typically at the inflow and outflow of primary/secondary treatment.
- **Component Cleaning (semi-annually)** – Automated systems typically perform a back-pulsing or auto-cleansing on a weekly basis. Additionally, operators chemically clean filter and membrane components to prevent excessive bio-accumulation.
- **System Adjustment (variable)** – Adjustments are made to maintain optimal operating conditions such as consistent flow rates or balanced bacteria levels. This is typical to the first year of operation, and may extend depending on the degree of optimization desired.
- **Response to Alarms (variable)** – Operators respond to alarms or signals from the system signaling a system deviation from normal operating ranges.

### 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. For example, the MBR treatment system installed at OHSU (see Case Study) 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 Living Machine, conversely, 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** – Often the largest energy consumer of the system, depending on the length of pipe runs and the flow capacity required.
- **Treatment** – Energy consumed to screen solids from influent, aerate tanks and recirculate biologically activated solids.
- **Disinfection** – Components such as UV and Ozonation that require electricity for final sterilization of water. Post-treatment after water is stored may require additional energy.
- **Monitoring Equipment** – Energy consumed by in-line meters, dedicated computer systems for control interface, and system alarms.

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<sup>6</sup> Rocky Mountain Institute, “Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques,” November 2004, Nov. 30, 2007, <http://www.rmi.org/sitepages/pid172.php>.

## Equipment Replacement

Most onsite wastewater treatment systems are designed to function continuously for 20 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 O&M costs.<sup>7</sup> Replacements generally consist of the following:

- **Filters/Membranes** – Industrial/commercial grade filtration and membrane components are typically rated for effectiveness over a 15 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 20 years or more. Failure of components is typically due to blockage from wastewater constituents.

## Waste Removal

Most wastewater treatment systems are designed to biologically process solids, 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.

- **Biosolids, Oils and Grease** – Constituents that are screened and skimmed from the influent prior to entry into the treatment process. These are typically dewatered and disposed of in landfills, or sent to a secondary facility for stabilization and reuse as soil amendment.
- **Sludge** – Settled solids from the primary and secondary treatment process, often reused within the system for bacteria stabilization. Depending on the system, this may need to be periodically removed by a septage service, discharged to municipal treatment, or transported to a secondary facility for dewatering and stabilization (similar to above).

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<sup>7</sup> Rocky Mountain Institute, "Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques," November 2004, Nov. 30, 2007, <http://www.rmi.org/sitepages/pid172.php>.

## What are the primary issues and concerns for public agencies?

Transferring the task of treating water to the individual site owner carries certain risks to a regulating body or public utility. These risks are commonly assessed under two primary considerations:

- **Liability** – legal implications of system failures or inadvertent damage to natural resources
- **Public health and safety** – injury or infection caused by contamination or unintended reuse

These risks are best understood by regulating bodies, yet largely dependent on how an owner implements an onsite system. Thus, the most effective means of addressing these issues is through open collaboration in the early stages of a project. This will facilitate better navigation through the regulation and approval process, as well as foster a mutual understanding of how risks are offset by both parties. Below are several examples of solutions that may address these considerations.

### Design for System Redundancy

Designing onsite treatment processes with redundancy is a very effective means of avoiding system failure. If systems are intended to accept wastewater on a continuous and uninterrupted basis, as they typically are, this is particularly critical. To prioritize the elements of a system that require redundant components, the system should be analyzed for points of failure in the following areas:

- **Conveyance** – Pumps, pipes or filters that facilitate the movement of wastewater should have alternative paths in case of a backup or component failure.
- **Storage** – Overloading of the system design capacity should be accommodated by backup storage or a rerouted path to an acceptable means of discharge.
- **Monitoring** – Sensors and alarms that are critical to system functionality should be available at multiple locations, allowing redundant means of manual and automatic sampling.
- **Discharge** – Suspension of wastewater treatment due to system failure, maintenance, or overload should be accommodated by means to reroute effluent, either to alternative discharge locations or the convention sewage infrastructure.

### Responsibility for Long-term Ownership and Maintenance

While system failure is a concern for any owner of an onsite treatment system, long-term responsibility for the maintenance of system ultimately affects the regulating authority. Consequently, the risks of permitting the use of onsite treatment are minimized when an owner is a stable and long-term occupant of the property. By avoiding the uncertainty of whether or not the next owner will maintain the same quality control measures, this better ensures consistent operation and maintenance throughout the life of the system.

Risks can also be mitigated at the design and construction stage through a long-term maintenance plan. Comprehensive labeling of system components and documentation of procedures will ensure consistent knowledge transfer between facility operations staff. Third-party commissioning of systems on an ongoing basis may better ensure long-term functionality and adherence to the design intent. Assurance of these measures may be demonstrated through contracted work.

### Compliance with Future Regulation

While any treatment system may be designed to meet regulations for water quality or safety standards, future regulations may change to be more stringent. This is a risk in the permitting of user-owned treated systems, as they may need future upgrades or retrofitting. However, onsite treatment systems benefit from the value of small scale; upgrades 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 process to design systems that are effectively “future-proof”.

## How does onsite treatment affect infrastructure development?

Urban growth and development is a positive economic indicator, yet an ongoing challenge for municipal water utility providers. As population increases in any region, measures must be taken to either control or accommodate the associated water demand. Seattle, for example, has built a legacy of water conservation. Despite steady increases in population, water consumption in the region peaked in the 1980s. This was a result of combined factors of drought and regulation, but was accomplished primarily through conservation measures.<sup>8</sup>

Onsite treatment is in fact one means of reducing future loads to the municipal system through conservation. Onsite

treatment can potentially reduce water consumption in modern buildings by 48-95%, and reduce the discharge of wastewater by 60-95%.<sup>9</sup> Additionally, onsite treatment creates decentralized capacity, which helps mitigate the peak condition impacts of heavy rainfall or drought.

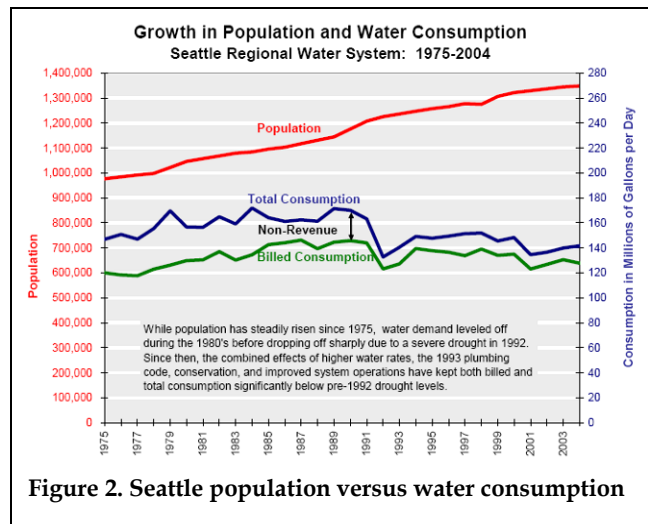


Figure 2. Seattle population versus water consumption

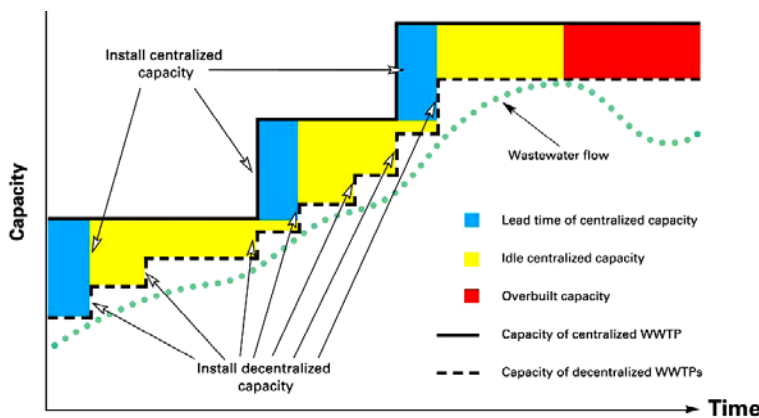


Figure 3. Matching future demands with centralized vs. decentralized capacity. Source: Rocky Mountain Institute, "Valuing Decentralized Wastewater Technologies"

treatment can potentially reduce water consumption in modern buildings by 48-95%, and reduce the discharge of wastewater by 60-95%.<sup>9</sup> Additionally, onsite treatment creates decentralized capacity, which helps mitigate the peak condition impacts of heavy rainfall or drought.

The most significant advantages of onsite treatment, however, are associated with infrastructure expansion. Expansion of treatment capacity typically requires the periodic installation of large municipal treatment facilities with long lead times of funding and construction. To accommodate this pace of development, new facilities are designed to meet future demands and are consequently "overbuilt" with idle capacity. For example, in Washington State, Snohomish and King counties are currently building a facility - Brightwater - that will phase in an additional 54 million gallons of treatment capacity per day over a 30-40 year period.<sup>10</sup> Beyond the burdens of capital cost, new capacity at this scale has the risk of creating a short term disincentive for onsite treatment or conservation in order to validate the investment. Alternatively, onsite treatment systems are built in a decentralized growth model where capacity is added as it is needed, thus scaling to match demand more directly.

Small scale systems have additional benefits that relate to localized treatment. For example, onsite treatment can be tailored to remove specific contaminants at the source rather than transferring them to a central treatment facility. This may reduce municipal treatment demands in areas of imbalanced contaminant loading. Additionally, the risks of failure for a single onsite system are less significant than those at a central facility, meaning liability can be shared between the utility and site owner.

<sup>8</sup> Seattle Public Utilities, "Demographics and Water Use Statistics", Nov. 29, 2007, [http://www.seattle.gov/util/About\\_SPU/Water\\_System/History\\_&\\_Overview/DEMOGRAPHI\\_200312020908145.asp](http://www.seattle.gov/util/About_SPU/Water_System/History_&_Overview/DEMOGRAPHI_200312020908145.asp).

<sup>9</sup> Edward Clerico, "The Future of Water Reuse in America," October 30, 2007, 2

<sup>10</sup> King County, Wastewater Treatment Division "Brightwater Wastewater Treatment Plant", July 14, 2006, December 21, 2007, <http://dnr.metrokc.gov/WTD/brightwater/facilities/treatment-01.htm>.

## How are costs and benefits leveraged?

Promoting onsite treatment systems effectively transfers the services of water supply and treatment from the municipal level (utility) to the local level (owner). This allows utilities to transfer a portion of the capital costs associated with expanded capacity to the individual project owner. However, to leverage this acceptance of upfront costs, owners that install onsite treatment systems are also provided with certain incentives for reducing demands to the municipal infrastructure. This concept of a cost and benefit shifting strategy, as shown below, should be central to the incentive structure of a water utility provider.

	Capital Costs	Expenses	Revenue
Utility	New central treatment facilities Water delivery infrastructure	Operations & maintenance	User fees (rates and permits)
		Insurance	System Development Charges (utility connection fees)
		New connections, Repairs & rebuilds	Taxes
↓ ↓ ↓ <i>Costs, Expenses, and Revenue Shifted from the Utility to the Owner</i>			
Owner	Onsite treatment system Duplex plumbing Collection systems	Operations & maintenance	Reduced water use & discharge fees, reduced permitting fees
		Insurance	Reduced connection fees
		Repairs & rebuilds	Grants/incentives

**Table 5. Transferring costs and benefits from utility to owner**

To promote the installation of new onsite wastewater treatment systems, the revenue provided to the owner (in the form of reduced fees and incentives) must be significant enough to offset the capital costs and long-term expenses of a system within a reasonable timeframe. Conversely, the revenue that is surrendered to the owner as incentives must be validated to the utility through the actual offset of water demands and infrastructure development costs. Thus, the balance of cost and benefit between utility and user is dependant on numerous variables that fluctuate over time, among them being system costs, treatment technology, program budgets and development trends.

Beyond these financial tradeoffs, fostering knowledge transfer is another important opportunity. As individual owners become operators of treatment facilities, a utility can provide extensive technical support - staff training, information resources, etc. - to make the adoption of onsite treatment less daunting. These services may present challenges of expense, but will likely result in unforeseen benefits; by creating a community that shares knowledge resources, technological, and strategic innovations may result from numerous, nimble parties that collectively solve issues related to regional wastewater treatment.

## How do onsite treatment systems receive financial support?

External funding sources are often critical to the feasibility of pursuing onsite wastewater treatment. Municipal wastewater treatment plants often receive public financing for capital improvements, operations and maintenance. In recent years the greater acceptance of onsite wastewater treatment technologies has resulted in public funding for decentralized treatment systems. Financial support is primarily dispersed in the following ways:

- **Incentives** – reduced permitting costs, connection fees, utility fees or other indirect expenses
- **Grants** – funding given to projects that align to water resource initiatives
- **Loans** – borrowed funds to offset capital costs

Funding of onsite treatment is available through regulatory agencies at the local, state, and federal level. Opportunities for support are constantly changing as divisions of government adopt new initiatives; projects are awarded funding by demonstrating alignment to water resource initiatives that are relevant to the site. Below are examples of the funding available in the Seattle region at each regulatory level.

**Local incentives** are provided through county or regional water resource regulatory bodies as well as city utility providers. These incentives typically reward demonstration projects that showcase water resource preservation that is targeted towards local water issues.

- **Seattle Public Utilities Watersmart Program** – Qualified technologies are eligible for \$10 per gallon of water saved per day, subject to performance verification.  
[http://www.savingwater.org/business\\_construction.htm](http://www.savingwater.org/business_construction.htm)
- **King County Waterworks** – Grants up to \$50,000 for projects that protect or improve natural water resources. The reuse of biosolids and reclaimed water is specifically referenced.  
<http://dnr.metrokc.gov/wlr/pi/grant-exchange/waterworks.htm>
- **King County Green Building Grants** – \$15-25,000 grants available based on the LEED certification level achieved. Onsite wastewater treatment is covered in this program.  
<http://www.metrokc.gov/dnrp/swd/greenbuilding/incentives>

**State incentives** are provided through environmental regulation bodies that manage state-level water resources. These incentives are targeted towards projects that address community or watershed-level issues.

- **Washington Department of Ecology, Reclaimed Water Grants Program** – Grants provided to local governments within the Puget Sound area that complete reclaimed water projects. Funding is targeted to areas with water shortages or projects that address ecosystem restoration. This may serve as an indirect funding source for onsite wastewater treatment systems within a qualified location.  
<http://www.ecy.wa.gov/programs/wq/funding/funding.html>

**Federal incentives** are provided through the U.S. Environmental Protection Agency. Funding is routed through state agencies to support wastewater initiatives.

- **Clean Water State Revolving Fund** – Federal low or no-interest loans that support state level water initiatives. This includes indirect funding of public-private partnerships. Funding is available for biosolids processing and water reuse; both potential components of onsite treatment systems.  
<http://www.epa.gov/owmitnet/cwfinance/cwsrf>

## Next steps

Seattle Public Utilities, in cooperation with the City of Seattle, will continue to explore opportunities to support the implementation of onsite wastewater treatment systems as well as other technologies that realize the economic, social, and environmental benefits of water reuse. Pursuing these strategies will present unique opportunities and challenges in coordinating the complementary efforts related to water management within the City of Seattle. Thus, a critical step to initiating these efforts will be to engage the related departments within the City of Seattle in a high level dialogue on the future of water management in the region. Questions to stimulate this discussion may include the following:

- What are the future water demands in the City of Seattle and Puget Sound region?
- What is the current state of water regulations in Seattle? How do these regulations compare to other regions or countries?
- What is the current state of water treatment technology? What technologies are on the horizon?
- What level of interest do local developers have in onsite water treatment and other reuse technologies? What economic barriers or opportunities exist?

## Additional Resources

### Websites:

- EPA - Wastewater - Technology Fact Sheets: <http://www.epa.gov/owm/mtb/mtbfact.htm>
- National Small Flows Clearinghouse: [http://www.nesc.wvu.edu/nsfc/nsfc\\_links.htm](http://www.nesc.wvu.edu/nsfc/nsfc_links.htm)
- Vancouver Convention & Exhibition Centre: [http://www.gewater.com/pdf/Case\\_Studies\\_Cust/Americas/English/CS\\_VANC\\_COMWW\\_1206\\_NA.pdf](http://www.gewater.com/pdf/Case_Studies_Cust/Americas/English/CS_VANC_COMWW_1206_NA.pdf)

### Articles/Papers:

- Rocky Mountain Institute (RMI), "Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques": <http://www.rmi.org/sitepages/pid172.php>.
- "Water from Water: Closing the Cycle": [http://www.siwi.org/downloads/WF%20Magazine/Water\\_Front\\_April\\_2001.pdf](http://www.siwi.org/downloads/WF%20Magazine/Water_Front_April_2001.pdf)
- H. Yamagata, M. Ogoshi, Y. Suzuki, M. Ozaki and T. Asano, "Onsite water recycling systems in Japan," *Water Supply*, Vol. 3, No. 3: 149-154.

### Books:

- Ronald W. Crites and George Tchobanoglous, *Small and Decentralized Wastewater Management Systems*, (McGraw Hill, 1998)

### Manufacturers:

- MBR: Intelligent Community Services (ICS): <http://intelligentcommunityservices.com/>
- ZENON Membrane:
  - GE Water Process Technologies: [http://www.gewater.com/industries/green\\_building/](http://www.gewater.com/industries/green_building/)
  - Apsco, Inc. (membrane technology): <http://www.apsco-inc.com/>
- Living Machine: [http://www.oberlin.edu/ajlc/systems\\_lm\\_1.html](http://www.oberlin.edu/ajlc/systems_lm_1.html)

## Case Study: OHSU Center for Health and Healing



Oregon Health & Science University (OHSU) recently expanded its campus to include the Center for Health & Healing building, which includes several different types of university operations, including biomedical research, clinical space, outpatient surgery, and educational space.<sup>11</sup> The building has received LEED-NC Platinum certification, the first medical and research facility in the U.S. to have achieved this rating. The building features several sustainable design features; this summary highlights the water strategies.

### *Facts*

**Building Type:** Medical office and wellness building

**Building Size:** 400,000 square feet, 16-story

**Location:** Portland, Oregon

**Completed:** 2006

**Treatment system:** Membrane Bio-Reactor (MBR) wastewater treatment facility deployed by ICS

**Capacity:** 30,000 gallons per day

**Cost of wastewater treatment system:** \$1.2 million to build and the simple payback from both initial and operational savings is 1.8 years<sup>12</sup>

**LEED Rating:** LEED-NC Platinum

### Water Strategies

- Onsite Membrane Bio-Reactor (MBR) wastewater treatment facility treats approximately 30,000 gpd (effluent meets the highest standards for reuse, established by the State of Oregon Department of Environmental Quality, Level IV)
- 100% onsite rainwater reuse system that harvests and stores rainwater in a 22,000-gallon fire-suppression tank; rainwater reclamation system keeps all rainwater on site<sup>13</sup>
- 73% of water used in building comes from captured or reclaimed water, reducing water bills to less than \$100 per month<sup>14</sup>
- Reclaimed water from rainwater, ground water and effluent is used for toilets, landscape irrigation, and the cooling tower
- Lower-water-using fixtures for sinks, toilets, urinal and showers

### Challenges

- Accurately predicting wastewater inflow from the building for sizing the system capacity
- Design for system redundancy and extra capacity to demonstrate failure prevention
- Negotiation of liability for onsite discharge with the City of Portland

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<sup>11</sup>"Fast Facts: The Center for Health and Healing at OHSU's River Campus," Interfacing Engineering, Nov. 30, 2007, [http://www.ieice.com/pdfs/news/press-kit/OHSU\\_case-study.pdf](http://www.ieice.com/pdfs/news/press-kit/OHSU_case-study.pdf).

<sup>12</sup>"ICS Creates Wastewater Solution for OHSU Medical Building," *WaterWorld*, Jun. 21, 2006, Nov. 30, 2007, <http://www.pennnet.com/articles/258486>.

<sup>13</sup>Cascadia Region Green Building Council, OHSU Center for Health & Healing, Dec. 7, 2007, <http://www.cascadiagbc.org/lbc/competitions/2007-greenbuild-lbc/ohsu/ohsu-1/>.

<sup>14</sup>Katie Zemtseff, "3 NW Project Win Awards for 'Living Buildings'," *Seattle Daily Journal of Commerce*, Nov. 28, 2007, Nov. 29, 2007, <https://www.djc.com/news/en/11195293.html>.



## Case Study: The Solaire



The Solaire apartment building is the “first green residential high-rise building that incorporates advanced materials, energy conservation and water reuse in an urban setting.” The building has several sustainable design features, including an onsite water recycling system, which was the first system built inside a multi-family, residential building in the U.S.<sup>15</sup>

### *Facts*

**Building Type:** Multi-unit residential

**Building Size:** 357,000 square feet, 27-story

**Location:** New York City, New York

**Completed:** August 2003

**Treatment system:** ZENON Membrane Solutions from GE Water & Process Technologies

**Treatment Plant Size:** 700 sq. feet

**Capacity:** 25,000 gallons per day

**LEED Rating:** LEED-NC Gold

### **Water Strategies<sup>16</sup>**

- Onsite wastewater treatment system recycles 100% of the building’s wastewater for use in cooling towers, toilets, and 5,000 gallons per day are provided to the adjacent public park.
- 50% - 75% less potable water is needed from the municipal water supply than would be used in a conventional apartment building, and no potable water is used outdoors.
- Stormwater runoff (approximately 170,000 gallons of water per year) is collected in a storage tank in the building’s basement to be used for irrigation of the rooftop gardens.
- The roof system was designed to retain nearly 70% of rainwater for eventual use by the plants.
- Water-efficient fixtures and toilets

### **Additional Information:**

- USGBC Case Studies: <http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=273>
- GE Water & Process Technologies, Green Building: [http://www.gewater.com/industries/green\\_building/](http://www.gewater.com/industries/green_building/)

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<sup>15</sup> “Solaire Apartments, Battery Park,” GE Water & Process Technologies, 2006, Nov. 21, 2007, [http://www.gewater.com/pdf/Case\\_Studies\\_Cust/Americas/English/CS\\_BATT\\_COM\\_WW\\_1106\\_NA\\_GE\\_Logo.pdf](http://www.gewater.com/pdf/Case_Studies_Cust/Americas/English/CS_BATT_COM_WW_1106_NA_GE_Logo.pdf).

<sup>16</sup> “20 River Terrace - The Solaire,” U.S. Green Building Council, December 4, 2007. <http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=273>.

## Case Study: Urban Onsite Treatment in Japan

In the U.S., reclaimed wastewater is mainly used for agricultural and landscape irrigation. For example, "In California, where the largest number of wastewater reclamation and reuse facilities in the U.S. have been developed, at least 330 million m<sup>3</sup> of municipal wastewater is currently reused, which is about 8% of the generated total."<sup>17</sup>

In Japan, however, reclaimed wastewater has gained wide acceptance for non-potable use in urban areas. Each year, approximately 130 onsite wastewater recycling systems are installed in Japanese cities. These systems were first installed in the 1960s and as the economy strengthened in the 1980s, the number of these systems grew as well.<sup>18</sup>

Japanese regulation for onsite wastewater treatment systems is primarily driven by the intent to promote water conservation and thereby reduce demands on public sewerage systems. "The Tokyo Metropolitan Government established a regulation in 1984 requiring newly constructed large buildings to install onsite water recycling system or take reclaimed wastewater from the regional water recycling system if floor space exceeds 30,000 m<sup>2</sup> or using more than 100 m<sup>3</sup>/day of non-potable water."<sup>19</sup> In 1993, to further conserve rainwater and prevent flooding, the government also tried to pass regulation to install onsite rainwater recovery and detention systems.

According to a survey of 23 wards of the Tokyo Metropolitan Government District, "on average about 61% of non-potable water demands were met with reclaimed water and the rest was supplemented by tap water from the municipal water supply." Reclaimed water in the buildings that were surveyed was only used for non-potable uses, primarily for toilets.

In Japan, onsite water recycling systems are providing a safe and economical alternative to wastewater treatment with the survey reporting "no serious accident involving human health by accidentally ingesting reclaimed water" and only a few instances of technical problems and odor in some buildings.<sup>20</sup>

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<sup>17</sup> Takashi Asano, "Water from Water: Closing the Cycle," Stockholm Water Front, Apr.1, 2001: 4 -6, Nov. 30, 2007, <http://www.siwi.org/downloads/WF%20Magazine/Water%20Front%20April%202001.pdf>.

<sup>18</sup> H. Yamagata, M. Ogoshi, Y. Suzuki, M. Ozaki and T. Asano, "Onsite water recycling systems in Japan," Water Supply, Vol. 3, No. 3: 149-154.

<sup>19</sup> Yamagata, et. al., 150

<sup>20</sup> Yamagata, et. al., 154