San Francisco
Water Power Sewer
Services of the San Francisco Public Utilities Commission








Onsite Water Reuse System Innovation Projects

San Francisco Public Utilities Commission
September 2021

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The circulating playground water feature “Amaoto No Komichi” (photo source: www.city.hiroshima.lg.jp/site/gesuido/2638.html)

The green roof reduces runoff, insulates the building, and is irrigated by the onsite reuse system (image courtesy of NSU)

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The San Francisco Public Utilities Commission (SFPUC) is committed to diversifying our water supply portfolio through the development of local water supplies. Our Conservation, Recycled Water, Groundwater, and Onsite Water Reuse Programs have already had significant success in increasing our local water supply reliability, making us less vulnerable to disrupted service from drought and natural disasters. Our newest addition to this list of pioneering programs, the Innovations Program, will continue to build upon our efforts to develop local water, while also furthering our goal of exploring new ways in which we can conserve and reuse water, recover resources, and diversify our water supply.

This report highlights developments in San Francisco, as well as other national and international projects, that have incorporated innovative technologies to reuse water and recover resources. Opportunities exist for buildings to not only recycle water onsite, but become vehicles for resource recovery, tapping into the potential for thermal heat, nutrient and biosolids recovery as well as a potential source of drinking water. These projects are providing multiple benefits, encouraging testing of forward-thinking ideas, and promoting opportunities to develop partnerships. Information about San Francisco's Innovations Program is available at **sfpuc.org/programs/future-water-supply-planning/innovations**. More information about San Francisco's Onsite water Reuse Program is available at **sfpuc.org/construction-contracts/design-guidelines-standards/onsite-water-reuse**.

Treatment system RO skid (image courtesy of Seismic Brewing)

Vashantek and Tarabo Urban Decentralized Wastewater Collection and Treatment Systems – Dhaka Slums, Bangladesh

Vashantek community post installation (image courtesy of Water1st International)

Project Status: Completed

Project Size: Collection and Treatment System for 575 Households

Alternate Water Sources:
- Raw Sewer (Blackwater) from Community Toilets

End Uses:
- Treated Discharge to Environment (No Direct Reuse)

Treatment System Size: Anaerobic Upflow Filter Design Flow 850 Gallons/Day. Empty Bed Contact Time Estimated 9 Days

Drivers: To Improve Living Conditions with a Gravity Flow Collection System Designed for Low Capital Costs, Easy Installation, and Local O&M

System Cost: USD $31,800

Annual O&M Cost: USD $480 (Estimated)

Project Description:

The non-profit Dushtha Shasthya Kendra, which works to reduce poverty across Bangladesh, teamed up with Water 1st International and the local government to finance and build two decentralized wastewater treatment systems (DEWATS) with small anaerobic upflow wastewater treatment plants in the slum communities of Vashantek and Tarbo in Dhaka, the capital city of Bangladesh. These wastewater systems demonstrate remarkable progress in a city where 80% of the 18 million inhabitants are disconnected from any kind of wastewater collection system.

These wastewater treatment systems provided a vast improvement to the quality of life for the 640 residents of Vashantek and the 1,750 residents of Tarabo. Prior to the systems being put in place, the discharge of untreated sewage to local areas and water bodies was hazardous to human and environmental health and caused a fowl stench. The systems require no pumping or energy inputs and are providing significant treatment with over 40% reduction in COD, 50% reduction in phosphorous, and over 80% reduction of TSS.

Drivers For Onsite Water Reuse:

The improvement in the local area living conditions is striking when compared to pre-installation conditions. The sewage smell is noticeably absent! During a February 2018 site assessment, when explaining why they continued to maintain the collection system, community members were emphatic that the improvement in community living conditions was nothing short of miraculous.

Ownership Model:

The DEWATS systems are governed and maintained by the local community. Ongoing baseline water quality data is monitored to determine the filter replacement schedule.

Role of Local Government:

Support to facilitate the construction and operation.

Tarabo anaerobic treatment at work (image courtesy of Water 1st)

Project Cost and Funding:

The $31,800 project was funded by Water 1st International, a Seattle based non-profit that works to implement clean water supply and sanitation services to the world's most vulnerable communities.

Lessons Learned:

While the treatment portion of these wastewater systems is certainly interesting and appears to be working, the heart of this project is the successful implementation of a piped wastewater collection system in one of the most challenging settings on the planet and continued operation of this system by the poorest of the poor. Success here is determined by the drastic improvement in local living conditions, continued maintenance and governance of the system by the local community, the resiliency of the system to recover from the monsoon conditions (collection and treatment), and the fact that ongoing baseline water quality data is being collected and is used to determine filter replacement.

The Vashantek and Tarabo experiences provide a proof of concept for DEWATS using locally based management as a viable and implementable approach to addressing the health, livability and environmental issues surrounding the current crisis of untreated and unmanaged human fecal waste in urban areas of the developing world. This approach allows for implementation based on a wide variation in funding. The DEWATS allows future incorporation of the facilities into larger solutions and for staged treatment options. The DEWATS concept is compatible with potential reuse options or incorporation of future toilet modifications.

Reference: Steve Deem, Water 1st International (stevedeem@water1st.org)

Lubhu Fecal Sludge Treatment Plant – Lubhu, Nepal

A view of the treatment plant's prefabricated modules (photo courtesy of ENPHO)

Project Status: Completed

Project Size: 3,229 Square Feet

Alternate Water Sources:
- Blackwater

End Uses:
- Irrigation
- Soil Amendments
- Biogas

Treatment System Size: 226 Gallons/Day

Potable Water Use Reduction: 50%

Drivers:
- Public Health (Manage Sewage)
- Pilot Demonstration Project to Demonstrate the First Prefabricated FSTP Modules in Nepal for Fecal Sludge Treatment
- Optimum Resource Recovery: Reuse of All Possible End Products Closing the Sanitation Loop

System Cost: USD $70,000

Annual O&M Cost: USD $2,320

Owner: Nepalhilfe Beilngries, Kathmandu

Project Description:

The 3,229 square foot Fecal Sludge Treatment Plant (FSTP) located in Lubhu, Nepal was built by the Environment and Public Health Organization (ENPHO) in collaboration with Mahalaxmi Municipality, BORDA, the CDD Society, and Nepalhilfe Beilngries. The FSTP piloted the use of prefabricated modules for construction, and is designed for resource recovery, with a treatment process that generates water suitable for irrigation, transforms bio-solids into soil fertilizers, and captures biogas that can be used for cooking. As the first of its kind in Nepal, the FSTP provides a model for how waste can be transformed into valuable resources.

Drivers for Onsite Water Reuse:

The primary objective of the project was to safeguard the health of people residing in relief camps built during emergency response to a devastating earthquake on April 25th, 2015. Ten such camps were built in Lubhu, situated in Mahalaxmi Municipality of Kathmandu Valley, Nepal. These camps were provided with on-site sanitation systems to improve sanitation conditions and safeguard the health of the people residing in the camps. But as time passed the emergency latrines filled up and overflowed with fecal sludge, posing a public health risk. Without a fecal sludge treatment plant in Kathmandu Valley, the unsafe disposal of the fecal sludge was inevitable.

Additionally, this project was intended to showcase a successful model of resource recovery from fecal sludge. The Nepalhilfe Beilngries' orphanage, which operates a small farm adjacent to the FSTP, utilizes recovered water for crop irrigation and treated bio-solids for soil fertilizer.

Ownership Model:

The FSTP is owned, operated, and maintained by Nepalhilfe Beilngries, Kathmandu, with technical support of the ENPHO and other administrative support of Mahalaxmi Municipality. Nepalhilfe Beilngries has appointed a caretaker of the facility who was trained in O&M, a sanitation safety plan, personal hygiene and safety measures, and end-product reuse.

Role of Public Utility in Project:

The private companies that provide fecal sludge emptying and transport services pay a tipping fee for desludging into the plant. ENPHO regularly provides technical support and Mahalaxmi Municipality provides administrative assistance.

Project Cost and Funding:

The total project cost $70,000 and was implemented with the financial support from the CDD Society.

Lessons Learned:

The most typical challenges for treatment plants in Nepal are land acquisition and successful O&M. A key lesson from this project was that resource recovery can be sufficient incentive for people and the community to resolve land issues and operate the plant effectively.

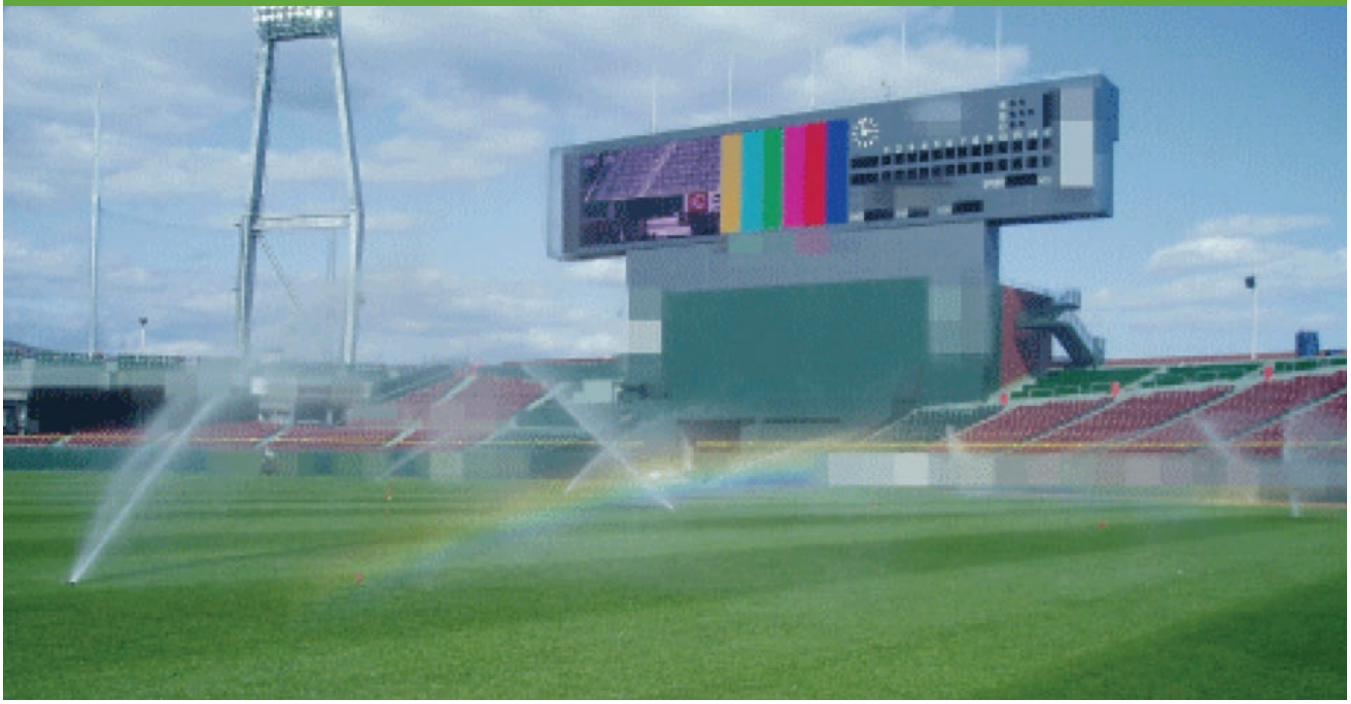
The land where the FSTP was sited was originally intended to farm a year-round supply of food for the orphanage. However, water scarcity and the expense of fertilizers made it impossible to farm the land year-round as planned by Nepalhilfe Beilngries. Since one of the provisional designs of the FSTP was to recover water and bio-solids for farming, Nepalhilfe Beilngries agreed to provide the land for the plant.

The simplicity of the FSTP's design allows for proper and regular O&M in the absence of highly trained labor. Because the treatment plant requires fecal sludge as the core feeding material to operate, it is critically important to the continued operation of the plant that the people desludging the latrines have adequate incentive to do so. Engaging all stakeholders was key to the project's success.

Reference: Rajendra Shrestha, Environment and Public Health Organization (ENPHO)
(rajendra.shrestha@enpho.org)
(977-1- 5244641, 5244051)

The orphanage farm utilizes recycled water for irrigation and treated bio-solids for soil fertilizer (photo courtesy of ENPHO)

Mazda Stadium – Hiroshima, Japan



The baseball field's rainwater fed sprinkler irrigation system (photo source: www.city.hiroshima.lg.jp/site/gesuido/2638.html)

Project Status: Completed

Project Size: 3 Acres (Size of Baseball Field)

Alternate Water Sources:
- Rainwater

End Uses:
- Toilet Flushing
- Water Feature
- Irrigation

Treatment System Size: Not Available

Potable Water Use Reduction:
1,630,000 Gallons/Year (Measured In 2019)

Drivers:
- Water Use Cost Savings
- Flood Control Measures

System Cost: $2,040,000

Annual O&M Cost: $13,900 for Disinfection and Water Feature O&M

Owner: Hiroshima City

Project Description:

The Mazda Zoom-Zoom Stadium, home to the baseball team the Toyo Carp in Hiroshima, Japan, underwent a massive renovation to incorporate an onsite regional stormwater project which includes a rainwater reuse system. Completed in 2019, the renovation installed a subsurface reservoir below the baseball field to collect stormwater runoff from the stadium and surrounding area, managing a total drainage area of 128 acres. As a multi-purpose water reuse effort, the project won the "Circulation Michi Sewerage Award" from the Water Division of the Ministry of Land, Infrastructure, Transport and Tourism. About 7% of the reservoir (264,000 gallons) is segmented for the rainwater reuse system, while the other 3.5 million gallons of storage capacity prevent stormwater from inundating the sewer system, most critically preventing flooding of the nearby Hiroshima Station, which has an underground plaza and passageways.

The rainwater treatment system disinfects the runoff with chlorine and passes it through a filtration system before it is re-used for the baseball field's sprinkler irrigation, for the stadium's toilet flushing, and for a circulating water feature outside the stadium called the "Amaoto no Komichi". The "Amaoto No Komichi" has educational signage about sustainable stormwater management, is designed for children to play in, and is lit up at night.

Drivers for Onsite Water Reuse:

A key driver for the rainwater reuse system was to reduce the stadium's water charge.

Ownership Model:

The stadium is owned by Hiroshima City. The O&M of the rainwater reuse system is outsourced to Hiroshima Toyo Carp Co., LTD.

Role of Public Utility in Project:

The Sewerage Bureau of the Hiroshima City Government took a strong initiative to install the stormwater reservoir under the baseball stadium because there is such limited space for large scale stormwater control measures in the densely urban area. Without these measures in place, heavy rainfall over 0.78 in/hr exceeds the drainage capacity of the sewer and would result in flood damages.

Project Cost and Funding:

The total project cost was $2,040,000, half of which was subsidized by the Japanese National Government, while half was paid for by municipal bonds and the allocation of local tax funds.

Lessons Learned:

When there is a series of games with full stadiums of spectators, the supply from the water reuse system cannot meet the toilet flushing demand.

Reference: Hiroshima City Government, Sewerage Bureau, Facility Management Department, Planning and Management Section (g-keikaku@city.hiroshima.lg.jp)

The circulating playground water feature "Amaoto No Komichi" (photo source: www.city.hiroshima.lg.jp/site/gesuido/2638.html)

Seismic Brewing Company – Santa Rosa, CA

Seismic Brewing facility (image courtesy of Seismic Brewing)

Project Status: Completed

Project Size: 15,000 Square Feet

Alternate Water Sources:
- Industrial Process Water

End Uses:
- Boiler Feed
- Tank Cleaning
- Motor/Gearbox Cooling
- Facility Washdown

Treatment System Size: 8,000 Gallons/Day

Potable Water Use Reduction: 50%; 300,000 Gallons/Year (In 2020; Expected to Increase to 500,000 Gallons in 2021 and Continue to Grow with Brewery)

Drivers: Sustainability Goals

System Cost: Not Available

Annual O&M Cost: Not Available

Owner: Seismic Brewing Company

Project Description:

Seismic Brewing's water treatment and reuse system was installed in 2016 as the brewery completed construction. The system treats wastewater from the brewing process so it can be reused onsite, helping to reduce the brewery's potable water demand. In the brewing industry, the average water consumption is 7 gallons of potable water per every gallon of beer brewed, whereas at Seismic it is now just 2.7 gallons of potable water per every gallon of beer brewed. Treated wastewater is reused for non-potable processes such as facility washdown, boiler feed, cooling motor gearboxes, and tank cleaning.

In developing the brewing facilities, Seismic pursued a holistic water treatment approach and undertook groundbreaking efforts to reduce water consumption. A majority of the equipment was provided by Cambrian Innovation, Toray Industries, ClearBlu Environmental, and Water Works Inc, with the engineering integration and operation of these components done by the brewery itself. The system incorporated Cambrian's EcoVolt Mini, a system specifically designed for small and midsize food and beverage producers. The Ecovolt is a highly automated system able to provide advanced wastewater treatment. To polish the water after filtration, it undergoes a high-recovery reverse osmosis process and UV disinfection. Other key components of the water treatment system are a primary screening unit for solids removal, an equalization tank, and a "headworks" unit, which is effectively the system's control room.

An additional benefit of the onsite treatment and reuse of the brewery's wastewater is the avoidance of additional City sewer fees for industrial process water treatment.

Drivers for Onsite Water Reuse:

Seismic Brewing was founded with sustainability, including water conservation, as a core principle. The Seismic team recognized that to brew as responsibly as possible they would need to pursue an ambitious approach to maximizing water and energy efficiency. The onsite water treatment and reuse system, coupled with various clean energy initiatives, help to reduce the brewery's resource and carbon footprint.

Ownership Model:

Seismic Brewing Company is the sole owner and operator of its water treatment and reuse system.

Role of Public Utility in Project:

The public utility encouraged the project's efforts but didn't play a significant role in the development of the reuse system. By avoiding the one-time connection and demand fees that would normally be paid by a larger water customer, Seismic was able to greatly offset the cost of the system.

Lessons Learned:

Breweries are excellent applications for water reuse systems due to high water demand and numerous suitable uses for non-potable water. With that said, most craft breweries have a very high barrier for entry into on-site water treatment and/or reuse. Cost and complexity of these systems are still very high for most small breweries, but it is slowly becoming more approachable. The system at Seismic Brewing will hopefully serve as a test case and successful example for other small craft breweries to follow, especially given the increasing drought conditions in California.

Reference: Andy Hooper, Seismic Brewing Company (ahooper@seismicbrewingco.com)

Treatment system RO skid (image courtesy of Seismic Brewing)

The New School – New York City

The New School's University Center (image courtesy of NSU)

Project Status: Completed

Project Size: 375,000 Square Feet

Alternate Water Sources:
- Blackwater
- Graywater
- Rainwater

End Uses:
- Toilet Flushing
- Cooling Tower Make-Up
- Irrigation
- Laundry

Treatment System Size: 40,000 Gallons/Day

Potable Water Use Reduction: 74%

Drivers: Education, Sustainability Goals, ROI in Cost Savings, LEED Certification

System Cost: Not Available

Annual O&M Cost: Not Available

Owner: The New School

Project Description:

Working with Natural Systems Utilities (NSU), the New School installed water conservation fixtures and an on-site water treatment and recycling system during the construction of its University Center. Located on 5th Avenue, the University Center stands 16-stories, and was opened to the public in 2014. Its water systems were designed to reduce water use by 74% and reduce discharge into the combined sewer by 89%. All of the building's wastewater is collected and treated at the University Center including water from toilets, sinks, showers, laundry, etc. Stormwater is also included as a source of reclaimed water after it is detained by the vegetated green roofs. The University Center contains one of the largest operating in-building water recycling systems in New York City with a treatment capacity of 40,000 gallons per day, and it is one of the first buildings approved to reuse treated water for laundry. Other uses include toilet flushing, irrigation of the green roof, cooling tower make-up, and sidewalk maintenance. The University Center is LEED Gold certified and achieved every point in LEED's water efficiency category.

The water recycling system consists of a membrane bioreactor followed by a multiple barrier approach for disinfection. The bioreactor is an activated sludge system with membranes that have an effective pore size of 0.4 microns. The disinfection system consists of an ozone generation and contacting system, used for oxidation and color removal, followed by an ultraviolet light system for additional disinfection. Finished water in the storage tank is circulated through the ozone and UV systems to maintain the level of disinfection. Surplus raw wastewater and residual biosolids are discharged to the city sewer system. Automatic potable water fill valves at the water storage tanks ensure an uninterrupted supply of water. In this way, there is a backup system to provide water service in case the recycling system is out of service for maintenance or repair. A computerized system automates control of the entire process.

Drivers for Onsite Water Reuse:

Many communities worldwide are approaching, or have already reached, the limits of their available water supplies. Water demand exceeds sustainable supply in many areas and the current practices of diversion, consumption, use, and disposal are depletive and destructive. The New School University adopted a “water fit for purpose” strategy to address this challenge where all sources of water were considered and all opportunities to reduce water use were identified.

Ownership Model:

The system is owned by The New School and NSU designed, built, and has operated and maintained the system since construction was completed.

Role of Public Utility in Project:

New York City played an integral role in this water reuse system’s permitting and approval process. The onsite system is backed up by public infrastructure, which allows the discharge of biosolids into the city sewer. This is mutually beneficial because it eliminates the need for pumping and hauling while the system’s aerobically active biomass provides in-pipe treatment and organics to the City’s sewage system during dry weather conditions.

Project Cost and Funding:

The project was privately funded, and qualifies for the Comprehensive Water Reuse Program rates which reduce water and sewer fees from the City of New York by 25%.

Lessons Learned:

- Previous installations paved the way for laundry to be added as an approved use for non-potable water, ultimately leading to a higher percent reduction in water use and sewer contribution.
- Getting involved early in a project is key to being successful. This will allow for the system to be optimally located reducing the need for pumping, improving access to equipment, and reducing risk while improving reliability.
- Continuous improvements on headworks and influent screenings greatly improves the system’s longevity and reduces life cycle cost of downstream equipment.
- Reverse osmosis can be added as a sidestream for cooling tower reuse where source water conductivity is high.

Reference: Phil Skalaski, The Durst Organization (PSalaski@durst.org), (212) 257-6600

The onsite reuse system’s control panel (image courtesy of NSU)

The Solaire – New York City, NY

The Solaire residential tower (image courtesy of NSU)

Project Status: Completed

Project Size: 383,000 Square Feet

Alternate Water Sources:
- Blackwater
- Graywater
- Rainwater

End Uses:
- Toilet Flushing
- Cooling Tower Make-Up
- Irrigation

Treatment System Size: 25,000 Gallons/Day

Potable Water Use Reduction:
%50; 9 Million Gallons/Year

Drivers: Battery Park City Authority Green Initiatives, Sustainability/LEED Certification, Anticipated Future Cost Savings

System Cost: Not Available

Annual O&M Cost: Not Available

Owner: Albanese Organization

Project Description:

Completed in 2003, The Solaire was the country's first environmentally advanced residential high-rise tower, and the first new development to be completed in lower Manhattan following September 11th, 2001. Standing 27-stories tall, the luxury apartment building is located by the waterfront of the Hudson River in Battery Park City. The building is LEED Platinum certified, and features naturally harvested building materials, a landscaped roof terrace with herb gardens, photovoltaic panels built into the façade, electric vehicle charging stations, and a wastewater treatment and reuse system.

The project's developer, The Albanese Organization, partnered with Natural System's Utilities (NSU) to design and construct Solaire's wastewater reuse system. The system features a membrane bioreactor with ultraviolet and ozone disinfection. Treated water is reused for flushing toilets in the 293 apartment units, for cooling tower make-up, and for irrigation of the green roof and adjoining teardrop park. Over the years the system has been upgraded to reduce energy consumption, utilize online biological monitoring, and a thermal energy recovery system has been installed to achieve net zero energy water reuse.

Drivers for Onsite Water Reuse:

Inspired by New York's first "green" commercial high rise at 4 Times Square, the Battery Park City Authority (BPCA) assembled a multidisciplinary team to set environmental standards for residential development in Battery Park City. Motivated by sustainability goals, Albanese proposed this onsite water reuse system which exceeded the BPCA's requirements set forth in its environmental standards for water conservation and reuse. With rising water and sewer rates, and incentives such as the comprehensive water reuse program provided through NYCDEP, the system has begun to pay for itself.

Ownership Model:

The water reuse system is owned by Albanese Organization and NSU designed, built, and has provided operation and maintenance services since 2003.

Role of Public Utility in Project:

New York City played an integral role in this water reuse system's permitting and approval process. When the reuse system was first proposed, it was not allowed according to city code, so the BPCA staff had to reach out to the utility commissioners to advocate for the project's approval. The onsite system is connected to public infrastructure so that biosolids can be discharged to the sewer. This eliminates the need for pumping and hauling, while the City's sewer system benefits from Solaire's aerobically active biomass that provides in-pipe treatment and organics to the city sewage system during dry weather conditions.

Project Cost and Funding:

The Solaire building's total construction cost was $91.5 million. Initially, the Albanese Organization setup a venture partnership with Northwest Mutual to finance the project through a combination of debt and equity investment, however the September 11th attack in 2001 directly impacted the development site and the project's financing agreements with lenders. Albanese was the first developer to apply for and receive tax-exempt Liberty Bonds that were approved by U.S. Congress through the New York State Housing Finance Agency to aid redevelopment after the attack. Albanese estimates that its investment in environmental features added 14.5% to the project's overall costs, though some of this investment is recovered by cost savings from improved efficiencies and an environmental premium on its apartment units' rent prices. Because the onsite water treatment system reduces the building's burden on public water infrastructure, it saves somewhere between $50,000-$100,000, and these cost savings are anticipated to grow with increasing water and sewer rates.

Lessons Learned:

- Increase of overall reuse percentage by working closely with cooling tower consultants to improve water quality and ultimately allow for 100% reclaimed water to be used as cooling tower makeup.

- Reduction in energy by improving blower operations.

- Reduction of chemical consumption by eliminating the need for chlorination while implementing other forms of disinfection such as UV and Ozone.

- Incorporation of online biological monitoring

- Implementation of a patented heat recovery system designed to extract sensible heat from treated effluent and pre-heat the domestic hot water. This has resulted in a net energy neutral operation reducing the buildings overall carbon footprint. It also increases cooling tower efficiency by reducing the temperature of the make-up water. (NSU Patent # US9719704B2)

Reference: Miroslav Salon, Albanese Organization (msalon@verdesian.com), (212) 528-2200

The green roof reduces runoff, insulates the building, and is irrigated by the onsite reuse system (image courtesy of NSU)

Bullitt Center – Seattle, WA

The Bullitt Center (photo by Nic Lehoux)

Project Status: Completed

Project Size: 50,000 Square Feet

Alternate Water Sources:
- Rainwater

End Uses:
- Potable Drinking Water

Treatment System Size: 1,700 Gallons/Day

Potable Water Use Reduction:
100%; 125,000 Gallons/Day

Drivers:
To Achieve Living Building Certification in Alignment with the Bullitt Foundation's Environmental Mission, and to Lower Barriers for Constructing More Sustainable Buildings in the Future

System Cost: Not Available

Annual O&M Cost: $60,000

Owner: The Bullitt Foundation

Project Description:

The Bullitt Center has a fully operational rainwater-to-potable water system in a dense urban setting in Seattle. The building was designed, built, and operated to demonstrate what is possible, attempting to do everything right from the perspective of regenerative design, and the water system is a key component of the project. The sustainable water features at the Bullitt Center consist of three elements: the rainwater harvesting system designed to achieve "net-zero" water use and provide potable water for all building uses (including drinking water), a vacuum flush toilet system to reduce water use and wastewater production, and a graywater system to complete the hydrologic cycle by infiltrating treated water for groundwater recharge.

Rainwater is captured at the 7,000-sf roof and routed to a 56,000-gallon concrete cistern in the basement. The rainwater is sent through a vortex filter, which removes large particulates, followed by ultra-filtration in three ceramic filters with the finest removing viruses. Following this, the rainwater is also passed under ultraviolet light and through activated charcoal and a small amount of chlorine is added. Treated water is stored in two 500-gallon day-use tanks.

Graywater from sinks and showers drains into a 500-gallon storage tank in the basement of the building and then pumped up to a constructed wetland at the third-floor green roof for treatment. The graywater is circulated through a series of drip lines to allow plants to absorb nutrients, and then is released into bio-swales along the edge of the site where the water filters down through 20 feet of gravel before it reaches the water table.

Drivers for Onsite Water Reuse:

The primary driver of the building's rainwater-to-potable water system was the Bullitt Foundation's mission of safeguarding the natural environment and promoting responsible human activities and sustainable communities in the Pacific Northwest. To demonstrate this, the project pursued the ambitious "Living Building Challenge" certification that required, among other performance imperatives, that all water demands be met with onsite sources and all be treated and managed onsite.

Ownership Model:

The Bullitt Foundation owns the water system and manages the Bullitt Center. The Foundation has contracted with Water & Wastewater Services Herndon to manage the water system, performing the day-to-day operational tasks such as preventative maintenance, water quality monitoring, cross connection control, and field engineering. The operator needs special certifications as required by state regulation.

Role of Public Utility in Project:

The project required a formal agreement from the Seattle Public Utilities (SPU) to allow the formation of a new Group A public water system within its retail service area. The Bullitt Center maintains two connections to SPU service, for the fire sprinkler system and for emergency domestic supply. Prior to final approval of the water system the SPU provided potable water through the emergency domestic connection.

Project Cost and Funding:

The overall cost to construct the Bullitt Center was $28.5 million, and the estimated cost of annual O&M is $60,000.

Lessons Learned:

It was important to research and understand the relevant rules and regulations before developing the Center's water system plan because regulations, guidance, and enforcement vary by state and jurisdiction. The Washington State Department of Health (WSDOH) oversees implementation of the overarching EPA regulations and additional State regulations. It was necessary to develop a water system plan with qualified engineers and architects for WSDOH's review and approval in advance of construction.

At the Bullitt Center, the building engineer can release water stored in the rainwater cistern in advance of a storm so it can capture stormwater while it is raining and mitigate peak flows into the combined sewer. If this strategy could be implemented at scale across a system of cisterns controlled by the stormwater authority, the potential stormwater management benefits are significant.

A major challenge was that WSDOH requires National Sanitation Foundation (NSF) certification or testing to NSF standards for every part of the system that contacts rainwater before it reaches the cistern, including the solar array on the roof. If possible, finding system components that already have NSF approval would save the time and money required to test components to ensure that they meet NSF standards.

The Bullitt Center team explored the possibility of delivering safe drinking water without chlorine, but found that it is required by the federal Safe Drinking Water Act without exception, and regulatory authorities cannot grant waivers to its use.

Reference: Salley Anderson, Bullitt Foundation (sanderson@bullitt.org)

Additional Information: https://bullittcenter.org/2018/11/01/rainwater-to-potable-water-system-is-live/

Onsite reuse system (image from Gray & Osborne Inc., Consulting Engineer's Bullitt Center Water Treatment System Engineering Report)

PureWater SF – San Francisco, CA

Project Status: Completed

Project Size: 277,500 Square Feet

Alternate Water Sources:
- Blackwater
- Rainwater

End Uses: Testing and Analysis for Potential Potable Reuse Applications

Treatment System Size: 45-50% Recovery; 4,000 Gallons/Day

Potable Water Use Reduction: Research project did not provide a potable offset; however, 1:1 potable water use reduction would be anticipated with implementation

Drivers:
- Test Treatment Process Reliability
- Staff and Public Engagement
- Operator Training
- Support State and National Research

System Cost: $1.2 Million (Includes Operation And Maintenance Cost)

Owner: San Francisco Public Utilities Commission (Project & Site), The United States Bureau Reclamation (Equipment), and The Water Research Foundation (Analytical Data/Report)

SFPUC Headquarters

Project Description:

PureWaterSF was a building-scale Direct Potable Reuse (DPR) research and demonstration project aimed at better understanding the opportunities and challenges of decentralized potable reuse along with collecting data relevant for both small- and large-scale potable reuse.

The PureWaterSF treatment system train was temporarily added to a pre-existing constructed wetland system that treats blackwater and rainwater for toilet flushing at the office headquarters building of the San Francisco Public Utilities Commission (SFPUC) in downtown San Francisco. The PureWaterSF advanced water treatment (AWT) system included ultrafiltration, reverse osmosis, and an ultraviolet advanced oxidation process (UF/RO/UV AOP) to purify the tertiary recycled water effluent from the existing wetland system. The AWT train, which was designed to have a small footprint while producing high-quality water able to meet drinking water standards, was able to treat approximately 85% of the water from the wetland system. During operation, the system was online from Monday through Friday, 24 hours a day.

This research project was completed in two distinct phases. First, the treatment and monitoring system was designed and installed in June of 2018 and the system was tested and monitored for eight months through February 2019. During the second phase from June through October 2019, analytical samples of the wastewater were periodically collected at every stage of the treatment train for lab analysis of water quality parameters to verify the system's ability to meet drinking water standards and to document treatment performance. After analysis, all the water produced by the AWT was recombined with the brine and returned to the building's toilet flushing system.

Drivers for Onsite Water Reuse:

With two combined wastewater/stormwater treatment plants but no drinking water treatment plant within the City and County of San Francisco, the SFPUC is very interested in understanding and exploring the potential for DPR as a future water supply. The location and scale of this initial research project were selected for high visibility, to support project goals, and to allow for more direct management of project staff. It was advantageous to collect wastewater from a such small sewershed, which has greater variation in wastewater strength and quality, so that the treatment system's ability to handle variation could be more easily observed and the reliability of its process tested. It also provided an opportunity to train operators onsite, and to contribute to statewide data that will inform the development of DPR regulations that are to be conceived by 2023.

Ownership Model:

Designing the AWT, purchasing and installing the equipment included in the system, and testing the online monitoring system were completed by the SFPUC and its consultant with financial support from the United States Bureau of Reclamation (USBR). The second phase of the project, which included the water quality testing and analysis, was conducted with funding support from the Water Research Foundation. Each funding partner owns components of the project based on the terms of its grant agreement with the SFPUC.

Role of Public Utility in Project:

The SFPUC hosted the project at its headquarters, provided funding, day-to-day oversight and coordination, and was directly involved in every aspect of the project. SFPUC operators received training to operate the system and helped with troubleshooting over the course of the research. SFPUC staff worked closely with the consultant team and conducted regular staff tours and public outreach.

Project Cost and Funding:

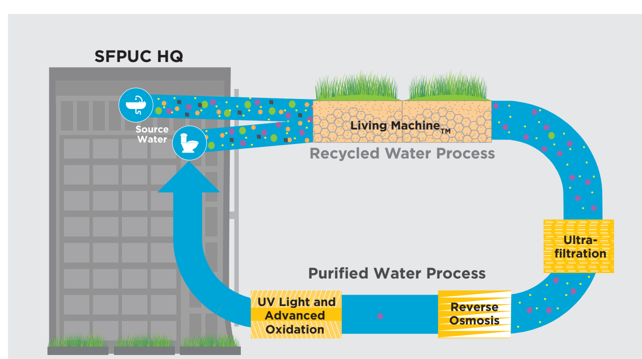
USBR provided grant funding of $200,000 toward the purchase and installation of AWT equipment. WRF provided a grant of $200,000 for water quality testing and data analysis. The SFPUC provided in-kind staff time and funds totaling $800,000 toward completion of the project.

Lessons Learned:

The AWT system consistently provided high quality water, as did PureWaterSF at the building scale. Consistent influent water quality, critical control point monitoring, and the ability to divert off-specification water were all important design objectives. PureWaterSF did experience greater variability in pathogen concentrations and some chemical spikes compared to larger-scale potable reuse projects, though it was still within the range of what is generally observed within centralized municipal wastewater. Given the sensitivity of a small sewershed to chemical inputs, additional barriers would likely be required for pathogen reduction.

Operations and maintenance (O&M) considerations in potable reuse projects include operational needs, source control, operator skills, and accuracy of online monitors. While potable reuse systems are not generally designed for intermittent operations, PureWaterSF only operated during the workweek. Long weekends required particularly careful preparation to preserve the AWT equipment, especially the RO membranes. Source control can be customized based on the size and nature of the sewershed. Although much of the AWT processes are automated, it was important to have highly skilled operators for frequent calibration, chemical batching and troubleshooting. For small-scale operations, it may be most efficient to manage networks of facilities at one central location. Finally, online monitors need to be highly sensitive at very low concentrations, especially for small scale decentralized systems, so it is important to test and identify the most appropriate online monitoring systems. Continuous online monitoring is a critical part of a well-designed potable reuse system.

Reference: Manisha Kothari, SFPUC (mkothari@sfwater.org)



Schematic of treatment system