

From Pits to Potable: A Look at the Evolution of Onsite and Water Reuse

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Thank you very much for having me.

It's been many years since I've been to this wonderful state and I'm happy to be back.

The Business of "Waste" Water



01/07/2019 #2

15th Century Definition of Wastewater:

Water that has been used

In this industry we've all found ourselves stuck in a hole covered in dung wondering what drove us to choose this line of work. Hopefully today is one of the days we are reassured of the good work that we do in this world and can find inspiration to continue to pursue this passion for cleaning our used water.

Understanding the Past

Understanding the practices and solutions of the past can provide a lens with which to view the present and future.

Wastewater Evolution

- Prehistory & Medieval Times
- Mid-Modern & Contemporary Times
- Current Day
- Case Studies

I believe that understanding the practices and solutions of the past can provide a lens with which to view the present and future.

Today we will be taking a brief look at those past practices and solutions, then view the current day situation and discuss a few case studies

3000 BCE Wastewater Treatment

Minoans in Crete develop first advanced disposal system



01/07/2019 #4

The human thought of disposing sewage began around 3000 BC

Minoans in Crete developed advanced sewerage systems that disposed of wastewater to the rivers, the sea, or to agricultural land for irrigation and fertilization purposes.

3000 BC – 1850 AD

- Land application
- Direct raw discharge
- Privies

4,850 YEARS!

Only 3 disposal techniques utilized for 4,850 years.

Reuse Around 1000 AD

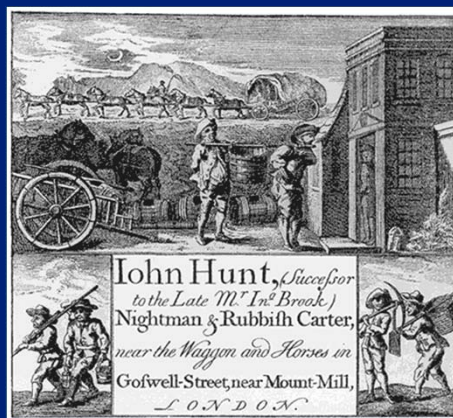
- In London, the contents of the city's outhouses was collected every night by commissioned wagons and delivered to the nitrite beds, where it was laid into specially designed soil beds to produce earth rich in mineral nitrates. The nitrate rich-earth would be then further processed to produce saltpeter, or potassium nitrate, an important ingredient in black powder that played a part in the making of gunpower.
- Many of the initial issues were water were spearheaded by religious orders. Cistercians near Milan introduced sewer water as fertilizer in 1150 AD.
- The cesspool was one of the technical developments of the Renaissance.

Many of the changes in water issues were spearheaded by religious orders. “Near Milan, the Cistercians introduced the use of city refuse and sewer water as fertilizers on their land about 1150 AD

The cesspool was one of the technical developments of the Renaissance.

Early Modern Period 1500-1900 AD

- Early onsite career in “night soil.”
- 1530 decree required property owners to construct cesspools in each new dwelling.
- Still happening today!



01/07/2019 #7

Night soil is a historically [human excreta](#) collected from [cesspools](#), privies, and [septic tanks](#), etc. This material was removed from the immediate area, usually at night, by workers employed in this trade called nightmen.

The pay was decent, even if the work was not. The night soil men used rudimentary long-handled dippers or buckets to scoop the waste into barrels or tanks on a wagon.

A typical privy vault had to be emptied and cleaned a couple of times a year.

By 1880, two-thirds of flush toilets still emptied into backyard cesspools, which had to be cleaned sometimes as often as every 10 days to keep from overflowing.

The Indian government's Union Ministry for Social Justice and Empowerment stated in 2003 that 676,000 people were employed in the manual collection of human waste in India.

Modern Japan still has areas with ongoing night soil collection and disposal.

The Early Business of Wastewater

Early adoption of water reuse has been documented through the use of cesspit waste to make gun powder and, additionally, the use of lagoons and other dispersal systems to utilize the water and nutrients for farming or fish ponds.

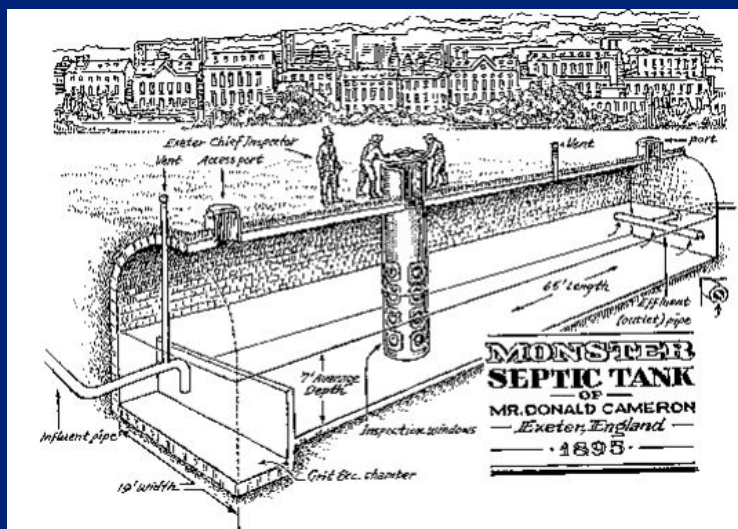
Wastewater became a business once people realized they could utilize it as a product. Creating gunpowder, fertilizer, and feed.

First Agricultural Use

- The first known application of wastewater for agricultural usage occurred in Bunzlau (modern day Poland) in 1531.
- Later, in 1650, land application was used in Scotland



Invention of Septic Tanks - 1860's



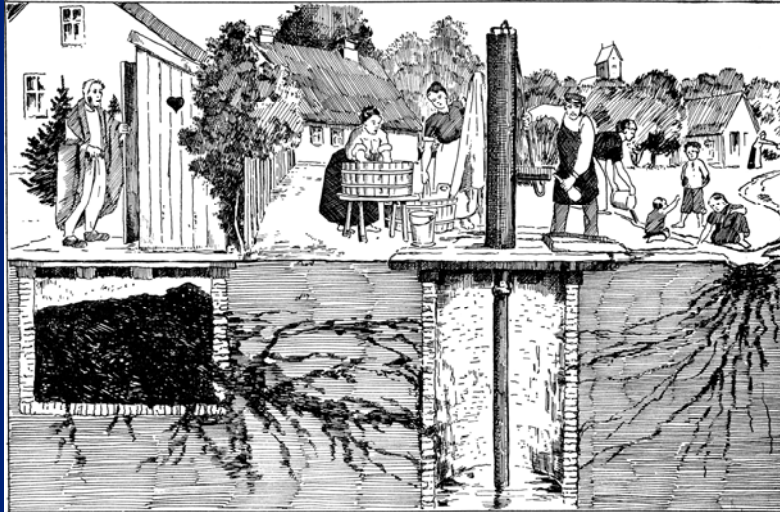
01/07/2019 #10

In 1860 Louis Moureas invented the septic tank; however, it would not be given this name until 1895.

Septic tanks at this stage were large and were used to treat sewage from communities.

The first time we see a real understanding of the benefit of removing solid.

Contamination & Disease Linked



01/07/2019 #11

A link between wastewater discharge and contaminated potable water sources and the cause of disease began to change mindsets with regards to the disposal of waste.

In the mid-19th century a world-wide epidemic of cholera occurred.

The relationship of cholera to water was discovered by the English physician John Snow.

Snow traced the contamination to public wells that were being contaminated by privy vaults in the epidemic of 1854 in London.

The need to solve this health care concern in large cities marked the 19th century as the beginning of municipal socialism.

The remaining 88,000 Cesspools in Hawaii have recently been declared a 1.75 Billion Dollar crisis that is threatening the drinking water, coral reefs and famous beaches that are the lifeblood of its tourist economy. They are working hard to remediate the problem today.

Early Wastewater Treatment - 1868



01/07/2019 #12

Edward Frankland, in 1868, developed trickling sand filter technology.

He devised a system consisting of six-foot high, ten-inch wide cylinders, filling each with different medias like sand and soil.

He then ran sewage at different doses through the different tanks.

He calculated the capabilities of the different media in purifying the wastewater.

The above picture is of a raking crew on a sand filtration system in London in 1905

Sewage Treatment Law - 1876

- The Rivers Pollution Prevention Act was passed as early as 1876 as the first cohesive body of laws on sewage treatment.
 - Preference was initially given to natural irrigation techniques, which were later developed into artificial biological processes.
 - Irrigation was also seen as a convenient method of fertilization.
 - Consciously utilizing the self-purifying capacity of water was also considered a natural cleaning process.

Largely in response to the problem of sewage pollution, Parliament passed the Rivers Pollution Act of 1876.

This Act forbid pollution and solid matter from being deposited into streams and rivers.

The Act had little effect, however, because it provided no clear definition of pollution and created no clear enforcement mechanism.

The Fathers of Process Treatment

- In 1882, Warington wrote that, “Sewage contains the organisms for its own destruction, and these may be so cultivated as to effect the purpose.”
- In 1887, William Dibdin – London Metropolitan Board of Works stated, “In all probability, the true way of purifying sewage will be first to separate the sludge, and then turn into neutral effluent a charge of proper organism, whatever that may be, specially cultivated for the purpose; retain it for a sufficient period, during which time it should be fully aerated, and finally discharge it into the stream in a purified condition.”

The first statements in the development of the modern treatment process.

Dibdin defined the multi step treatment process

1900-1940

- Advancement of new treatment technologies began appearing
 - The first publications developed by the federal government in the 1920's to deal with on-site wastewater management issues addressed the design of septic tanks
- First Facultative Lagoons
- Improvement of Septic tanks
- Advancement of Packed-bed filters
- First Activated Sludge Process

First government onsite publication in 1920 on the design of septic tanks

Facultative Lagoon Treatment were utilized around 1900

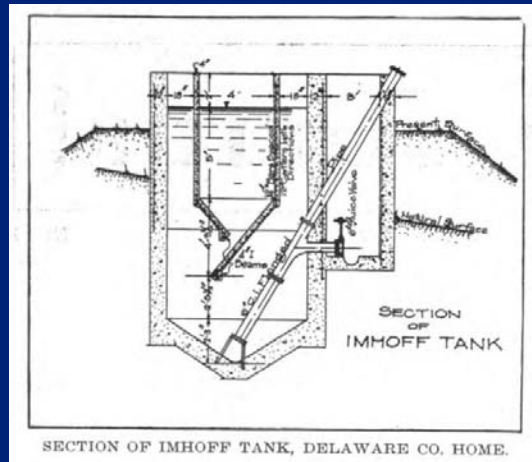
Imhoff Tanks designed in 1906

Improvements on sand filtration systems occurred

The first activated sludge processes were developed

Imhoff Tank

- Imhoff tank developed – 1906



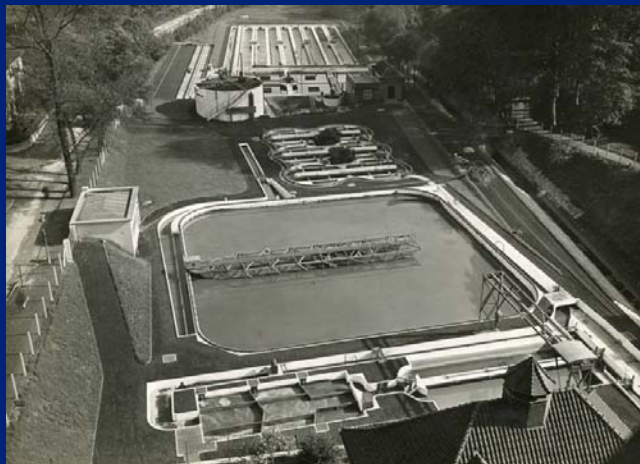
01/07/2019 #16

The first imhoff plant was put into operation two years later.

The main advantage of this type of tank over the septic tank is that sludge is separated from the effluent, which allows for more complete settling and digestion.

Activated Sludge

- Activated-sludge process developed – 1912



01/07/2019 #17

The first activated sludge process was developed in Boston in 1912.

By the time the first book was written in 1927 on the activated sludge process the process was being used in the US, Denmark, Germany, Canada, the Netherlands, and India. By 1938 the process was utilized in hundreds of plants around the world.

The activated sludge process and its many variants is now the main engine of secondary sewage treatment and has probably had the biggest impact of all processes upon environmental improvement in the past century.

1940-1950

- USPHS and National Housing Agency researches household sewage disposal systems
 - Findings
 - Homeowners were uninformed about maintenance
 - Most common complaints
 - ~ Seepage to surface
 - ~ Odor nuisances
 - ~ Plumbing stoppages
 - ~ Sewage backing up

In the 40's the USPHS and National Housing Agency researched home sewage systems

Findings

- Homeowners didn't understand that maintenance was necessary – I could put that on just about every slide for the rest of the 20th century!
- Complaints included surfacing, odors, stoppages and backing up – Those complaints sound familiar too!

1950-1960

- In the early to mid 1950's, with the housing boom created by returning WWII veterans, design concerns addressed by the U.S. Public Health Service included improved tank designs and the use of a percolation test to assess the hydraulic capacity of a site.
- Europe outlaws cesspits

The housing boom shortly after WW2 created concerns with how we addressed wastewater, and lead to the development of improved tank designs and the use of perc tests to address hydraulic capacity

Around the same time Europe outlaws cesspits

1960-1970

- In the 1960's, the Federal Government passed the first of the Clean Water Acts. This act established the USEPA, and one of the first of the EPA activities initiated soon after its formation was the creation of the construction grant program for the development of wastewater infrastructure.
- Surface aeration of lagoons
- Research on Recirculating Sand Filters
- Issues with the nitrification in activated-sludge processes led to the development of anoxic reactors for denitrification

01/07/2019 #20

The 60's brought the first Federal Government Clean Water Acts, and the establishment of the EPA.

Aeration was incorporated into lagoons to improve the lagoon treatment process.

Mike Hines and other began research on recirculating sand filter processes.

Nitrification issues were recognized in activated sludge processes and led to the development of anoxic reactors for process denitrification

1970-1980

- The Clean Water Act Amendments of 1972 – This federal program established an incentive system whereby communities could qualify for a large federal grant if the wastewater treatment technology proposed was deemed an innovative or alternative technology. Onsite wastewater management systems are considered innovative and alternative and would qualify.
- Industrial electronic advent made automatic controls of process units possible
- First modern recirculating sand filter (RSF) used in Illinois
- Phosphorus removal included in activated-sludge process in 1974
- Influx of “package plants” within neighborhoods operated by HOA’s

01/07/2019 #21

The 1972 Clean Water Act Amendments provided an avenue for federal funds to be available for wastewater infrastructure. Onsite systems were considered innovative and alternative technologies and received funding.

Residential and commercial low pressure pipe systems, mound systems, recirculating sand filter systems, and the first residential spray irrigation systems were constructed through this effort.

Many of the systems constructed in the late 1970’s remain in operation today.

The advent of automated electronics improve process controls

Modern recirculating sand filters were put into operation

And an influx of activated sludge package plants were installed all over the place.

The Decline of Water Reuse

- Through the industrial revolution of the 20th century, many treatment processes were developed in order to reduce disease.
- Water reuse declined with the development of intensified wastewater treatment methods, but has seen resurgence with population growth, the development of megacities, climate change, rapid development in technology, and the recognition that fresh water is limited.

With the focus disease prevention treatment processes in the 20th century water reuse declined in exchange for mechanical treatment methods. Water reuse however has seen a resurgence in recent decades.

1980-1990

- Evolution of today's RSF
- Removal of package plants and connection to centralized sewer
- Course-bubble aeration utilized in activated-sludge plants
- Personal computing leads to the development of computer models of treatment processes and automation



01/07/2019 #23

Evolution of RSF's occurred

The desire to take "sewer" everywhere sparked the removal of many package plants and connection to centralized systems

Decentralized systems were considered temporary solutions, only necessary until the centralized systems were installed....this is still many people perception today.

Course bubble aeration was developed for activated sludge plants

The personal computing wave leads to further development of automated processes and computer modeling of wastewater processes, specifically Activated sludge process modeling.

1990-2000

- 1997 EPA Response to Congress on Use of Decentralized Systems
- Decentralized systems no longer considered short term solution
- Alternative media used to improve efficiency and reduce size of packed-bed filters
- Constructed wetlands – The rise in interest in less-sophisticated systems driven by the desire to provide safe treatment at a lower cost
- Drip irrigation
- Demonstration projects
- Fine-bubble aeration becomes common in activated-sludge plants
- The comeback of the sequencing batch reactor (SBR) plant

01/07/2019 #24

The EPA's 1997 response to congress reaffirms that decentralized systems are not temporary solutions but long term alternatives.

Alternative medias are utilized to improve efficiencies and size of packed bed filters

Constructed wetlands surface as alternatives for low energy treatment

Drip irrigation makes a debut as a wastewater alternative for irrigation

Many demonstration projects with new wastewater technologies and packaged systems are installed an tested.

Fine-bubble becomes the preferred alternative for activated sludge plants

And, the SBR makes a comeback as a reliable alternative no that automation had reached a point in development to reduce operational oversight.

2000-2010

- New ways of thinking –
 - Human waste is a resource
 - Management demands are real and increasing
 - Reuse and reclamation are necessary
 - Small/decentralized systems are possible and often desirable
- MBR technologies emerge – Bringing renewed interest in wastewater reclamation
- Improvements in disinfection, such as ozone & UV, add to the interest and ability to reuse waters
- Integrated water management at the forefront - Onewater
- Development of SCADA and telemetry-operated decentralized facilities
- Remote monitoring and data collection quickly becomes common

01/07/2019 #25

At the break of this century a new wave of thinking started to get legs. Maybe we shouldn't be thinking of this as waste, but as a resource.

Smaller systems and reuse was becoming more desirable alternatives.

MBR technologies started to emerge

Various disinfection alternatives became available.

The concept of a single management for all water resources was discussed – Onewater Concept

Telemetry based controls became common and economic alternatives for smaller systems

Remote monitoring and data collection was now possible for all systems.

2018

New Technologies of Interest

- Membrane aeration alternative to coarse and fine bubble
- Membrane bioreactors (MBRs) are becoming more economical
- Upflow anaerobic sludge blanket systems for blackwater only in combination with greywater reuse
- Small Wastewater heat and gas energy recovery systems in combination with building reuse systems – potential for partial offset of energy consumption

Today push for technology advancement are driven by;

- Non-potable and potable water reuse
- Greater nutrient reduction
- Energy and Operations Efficiency

01/07/2019 #26

A few new technologies of interest

The price and efficiency of Membrane Aerated BioReactors makes them very attractive, along with the nitrification/denitrification potential.

Membrane systems have become 4 times more economic over the past 30 years, which allows them to be cost competitive in decentralized applications.

Upflow Anaerobic Sludge Blanket systems are not a new idea, however utilizing them for blackwater treatment from lower flow toilet and kitchen waste systems may be, this has potential for residential reuse systems.

Heat and gas recovery for energy conservation has potential to impact our industry in the coming years as well.

The three elements that I see driving innovation today include; reuse, nutrient reduction, and energy and operations efficiency.

Today's Situation

- Water scarcity
- Shifting climates
- Weather patterns
- Population growth
- Nutrient scarcity and expense
- Increased price of water



“Estimates show that with current practices, the world will face a 40% shortfall between forecast demand and available supply of water by 2030. Today, 70% of global water withdrawals are for agriculture. Feeding 9 billion people by 2050 will require a 60% increase in agricultural production and a 15% increase in water withdrawals.”
(World Bank 2017).

We are all aware of the **current water situations** we face.

Scarcity

Climates shifting

Patterns in weather

Growth

Nutrient needs

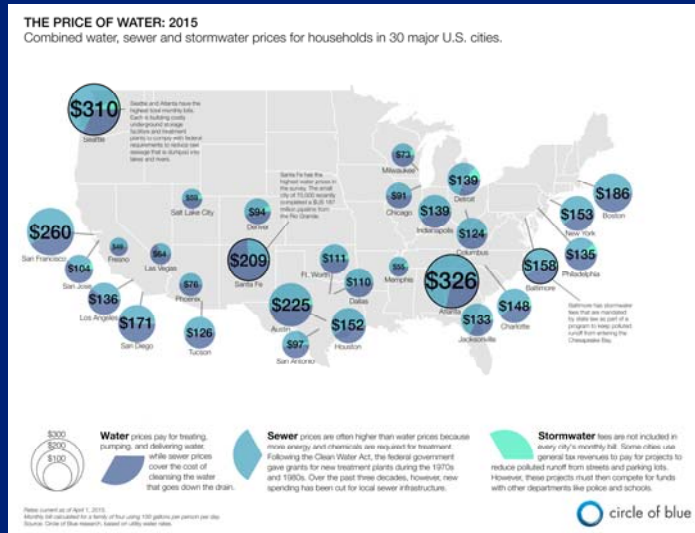
And the Annual increases in the price of water

The **World Bank** estimates that we could be looking at a **40% shortfall between demand and supply by 2030.**

All **data** points toward **higher demands and more scarcity**...which will in turn continue to **increase the price of water.**

United States Water Pricing Overview

(courtesy of Circle of Blue)



01/07/2019 #28

This illustration, published by the Circle of Blue in 2016, provides a picture of how water prices have increased in the last few years. Between **2010 and 2015**, the average price of water **increased by 41% in thirty major cities across the US**.

These are monthly combined rates for water and sewer, and some as you can see are as high as \$326 (Atlanta)

In many parts of the United States, **drought and increased demand** have led **governments to impose scarcity restrictions** on both **residential and industrial users**.

Recycling, Reclamation, & Reuse – Decentralize

With the price of water rising annually and freshwater sources are being depleted, it becomes increasingly important – both economically and environmentally – to reduce potable water consumption and increase water recycling.

Investing in efficiency should be a lot more effective than mindlessly plowing more money into the expansion of existing systems.



With improved effluent water quality, there has been a global trend to diversify water reuse practices beyond agricultural and landscape irrigation, to recreation and environmental reuse, industrial reuse, groundwater recharge and potable reuse.

We're all familiar with the need to **reduce potable water consumption** and the need to **increase water recycling**. Of the available alternatives **decentralized water recycling can offer security and independence at an economical price**.

Its my belief that Investing in efficiency should be a lot more effective than mindlessly plowing more money into the expansion of existing systems.

Sustainability Market Drivers

- As of late 2016, all but three states had implemented regulations for non-potable water reuse.
- National Blue Ribbon Commission
- NSF/ANSI 350 and 350-1
- USGBC LEED, SITES, and Living Building Challenge
- San Francisco 12C Non-potable Reuse Health Code



01/07/2019 #30

We are making **great strides** toward a **sustainable water future** with **all but 3 states** implementing **regulations for non-potable water reuse**.

Additionally, The **US Water Alliance** has partnered with the [Water Environment & Reuse Foundation](#) and [Water Research Foundation](#) to establish the **National Blue Ribbon Commission** which serves as a **forum for collaboration and knowledge exchange** on **policies, best management practices, procedures, and standards for on-site water systems for non-potable purposes**.

NSF/ANSI has established the **350 standard and certification** for **on-site residential and commercial greywater treatment systems**. Treated effluent that meets this standard can be used for **restricted indoor water use**, such as **toilet** and urinal flushing, and **unrestricted outdoor water use**, such as lawn **irrigation**.

Another factor in acceptance for water reuse is the rising **trend in sustainable building**, which is driven mainly by **client demand**, however in many areas we are seeing a **trend toward government involvement** in the requirement of **green building practices**.

Change agents in this green building industry include **Living Future with the Living Building Challenge, Leadership in Energy and Environmental Design (LEED), and the Sustainable SITES Initiative.**

In addition the San Francisco 12C health code is making waves

2018 Resources Decentralized Non-Potable Guidelines

William J Worthen Foundation –

1. Onsite Non-Potable Water Reuse Practice Guide

<https://www.collaborativedesign.org/>

US Water Alliance –

1. Blueprint for Onsite Water Systems: A Step-by-Step Guide for Developing Local Programs to Manage Onsite Water Systems
2. A Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems
3. Model State Regulation for Onsite Non-potable Water Programs
4. Model Local Ordinance for Onsite Non-potable Water Programs
5. Model Program Rules for Onsite Non-potable Water Programs

www.uswateralliance.org/initiatives/commission/resources

01/07/2019 #31

All of these resource are focused on the establishing a regulatory environment and design requirements for non-potable water reuse programs. Both the William Worthen Foundation and the US Water Alliance are paving the way in water reuse.

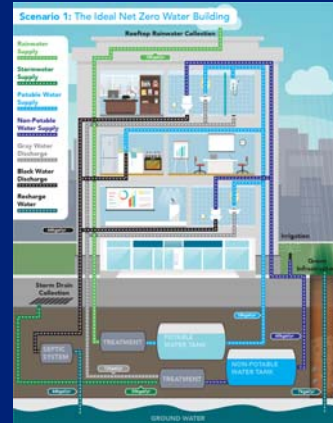
Future - Urban Building Water Reuse

Ideal Urban Building Water:

- Rainwater catchment – potable water supply
- Stormwater catchment – non-potable supply
- Greywater collection – non-potable supply
- Blackwater collection – composting or discharge

Alternative Urban Building Water:

- Rainwater catchment – non-potable water supply
- Greywater collection – non-potable water supply
- Stormwater catchment – city service
- Blackwater collection – city service
- Potable water –city service



There is no one size fits all method, it will take a suite of technologies and techniques to meet out coming water management needs.

Future – Decentralized Grey & Black Water Reuse

- San Francisco 12C REQUIRES all new buildings over 250,000 sqft to incorporate greywater reuse into the design and operation of the facility for irrigation, toilet flushing, cooling towers, etc.
- Salesforce new complex in SF will take it to the next level, installing a full BLACKWATER treatment system for reuse including irrigation, toilet flushing, and other uses.
- Other jurisdictions around the country have started to follow suit by requiring water balances during new commercial building planning and greywater reuse within buildings.

Future – Indirect and Direct Potable Reuse

“Appropriate and necessary treatment and reuse of wastewater to augment existing water resources is a rapidly expanding approach for both non-potable and potable applications. EPA recognizes that potable reuse of water can play a critical role in helping states, tribes, and communities meet their future drinking water needs with a diversified portfolio of water sources.”

EPA 2017 Potable Reuse Compendium

Indirect and Direct potable water reuse is a hot topic today as well

The EPA reported in 2017 in its Potable Reuse Compendium;

“Appropriate and necessary treatment and reuse of wastewater to augment existing water resources is a rapidly expanding approach for both non-potable and potable applications. EPA recognizes that potable reuse of water can play a critical role in helping states, tribes, and communities meet their future drinking water needs with a diversified portfolio of water sources.”

Indirect Potable Reuse Examples

- Upper Occoquan Sewage Authority, North Virginia – Since 1978, Potable Water Source Reservoir Replenishment
 - Orange County Water District Ground Water Replenishment System – operated since 2008.
 - SWIFT (Sustainable Water Infrastructure For Tomorrow) project in SE Virginia – Hampton Roads Sanitation District (HRSD) will take highly treated effluent and add it to the Potomac aquifer, where it will indirectly supply sustainable groundwater for future generation.
 - Pure Water Program in the City of San Diego – The program will treat up to 83 MGD to produce 1/3 of the region's water supply by 2035.
-
- California, Texas, Nevada, Colorado, Arizona, Washington, Oklahoma, and Florida
 - Various military agencies are considering direct potable reuse

Future – Law and Rule Amendments

- Further development of greywater and blackwater reuse code
- Development of enhanced performance verification programs for all on-site systems
- Acceptance of risk based analysis for design and operation of non-potable water reuse systems
- Better training and education
- Flexibility to accept new technologies under proper risk based designs and performance verification programs
- Incentive programs for decentralized water reuse to reduce expense of infrastructure expansion

Orengo
SYSTEMS

The Ecovillage at Currumbin, Queensland, Australia



Photo(s) courtesy of Landmatters Pty Ltd

01/07/2019 #37

Now for the **case studies**. First off we are going to review a **decorated ecovillage** on the **Queensland Coast in Australia**.

The Ecovillage at Currumbin is an **international award winning sustainable community**. The **270 acre site** is set **7 minutes** from the **Currumbin Beach** on the **Gold Coast**.

The Ecovillage at Currumbin

- 272-acre site with 147 home lots, schools, shops, and offices
- Employs greywater reuse for toilet flushing, car washing, and irrigation
- Chosen by International Real Estate Federation as 2008's "World's Best Environmental Development"
- One of the most award-winning developments in Australia



courtesy of Landmatters Pty Ltd

01/07/2019 #38

The Eco-Village is home to more than **300 residents** and contains over **20 different types of community facilities**, including a community hall, kitchen, playgrounds, shops and a cafe.

The Homes use **rain water** for potable uses and share a **large commercial waste water treatment** system that delivers high quality **recycled water** back around the village for **toilet flushing, car washing, and irrigation**. The ecovillage is **100% water self-sufficient**

This community is the **most awarded** estate in Australia with over 33 [accolades](#), including being awarded "**The World's Best Environmental Development**" **2008**.



The Ecovillage at Currumbin

Sustainable features of the wastewater treatment facility include ...

- The use of polyethylene piping and watertight construction to eliminate infiltration and inflow (I&I)
- Anaerobic solids digestion to minimize solids-handling needs
- Packed-bed filter construction in the secondary treatment unit for reduced energy usage
- Nutrient reuse through irrigation
- No unpleasant odor generation
- Low noise
- Low greenhouse gas production
- Pleasing aesthetics
- High-quality reuse water



courtesy of Landmatters PtyLtd

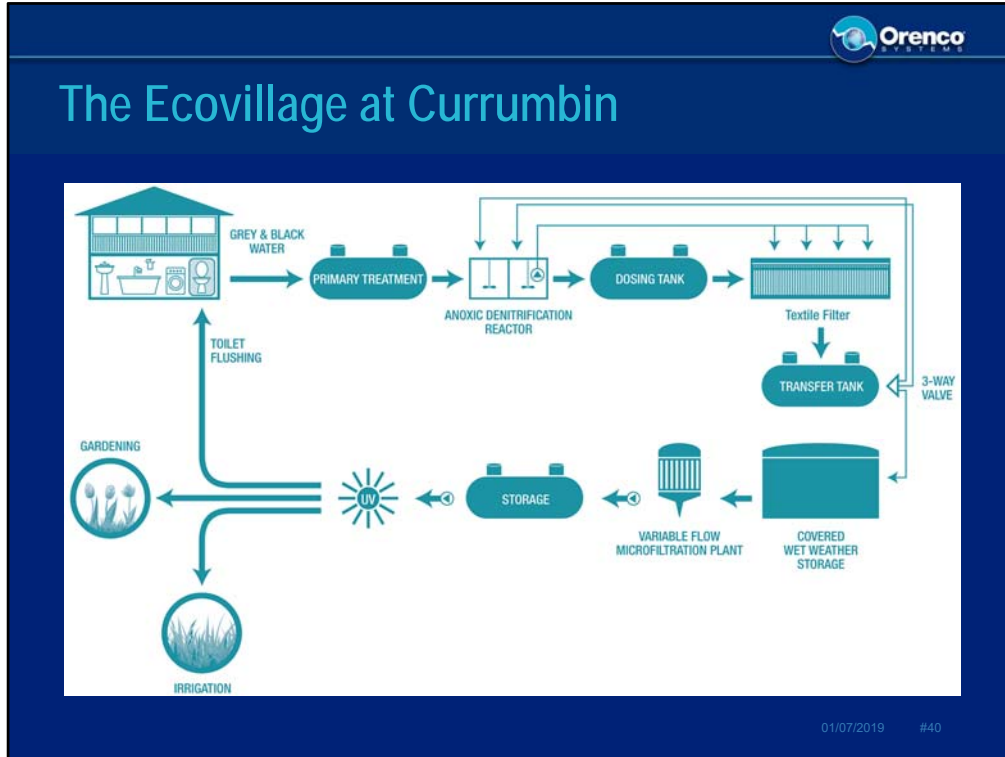
01/07/2019 #39

The Ecovillage encourage **sustainable** building practices which **improve quality of life** and help to **reduce on-going operation costs**.

The **features** of the wastewater **treatment** system are **similar**, designed to encourage **sustainable results** by **minimizing energy consumption and maximizing resource recovery**.

Maximizing solids digestion, nutrient reuse, minimal energy consumption, and maximizing non-potable water reuse are all elements the designers focused on to providing a **truly sustainable solution**.

As a result, **most residents have very small utility bills**.



Wastewater from the residence is **collected** in a primary tanks where solids are **settled and digestion is maximized**.

From the primary treatment tanks the wastewater **flows to a pre-anoxic reactor** which mixes with **recirculated water** from the **textile secondary treatment system for nitrogen reduction**.

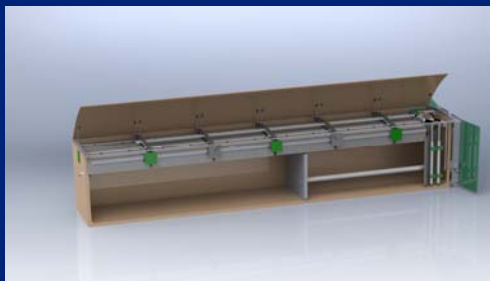
From **the pre-anoxic reactor** the **blended water** enters the **recirculation tank** which doses the secondary treatment system, a **packed bed filter textile system**.

Secondary treated **effluent** is then **stored** prior to being filtered through a **microfiltration unit**.

After final filtration, effluent is **stored again** and dosed out through **UV disinfection** and supplies the **various reuse applications throughout the community**.

Commercial Textile Treatment Process

- Recirculation pump
 - Intermittent doses
- Manifold
 - On top of textile
 - Percolates down
- Tank Chamber Distribution
 - Recirculation chamber
 - Filtrate chamber
- Recirculation-splitter baffle
 - recirculation return valve



01/07/2019 #41

The recirculation pump is timer controlled to ensure that small, intermittent doses of effluent are applied to the textile sheets throughout the day. This ensures an aerobic, unsaturated environment for optimal treatment to occur. A manifold rests on top of the textile sheets, which distributes the effluent evenly over the textile sheets. The effluent then percolates down through the textile sheets and is distributed between the recirculation and discharge chambers by means of the AX20-RT baffle.

The textile material is suspended from the top of the treatment unit, with most of the media (normally 70%) positioned over a primary “recirculation chamber” The remainder of the media is positioned over a separate “filtrate chamber” that is separated from the recirculation compartment by a recirculation splitter baffle, and from with filtrate is discharged.

The recirculation-splitter baffle is fitted with a swing-check valve for low-level equalization. Under low daily flow conditions, the swing-check valve allows 100% of the final filtrate to be returned to the primary recirculation-blend chamber for continued recirculation. The swing-check valve is similar to a check valve in that it allows preferential flow in one direction only, in this case, from the final filtrate chamber to the recirculation-blend chamber. The swing-check gate closes when the liquid head on the recirculation-blend side is equal to or greater than the liquid head in the final filtrate side. When the liquid head on the final filtrate side is higher, the pressure differential pushes the swing-check gate open fro filtrate to pass back to the recirculation-blend side of the baffle, thus providing for continued recirculation during periods of low or no inflow. Flow from the recirculation-blend chamber can only pass to the final filtrate chamber through the treatment media.

Critical to the success of the AX Treatment System is the method in which the effluent is loaded onto the textile sheets. Over the past three decades, timer-controlled applications have proven to play an essential role in optimizing the performance of both fixed and suspended-growth biological systems. A timer controlled pump in the treatment tank periodically doses effluent to the distribution manifold over the textile sheets. The effluent then percolates through the textile media and is treated by naturally occurring microorganisms that populate the filter. During periods of high flow, a timer override float will temporarily modify the timer settings to process the additional flow.

Conversely, during periods of low flow, the timer settings can be modified to reduce loading onto the filter.

Orengo SYSTEMS

Textile Treatment Process

- Constituents are removed through biological, chemical, physical processes
 - At the surface and within the top 6" to 12", matter is trapped and the greatest biofilm accumulation occurs
 - The top zone is mostly responsible for solids and organic reduction

01/07/2019 #42

Packed Bed Filters (PBF) are typically used for **domestic strength effluent**.

PBF treatment modes include: filtration and trapping, adsorption, biological decomposition, and biochemical transformations.

Textile filters are one specific type of packed bed filters. AX filters represent a specific textile configuration consisting of **aligned sheets**. Packed bed filters are typically **designed to follow primary treatment in a septic tank** to provide highly treated effluent for soil dispersal, although other final dispersal options, like reuse, are used. In some cases, the effluent is disinfected and discharged to surface waters. Textile filters are configured in typical recirculating treatment fashion such that a mix of **septic tank pretreated effluent is blended by recirculating filtrate, and then applied in small, frequent doses to the media surface**. The **media supports a fixed film of organisms** active in the treatment process.

At the surface and top 6 inches (more or less), **matter is trapped** and the **biofilm grows**. In this nutrient rich upper zone, most of the **organic material is trapped, decomposed, and digested**.

The **water holding capacity** of the media and of the biofilm are important in **ensuring sufficient moisture for maintaining healthy microbial environments**. (Note: too much WHC and unsaturated flow conditions yield to saturated flow conditions causing **inadequate conditions for water air interfacing** and appropriate oxygen transfer; too little WHC and the biofilms **dry and slough** disrupting consistent microbial activity and the establishment of specific microbial environments such as heterotrophic, or autotrophic.)

Both heterotrophic and autotrophic bacteria are found in these biofilms. There are many types of heterotrophs and autotrophs and they will vary in populations respective of each other and of their respective needs for the available free oxygen.

Filtrate from PBF is typically low in biochemical oxygen demand (BOD₅) and suspended solids (TSS) and concentrations of pathogenic organisms.

The Ecovillage at Currumbin

Class A+

- BOD₅ < 10 mg/L
- Turbidity < 2 NTU
- E. coli < 10 CFU
- 5 log removal of viruses and protozoa

Multiple Disinfection Barriers

- Micro-filtration
- Ultraviolet light
- Chlorine (optional)



courtesy of Landmatters Pty Ltd

01/07/2019 #43

The treatment plant is required to meet **Class A+ Reuse** water standards.

With the wastewater facility **providing** the **majority of non-potable** water for the entire community they felt it was **critical** that the design could **guarantee continual usage** with **minimal to no down time**.


Multiple disinfection barriers were required including **filtration, UV,** and an **option for chlorine injection**.

Orenco
SYSTEMS

The Ecovillage at Currumbin

Effluent quality:

- BOD₅ = 3.37 mg/L
- TSS = 1.85 mg/L
- Turbidity < 2 NTU
- E. coli < 1 cfu/100 mL
- Viruses/pathogens > 9 log removal



courtesy of Landmatters Pty Ltd

01/07/2019 #44

Effluent quality has easily met the Class A+ standard with 3.37 mg/L BOD, less than 2 mg/L TSS, turbidities under 2 NTU and E.Coli **well under the requirement without the addition of Chlorine.**

The **clear and odorless** effluent has become the **perfect source** for **non-potable water.**



Hassalo on 8th is located in **Portland Oregon's Loyd District**. The Lloyd district is almost entirely **newer development and retail**, with virtually no stand-alone houses.

It is just **minutes from downtown Portland** and has become a **hub for start-ups** and people wanting to live a few **minutes from the action in Portland's**.

Hassalo on 8th – EcoDistrict

- A 4-block sustainable urban development in the Lloyd EcoDistrict
- First mixed-use developments by American Assets Trust
- LEED Platinum development



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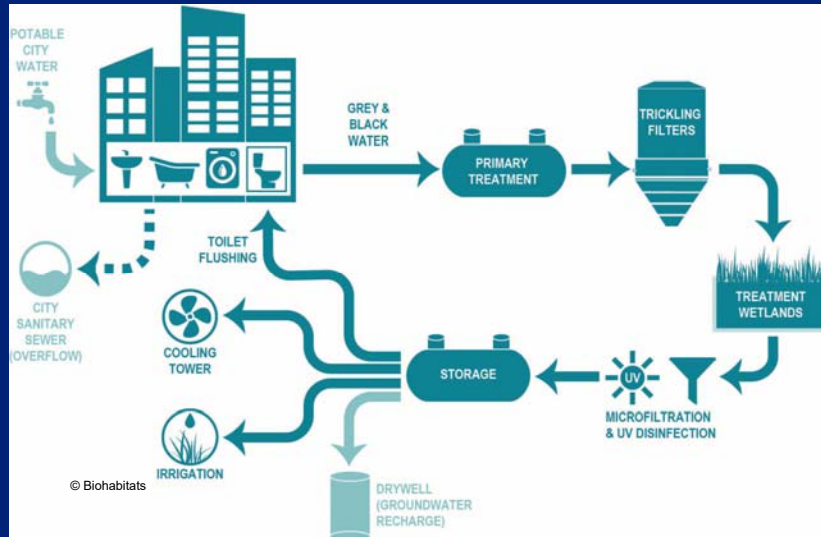
01/07/2019 #46

The Hassalo on 8th project was designed by Biohabitats to achieve LEED Platinum.

The development consists of a **4 block sustainability district** with mixed use buildings including a single existing repurposed structure and 3 new buildings.

The project was **completed in 2015** and As of **this fall** the project has been announced as **LEED Homes Project of the Year 2017** from the **U.S. Green Building Council**.

Hassalo on 8th



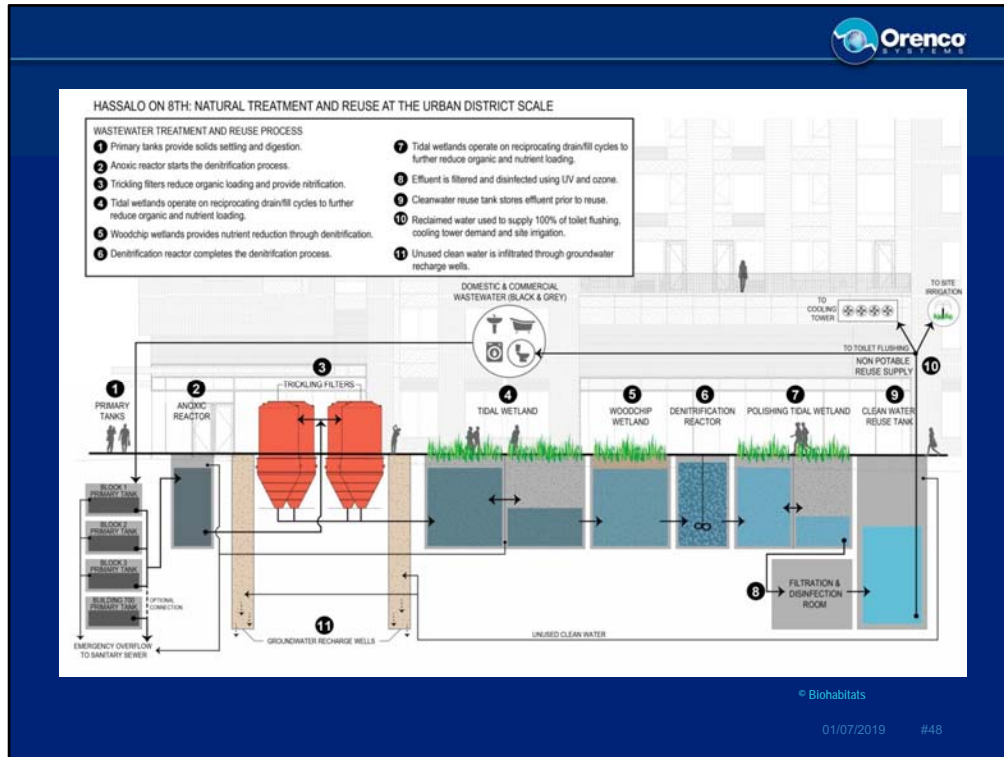
01/07/2019 #47

Primary tanks are located at the **various buildings** for solids **settling and digestion**. Primary treated water is **pumped** to a **packed bed filter system** and **recirculated through various wetlands** for polishing.

Additional **filtration and disinfection** are provided prior to **storage** and the water is then **reused for irrigating landscapes and flush toilets**.

The wastewater **system** design was **configured beautifully into the community** to aid in **aesthetics and the educational goals** the project team had for the development.

The system is so nicely integrated into the community that when I was in the **grocery store** last week and sparked up a conversation with the **cashier** regarding the wastewater system and what I was doing in town, which she **didn't even realize** was underneath the concrete at the **front door**, or that she had a **full view of the secondary filters** out the main windows. She was very pleased to know that the system was working well and providing for a more sustainable community.



Here is a closer look at the **complexity of the system**, sorry if this is difficult to see. This **graphic** is available at the Hassalo on 8th **website** if interested

THIS IS NORM, THE NATURAL ORGANIC RECYCLING MACHINE

The wastewater treatment system was **named NORM** by the **contractors during construction**. As the entire design and build team were very passionate about the project.

Designed with **state-of-the-art controls**, NORM is meeting **highest standards** for **non-potable reuse** and is **monitored 24/7** by certified wastewater operators to **ensure optimal system performance, water quality and of course safety for the residents**.

Trickling Filter Technology

Trickling filters

- It consist of a bed of crushed stones/pebbles covered with slime which consists of aerobic bacteria, algae, fungi, protozoa, worms & insect larvae
- Sewage is degraded by the aerobic bacteria when it passes through the bed and is collected at the bottom of the filter
- It helps in better removal of organic matter and also keeps the filter moist when the flow rate is slow

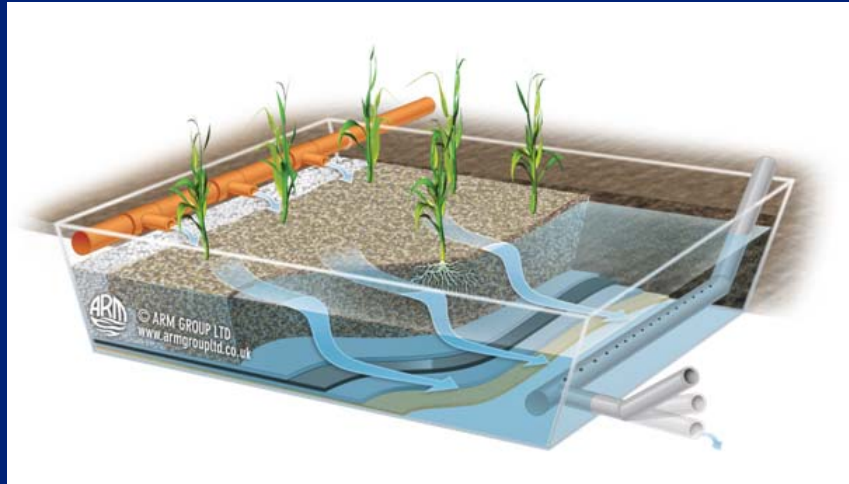
01/07/2019 #49

A trickling filter operations much like a sand filter, it's a type of packed bed filter with high loading rates, typically around 125 gpd/sft.

The interesting thing about these trickling filters is that they allows for a high level of treatment in a narrow and tall silo.

Additionally, the designers developed the outside of the units to become a beautiful feature in the landscape.

Wetland Technology



01/07/2019 #50

After that, the water goes to the tidal wetland, a woodchip wetland, denitrification reactor and finally a polishing tidal wetland to create conditions of flood and drain like in a tidal system which fosters naturally occurring microbial organisms that eat more of the nutrients. The wetlands are underneath and beside the pedestrian corridor on NE Water street, however the wastewater is located below layers of gravel or woodchips, so that the public is not exposed. At the very end of this process mechanical filters screen out fine particles. Ultraviolet and ozone systems kill any pathogens that might be present and makes the water safe for reuse. Clean water is stored and distributed for reuse in the three buildings that make up Hassalo on Eighth.

Hassalo on 8th – Stacked Benefit

- Pedestrian circulation
- Emergency access
- Landscape
- Iconic branding
- Wastewater treatment
- Educational
- Increases biodiversity



© Biohabitats

01/07/2019 #51

Many different **aspects of sustainability** were considered during the **project design** including how the **system fit into the community, education, and creating an iconic brand for the development.**

The **architectural** aspect of the facilities and the **marriage between the buildings and the wastewater treatment** are really quite beautiful.

This project is truly the **glimpse into the future of urban development.**

Hassalo on 8th

Guidelines for Class A+ recycled water for non-potable reuse for this application require the following:

- TN < 10 mg/L
- Turbidity < 2 NTU (24-hour average) / < 10 NTU (24-hour max)
- E. coli < 2.2 cfu/100 mL (7 day average) / < 23 cfu/100 mL (max)



© Biohabitats

01/07/2019 #52

Oregon required a **Class A+ recycled** standard for non-potable reuse with a specific **focus on TN, Turbidity, and disinfection.**

Another interesting fact about this project is that “NORM” has a twitter account...so, if you’d like to follow and keep up with its performance and impact on the community you follow it’s account.



Boy Scouts of America (BSA) Summit Bechtel Reserve West Virginia, USA



Photos and graphics in this case study BSA

01/07/2019 #53

Lastly, the Boy Scouts of America Summit Bechtel Reserve in West Virginia.

This facility covers an **impressive 10,000 acres** and features:

- **One of largest man-made rock climbing facilities in the world with over 60 climbing repelling and bouldering stations.**
- **5 miles of zip lines,**
- **4 manmade lakes covering over 75 surface acres and 4 Olympic size pools used for all types of aquatic activities.**
- **They have two mountain biking adventure areas that provide more than 36 miles of varied mountain biking trails.**
- **270,000 sq ft of extreme BMX terrain.**
- **An X games quality skate park.**
- **And, World class archery and shooting facilities**



BSA Summit Bechtel Reserve Project Goals

- Create a model for sustainability and environmental stewardship.
- Create a site that would be a “net zero energy” and “net zero carbon footprint” environment
- Protect the New River by eliminating any direct discharge of treated wastewater



01/07/2019 #54

During the bi-annual **Jamboree event** the Reserve becomes the **3rd largest city in West Virginia**

Key Sustainability **Features** of Project include:

- **Cogeneration using photovoltaic, wind turbines and fuel cells**
- **Geothermal wells**
- **Radiant cooling/heating**
- **Solar hot water**
- **Low flow fixtures and composting toilets**
- **Low-flow, pull-chain, ambient temperature showers**
- **A Low energy Blackwater system**
- **and a *Low energy Greywater system used to flush toilets***

The **BSA** wanted to treat **all of the waste onsite** and still ensure the water quality in the area would not be affected by tens of **thousands of temporary residents**.

BSA Summit Bechtel Reserve

- 336 shower facilities
- Reuse of greywater for toilet flushing
- Rainwater makeup
- Potable water makeup



01/07/2019 #55

Part of the facility design included **336 shower facilities** that **reuse greywater for flush toilets**.

They were designed with both **rainwater and potable water makeup** in the event there was **not enough greywater to flush toilets**.

Each **neighborhood** is outfitted with **3 shower facilities** and required **one Orengo AdvanTex greywater treatment system**.


That's a total of **112 separate treatment units**. Each treatment system is capable of treating **2,000 gallons per day**, for a total of **224,000 gpd**.

The **Preferred materials are fiberglass and HDPE to meet Living Building Challenge Requirements**. The system is **capable of cycling from a non-use condition to full treatment use in 24 hours or less** and automatically **diverting overflow to the black water treatment system**.

Orenco
SYSTEMS

BSA National Jamboree 2013 and 2017

The greywater system at the Summit Bechtel Reserve is designed to treat and reuse over 200,000 gallons (757 m³) per day, which saves over two million gallons (7,571 m³) of water during a Jamboree.



01/07/2019 #56

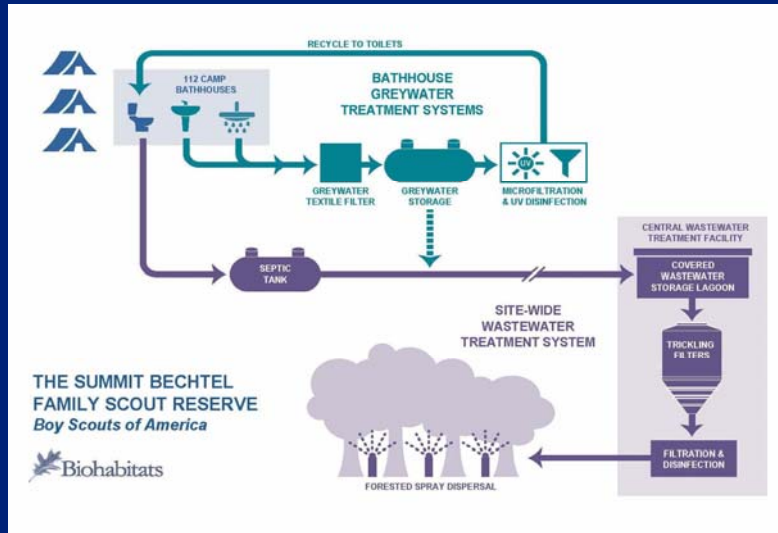
This is an **aerial view** of the **national jamboree in 2013**. The Boy Scouts of America held another **National jamboree in 2017** and the Summit will host the world scouting **Jamboree in 2019**.

One of the main **project goals** was to **protect the New River** by **eliminating any direct discharge of treated wastewater**.

The most **efficient** way to do this was to **capture, treat and reuse shower and sink water to flush nearby toilets**.

Blackwater is transferred to a **centralized treatment plant** located far **from camping areas**, where it is **filtered, disinfected**, and then dispersed through the forest via a **sprayed irrigation system**.

BSA Summit Bechtel Reserve



01/07/2019 #57

Effluent enters the greywater tank and is **recirculated over the textile sheets**.

A pump in the **discharge** chamber **periodically doses effluent** to a **UV disinfection** unit and into a **pressure tank** that provides the **water for the toilets**.

BSA Summit Bechtel Reserve



01/07/2019 #58

This type of PBF treatment systems are very simple, natural, and energy efficient.

They provide a solution for waste to be treated right at the facility—as close to the point of generation as possible.

The Urban Frontier House

Billings, Montana

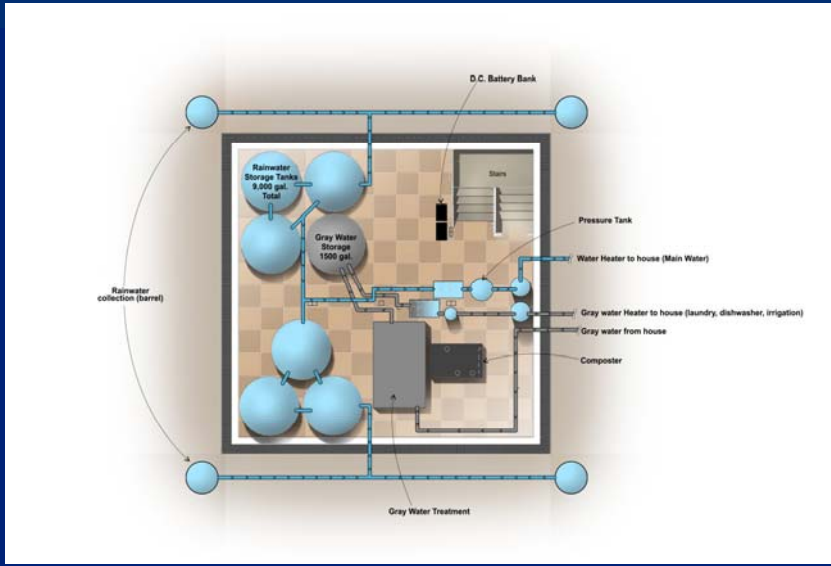


01/07/2019 #59

The Urban Frontier House in downtown Billings, Montana, is an off-grid, net-positive-water home that provides an excellent illustration of how energy and water efficiency can be included when designing sustainable homes in urban settings.



- **Site area:** 7000 SF
- **Total roof area:** ±3000 SF
- **Total house area:** 2400 SF
- **Garden room area:** 320 SF
- **Design began:** 2009 (1976)
- **Groundbreaking:** 2013
- **Construction start:** 2014
- **Occupancy:** July-October, 2016





01/07/2019 #63

Greywater Treatment Components

- Screen
- Media filter
- Micron filtration
- Disinfection
 - UV (standard)
 - Chlorine (optional)
- Telemetry controls
- Integrated controls for all sources, including make-up
- Treated water storage
- Rainwater make-up equipment

Physical processes include sedimentation and flotation. These processes happen in the primary clarifier of a sewage treatment plant and in the septic tank for onsite systems.

Septic tanks also provide anaerobic digestion - a biochemical process

Effluent screens and media filters provide mechanical screening preventing particles of some size from passing to downstream processes.

The microbes attached to the filter media aerobically degrade the organic carbon and nutrients in the septic tank effluent - another biochemical process.

If the septic tank is followed by a soil dispersal systems, the microbes are attached to the soil and aerobic biodegradation must occur in the soil to achieve wastewater treatment.



01/07/2019 #65



Greywater Textile Treatment

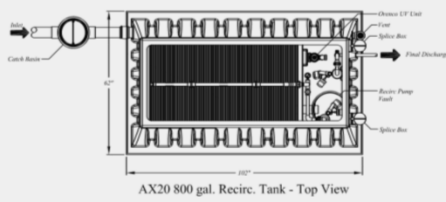
- Pre-packaged unit
- All equipment included in single package
- Textile is very energy-efficient treatment
- Packed-bed filter technology



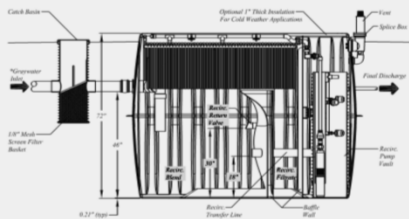
01/07/2019 #67

This unit may look familiar as it's the same unit used for residential and small commercial blackwater treatment. There is current development efforts to create a smaller unit specifically for residential greywater applications that will improve the economic of the overall package.

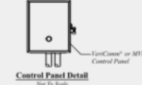
AX20RTUV Graywater System - UV with Pump Discharge



AX20 800 gal. Recirc. Tank - Top View



AX20 800 gal. Recirc. Tank - Side View



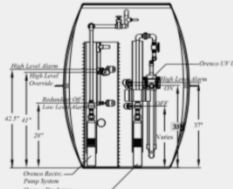
Control Panel Detail for 50 Liter

The 30-day average concentration of the graywater defined in the system may typically fall within the following ranges, or be lower.

USE USE Parameter	Range
TOC	100 - 1000 mg/L
TSS	10 - 100 mg/L
Turbidity	10 - 50 NTU
Total Kjeldahl Nitrogen - N	1.0 - 10 mg/L
pH	6.5 - 8.0
Sulfides	10 - 100 mg/L
Total Phosphorus - P	10 - 20 mg/L
Conductivity	100 - 400 µS/cm
COD	100 - 400 mg/L
TDS	100 - 1000 mg/L
Total coliforms	10 ³ - 10 ⁷ cfu/100 mL
E. coli	10 ¹ - 10 ⁵ cfu/100 mL
Temperature	20° - 30° C
Hardness	not pre-established (check shipping document for established (check shipping document) and pre-established (check shipping document) ranges)
Fats, oil and grease	

Design and Installation Notes

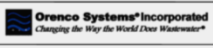
- For Required Concentration (Time) (Disinfection or Ion)
- Installation To Be Performed By An
- Authorized Trained Installer Only
- Shipping And Service To Be Performed By An Authorized Trained Service Provider



Discharge Chamber - End View

UNAUTHORIZED CHANGES & USES
 Changes to flow water heating
 changes the holding residual
 chlorine residual, disinfectant
 residuals, chlorine or ozone
 residuals and chlorine residual

PRODUCT CONFIGURATION DRAWINGS



Drawn By: Eiv Deth	Project: AX20RTUV Mode TB	Scale: 1" = 2'-0"
Drawn For:	Graywater System	Sheet: 1 OF 1
Temperature:		Rev. A-01
Date: 8/18/2011		

017072019 #08

This is a simple system that requires virtually zero maintenance, completely prepackaged for simple installation, and high quality effluent ready for disinfection and reuse.

Garden Room





01/07/2019 #70

The Blue Beast...a commercial composting unit that will change your perspective of composting toilets. Phoenix Unit from Advanced Composting Systems out of Montana.



01/07/2019 #71

The scary composting toilet!!

Indoor Use







Thousand Trails RV Resort, La Pine, Oregon

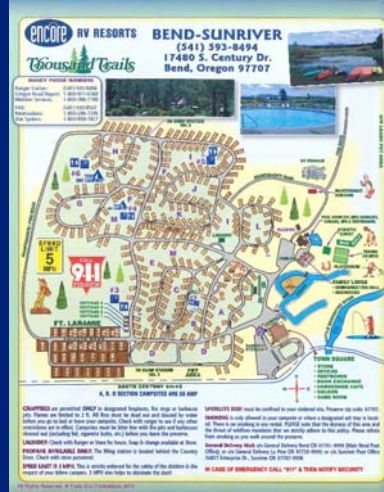


01/07/2019 #74

The Thousand Trails Bend/Sunriver facility located in La Pine Oregon is a high end RV resort. With many amenities and local activities it is a destination resort for RV enthusiasts.

Thousand Trails Amenities

- 283-acre site with 199 dry RV spots
- 34 home lots,
- 11 yurts and cabins,
- 2 RV dump location,
- Lodge and swimming facility
- Retail shop and offices



01/07/2019 #75

283 acres with

- 199 RV spots**
- 34 home lots**
- 11 yurts and cabins**
- 2 RV dump stations**
- A lodge and swimming facility**
- A retail Shop**
- and Office space**



Thousand Trails RV Resort

Features of the wastewater treatment facility include ...

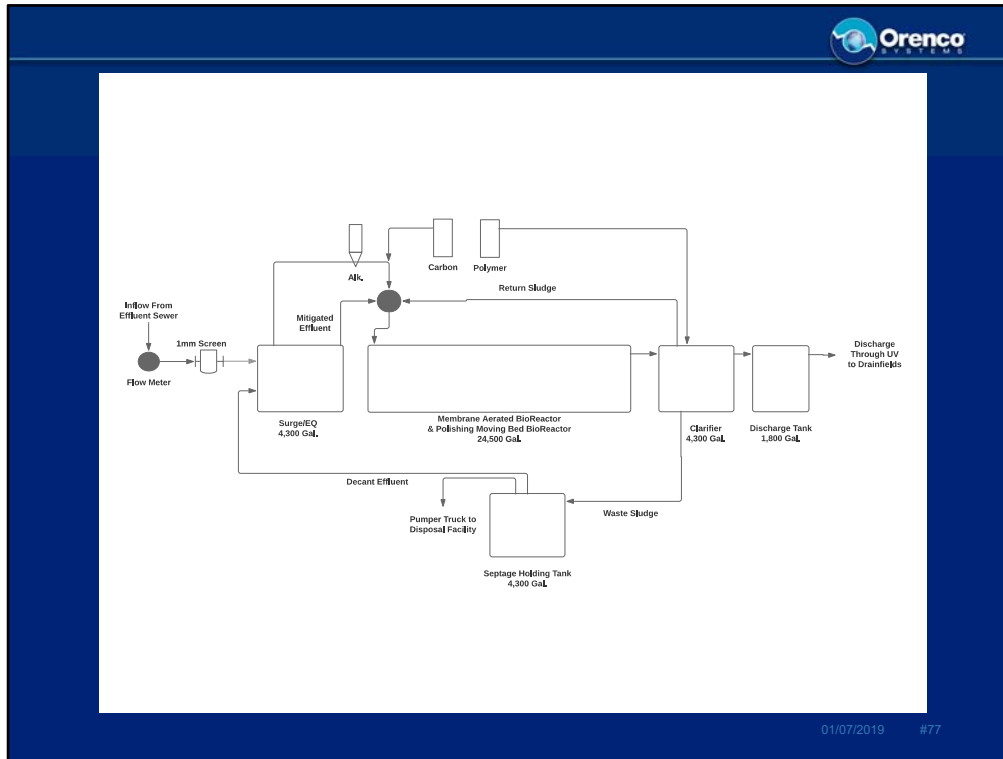
- Septic tanks at 13 locations for pretreatment; watertight construction to eliminate infiltration and inflow (I&I)
- Anaerobic solids digestion to minimize solids-handling needs
- Membrane Aerated BioReactor (MABR) construction in the secondary treatment unit for reduced energy usage
- No odor generation
- Low noise
- Low greenhouse gas production
- Pleasing aesthetics
- High-quality water



01/07/2019 #76

The **features** of the wastewater **treatment** system are designed to encourage **sustainable results** by **minimizing energy consumption** and **maximizing nutrient reduction** to **protect the local aquifer** which is a **drinking water source** for the **local inhabitants**.

Maximizing solids digestion, nutrient reduction, and minimal energy consumption, are all elements the designer focused on to providing a **efficient and economic solution**.



Wastewater from the residence is **collected** in a primary tanks where solids are **settled and digestion is maximized**.

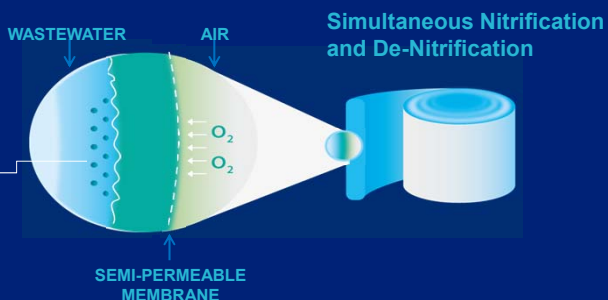
From the primary treatment tanks the wastewater **flows to a surge tank and then to the Membrane Aerated BioReactor**.

A 4 hopper clarifier is utilized for solids settling and return activated sludge dosing.

Effluent is **stored again** and dosed out through **UV disinfection** and prior to discharging.

Membrane Aerated Biofilm Reactors (“MABR”) Technology

- Nitrifying biofilm oxidizes nitrogen compounds to nitrate in the oxygen-rich, low-BOD layer
- Denitrifying biomass breaks down nitrate & remaining BOD



01/07/2019 #78

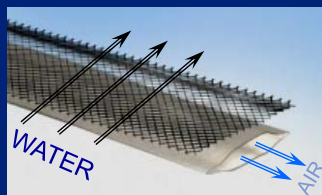
Oxygen is constantly supplied to a fixed biofilm that develops on the wastewater side of the membrane sleeve. Simultaneous aerobic and anoxic conditions develop in this zone, leading to simultaneous nitrification and denitrification using very little energy and space. This low-pressure, passive aeration offers significant energy savings over conventional, high-pressure aeration.

The MABR Technology

- Wastewater is in contact with the surface of an aerated sleeve of oxygen-permeable material
- Aerobic bacteria that develop on the surface of the sleeve treat the wastewater



One spirally wound long sleeve



01/07/2019 #79

Ambient air is delivered by diffusion through a patented membrane to the wastewater, eliminating the need for pressurized air, as used in conventional systems.

The MABR is able to substantially reduce energy costs, operation and maintenance expenses, all while producing a very high quality effluent.

Thousand Trails RV Resort Effluent Requirements

WPCF Permit

- $BOD_5 < 10 \text{ mg/L}$
- $TSS < 10 \text{ mg/L}$
- $TN < 10 \text{ mg/L}$
- $E. coli < 10 \text{ CFU}$

The Systems is currently under construction, estimated completion in April 2019



The treatment plant is required to meet **WPCF nitrogen** water standards.

The Future of Water

In the near future, we need more emphasis on ...

- Integrating non-potable water reuse (and, possibly, potable reuse) as a standard
- Regularly using combined food and organic wastes for nutrient recycling
- Reducing overall treatment system footprint through improved technology
- Using heat energy from water to power collection, distribution, and treatment facilities
- Providing more education about responsible water usage



01/07/2019 #81

The near future looks promising and with continued innovation we are going to opening new doors to:

- **Non-potable reuse as the standard**
- **nutrient recycling**
- **heat recover and energy generation**
- **Smaller footprints**
- **And lower energy consuming systems**

These **factors** will **continue** be improved through **our industries technology advancement**.

In the future, reuse of water and resource recovery will be the norm.

Conclusions

- A “one size fits all” approach doesn’t work.
- Encouraging innovation, forward thinking, and acceptance of alternatives is critically important.
- We need to appropriately value potable water.
- Acknowledgment of the environmental benefits of responsible water recycling.

A **one-size-fits-all approach doesn’t work** in an evolving world. **Embracing alternatives** for individual and small community **decentralized recycling systems** is necessary.

We need to continue to **encourage innovation, forward thinking, and acceptance of alternatives** that **improve water resiliency and resource recovery**.

This **starts with** putting a appropriate **value on potable water** and emphasizing **the environmental benefits associated with responsible water recycling**.

Conclusions

- The rising costs of aging infrastructure, energy costs, potential for greenhouse gas tax, and the contamination of fresh water sources continue to drive innovation in water treatment technologies.
- The initial push for innovation continues to occur in places of extreme weather shifts and major fresh water pollution problems.
- The evolution in decentralized water technologies is tied to the economic incentives and flexibility of policies that lower the risk in experimentation.

Rising infrastructure costs, energy, and fresh water contamination are driving innovation.

Initial push for innovation occurs in places of extreme weather shifts or water pollution outbreaks.

The evolution of technology is tied to economic incentives and flexibility of policies to accept innovated experimentation.

Decentralized Is The Future

“Perhaps the best long-term solution to our water problems will be to abandon centralized water systems altogether. At first glance, this approach seems as if it would create more problems than it solves. But if we can figure out ways to meet our water needs with local resources, to safely treat our wastes close to where they are produced, and to drain the streets without a centralized storm sewer system, we might break free of the cycle of costly investments and environmental damage that currently plague our current water and wastewater systems.”

Water 4.0
A Different Tomorrow
David Sedlak

I'll end with a quote from David Sedlaks recent book Water 4.0

“Perhaps the best long-term solution to our water problems will be to abandon centralized water systems altogether. At first glance, this approach seems as if it would create more problems than it solves. But if we can figure out ways to meet our water needs with local resources, to safely treat our wastes close to where they are produced, and to drain the streets without a centralized storm sewer system, we might break free of the cycle of costly investments and environmental damage that currently plague our current water and wastewater systems.”

Thank You!

Tristian Bounds, P.E. – tristianb@orencosystems.com

Thank you for your time today!