Developer Toolkit

Innovative Onsite Wastewater Treatment:
Guide to Maximizing Land Use for Housing Development

Funded by the University of Vermont Leahy Institute for Rural Partnerships

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BRIGHTWATER TOOLS

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Our toolkit is for:

For architects, civil engineers, developers and housing advocates who struggle with wastewater challenges in Vermont. Our toolkit provides primary information, considerations, and implementation guides that can help stakeholders choose new options for water management in multi-family, affordable housing projects (serving 50+ people).

The toolkit includes innovative water management systems that can help developers confidently build in locations that are currently too expensive or limited by geographical constraints.

Who Can Use This Information?

Professionals and stakeholders who benefit from onsite water management systems

Architects & Designers

- Design dual plumbing into new buildings from schematic phase
- Specify appropriate toilet technologies and greywater fixtures
- Coordinate treatment system footprint with mechanical/structural teams
- Specify non-potable fixture labeling and signage

Developers & Owners

- Evaluate system feasibility early in site acquisition
- Understand regulatory pathway before design begins
- Compare capital cost vs. avoided septic/utility costs
- Incorporate VTDEC engagement from project kickoff

Engineers (MEP/Civil)

- Size treatment systems and storage volumes
- Design collection, treatment, and distribution piping
- Specify monitoring instrumentation and remote controls
- Prepare permit drawings and supporting calculations

Housing Advocates & Planners

- Identify villages where onsite systems unlock density
- Advocate for code pathways that enable greywater reuse
- Connect developers to VTDEC and UVM resources
- Evaluate reuse as affordable housing infrastructure

Introduction: Table of Contents & Abbreviations

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Greywater - water from dishwashers, sinks, laundry, and showers.

Blackwater - flush water, toilet paper, and human waste. Everything from toilets.

Abbreviations

AG	Agriculture
AHJ	Authority Having Jurisdiction
BWT	Brightwater Tools
BOD5	Biochemical Oxygen Demand over a five day period
CT	Composting Toilet
EQ	Exceptional Quality
GW	Greywater
IPC	International Plumbing Code
MEP	Mechanical, Electrical, and Plumbing
NSF	National Science Foundation
O&M	Operations and Maintenance
R&D	Research and Development
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UD	Urine Diversion
US EPA	United States Environmental Protection Agency
UV	Ultraviolet light
UVM	University of Vermont
VAAFD	Vermont Agency of Agriculture, Food, & Markets
VT	Vermont
VT DEC	Vermont Department of Environmental Conservation
WWTP	Wastewater Treatment Plant

THE RURAL VERMONT CHALLENGE

Why conventional systems fail rural villages

200+

VT villages without adequate wastewater infrastructure

80%+

Reduction in toilet water use with vacuum flush systems

3rd Option

A promising path beyond septic and centralized sewers is needed

No Municipal Sewer System

Establishing municipal wastewater treatment to unserviced areas is prohibitively expensive and faces significant local resistance.

Septic System Constraints

Many rural lots are unsuitable for traditional septic systems due to poor soils, shallow bedrock, or steep slopes — blocking permits entirely.

Affordable Housing Crisis

Left with minimal space and no sewer, limited housing can be built in village centers. This exacerbates the housing crisis and keeps prices high in rural villages.

Environmental Pressure

Conventional systems contribute to groundwater nitrate contamination and harmful algal blooms in nearby lakes and streams.

Introduction

A positive vision of the future for onsite wastewater management and reuse



Pipes

- Dashed lines are pipes.
- Dual piping separates waste streams

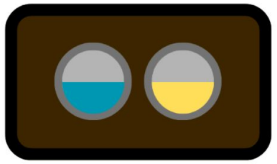


Image generated by Google Gemini AI to show what a 50-person alternative treatment development may look like. Every system configuration would be different depending on the goals of the people served.

Why Seek Alternative Solutions?

The case for alternative sanitation in rural Vermont villages - treatment plant issues

Septage is Undesirable at Some WWTPs

Septage is a variable and challenging material and therefore seen as problematic by some wastewater treatment facilities, which may limit acceptance.

"Approximately, **55%** of Vermont homes have decentralized wastewater systems, which is the highest of any state in the US."

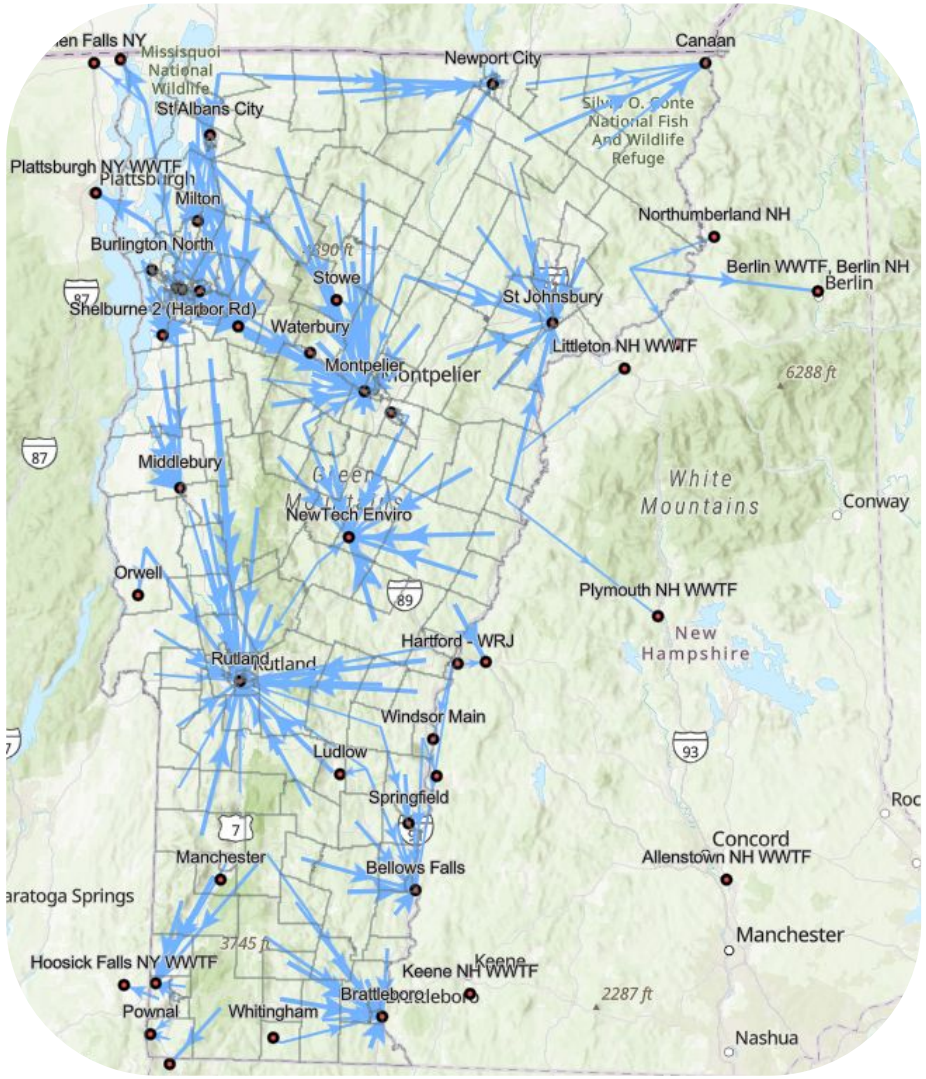
[WasteWater.pdf]

About **81.4 million** gallons of septage is generated per year in Vermont which must be hauled to wastewater treatment plants willing to accept it. (Left map)

[VTDEC_SeptageManagementStudy_TM_Final.pdf, Septage Management Evaluation - Overview]

Only about **6%** of current and potential residential land in Vermont has access to sewers. (Right map)

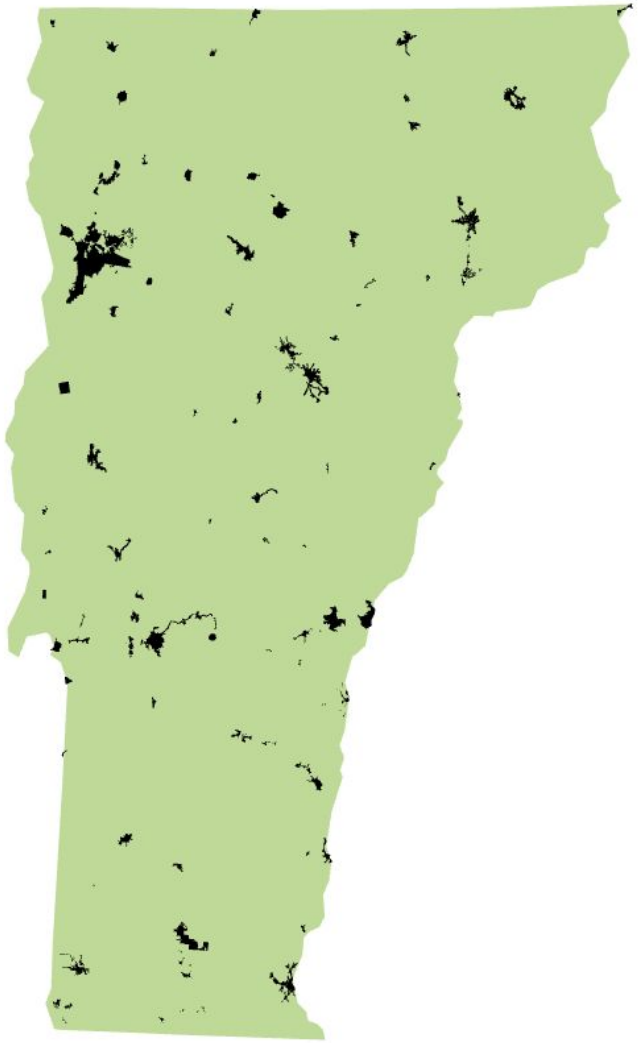
[Mapping Vermont's Wastewater Infrastructure | Leahy...]



Legend

Dots - Wastewater Treatment Plants that accept septage

Arrows - Where septage waste must be transported



Legend

Black - Land serviced by treatment plants (sewer access)

Why Seek Alternative Solutions?

The case for alternative sanitation in rural Vermont villages - limited land and challenges

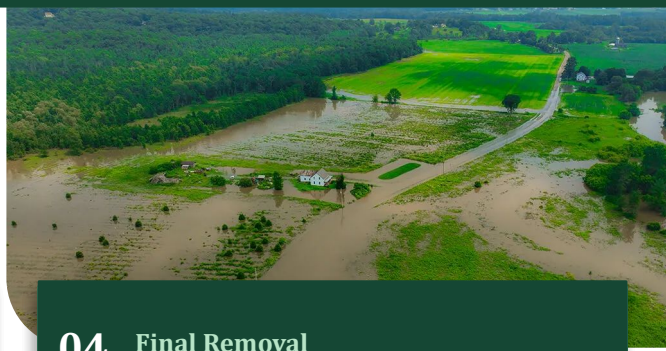


Photo Credit:
Check out Vermont's Open Farm Week, largest agricultural fair ,
Rock of Ages quarry ends tours and closes visitors center - VTDigger ,
How Big Is Lake Champlain In Vermont at Hazel Phillips blog ,
LaPlatte River Marsh Wetland one step closer to enhanced protections – Vermont Natural Resources Council ,
114,087 Green Mountain National Forest Vermont Royalty-Free Images, Stock Photos & Pictures | Shutterstock ,
Best Vermont Ski Areas | Vermont.com ,
Mount Mansfield | Explore Mount Mansfield Vermont

Method Used to Estimate the 74%

…of VT current & potential residential land is challenging for conventional septic systems and lacking sewers





01 Initial Removal

Removal of protected land and water

Large single type maps from VT State

- Prime Agricultural Land
- Protected Land
- Water
- Wetlands

02 Finding Current & Potential Residential Land

Removal of zoned land

Specific zoning from Rural Planning Commissions' future land use maps

- Industrial
- Resource (ex. logging forests)
- Conservation
- Working Lands

Lack of standardized labelling and definitions between RPCs added some challenges.

03 Removing Sewer Access

Remove land with sewer access

6% of VT Current and Potential Residential Land has access to sewers

Remaining land is forced to utilize on-site sanitation strategies.

04 Final Removal

Isolate soils best for alternatives

Removal of best suited septic soils and soils not suitable for development

- Class I soils, best suited with rapid-moderate permeability
- Soils with slopes entirely greater than 20%
- Soils with a flooding hazard





74%

of VT current & potential residential land is challenging for conventional septic systems and lacking sewers

Photo Credit:
2,600+ Green Mountain Vermont Stock Photos, Pictures & Royalty-Free Images - iStock ,
Lisa Emerson: Keeping Vermont weird ,
Burlington plots wastewater upgrades - VTDigger ,
UVM Launches Six Innovative Flood Research Projects

Why Onsite Wastewater Treatment?

The case for alternative sanitation in rural Vermont villages

200+

Vermont villages lacking adequate wastewater infrastructure

80%+

reduction in toilet water use with vacuum flush systems

~90%

volume reduction of collected urine by Brightwater Tools Freeze Concentrator

~74%

of current and potential residential land in Vermont is challenging for conventional septic systems and lacking sewers.

Unlocks Density

Sites currently unsuitable for standard septic can be developed with alternative systems, enabling more units per acre in village centers.

Protects Water Quality

Prevents nitrate leaching into groundwater and reduces phosphorus-driven algal blooms in Vermont lakes and streams.

Reduces Infrastructure Cost

Eliminates or dramatically reduces the leach field, a major cost and land burden for rural sites. No new sewer extension needed.

Creates Circular Value

Converts toilet waste into liquid fertilizer, compost and recovered water — reducing disposal burden and generating marketable resources.

Future-Proofs Affordable Housing

Alternative systems enable housing in villages where conventional septic is blocked, keeping development costs viable for affordable projects.

Resilient & Modular

Building-scale systems are not dependent on centralized infrastructure, providing resilience against utility disruption or expansion delays.

When is Onsite Treatment the Right Choice?

Scenarios where alternative systems are most appropriate and beneficial

IDEAL

Infill Village Development

Historic village center with no municipal sewer. Standard septic not viable due to lot size, soil conditions, or setback requirements. An alternative system enables density that would otherwise be impossible.

IDEAL

Rural Housing Subdivision

Rural parcels where establishing municipal wastewater treatment is cost-prohibitive. Clustered alternative systems of 10–50 units could help avoid the significant land demand of numerous individual septic systems.

GOOD FIT

Mixed-Use Commercial + Residential

Buildings with consistent daily occupancy provide reliable waste streams for biological treatment. Multiple end uses for reclaimed water increase system value.

GOOD FIT

Near Agricultural Partners

Proximity to farms or community gardens makes liquid fertilizer output especially valuable. Urine diversion systems maximize fertilizer quality and quantity.

CONSIDER

Low Occupancy or Seasonal Use

System biological components require consistent use. Seasonal buildings or low-occupancy units need careful sizing and startup planning. Consult an engineer for design guidance.

CONSIDER

Retrofit of Existing Buildings

Retrofitting dual plumbing is costly. Best suited to buildings undergoing major renovation. Greywater reuse may be viable without full replumbing.

How to Include a System in your Project

Step-by-step process for developers, architects, and engineers

01 Pre-Design

Assess site viability

Role: Developer

Confirm no municipal sewer is available or cost-effective. Identify wastewater volumes (occupancy × flow factors). For questions, refer to contacts sheet on slide 42.

02 Schematic Design

Choose system and engage VT DEC

Role: Developer + Architect

Determine the alternative system approach. Contact VT DEC early to understand permitting pathway. Reserve treatment room and routing space in building design. Incorporate system resilience into planning.

03 Design Development

Design dual plumbing & treatment

Role: Architect + MEP Engineer

Lay out separate greywater and blackwater drain lines from point of generation. Size treatment components with an engineer. Design for system redundancy and resiliency. Specify monitoring instrumentation and alert systems.

04 Permit Documents

Prepare permit package

Role: Civil + MEP Engineer

Submit VT DEC wastewater permit application(s) with system drawings, flow calculations, and treatment specifications. Coordinate with local jurisdiction for plumbing permit.

05 Construction

Install & commission

Role: Contractor

Install system components and piping. Commission in sequence: greywater first (clean water test), then blackwater stream. Vermont licensed Wastewater System and Potable Water Supply designer certifies installation.

06 Operations

Operate, monitor & report

Role: Owner / Operator

Implement operations plan: daily checks, weekly maintenance, monthly sampling. Submit mandatory VT DEC reports. A maintenance contract may be required. Communicate with building occupants annually. Refer to service provider for pickups.

What are the Basic Options?

A plain-language overview of the core technologies

Toilet Technologies

Vacuum Flush Toilet

Ultra-low flush, no composting on-site

Vacuum flush toilets use only 0.13-0.3 gallons per flush compared to the federal standard of 1.6 gallons. Compatible with several composter models.

Urine Diversion Toilet

Separates the two streams at source

Special bowl design diverts urine (~80% of nutrients) separately from feces. Enables urine fertilizer production and can reduce composting load significantly.

Composting Toilet

Low-flush + on-site composting

Waste goes directly into a contained composting vessel where microbes break down the waste, resulting in a useful compost product. This process helps kill harmful pathogens as well. Outputs are compost and leachate.

Treatment Technologies

Vermifilter

Waste goes into a contained basin where worms make vermicompost with the solids and the liquid seeps through the filter bed to create a cleaner liquid by-product.

Brightwater Tools Freeze Concentrator

Patented Freeze Concentrator reduces volume of urine by up to 90%, concentrating nutrients for fertilizer use while recovering clean water.

Pasteurizer & Carbon Filter

Thermal treatment removes pathogens and pharmaceuticals from the concentrate stream to levels safe for land application. Works in series with the Freeze Concentrator.

Greywater System

Passive or active treatment of greywater for reuse on property/nearby or discharge.

UV Disinfection

Final-stage disinfection for treated greywater. UV light inactivates remaining pathogens without adding chemicals.

Toilet Technologies - Vacuum Flush (VF)

80-92%

typical water savings of VF toilets

0.13-0.3

gallons used per VF flush compared to 1.6 gallon standard

~27%

household water dedicated to standard toilet flushing

A vacuum flush (VF) system utilizes pumps to create suction in the pipe network to pull waste through to the next part of the treatment system. These pumps can either be central for an entire system or incorporated within the toilets themselves.

VF allows for complex pipe designs and smaller pipe diameters. With the VF toilet, the compact design allows for flexibility and efficiency. Some VF pumps can even service multiple buildings.

R&D Status - *Relatively Established*

Vacuum flush toilets have been available for 40 years, with significant innovation during that time. This technology is currently feasible with multiple strong brands offering VF toilets. As further development and projects incorporate VF, costs will likely lower, reducing the financial barrier to implementation.

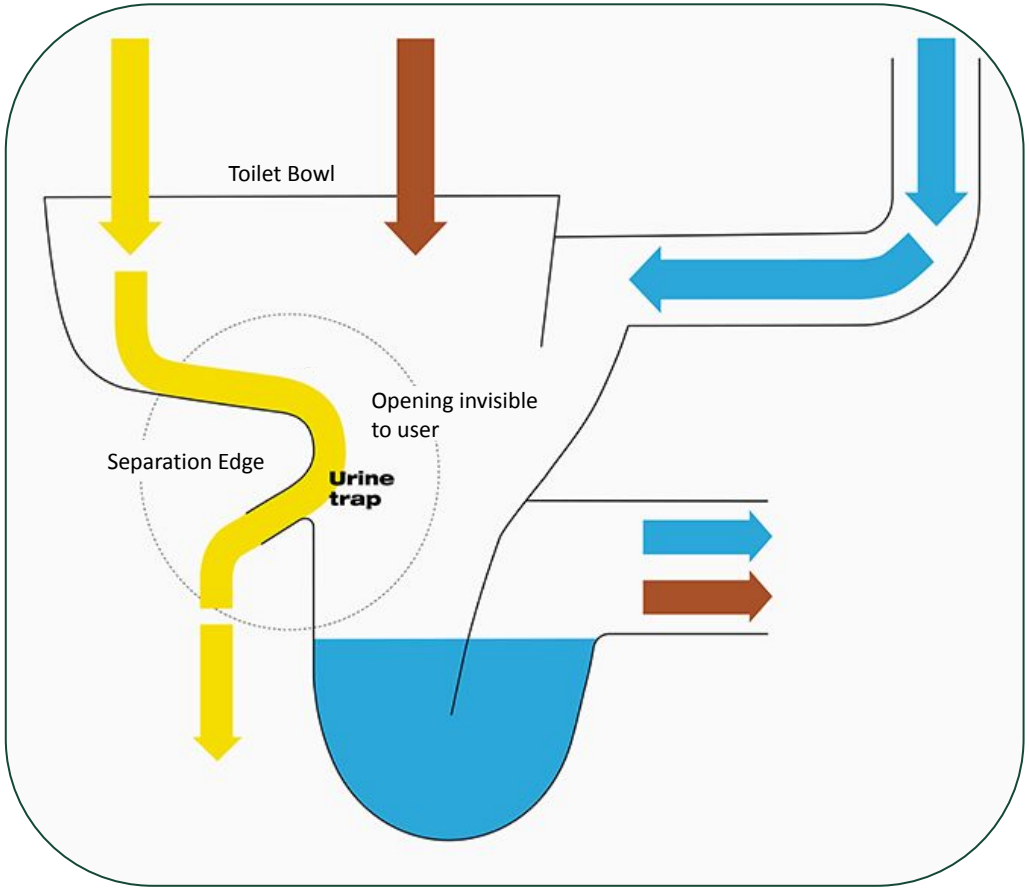




Various VF Toilets are available (Top), Vacuum Flush Central Pumps (Bottom)
[EcoVac new — Wostman, Jets® Group | Jets® vacuum units and systems]

Toilet Technologies - Urine Diversion





Diverting urine is useful to capture nutrients without the pathogen risk from feces.

The majority of valuable nutrients that make up fertilizers are found in urine compared to the rest of human waste.

- 70-90% of Nitrogen
- 45-80% of Phosphorus
- 70-95% of Potassium

Typically, four out of five flushes are for urine. Therefore using a UD toilet can also reduce water use by ensuring flushing is only needed for feces.

UD toilet (top), UD diagram (right)
[Urine-diverting-porcelain-pedestal-inside-870x870.jpg (870×870) , LAUFEN and EOOS design first gravity flushed urine-diverting toilet]

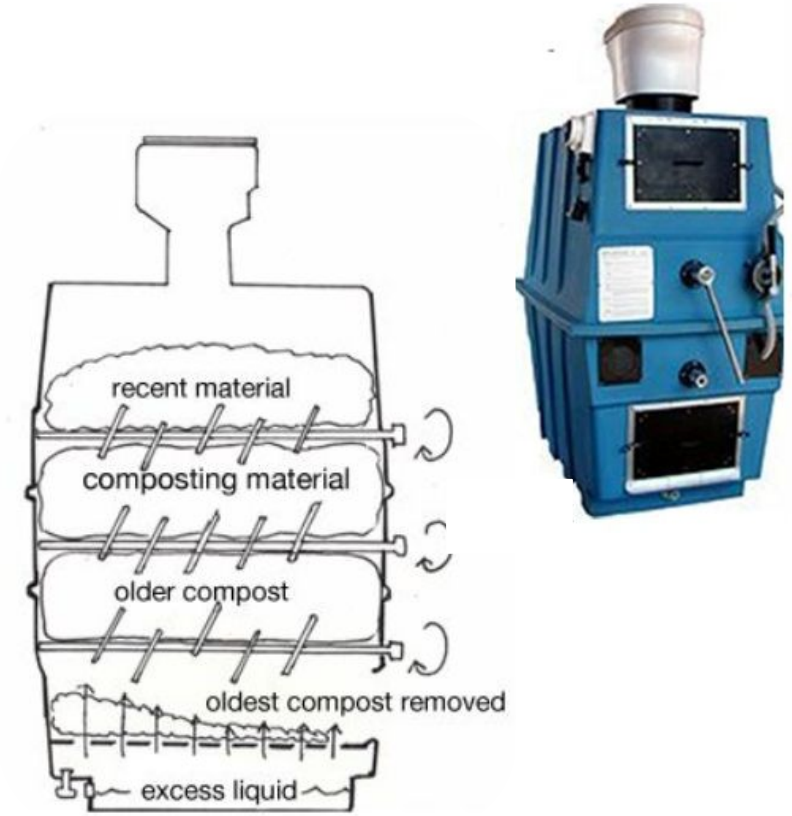
R&D Status - *Relatively Established*

There are currently only two UD toilet companies. Growing advocacy from groups such as the Rich Earth Institute has led to greater UD practices in and around Brattleboro, VT and other areas. As interest grows, this technology will likely become implemented in more toilets.

Toilet Technologies - Composting

Human waste, toilet paper, and any water from flushing is sent into a composter to be turned into a useful compost product.

- Urine diversion is valuable alongside use of composting because it reduces the water in the compost pile and the size of the composters needed.
- 50-90% volume reduction of waste.
- The leachate produced from the compost can be removed either with:
  - Automatic pump - electric sewage pump
  - Manual pump - marine bilge pump
  - Gravity drain
- Wood shavings or sawdust are typically used as a bulking agent to improve airflow in the pile and to reduce the water content of the pile. This ensures proper composting processes take place to kill off pathogens and create a quality compost.
- A ventilation system with a back-up generator ensures air quality is not impacted by this system.
- Compost typically only needs removal once a year from the bottom of the pile.
- Compost can be buried on-site or removed by a licensed hauler. (Refer to Regulations, slide 32)



Large Composter Diagram
[Large Bin Composting Systems – The Green Center]

R&D Status - *Further Development Needed*

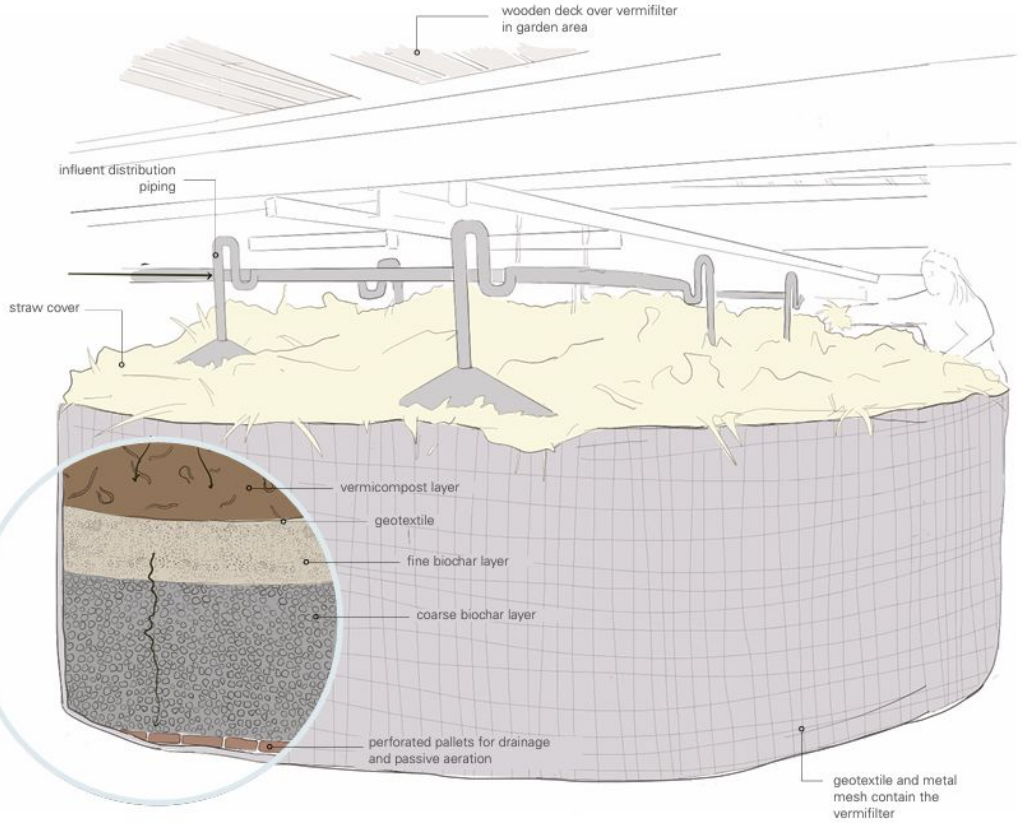
While the technology has been around for a long time, use in medium/large scale developments has only been relatively recent. Due to this, few companies make composters for such developments, while only one of those companies makes composters compatible with vacuum flush toilets. Greater interest and advocacy is needed to help further develop this industry.

Treatment Technologies - Vermifilter

A vermifilter utilizes earthworms to break down organic matter and aerate the filter. This allows for microbes to easily engage in the composting process.

- Low cost and energy demand
- Can use local materials for the filter
- Robust system
- Low maintenance
- Can handle variable loads
- Consistent temperatures, even in the winter

The solids remain at the top while the liquid seeps through filter media which consists of biochar, gravel, or wood chips. This system produces both vermi-compost and a liquid. Compared to composting, more liquid passes through and less solids are retained which can make end-product management easier. The liquid by-product has been treated through physical filtration in the media and organic decomposition.

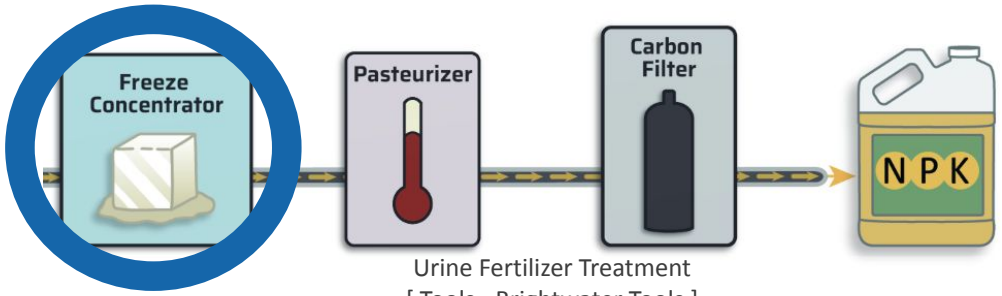


Mockup of a vermifilter that serves 100 people in Switzerland.
[Eawag, Circular Sanitation Toolbox]

R&D Status - *Needs Development*

While this technology is promising, only two projects at-scale are currently being conducted in Switzerland. The existing understanding of vermifilters comes from small-scale usage and laboratory tests, leaving a lack of real-world community use. More research and development will hopefully make this a viable solution for developments in the US. Further, advocacy will be needed on the classification of the liquid by-product for proper management and reuse.

Treatment Technologies - BWT Concentrator



Urine Fertilizer Treatment
[Tools - Brightwater Tools]

The Brightwater Tools' Freeze Concentrator leverages the physical process of freezing to remove water and condense waste.

- Inside the concentrator, batches of urine are partially frozen, resulting in the formation of pure ice crystals and a nutrient-rich concentrate.
- After the concentrate is drained, the ice crystals are melted and the water is removed to be lightly treated and reused.
- The resulting concentrate, with ~90% of the nutrients, can then be pasteurized and filtered for use as a fertilizer.
- The remaining, low-nutrient liquid can be treated with greywater for potential reuse.



Freeze Concentrator
[Tools - Brightwater Tools]

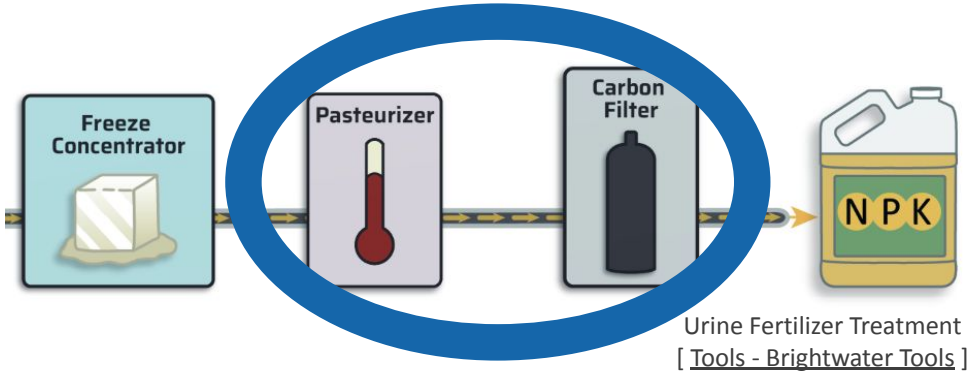
Technology Benefits:

- Processes high-strength liquid wastes
- Energy efficient
- Uses no harsh chemicals
- No active management
- Doesn't require stabilized nitrogen

R&D Status - *Relatively Established*

The BWT Freeze Concentrator has been consistently proven to yield promising results with urine in Brattleboro, VT and pilot tests across the world. BWT is seeking implementation in a development to prove its technology with consistent, household use.

Treatment Technologies - Pasteurizer & Carbon Filter



Urine Fertilizer Treatment
[Tools - Brightwater Tools]



BWT Fertilizer Product

The Brightwater Tools' Pasteurizer sanitizes high strength wastewater.

- The treated product meets US EPA requirements for use in agriculture.
- The Pasteurizer heat exchange technology minimizes energy use and nutrient loss.
- It is fully automated and can sanitize up to 150 gallons per day.

The Brightwater Tools' Carbon Filter removes contaminants.

- Granular activated carbon filtration removes organic micropollutants such as pharmaceuticals from liquid wastewater.



BWT Pasteurizer (left) and Carbon Filter (right)
[Tools - Brightwater Tools]

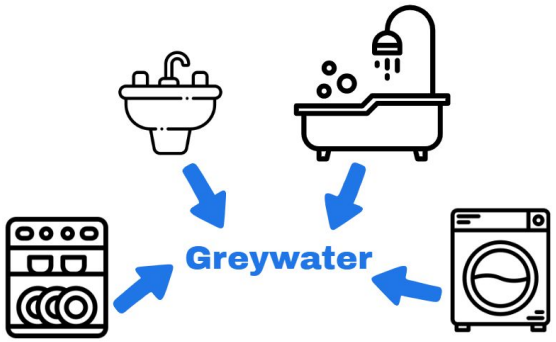
R&D Status - *Established*

Both Pasteurizers and Carbon Filters are well established technologies for wastewater with various companies providing these technologies.

Treatment Technologies - Greywater

Greywater Overview

- 50-80% of all water consumed by a household becomes greywater (GW)
- GW is wastewater from dishwashers, sinks, showers, and laundry
- GW is low in nutrients and pathogens which makes it easier to treat
- Treatment systems approved as VT DEC Innovative/Alternative systems are available.
- Estimated volume of 1,600-1,750 gallons/day for 50 people
- GW can be a good source for subsurface discharge where plants can utilize the water. Plants that can thrive on treated GW range from fruit trees to shrubbery to perennials.



Only treated greywater can be discharged through an engineered subsurface system. Greywater cannot be sprayed, released above ground, or applied to edible roots.





Greywater discharge to meet water demand diagram (left) and greywater discharged to a landscape/garden (right)
[*Greywater, Green Landscape* by Laura Allen, Greywater Garden — MIRIDAE]

End-Uses *(best option is site dependent)*

Direct Discharge - lowest footprint, highest permitting work, contact VT DEC

Subsurface Discharge - variable footprint, can be utilized to meet water needs of plants

Temporary Storage - medium footprint and cost. Can only be temporary due to large volumes.

Greenhouse - can be designed similar as a constructed wetland or more focused towards soil media. This will use plants to uptake and filter greywater. Largest footprint and cost, adds community value.

Treatment Technologies - Greywater

Specific Greywater Technologies

Treatment Options: *(dependent on site and end-use)*

- **Physical filters/screens**
  These are commonly used to remove debris, greases, and organics prior to other treatment strategies.
- **Sand/mulch bed filter**
  Beds of sand or mulch to trap and adsorb contaminants. Mulch beds usually have the added benefit of biological activity to help break down organics in greywater.
- **Activated carbon filter**
  With millions of tiny pores, activated carbon filters are very effective at removing odors, colors, organics, and contaminants in greywater.
- **Aerated basin**
  This treatment consists of a tank which air is bubbled into to support the bacteria present, who consume organic contaminants.
- **Constructed Wetlands**
  Greywater flows through a wetland filled with plants which take up nutrients while roots and the bed media help act as a filter to further treat the greywater. This system behaves and is designed similarly to green stormwater infrastructure.
- **Disinfection**
  Chlorine, ozone, or ultraviolet light are used to inactivate harmful pathogens to ensure greywater is safe for reuse.





A greywater filter diagram (top) and greywater treatment planter (right)
[Smart Water Recycling for Homes & Buildings | Hydraloop , The Estuary | Sustainable Greywater Filtration System]

R&D Status - *Established*

Greywater treatment and reuse has been established as a common way to reclaim significant water quantities for a long time. While the technologies exist for various scales and even as NSF 350 certified package systems, the regulation has not caught up in many states. In Vermont, greywater is not its own regulated category making its reuse limited and challenging. Not all of these technologies are available/allowed currently which leads to the importance of advocacy. (See regulations & advocacy slides for more).

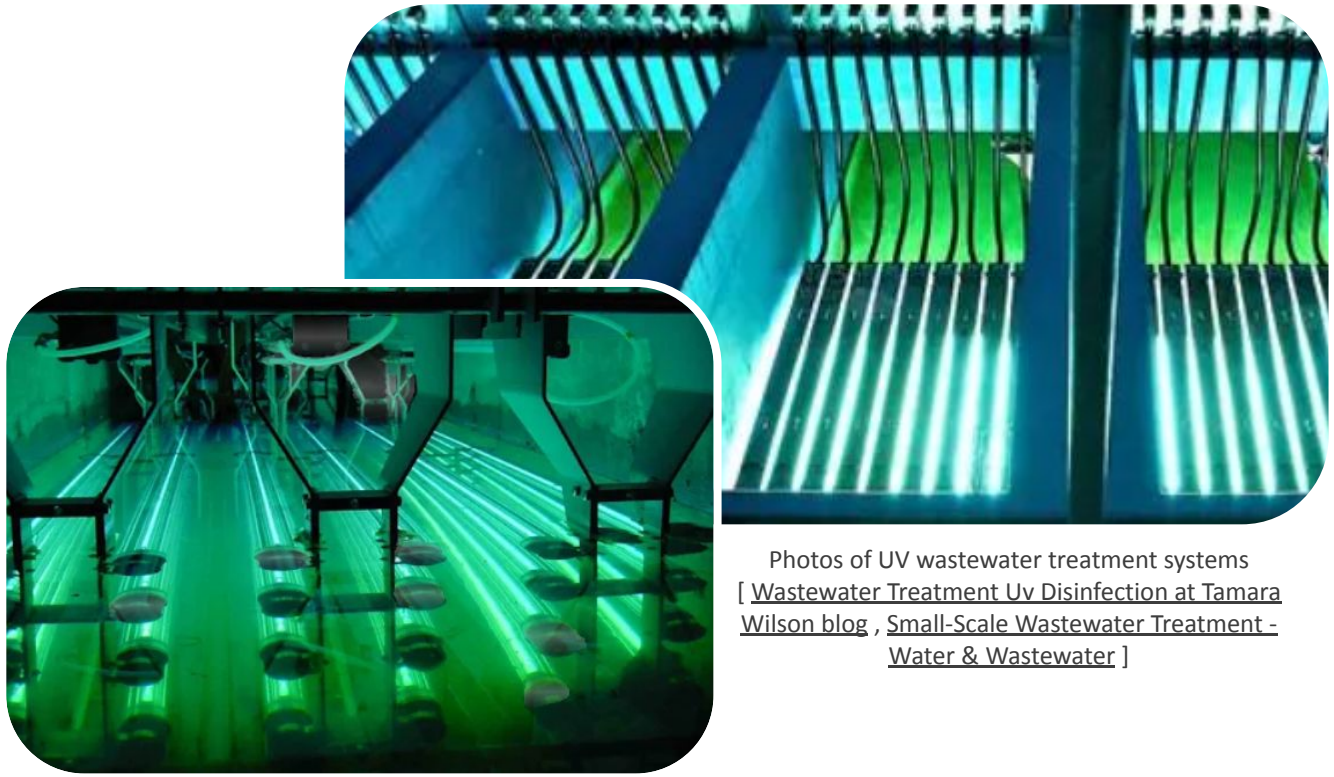
Treatment Technologies - UV Disinfection

When a correct dose of UV light is applied for seconds to a minute, pathogen DNA is damaged which inhibits replication, inactivating harmful pathogen populations.

UV light has an additional benefits over other disinfection processes:

- No risk of toxic off-gasses such as with ozone
- Less space required
- No Chlorine residuals (harmful to plants)
- No need to supply inputs (shipments of chlorine/ozone)
- Relatively cost effective
- Only input is electricity
- Effective at killing pathogens

**It is important to maintain a consistent flow to keep UV lamp temperature regulated and for effective treatment.*

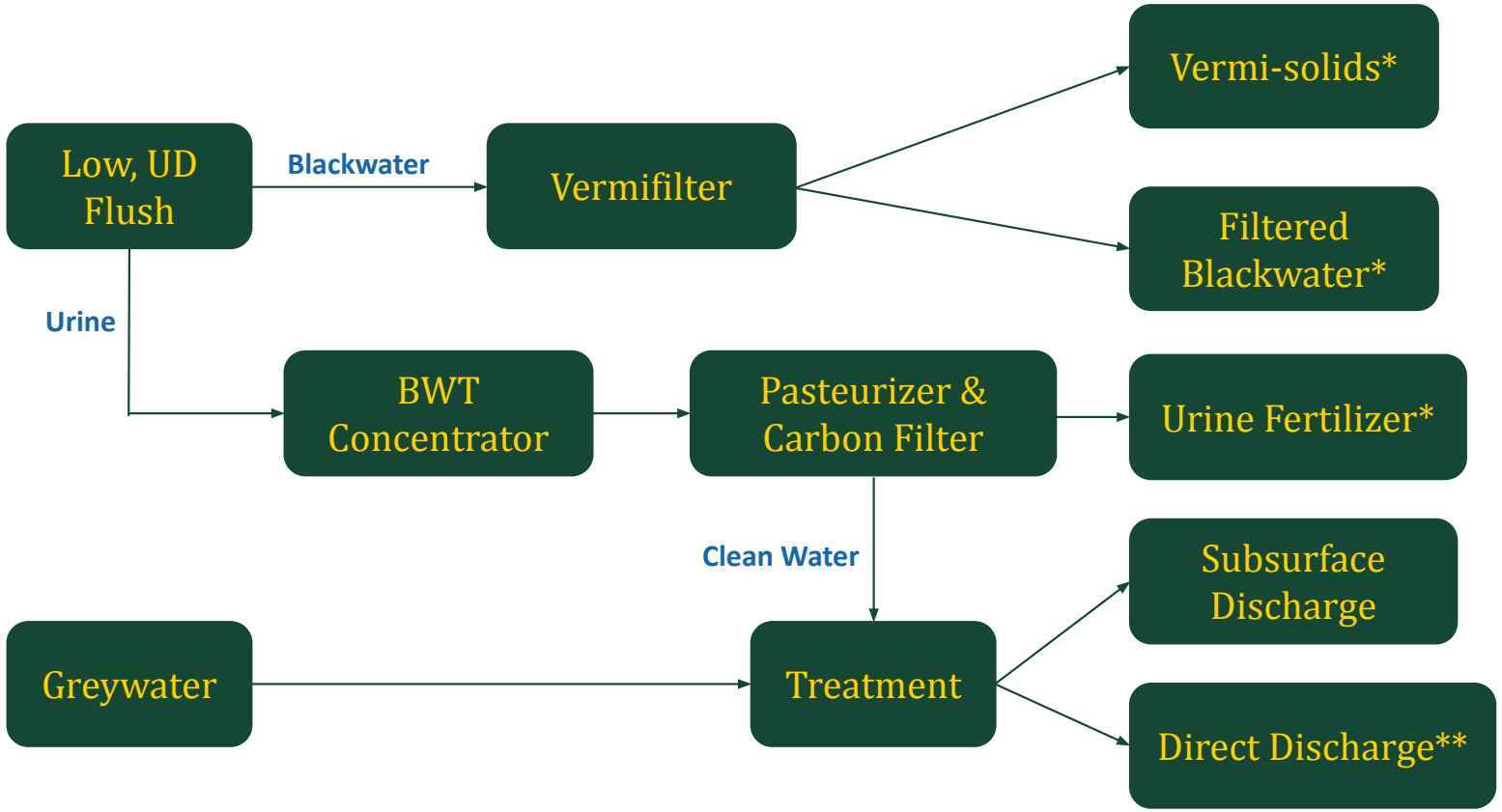


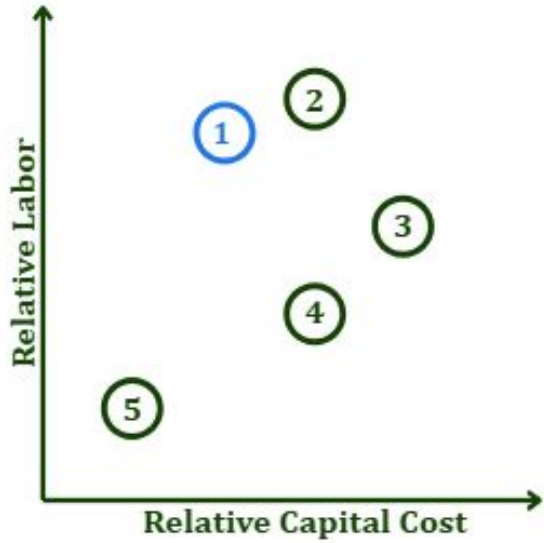
Photos of UV wastewater treatment systems [Wastewater Treatment Uv Disinfection at Tamara Wilson blog , Small-Scale Wastewater Treatment - Water & Wastewater]

R&D Status - *Established*

UV disinfection is found to be effective at large and small scales alike while producing space and cost savings which has led to an increasing adoption of this technology. With ~20% of US municipal treatment plants utilizing UV disinfection, this technology is proven and established for wastewater / greywater systems.

Alternative - System 1





Legend

Arrow with "urine" - *toilet with urine diversion capability*

***** - *waste/product that must be hauled away or distributed*

*** - complex regulatory requirements, contact VT DEC*

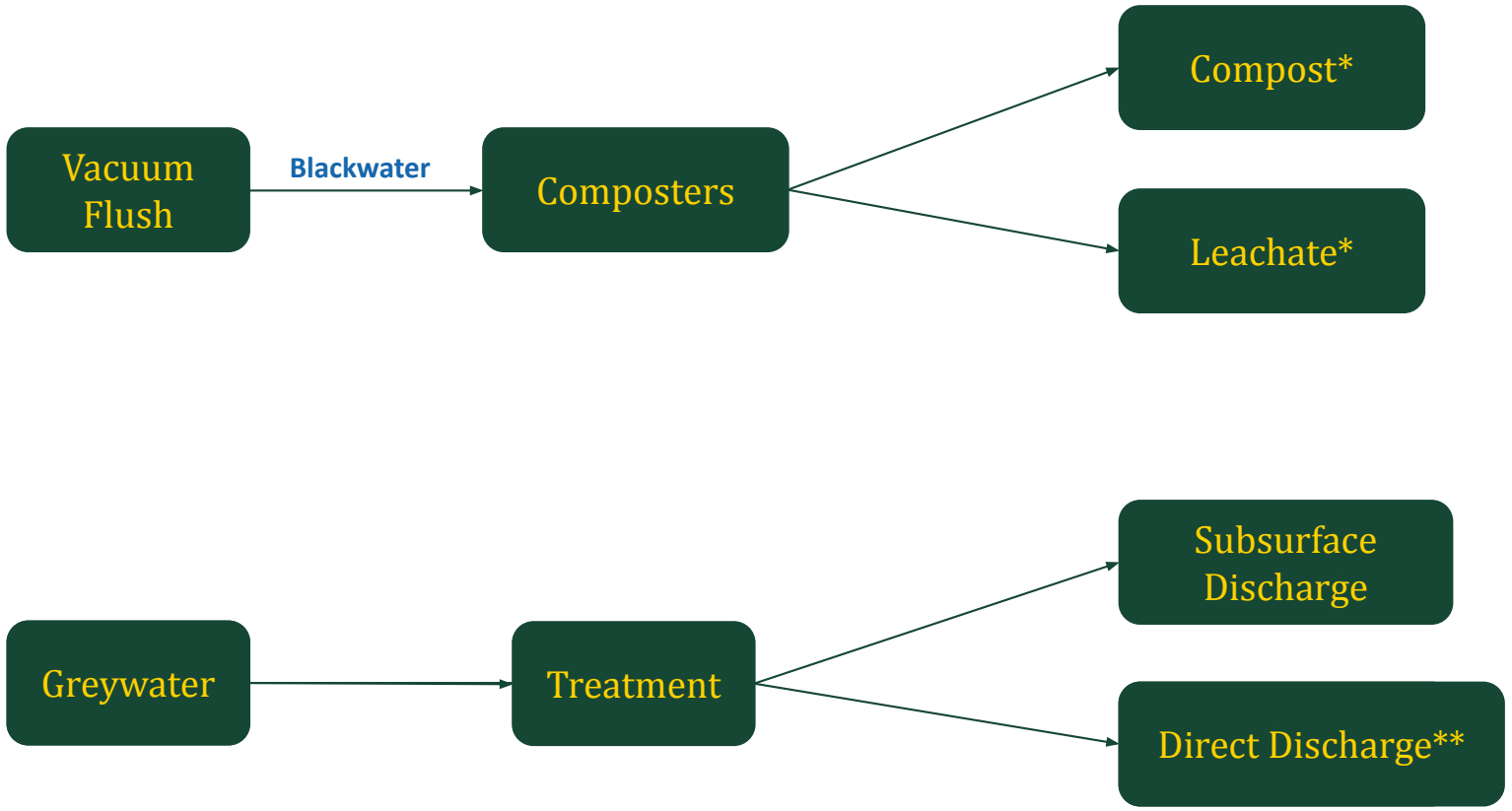
Benefits:

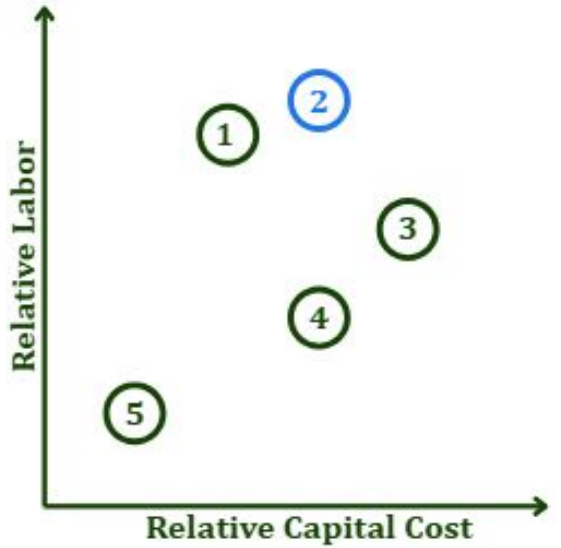
- Urine fertilizer production
- Low cost and footprint
- Greywater for subsurface discharge
- Decreased water demand
- No septic leach field
- Less solids produced than composting - easier to manage

Drawbacks:

- More development needed for vermifilter technology
- Greater water use without vacuum flush
- More liquid by-product from vermifilter than composting
- Present regulations would have the vermifilter products sent to WWTP

Alternative - System 2





Legend

** - waste/product that must be hauled away or distributed*

*** - complex regulatory requirements, contact VT DEC*

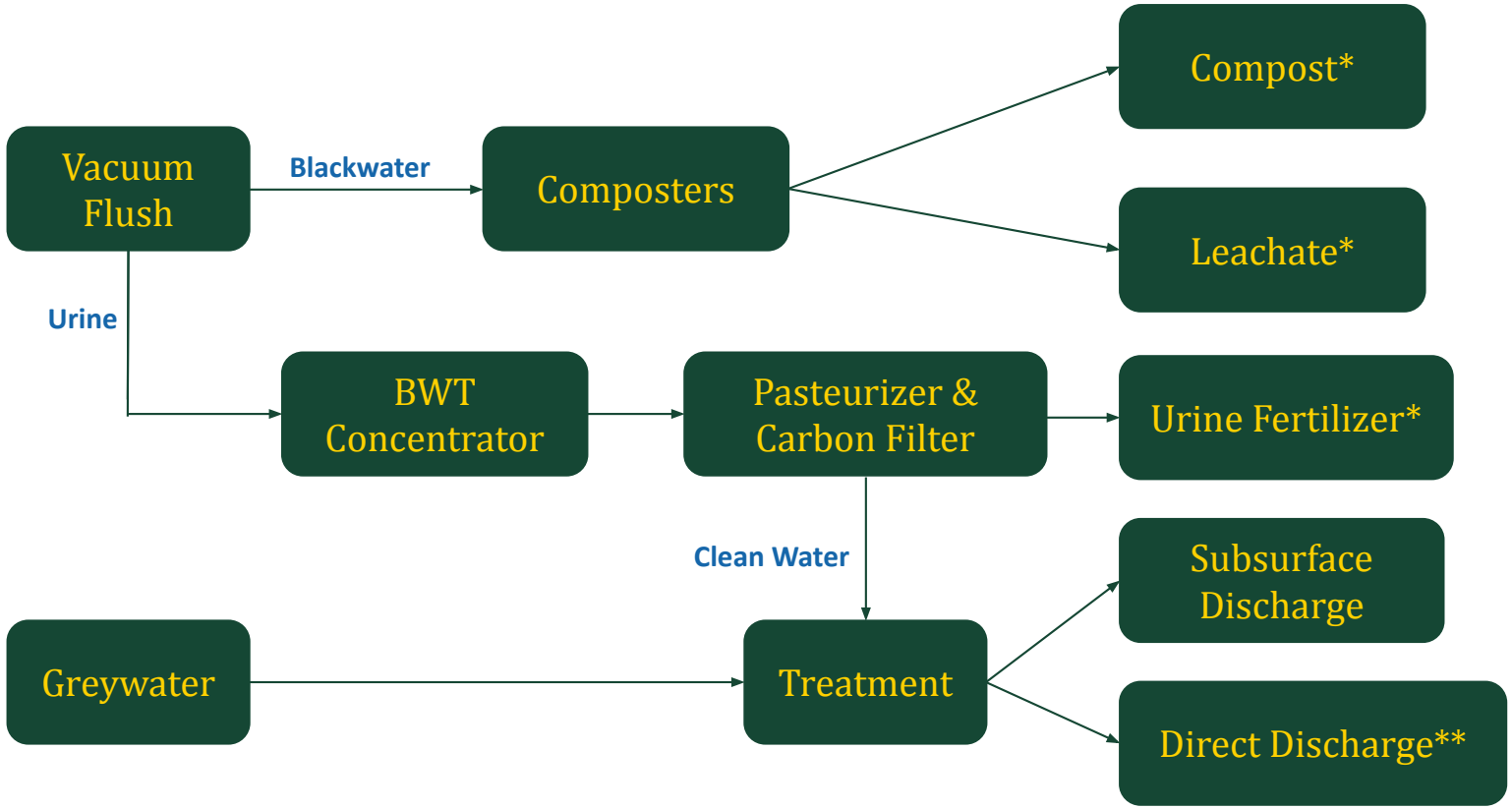
Benefits:

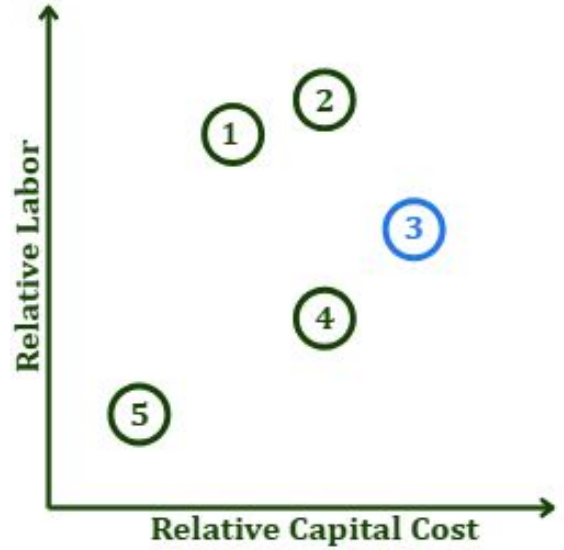
- Low footprint
- Very low water demand
- Greywater for subsurface discharge
- Compost product
- No septic leach field

Drawbacks:

- No urine fertilizer product
- Greater composter volume without urine diversion

Alternative - System 3





Legend

Arrow with "urine" - *toilet with urine diversion capability*

***** - *waste/product that must be hauled away or distributed*

*** - complex regulatory requirements, contact VT DEC*

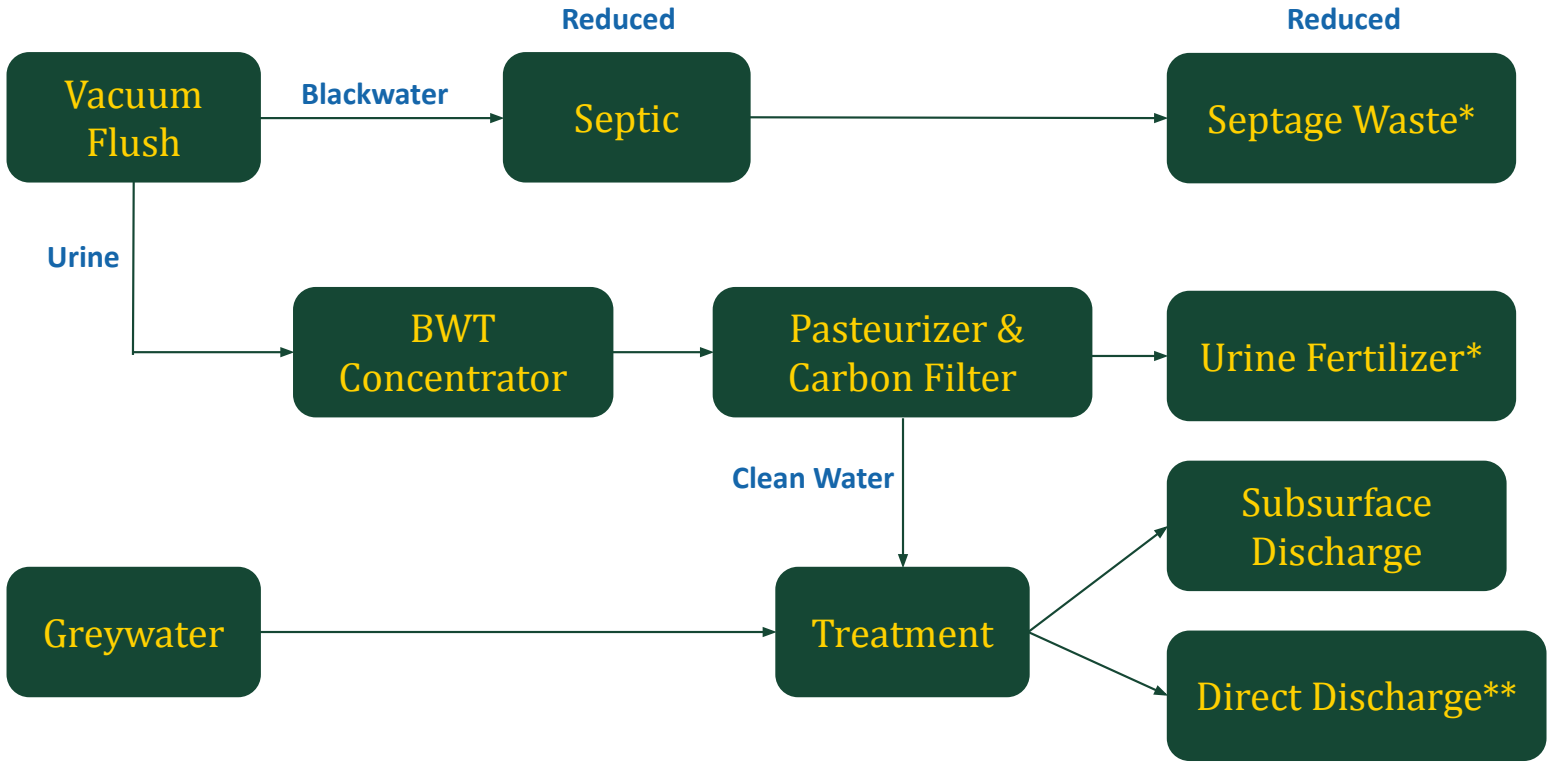
Benefits:

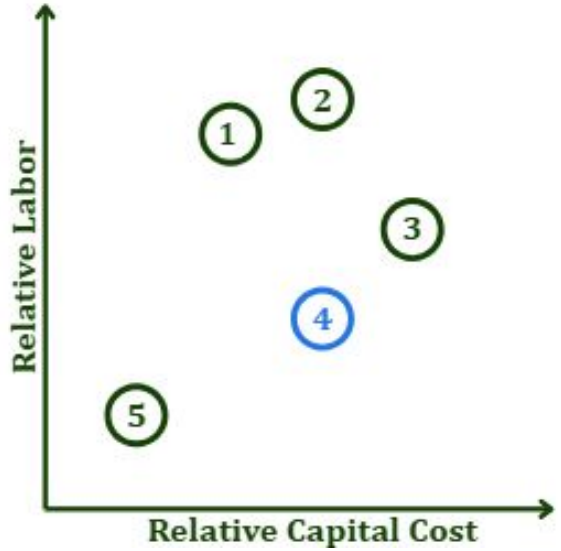
- Low footprint
- Very low water demand
- Urine fertilizer production
- Compost product
- No septic leach field
- Greywater for subsurface discharge

Drawbacks:

- Highest relative cost
- Relatively high O&M

Reduced Septic - System 4





Legend

Arrow with "urine" - *toilet with urine diversion capability*

***** - *waste/product that must be hauled away or distributed*

*** - complex regulatory requirements, contact VT DEC*

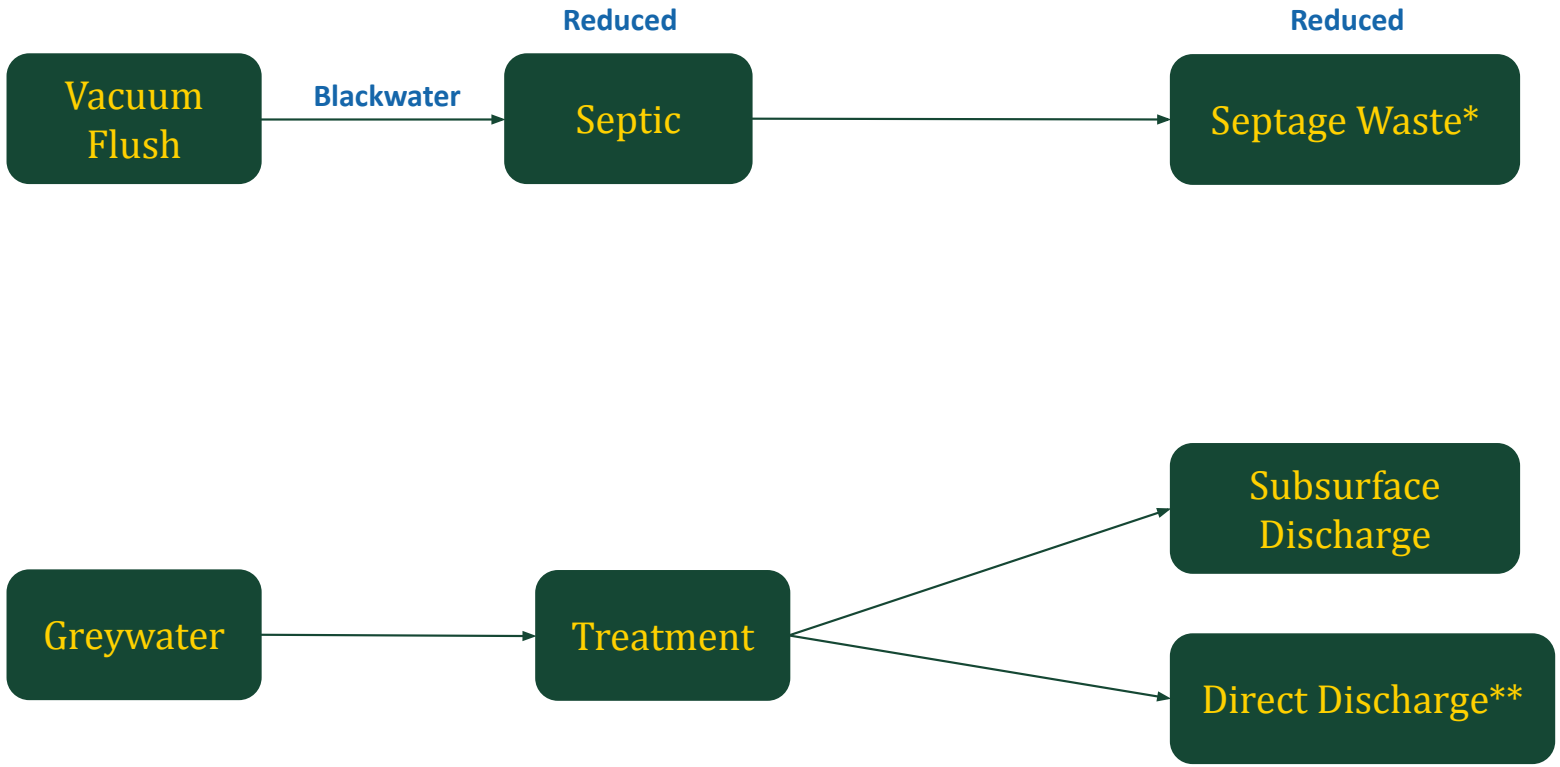
Benefits:

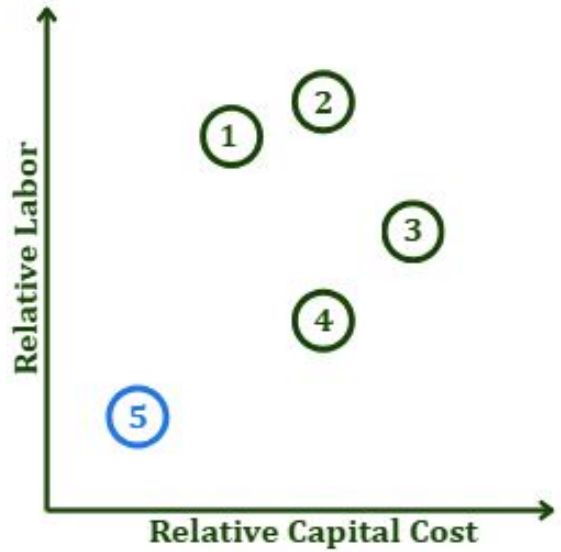
- Reduction of septic tank & leach field area
- Urine fertilizer production
- Greywater for subsurface discharge
- Very low water demand

Drawbacks:

- Leach field still required
- Septage waste hauling
- Still need a septic system
- Need at least some soil suited for septic on site

Reduced Septic - System 5





Legend

** - waste/product that must be hauled away or distributed*

*** - complex regulatory requirements, contact VT DEC*

Benefits:

- Reduction of septic tank & leach field area
- Greywater for subsurface discharge
- Very low water demand
- Lowest O&M
- Easiest to retrofit
- Lowest cost

Drawbacks:

- Still need a septic system
- Need at least some soil suited for septic on site
- No resource recovery from blackwater

System Comparison

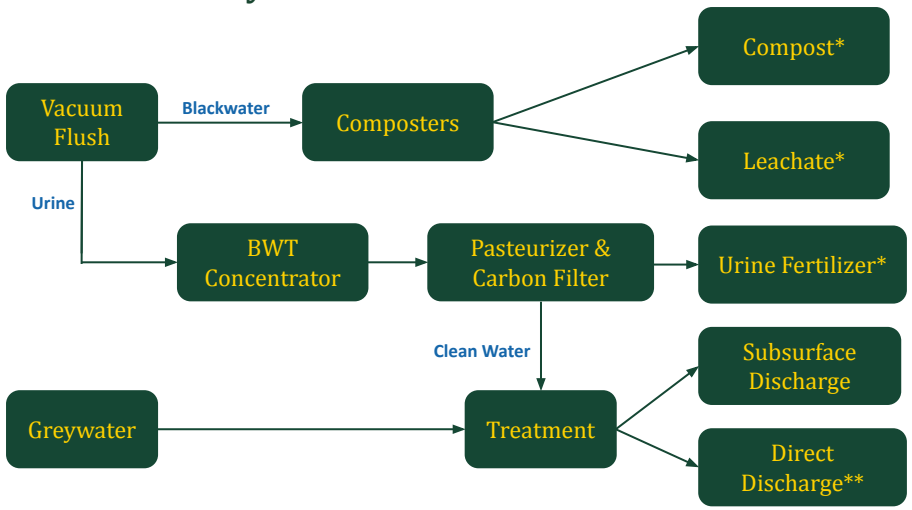
Which system is best for your site?

Configuration	Toilet Type	Blackwater Treatment	Urine Treatment	Greywater Treatment	Outputs	Best For
Alternative 1	Low/micro flush with urine diversion	Vermifilter	Brightwater Tools	Site-dependent	Urine fertilizer, Greywater for subsurface discharge, Vermi-filtered blackwater, Vermi-solids	Small scale developments currently.
Alternative 2	Vacuum flush	Composter	None	Site-dependent	Compost product, Leachate, Greywater for subsurface discharge	Small to medium scale.
Alternative 3	Urine diverting, vacuum flush	Composter	Brightwater Tools	Site-dependent	Urine fertilizer, Compost product, Leachate, Greywater for subsurface discharge	Medium scale for most budgets.
Reduced Septic 1	Urine diverting, vacuum flush	Septic	Brightwater Tools	Site-dependent	Septage waste, Urine fertilizer, Greywater for subsurface discharge	Flexible
Reduced Septic 2	Vacuum flush	Septic	None	Site-dependent	Septage waste, Greywater for subsurface discharge	Flexible

Operation & Maintenance Schedule Example

Good work yields good products.

Alternative System 3



- These schedules vary by manufacturer.
- Always consult the product manual and/or engineer.
- Innovative/Alternative Technologies require management, contact VT DEC early during planning.

Frequency	Composter	Greywater	General
Weekly	Add bulking agent, rake pile flat if needed, and check leachate pump for clogs	Check sensor readings and filters for clogs.	/
Monthly	Check pile moisture (add water or bulking agent if needed). Check ventilation and leachate systems. Leachate pickup by a service provider, if not utilizing leachate in system.	Replace mesh filters (every 6 months).	Urine fertilizer pickup and check for freeze damage (winter).
Annually	Remove and apply finished compost (~12 ft^3/vessel). Clean composter ventilation system if needed.	Flush system and replace carbon filters. (Replace carbon filters for urine as well).	Full system inspection, VTDEC reporting as required, and check that treatment systems are working properly. General plumbing maintenance done as needed.

Commissioning

- Set up starter beds for composters with bulking material and a pack of compost microbes or some fresh compost.
- Run GW system with clean water before introducing greywater to verify flow and instrumentation
- Collect baseline water quality samples before first reuse event.

Operation & Maintenance

Good work yields good products.

Best Practices

Cleaning - Composters & GW

Never use harsh cleaning chemicals. Do not use disinfectants on the toilet. White vinegar + citric acid for UD system. Use biodegradable soap and water for the toilet bowl. For disinfection, can use 3% hydrogen peroxide with a sponge and wipe for bowl, but do not pour it down the toilet.

Cleaning Sinks/Shower

Use biodegradable products to maintain the greywater quality.

Dishwasher

If possible/necessary for your area, use a plant-friendly detergent to reduce the salts in the greywater. This is usually more of a concern in drier regions.

Kitchen Sink

Use a sink screen to reduce the amount of organics to be treated in the greywater. In-sink grinders should not be used with a greywater system.

Composter

Avoid putting food scraps into the composting toilet to prevent nitrogen overloading.



Image of cleaning a toilet (left) and image of a sink screen (right).

[woman-hand-with-spray-bottle-cleaning-toilet-bowl-bathroom_392895-124920.jpg (417×626), Best price for Vegetable washing basin filter screen, stainless steel sink leak screen, kitchen residue universal kitchen sink filter screen, sewer network Color-Silver 1001308407]

For best results, test for:

- Composter first batch - coliform test to make sure composting process is properly managed
- Composter - temperature and moisture, for best results, track compost removal times and add wood shavings/chips to control moisture
- Greywater (if direct discharge) - temperature, turbidity, TSS, BOD_5

Regulations

Vermont regulatory framework — always verify current requirements with VTDEC and your local jurisdiction

Permits Required

Habitability Permit

A plumbing variance is needed.

Solid Waste Management Certification

Required to manage human waste and certify processing of VT EQ Urine. (See 10 V.S.A. §6605)

Fertilizer Product Registration

Annual VAAFM Fertilizer Registration required if EQ Urine is moved off-site or sold.

NPDES Discharge Permit (Optional)

Allows for discharge of greywater/leachate into water body with treatment requirements. Avoids requirement for a leach field, but a more involved permitting process.

Key Regulation Frameworks

Wastewater System & Potable Water Supply Rules

“Filtrate Effluent” classification and compost regulations.

2027 IPC Rules

Vermont has adopted the 2021 IPC Rules, requiring a variance to use the urine diversion appendix in the 2027 IPC Rules.

VT DEC Innovative/Alternative (I/A) Wastewater Technology Approval Process

Vital to use any of these systems. Can chose already approved systems from the list or go through the experimental pathway for new technologies. All systems require maintenance contracts.

Useful Regulatory Information

Treated Greywater

Vermont does not have a greywater regulatory category, which means greywater is classified as blackwater still. This makes it challenging for reuse and treatment.

For shallow subsurface infiltration, must meet “filtrate effluent” treatment requirements following an approved or experimental innovative/alternative treatment system and use a subsurface drip system.

Direct discharge to a water body would be novel and require careful planning with water quality regulators.

Compost Product - Composting Toilets

According to the Wastewater System & Potable Water Supply Rules, for the compost to be applied, it must be at an approved site on the property. Compost must be applied through a shallow burial while maintaining distance from the subsurface water table and bedrock. If the compost cannot be applied on-site, it must be removed by a licensed septage hauler. Alternatively, a biosolids permit could be obtained; however, this will result in significant documentation requirements and compliance overhead.

Leachate - Composting Toilets or Vermifilter

While both leachates have valuable nutrients, VTDEC classifies both as blackwater. The leachate must be disposed or reused in the same way as described above under greywater.

Urine Fertilizer - Brightwater treatment product

VTDEC has a residuals category called EQ Urine which is used to certify the sanitization and safety of urine, after which the product can be registered with VAAFM as a fertilizer. The urine plumbing requires a variance from the 2024 IPC that VT currently uses; urine diversion is in the 2027 IPC.

Regulations - Advocacy

Getting ahead of the compliance treadmill

Greywater

Advocating for a greywater regulatory category can allow for greater reuse of greywater. This category can directly allow irrigation, creating a smoother permitting process.

Vermi-compost

As vermifilters become a viable technology, it will be important to add best practices for this technology to the wastewater rules.

Compost

While compost regulations are relatively well defined, it would likely be beneficial if the wastewater rules allowed for compost to also be applied to adjoining properties. This would open up more end-uses for the compost.

Leachate

A category for filtered blackwater or leachate would improve how leachate from vermifilters and compost is used to ensure maximum nutrient reclamation while maintaining safe practices.

Need for Advocacy

It is important to advocate for specific regulatory categories for the useful products of these alternative systems to ensure they can be used appropriately and safely. Further, advocacy for alternative systems is important to keep Vermont on the forefront of sustainability trends.

Pushing the Needle

Green building certifications such as the Living Building Challenge by Living Future and LEED are encouraging sustainable building practices throughout the country and abroad.

Groups such as Greywater Action, Rich Earth Institute, and the Cape Cod Commission have further been encouraging these practices by advocating for the use and proper regulation of these technologies.

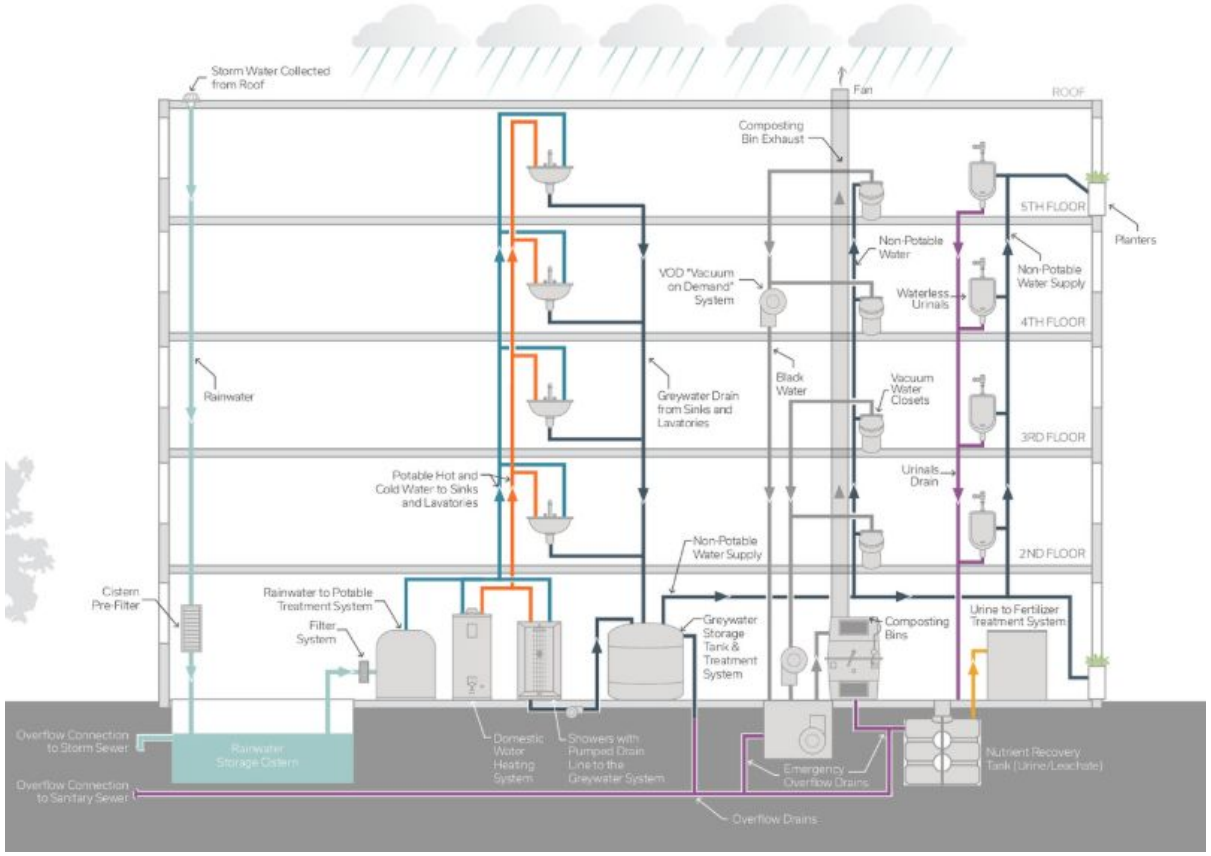
Management

VT DEC requires management of systems that use any technologies under the innovative/alternative wastewater treatment approval process.

Clearer rules for this management would allow for the creation of independent entities to manage systems; creating a smoother process and better system experience.

Case Study #1

Full Alternative System Case Study



System diagram of the PAE Living Building
[Portland Living Building | PAE]

Completed: 2021

PAE Living Building - Portland, Oregon

An advanced building utilizing rainwater collection, vacuum flush toilets, composting toilets, urinals to divert urine for fertilizer production, and greywater collection and reuse.

With 58,000 sq ft, this building houses 250 tenants and the offices of PAE Engineers. The building has 20 composters and a greywater treatment system. With the UD system, approximately 8,000 gallons of urine is diverted for fertilizer production each year. These urine fertilizer products and compost are sent to local farmers and garden centers. Treated greywater is reused for toilet flushing and irrigation.





Photos of the building (left) and the composters in the building (right)
[PAE Living Building - Living Future]

"...there is a 73% water savings over a typical building of this kind built to code"

[PAE Living Building - Living Future]

Case Study #2

Urine Diversion and Urine Fertilizer Case Study

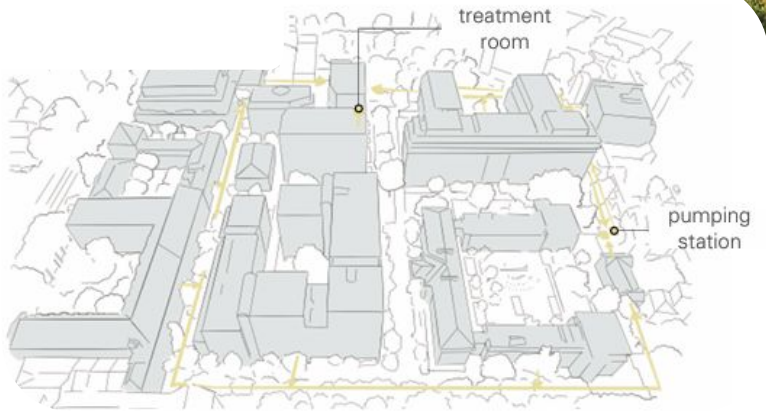
Construction Ends: 2026

Saint Vincent de Paul Neighborhood - Paris, France

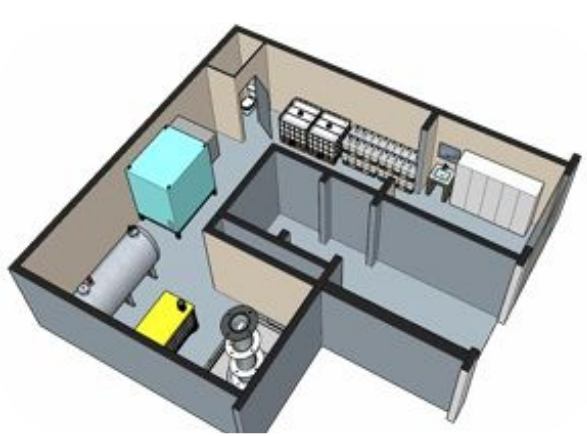
This neighborhood consists of ten renovated or newly constructed buildings connected by a network of pipes. The residents/visitors of the 600 homes and community spaces will use urine diverting toilets and have the urine sent through this pipe network to a 'micro-factory'. This is a 750 sq ft room with the urine treatment technology. When all the buildings are reopened, the neighborhood is expected to produce 47,000 L/year of urine fertilizer. This neighborhood intends to send urine fertilizer to the City of Paris for lawn and nursery application, and potentially to farmers in the Ile de France region as well.



Rendering of the completed construction in the complex.
[Diapositive 1]



Mockup of the complex with the pipes for the urine and treatment room outlined.
[Eawag, Circular Sanitation Toolbox]





3D Model of central treatment facility (left) and photo of treatment technology (right)
[Diapositive 1]

Case Study #3

Composting, Low/No Flush Toilets Case Study



Cobb Hill Cohousing Development

Cobb Hill Cohousing - Hartland, Vermont

Developed: 2003

This environmentally conscious housing development was the vision of professor Donella Meadows and has grown to 54 occupants spread across 23 households. Every house has composting toilets with a total of 21 composters across the development. Compost is transferred once a year into an outdoor compost pile and left for 38 months before use in community/personal gardens. Leachate and greywater are sent into a septic and leach field system which is smaller than typical due to the reduced water usage from composting toilets. Well-trained residents keep system functioning.



Aerial view of the development

[Available Houses — Cobb Hill CoHousing]



Composter at their community house

> ***Satisfied with the system… get to have fresh compost for the gardens each year.***
>
> [Resident]

Case Study #4

Urine Diversion and Urine Fertilizer Case Study





Urine fertilizer farm application [Rich Earth Institute Home]

Rich Earth Institute - Brattleboro, Vermont

Founded: 2012

As a non-profit research institute, the Rich Earth Institute is dedicated to research, education, advocacy, and innovation using resources from human waste.

Rich Earth operates the only community scale pilot in the United States demonstrating urine reuse on farms. This pilot has collected over 86,000 gallons of urine for application as fertilizer on 13 local farms since its founding.

To help achieve its innovation goal, Rich Earth Institute created a spin-off company, Brightwater Tools. Brightwater Tools seeks to achieve urine recycling at scale through its innovations and patented technology.



Urine treatment [Rich Earth InstituteHome]

"Rich Earth's multi-year controlled trials found no significant difference between hay yields when using urine fertilizer or synthetic fertilizer..."

[Rich Earth Institute : Farming]

Case Study #5

Greywater Case Study



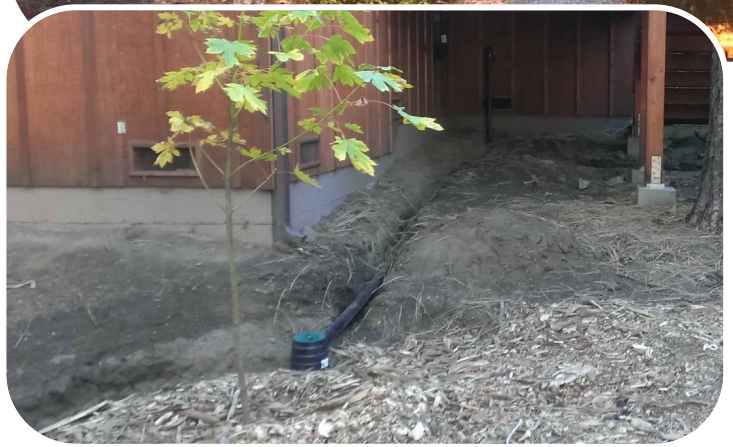


Photo of the pipe leading to the mulch basin during construction.
[Greywater Systems in Freezing Climates - Greywater Action]

Photo of the Evergreen Lodge.
[*Greywater, Green Landscape* by Laura Allen]

Renovated: 2001

Evergreen Lodge - Yosemite, California

Using a mix of simple gravity-fed branch systems and automated systems, the Evergreen lodge recycles nearly a million gallons of greywater annually. With the 55 guest cabins, the lodge replaced all its irrigation needs with greywater. Due to the warmth of GW, the soil remains biologically active even in the winter with the lodge also observing improved soil quality through the decompaction of soil. Despite all the various products used by guests, the lodge has had no issues with salts from GW irrigation.



The Evergreen Lodge in the winter. [Greywater Systems in Freezing Climates - Greywater Action]

> ***"[The] Evergreen lodge recycles a million gallons of greywater a year, even in the snow."***
>
> [Greywater Systems in Freezing Climates - Greywater Action]

Case Study #6

Composting, No Flush Toilets and Greywater Case Study





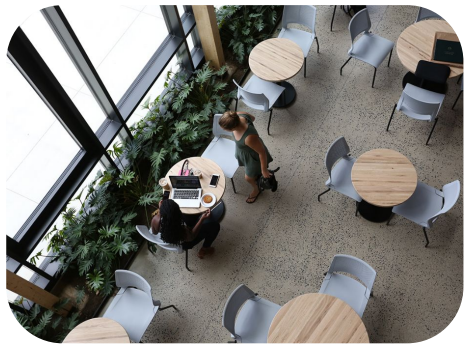
Photo of the Kern Center (top), aerial photo of the Kern Center (bottom)
[Hampshire College's R.W. Kern Center Is a Living Building ,
R.W. Kern Center - Living Future]

Completed: 2016

Kern Center - Amherst, Massachusetts

The Kern Center at Hampshire College is a ~17,000 sq ft building with classrooms, offices, and a cafe. This building uses six straight-drop dry toilets that feed into two composting chambers. The compost produced is used as fertilizer while leachate is collected and sent to a wastewater treatment plant (due to regulations).

A greywater system is also used on-site to reduce water use. After initial pre-filtration greywater is temporarily stored. It is then pumped into indoor planters and through an outdoor constructed wetland of native plants with the outflow either recirculating or disposed of in a leach field.





Indoor planters (left) and side photo of the Kern Center (right)
[R.W. Kern Center - Living Future]

"As designed, system can save up to 144,000 gallons of water per year" (via rainwater harvesting, dry toilets, and greywater)

[Clivus New England]

Additional Case Studies

Some Projects/Technologies Coming Soon



Vermifilters at Equilibre
[230719_SandecNews_2023_ES-compressed.pdf]



Domino Factory Redevelopment
[refinery at domino: brooklyn's long-awaited industrial renovation completes]



Prototype system by UAA
[Water Reuse Case Study: The Alaska Water and Sewer Challenge | US EPA]

Finalizing Pilot Research: 2026

Equilibre - Geneva, Switzerland

This project is one of the first to use a vermifilter at a large building scale. With 100 inhabitants, the data collected from this filter over the next few years will help show the viability of this technology.

Piloting

Alaska Water and Sewer Challenge - University of Alaska, Anchorage (UAA)

Thousands in rural Alaska lack flush toilets and running water due to remote locations and cold climates. This challenge, funded by Alaska DEC, has seen UAA propose a greywater reuse system and urine diverting dry toilets. The goal is to significantly reduce water demand for non-potable reuses. From laboratory tests, the team was able to reuse one gallon of water forty times. As the team begins to pilot this technology in rural Alaska, this could have meaningful impacts for sanitation practices across the country, especially in cold, rural regions.

Finalizing Construction: 2026

Saint Vincent de Paul Neighborhood - Paris, France

As mentioned in the case study slide, this soon to be completed project will test urine diversion and urine fertilizer production on a large neighborhood scale. This project is expected to produce up to 47,000 L (12,400 gallons) of urine fertilizer per year.

Finalizing Construction: 2026

Domino Factory Redevelopment - Brooklyn, New York

This redevelopment project will serve over 8,000 people and have an on-site treatment system with a capacity of 400,000 gallons per day. This on-site treatment system will consist of biological treatment, membrane filters, and UV disinfection to treat combined greywater and blackwater for reuse in cooling towers, irrigation, and toilet flushing. This project will reveal the effectiveness of treatment for reuse without separation of greywater and blackwater.

Conclusion

Importance of Alternative Sanitation Solutions



Image of a housing cooperative tending to gardens
using urine fertilizer, greywater, and compost. Generated by Google Gemini AI.



Urine fertilizer farm application.
[Rich Earth InstituteHome]



Toilet with flowers.
[14 DIY Ideas to Upgrade Bathroom Old Items For The Garden]

Currently Vermont is in the midst of an affordable housing crisis and battling nutrient pollution in its various water bodies. This can create a tough situation for developers looking to build more housing to ease this crisis while trying to conform to regulations to reduce nutrient pollution from the new septic systems. Even though some of these alternative systems are not ideal for every site, and advancements in both technology and regulations remain needed, the potential benefits can be significant:

- Support local agriculture
- Reduce nutrient pollution
- Reduce water consumption and costs
- Encourage sustainable practices/development

Nationwide, 20% or 66 million Americans rely on decentralized wastewater systems like septic. Vermont has the highest rate of any state with about 55% relying on those systems.

[US Wastewater Infrastructure | ASCE , WasteWater.pdf]

Contacts and Resources

What if I have a question on the topic of …

Contacts

- Kimmerly Nace (CEO, Brightwater Tools) - kim@brightwatertools.com
- Lisa Truchon (Clivus Composters) - ltruchon@clivusne.com
- Paul Garner (Evac VF Toilets) - ext-paul.garner@evac.com
- Ried Nelson (Composters & Wostman VF, UD Toilets) - ried@compostingtoilet.com
- Clint Nelson (JETS VF Toilets) - clint@nordicamericas.com

VF - Vacuum Flush | **UD** - Urine Diverting

"The present system does harm in attempting to do good. The intention is good, the result is sad. Men think they are purging the city; they are emaciating the population… A sewer is a mistake " [In regard to wasting valuable nutrients.]

Les Miserables by Victor Hugo, 1867

Further Resources

Cape Cod Commission Fact Sheets:

Composting Toilets
Cape Cod Commission - Composting Toilets

Urine Diverting Toilets
Cape Cod Commission - Urine Diverting Toilets

Eawag Circular Sanitation Toolbox:

Guidelines, case studies, and useful information for various alternative, decentralized sanitation practices.
Eawag, Circular Sanitation Toolbox

Greywater Action:

Great practical guides and resources for greywater systems.
Greywater Action - For a sustainable water culture
Book - Greywater Green Landscape - Catching H2O

US EPA Information on Greywater:

Specific state regulations, key information, and case studies for various end-use applications.
Water Reuse Resource Hub by End-Use Application | US EPA

VT DEC Innovative/Alternative (I/A) Wastewater Technology Approval:

Provides list of current approved technologies and a process to get technologies approved.
Innovative and Alternative | Department of Environmental Conservation

References

Guide:

- Gilker, G., & Leurig, S. (2024). *NET ZERO WATER TOOLKIT A GUIDE TO NON-POTABLE ONSITE WATER REUSE FOR TEXAS DEVELOPERS AND OWNER/OPERATORS*. Net Zero Water Toolkit 2024.pdf

Sources:

- Village Water and Wastewater Initiative | Agency of Natural Resources
- Department of Housing and Community Development Releases the Latest Vermont Five-Year Housing Needs Assessment | Agency of Commerce and Community Development
- Westford residents vote down new wastewater treatment system
- UVM WasteWater.pdf
- Septic Systems and Surface Water | US EPA
- Residential Toilets | US EPA
- Vermont Open Geodata Portal Your source for geospatial data
- Ancillary Soil Interpretation Ratings for Septic Tank Absorption Fields in Vermont
- Mapping Vermont's Wastewater Infrastructure | Leahy...
- Septage Management Evaluation - Overview
- History of Cobb Hill — Cobb Hill CoHousing
- Eawag, Circular Sanitation Toolbox
- Saint-Vincent-de-Paul
- PAE Living Building - Living Future
- Wastewater Technology Fact Sheet Ultraviolet Disinfection
- This building gets the gold: Here's how it converts human urine into an eco-fertilizer - Laura Allen
- PAE Living Building: Closing the Loop on Water, Becoming Net Positive - Living Future Europe
- Portland Living Building | PAE
- Rich Earth Institute : Home
- Rich Earth Institute : Farming
- Technology Review of Composting Toilets
- Phoenix Composter Manual 2006
- Phoenix Composting Toilet Models
- RMSWhitePaper20180507.pdf
- Indoor Water Use in the United States
- Jets® Group | Jets® vacuum units and systems
- Vacuum collection - Evac
- EcoVac new — Wostman
- Greywater Environmental Management - A Review
- Treat wastewater in an environmentally sustainable way with worms - Sciena
- Advances in vermifiltration: A comprehensive review of recent developments and applications - ScienceDirect
- Greywater Systems in Freezing Climates - Greywater Action
- Graywater Solar Greenhouse
- 10 Greywater System Maintenance Tips
- Wastewater Technology Fact Sheet: Ozone Disinfection EPA September 1999
- Tipsheet 5 - UV Disinfection - Final.pdf
- Wastewater Technology Fact Sheet - Disinfection for Small Systems EPA
- Clivus New England
- R.W. Kern Center - Living Future
- Brightwater Tools - Building Bathrooms of the Future That Transform Waste to Resources
- Tools - Brightwater Tools
- Calculate Septic Tank Size | SepticCalculator.com
- VT DEC Wastewater System and Potable Water Supply Rules
- Alaska Water and Sewer Challenge | AK Dept. of Environmental Conservation
- Water Reuse Case Study: The Alaska Water and Sewer Challenge | US EPA
- 230719_SandecNews_2023_ES
- Water Reuse Case Study: Brooklyn, NY | US EPA
- US Wastewater Infrastructure | ASCE
- Review of the Greywater and Proposed Greywater Recycling Scheme for Agriculture Irrigation Reuses
- Innovative and Alternative | Department of Environmental Conservation
- Overview of Greywater Reuse
- Allen, L. (2017). *Greywater, green landscape : how to install simple water-saving irrigation systems in your yard*.
- Del Porto, D., & Steinfeld, C. (1999). *The Composting Toilet System Book*.

AI Statement: AI (Claude, Gemini, & Copilot) were used in this presentation, only for initial formatting and image generation.

Building confidently, beyond the conventional.

Innovative water management systems unlock much needed housing and economic opportunity in Vermont.

University of Vermont | Leahy Institute for Rural Partnerships

University of Vermont | Casella Center for Circular Economy and Sustainability

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Dr. Eric Roy, Associate Professor, University of Vermont RSENR & CEMS

https://brightwatertools.com/

BRIGHTWATER TOOLS