BCDHE
BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND ENVIRONMENT
PROMOTE - PROTECT - SUPPORT

Efficacy of "Eco-Toilet" Technologies for the Reduction of Nitrogen and Phosphorus Inputs into Groundwater; A Falmouth, MA Technology Study

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A Special thank you to Maureen Thomas, Water Resource Specialist at the Buzzards Bay Coalition for the use of slides relating to the West Falmouth Harbor Nitrogen-Reducing Septic System Demonstration Project

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FALMOUTH CWMP

Study Review:

Eco-Toilet Project
&
West Falmouth I/A Demonstration

Falmouth Eco-Toilet Project

- Falmouth, as part of CWMP, looking to assess the efficacy of different eco-toilet options
- Participants given financial incentives to participate in program
  - Offered $5,000 towards installation of technology plus septic pump-out
  - Opportunity, in certain areas, to avoid paying betterment for town sewer (approx. $17,000)

Photo credit Maureen Thomas, Buzzards Bay Coalition

About the program:

- Program: Followed 11 test sites
  - Total N = TKN + NO_2 + NO_3
  - Total P
- Technologies employed by participants:
  - Dubbletten Urine Diversion toilet
  - Sun Mar self contained unit
  - Phoenix Composting
  - Full Circle

Results assumptions

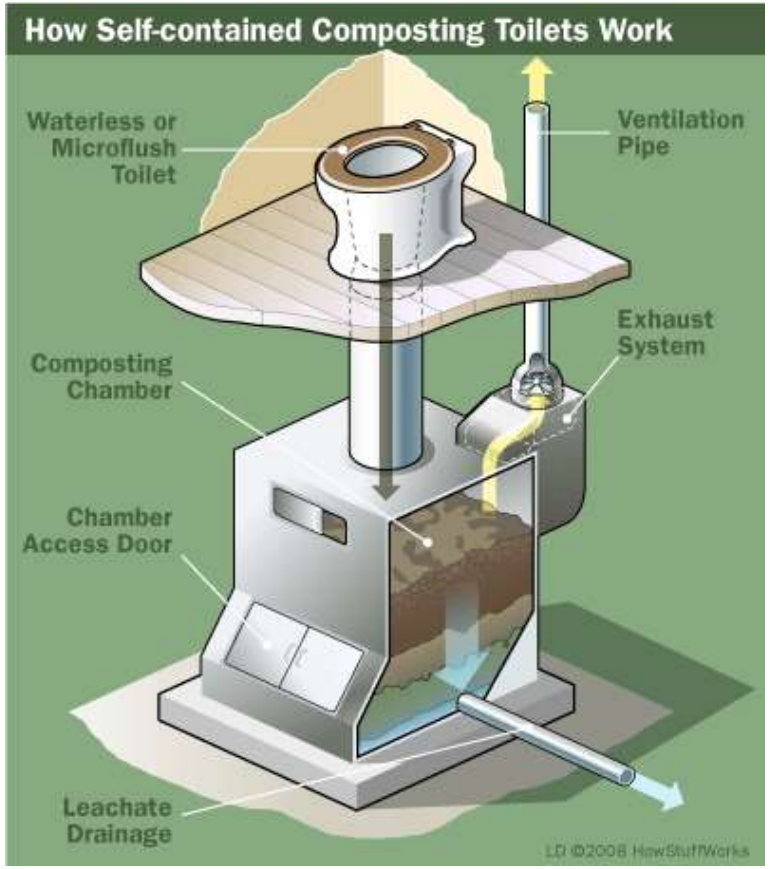
- **Water use**
  - Properties with no pre-installation sampling
  - Properties with erratic water use readings
  - Assumed 20% water use reduction from 55 gpd/person to 44 gpd/person
    - Gallons based on DEP Title 5
    - Percent reduction based on this study and EPA study showing toilets account for approximately 30% of household flow

https://www.flickr.com/photos/koiquest10/8341564245

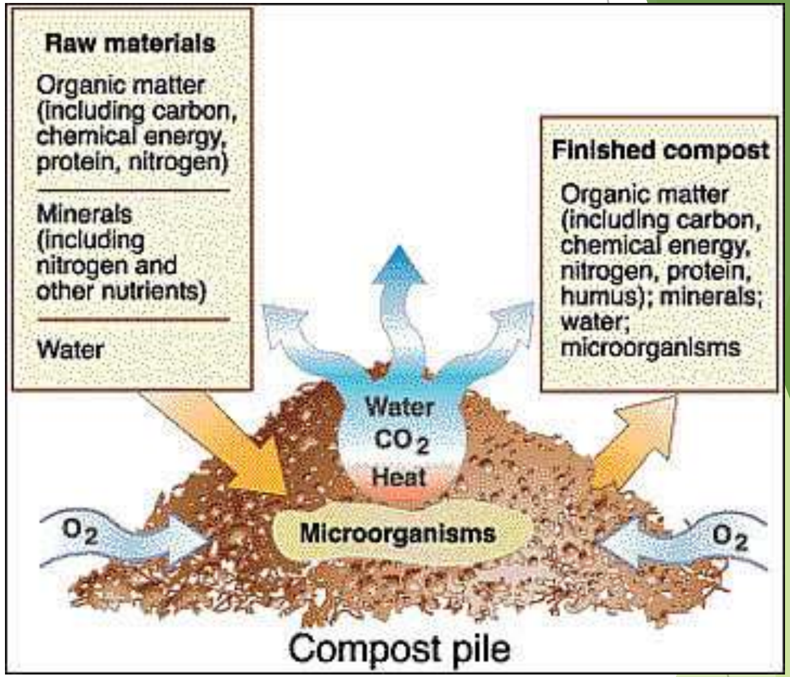
Results assumptions

- **Total nitrogen and total phosphorus**
  - Some properties with no pre-installation sampling
  - Some pre-installation samples were extremely high
  - Very few studies demonstrating typical residential effluent levels of TN & TP
  - Lowe, K.S. et al. "Influent constituent characteristics of the modern waste stream from single sources." *Water Environment Research Foundation, 2009.*
    - Mean values of all sites: 64 mg/L TN and 10.3 mg/L TP used for most sites with no preinstallation samples
    - Maximum values of all sites: 124 mg/L TN and 39.5 mg/L TP used for sites with abnormally high preinstallation samples

Composting toilets



Example of a composting toilet <http://home.howstuffworks.com/green-living/composting-toilet1.htm>



- Need regular “stirring” and monitoring of liquid levels and oxygen supply

Composting toilets

VacuFlush, foam flush or other

Direct gravity

“Matured” compost removed

Compost bin

Newest material is added to the top

Composting process proceeds as new material is added

Leachate “tea” is recirculated to keep compost moist and removed when capacity is exceeded

Composting toilets

It has been estimated that only 17 % N volatilizes from compost under ideal conditions. Reported losses range from 50%-94%

Aeration

Approximately 87% of N & P are removed in compost and volatilization/ evaporation combined

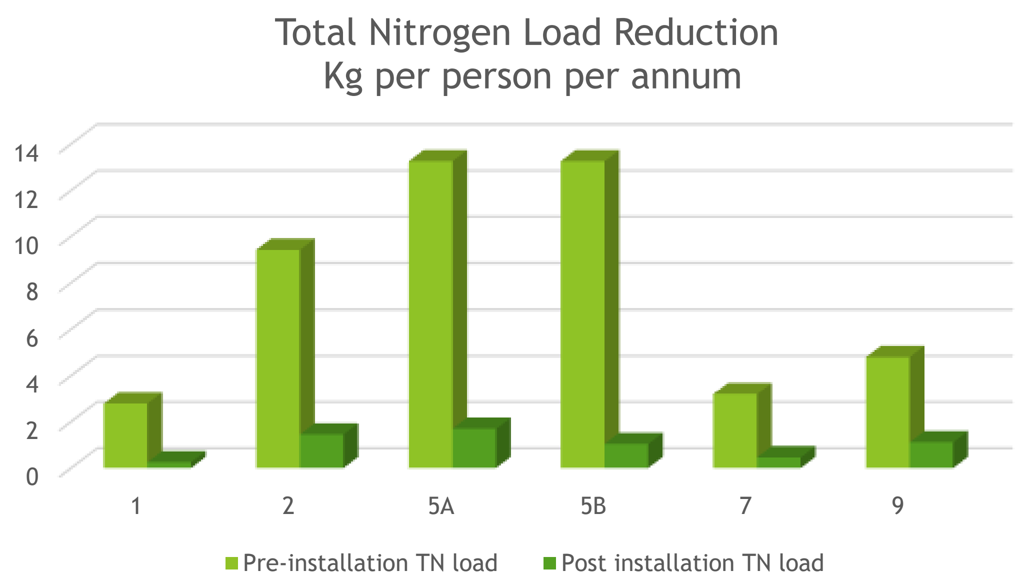
Approximately 13 % of N & P are removed in the leachate “tea”.

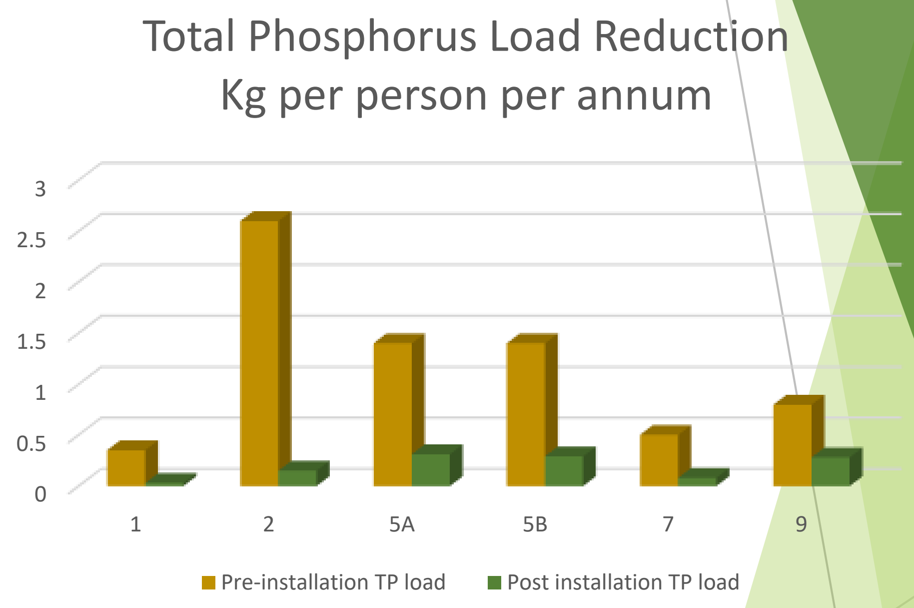



Composting toilets

- Five properties participated using composting toilets only
  - Case Study #1- 1 gravity toilet & 1 vacu-flush toilets- 2 adult occupants
  - Case Study #2- 1 composting toilet-2 adult occupants
  - Case Study #5- self contained composting unit- 1 household occupant
  - Case Study #7- 2 vacu-flush toilets- 2 adult occupants
  - Case Study #9- gravity toilet- installation pre-dates this program- 2 adult occupants and 2 children

Composting toilet results





Urine diversion

Approximately 80% of N and 50% of P in wastewater is in urine

Urine

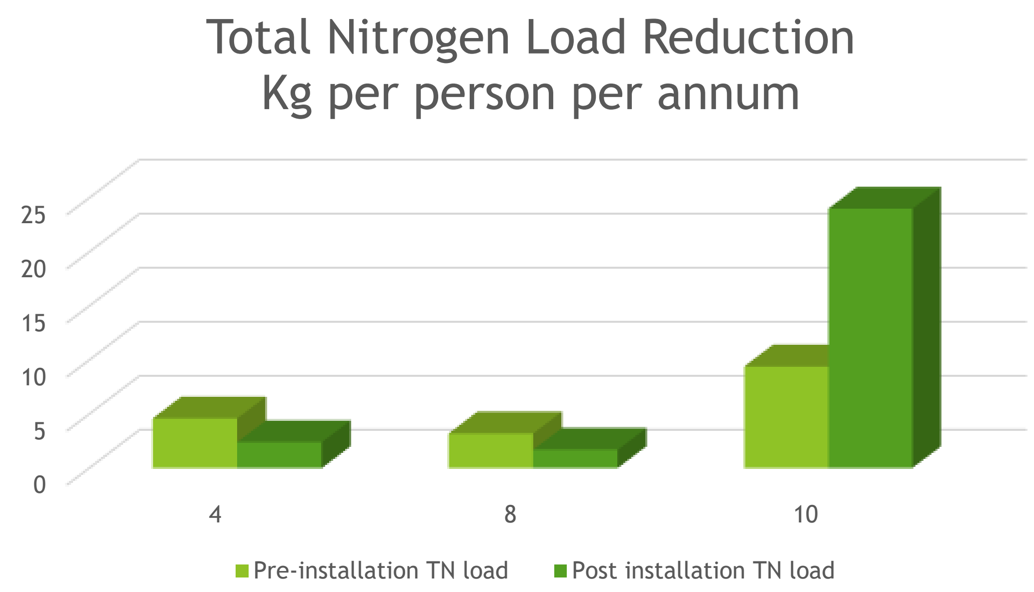
Feces & graywater

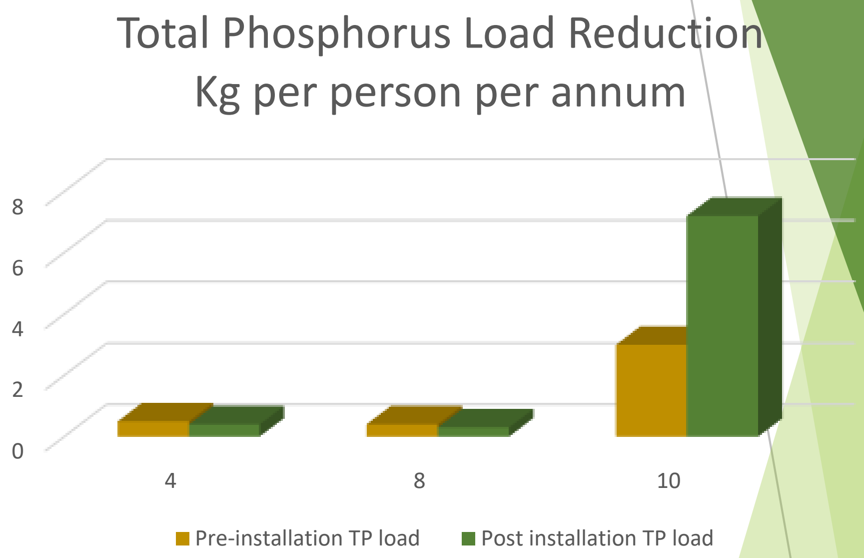
Septic Tank to SAS

SAS

Urine is held in a tank and removed when full.

Urine diversion results





Three properties participated using urine diversion toilets only

- Case Study #4- 2 adult occupants
- Case Study #8 – 2 adult & 2 child occupants
- Case Study #10 – initially 2 adults occupants, increased to 4 part way through study

Multiple technologies

Used combinations of composting toilets, and urine diversion toilets or toilet seats

- Case study #3:
  - Composting toilet installed on lower level
  - Urine diversion toilet installed in upper level bathroom (rarely used) Solids discharged to septic system
- Case study #6 & #11:
  - All solids sent to compost bin
  - Urine diversion seat to redirect urine to collection tank

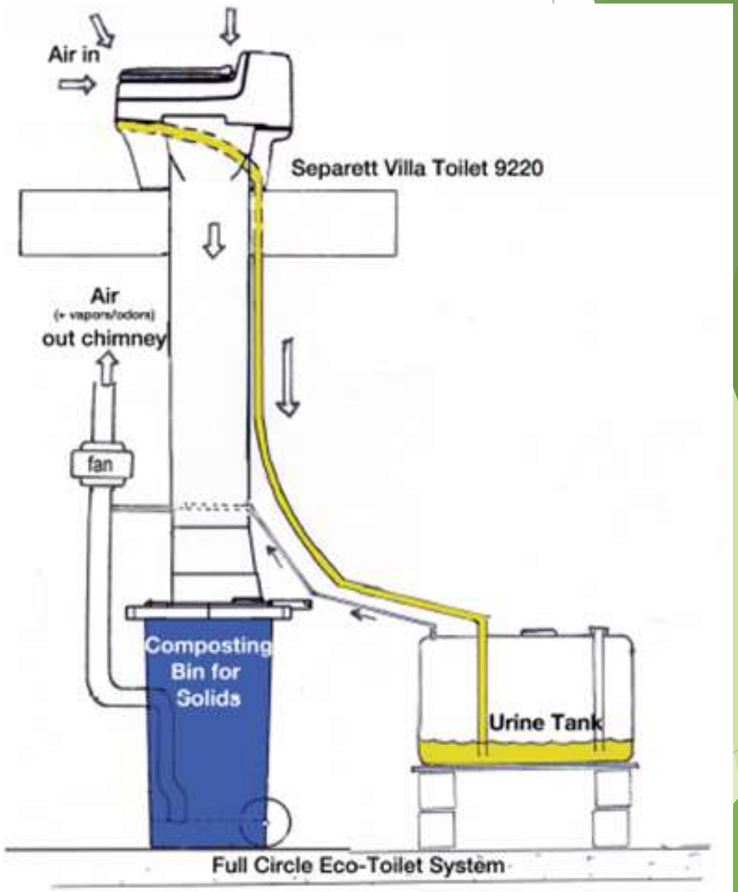
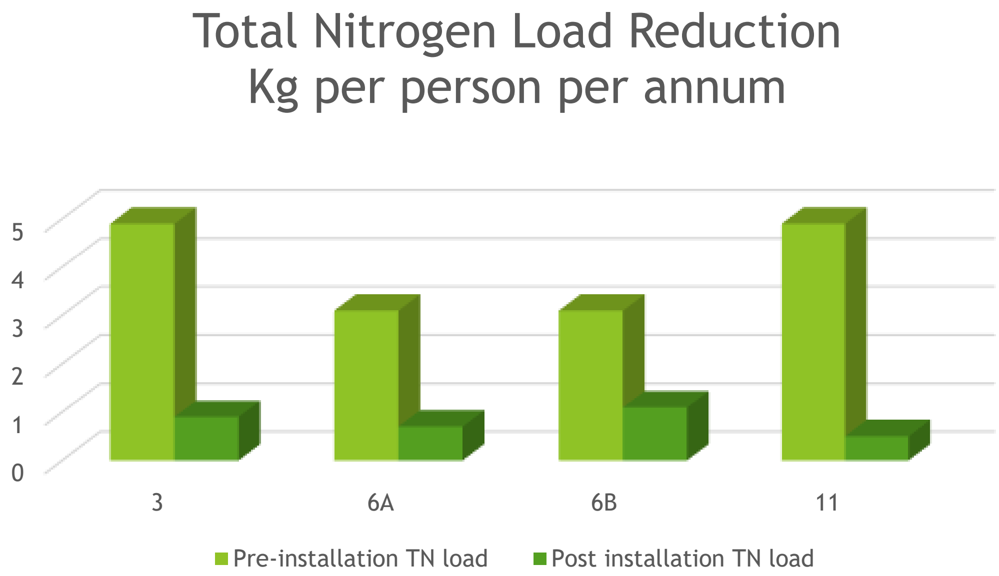
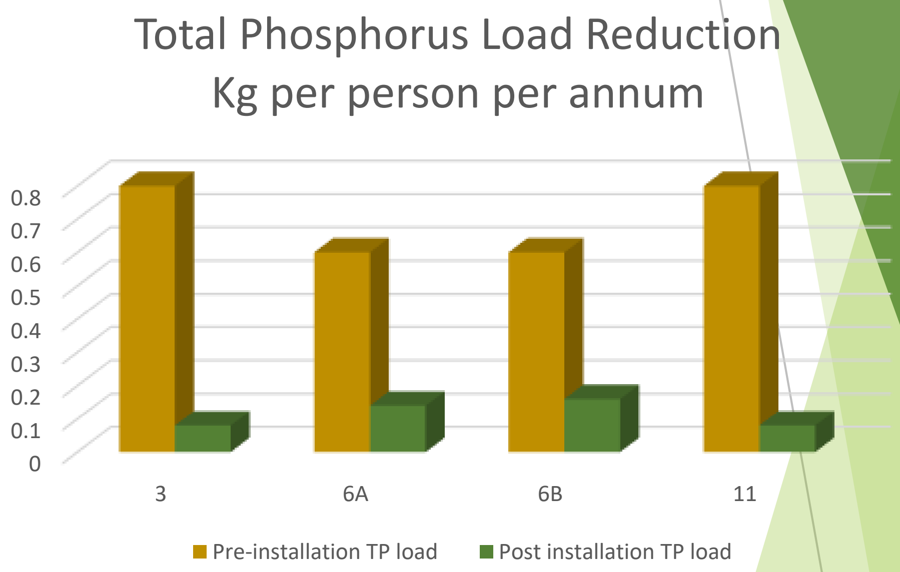


Diagram by Rolf Kluever

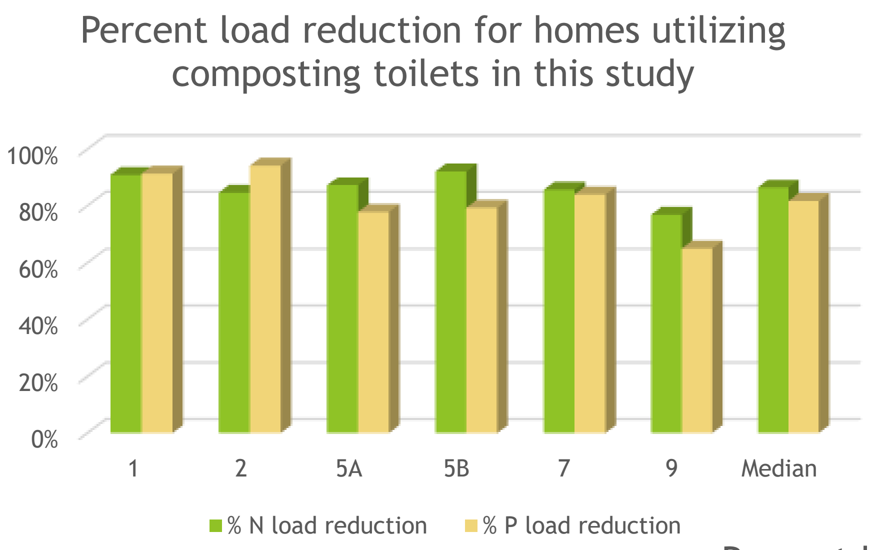
Multiple technology results

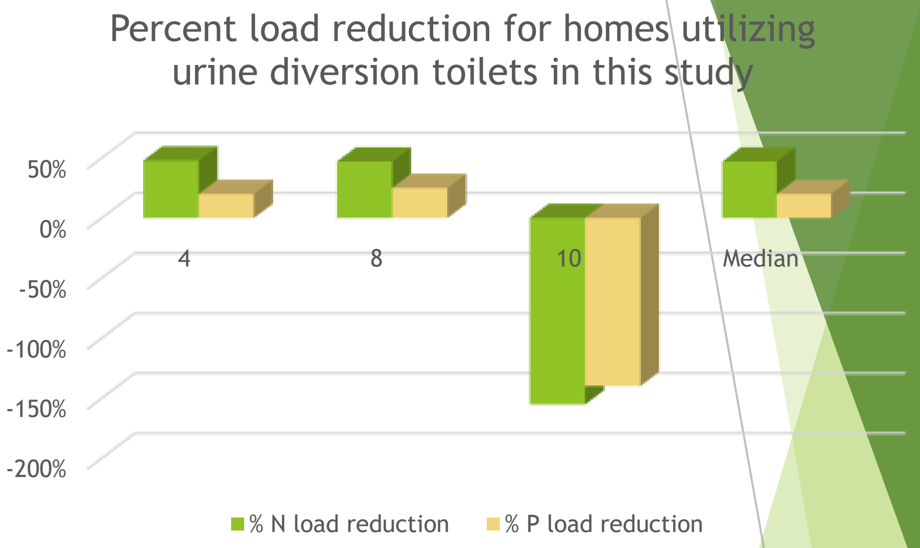


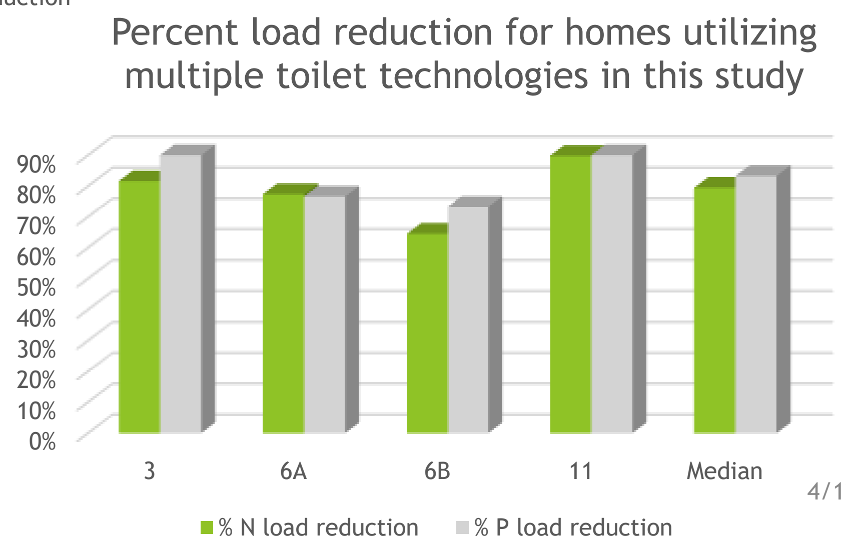


- Three properties participated using a combination composting and urine diversion technology
  - Case Study #3 – 2 adult and 2 child occupants
  - Case Study #6 – 2 adult occupants
  - Case Study #11 – 2 adult occupants

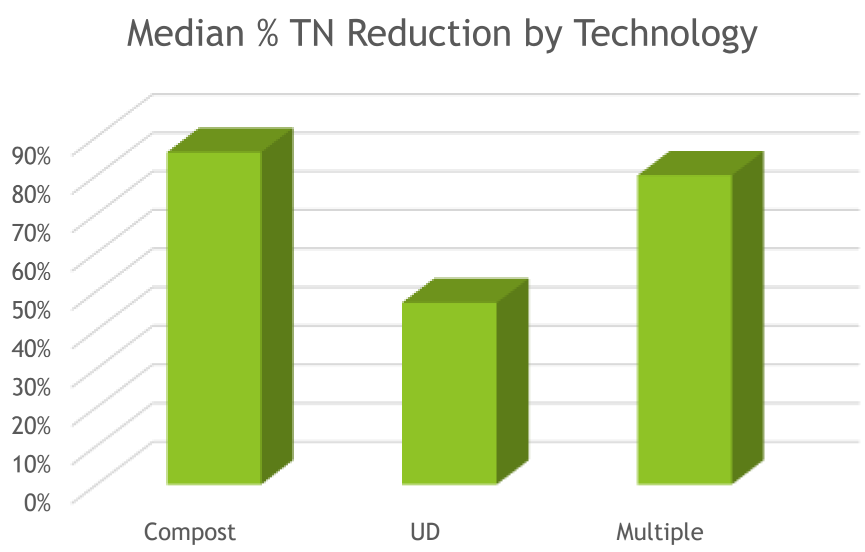
Percent load reduction for all properties

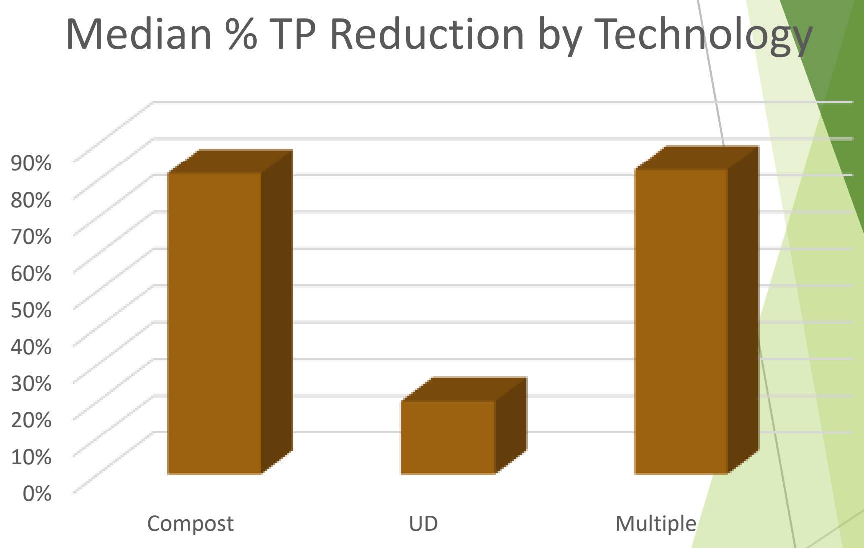






Side by side load reduction





Technology limitations

- Learning curve for new users and guests
- Social acceptance
- How to dispose of Urine, compost and compost toilet effluent
- Specific to UD
  - Difficult to “aim” properly
  - Urine ~95% water- High cost of collection, storage and transportation
  - High rates of direct application of urine thought to increase salinity and conductivity in the soils
  - Difficult to keep clean due to low water flow

Technology limitations

- Specific to composting toilets and multiple technology situation
  - Proper operation is key to success
    - Proper aeration
    - Moisture content
    - Proper temperature
    - Temperatures >50°C- 56°C(122°F- 133°F) for up to 3 days to kill pathogens
    - Flies and gnats
    - Back up battery for fan during power outage

Study limitations

- Sample locations variable- D-box not always accessible
- Takes time for septic tank to fill in order to sample
- Water meter readings not an accurate indication of usage-affected by irrigation etc.
- Pre-install numbers not known for some properties
  - Limited research has been done on constituents of wastewater
- Efficiency affected by knowledge and attentiveness of user/ operator
- Small sample size- 11 participants
  - 2 already had technology prior to study

Materials disposal

- Urine: use for fertilizer
  - Cost of transportation- 95% water
  - Urine generally sterile but may be contaminated with feces
  - Contains pharmaceuticals

- Rich Earth Institute- Vermont doing research

- Compost toilet effluent- (CTE)- AKA tea
  - Sent samples to Maine School of Composting
  - CTE- 98 % water
  - Added to 3 different feedstock for compost that are available on Cape
    - Oak leaves, horse bedding, wood shavings
    - Not enough nitrogen

Participant feedback

- Overall favorable
- One case cost to replace complete system was avoided (~>$15000)
- Some “hands on” maintenance required.
- Odor not an issue as long as fan was in operation- installation of battery suggested in case of power outage
- Hard to use & clean
- Social acceptance ?

West Falmouth Harbor Nitrogen-Reducing Septic System Demonstration Project

- Upgrade 30 existing septic systems within 300 feet of MHW of the harbor to nitrogen-reducing systems
- Use best available technologies that meet 12 mg/L total nitrogen removal or less
- Provide $10,000 subsidies to Phase I & $7,500 for Phase II homeowner volunteers
- Evaluate total costs & implementation logistics
- Monitor & report results

Photo credit Maureen Thomas, Buzzards Bay Coalition

Map prepared by: Buzzards Bay National Estuary Program, 2870 Cranberry Highway, East Wareham, MA 02538. www.buzzardsbay.org. March 10, 2015

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Qualifying Technologies

Nitrogen-reducing technologies meeting 12 mg/L TN	
AdvanTex AX20RT	Layered Soil Treatment Area
Amphidrome-SBR	Nitrex
Biobarrier MBR	NitROE/SanTOE
Bioclere	NJUN
Blackwater	RUCK
BUSSE Green Tech	Hydro-Kinetic
Eliminite	Waterloo Biofilter
GPC	SepticNET
Hoot	SeptiTech

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Monitoring Results

- Nitrogen-reduction goal of at least 67%
- Phase I & II median total nitrogen-reduction - 76%
  - Blackwaters – 59%
  - Eliminites – 78%
  - Hoots – 81%
  - Layer Cake – 90%
  - Fast – 43%

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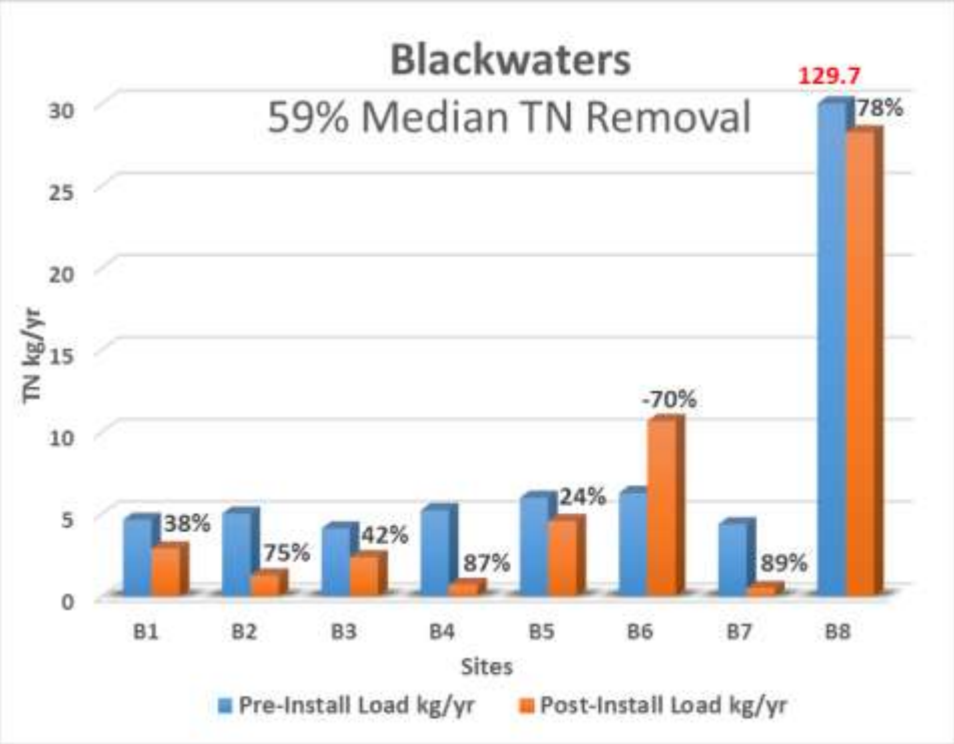

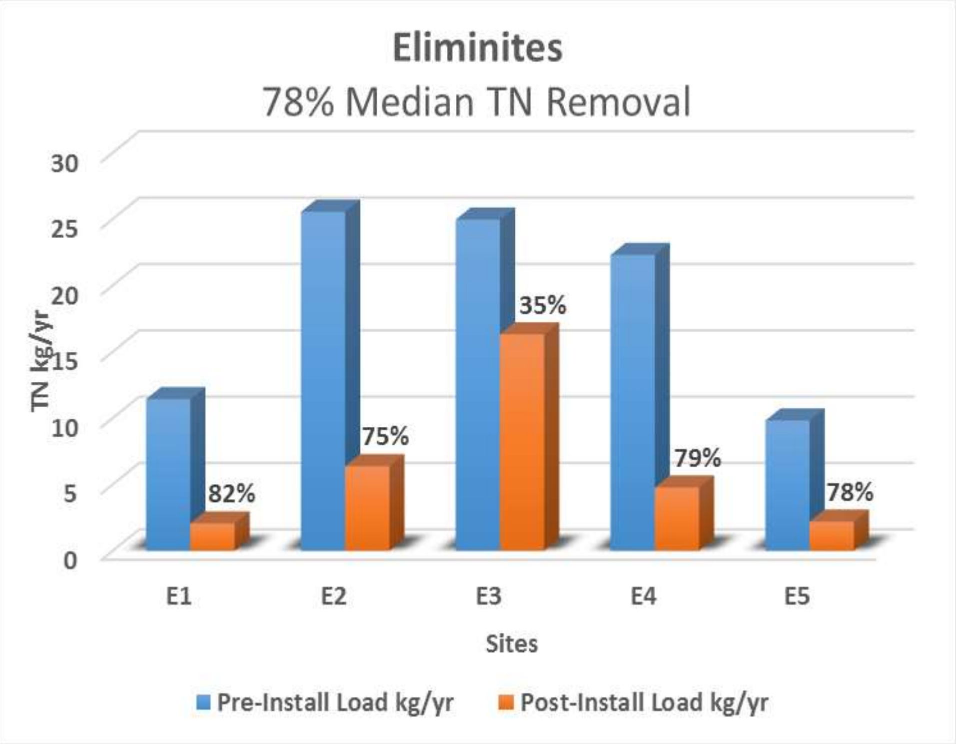

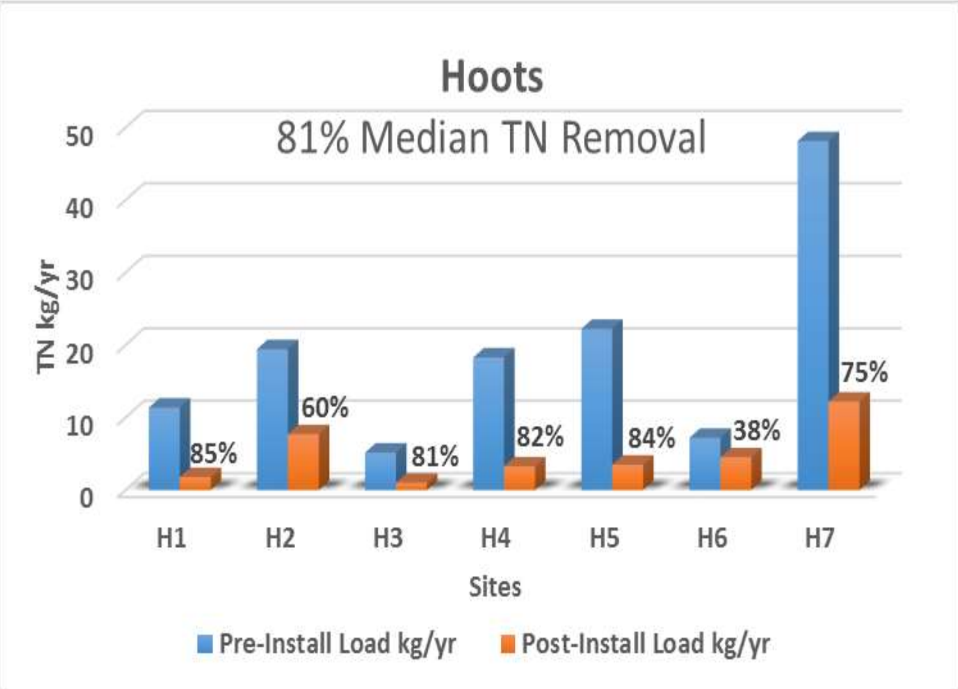

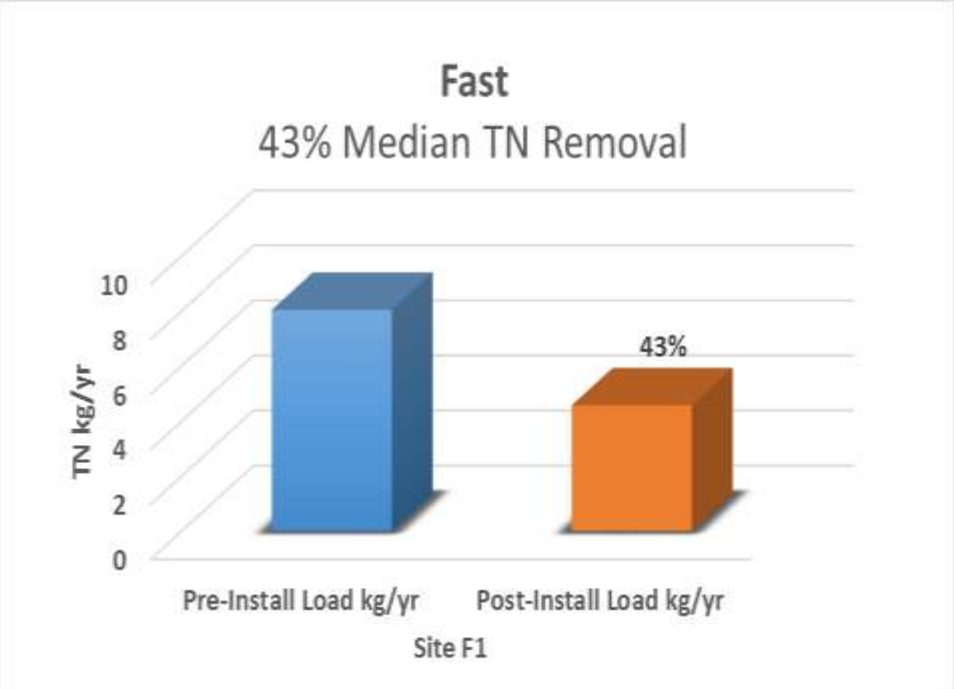

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Cost considerations

- UD Technology
  - Installation cost of ~ 500 gallon exterior tank- or smaller tank to be emptied more frequently
  - Installing/ Replacing fixtures
  - Re-routing plumbing
  - Cost of urine removal (every 1-2 years based on use)
- Composting Technology
  - Installing/ replacing fixtures
  - Installation of storage facilities
  - Electricity for fan- backup battery
  - Compost removal cost

Cost considerations

- Centralized wastewater treatment
  - High collection cost due to scattered population centers
  - Economies of scale
- I/A Technology
  - Efficiency tied to proper operation
  - Installation cost complete system
  - Annual O&M cost (Variable depending on town requirements)

Implementation Costs

ITEM	AVERAGE COST	COST RANGE
Equipment (denitrification tanks)	$8,437	$4,146-$10,625
Engineering	$2,620	$606-$4,200
Installation (adding a nitrogen-reducing system to an existing Title 5 system)	$11,096	$10,600-$15,350
Installation (full upgrade from a cesspool)	$20,675	$17,720-$25,600
Landscaping	$2,142.97	VARIABLE

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Operation, Maintenance, & Monitoring Costs

System	O & M	Sampling (BCDHE)	Required Sampling Frequency Year Round	/ Seasonal
Blackwater	$400/year	$52/month	N/A	Once/Year
Eliminite (pilot)	$1,000/year	$117/month	Year 1 - monthly Year 2 - quarterly	Year 1 - 3x/Season Year 2 - 3x/Season
Fast	$250/year	$52/month	4x/Year	2x/Season
Hoot	$350/year	$52/month	2x/Year	2x/Season
NitROE (pilot)	$1,000/year	$117/month	Year 1 - monthly Year 2 - quarterly	Year 1 - 3x/Season Year 2 - 3x/Season
Perc-Rite	$250/year	$52/month	Once/Year	Once/Year

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Lessons

- West Falmouth homeowners care about water quality & want to participate in restoration
- Neighborhood outreach is critical to success
- Cost, not technology, is the main concern for homeowners
- Upgrading on-site septic systems is not a one-size-fits-all project
- Disruption during installation can be minimized & systems can fit nicely [illegible]sting landscaping

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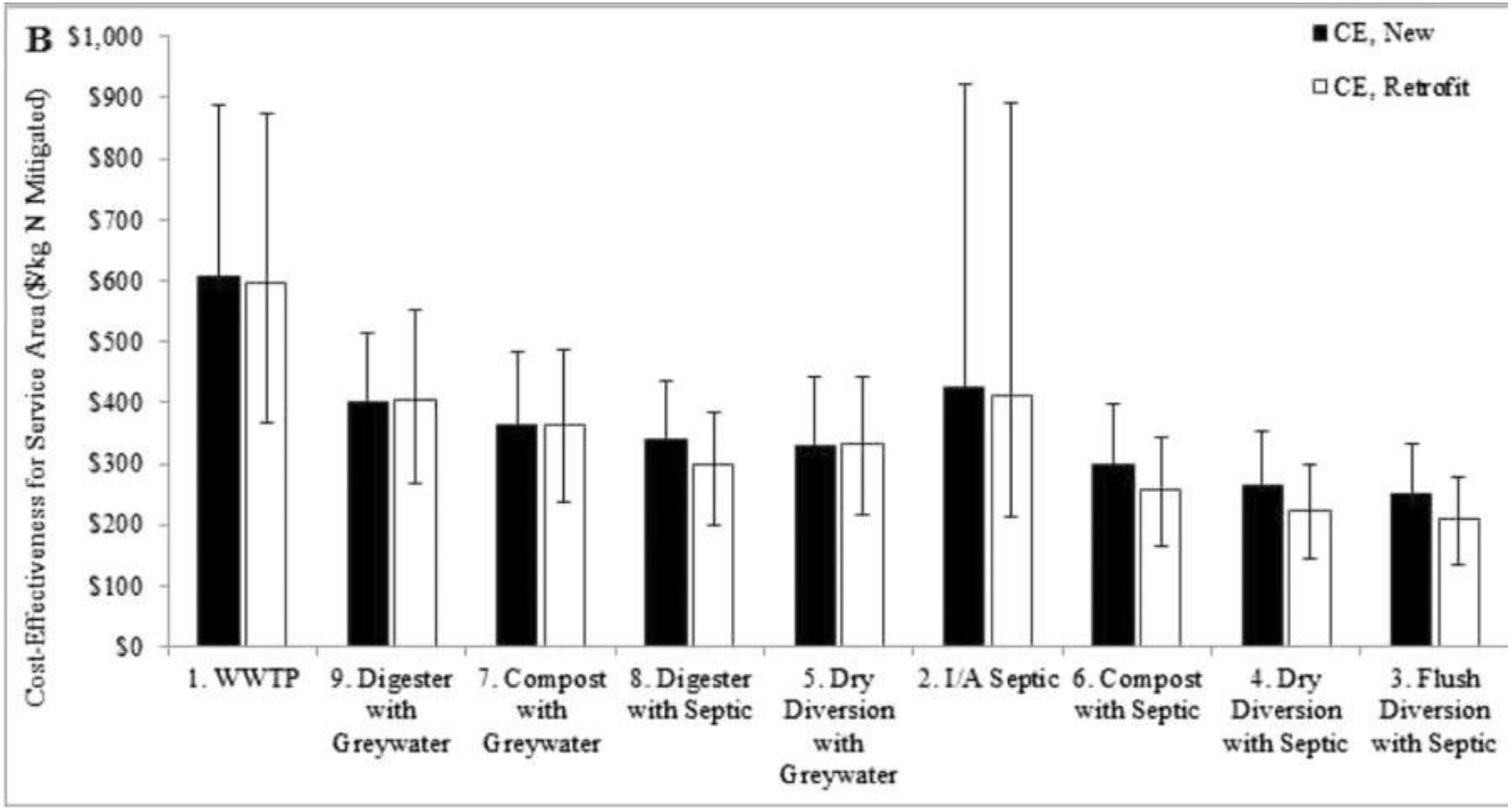
Keys to Success

- Collaboration
- Funding
- Neighborhood Advocacy
- Results



Cost-effectiveness of nitrogen mitigation by alternative household wastewater management technologies

AlisonWood[a]MichaelBlackhurst[b]TroyHawkins[c]XiaoboXue[d]NicholasAshbolt[e]JayGarland Journal of Environmental Management Volume 150, 1 March 2015, Pages 344-354

Project partners:

Town of Falmouth

Buzzards Bay Coalition

BCDHE

West Falmouth Village Association

Funding from US EPA grant through Southeast New England Coastal Watershed Program

Cape Cod Commission

THE FACTS

9 billion pounds
Amount of chemical fertilizer that could be replaced with the urine Americans produce each year.

320 pounds
Amount of wheat that could be grown in a year with the fertilizer from one adult's urine.

125 gallons
Approximate volume of urine an adult produces each year.

More than 15,000
Water bodies in the US impaired due to nitrogen and phosphorous pollution.

80 percent
Portion of the nitrogen and phosphorous pollution in wastewater caused by human waste.

1.2 trillion gallons
Amount of drinkable water we use each year to flush toilets.

4000 gallons
Amount of water you could save per year by diverting urine for fertilizer.

270 percent
Increase in phosphorus fertilizer price between 1993 and 2013.

http://richearthinstitute.org/

RICH EARTH INSTITUTE

QUESTIONS??

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