Eco-friendly Toilet Technologies

Presentation by:

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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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BCDHE

Barnstable County Department of Health and Environment

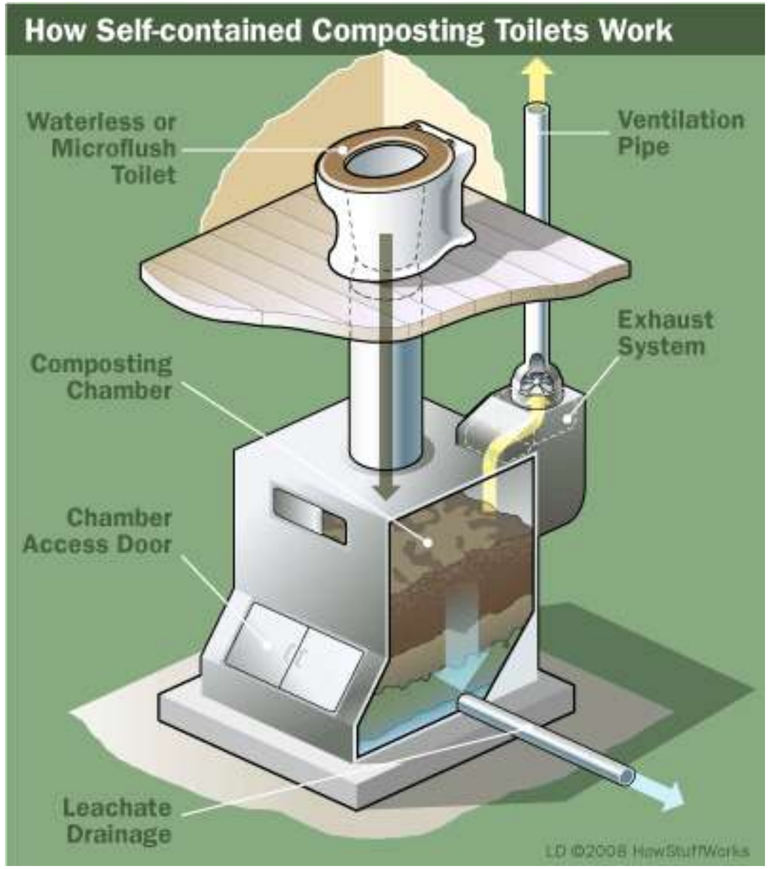
Promote - Protect - Support

County of Barnstable Massachusetts

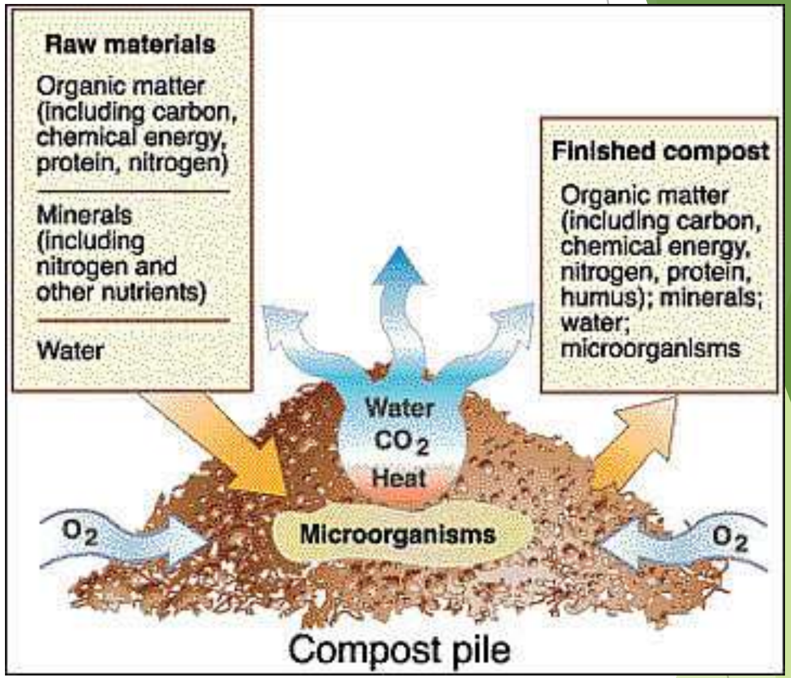
Falmouth Study & Technology Review

- Review 2 studies in Falmouth- Nitrogen and Phosphorus removal
  - Eco-toilet
  - I/A technologies
- Review types of technology used
- Installation considerations

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

10 – 30 % estimated reduction in waste volume

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”.

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.

Multiple technologies

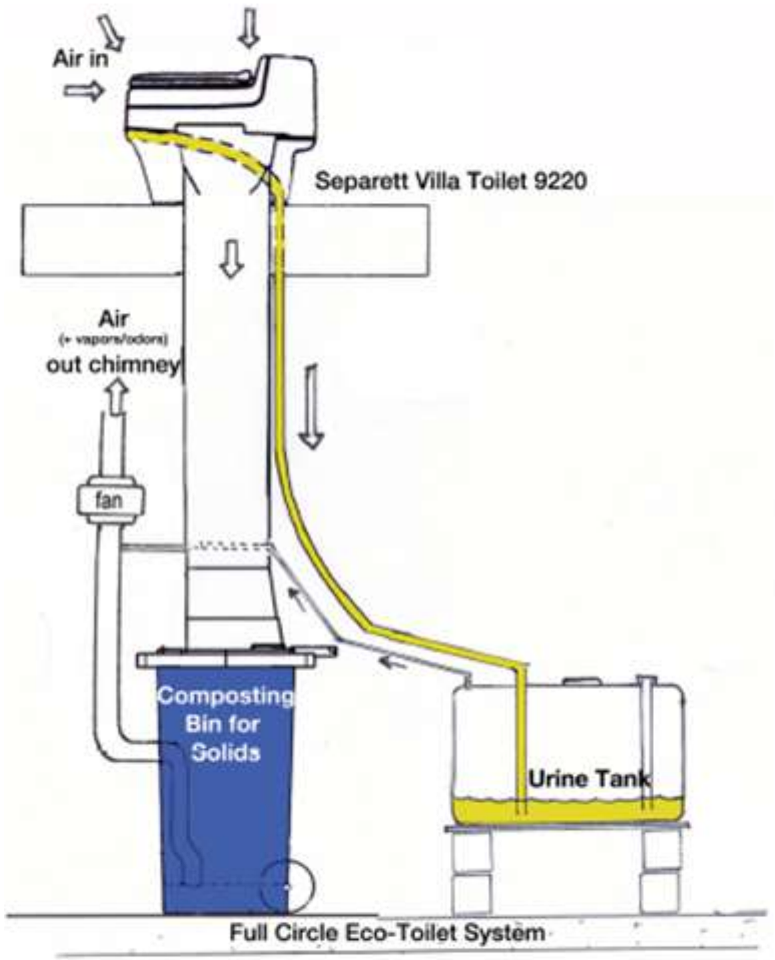
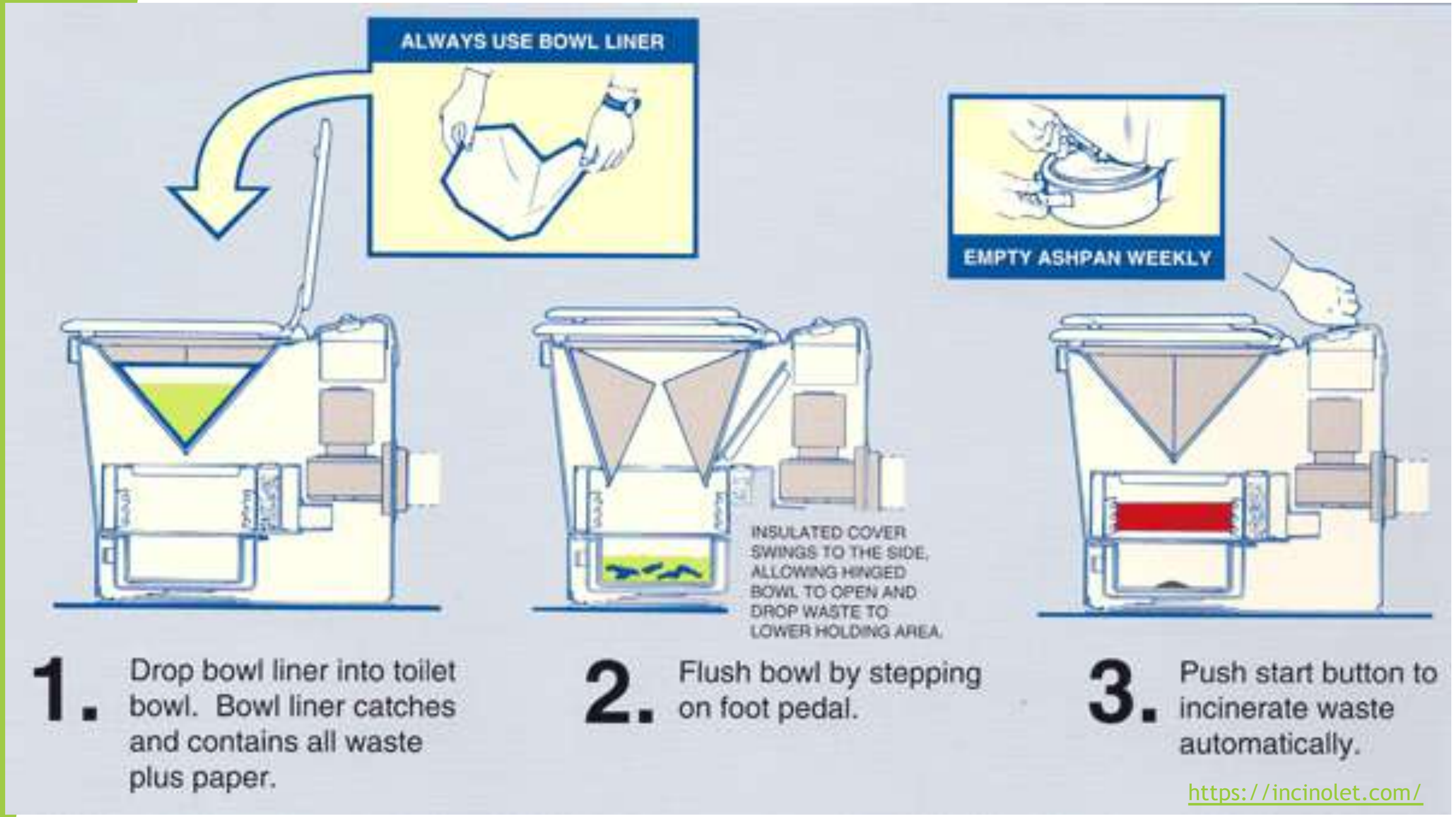
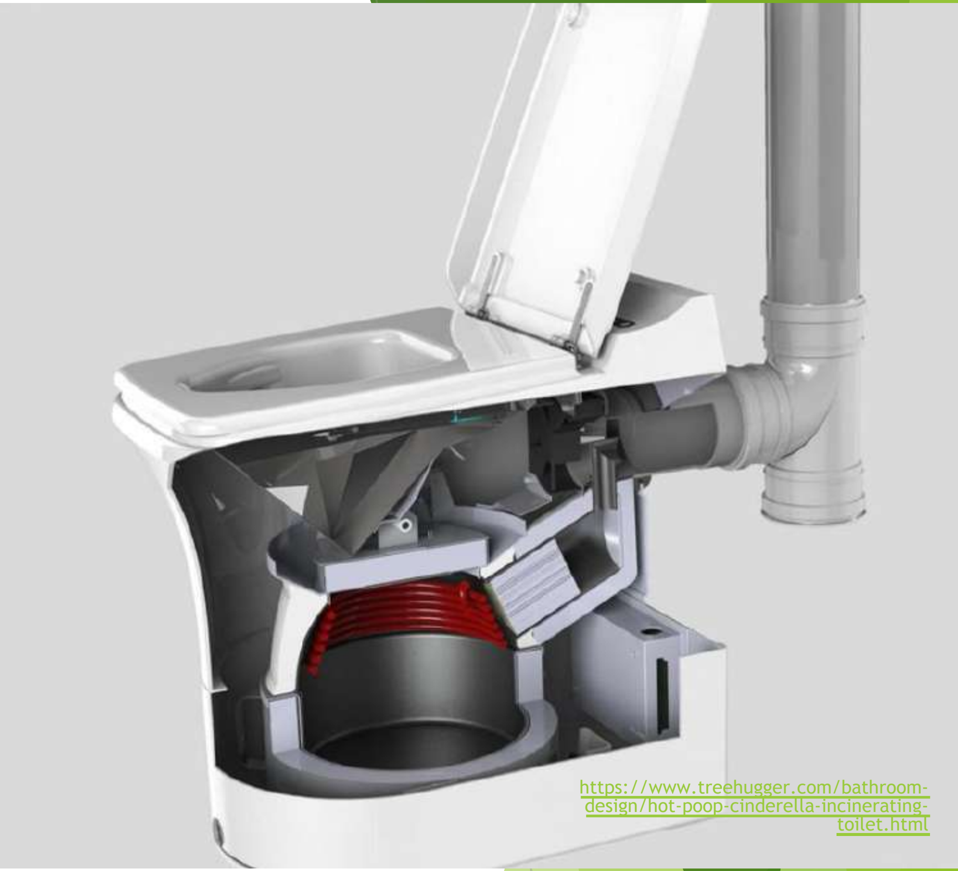


Diagram by Rolf Kleuver

Some locations may require a combination of technologies depending on the situation





Incinerating Toilets

Gas or Electric

- Incinolet
- Cinderella
- EcoJohn
- Destoilet

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

Technology limitations

- Specific to Incinerating toilets
  - Proper operation is key to success
    - Must use requires anti-foam agent, liner or other
    - Regular removal of ash
  - Electric- cannot use during power outage
  - Fire hazard if not installed properly (Chamber reaches ~1400°F)

Materials disposal- Compost

TABLE 1 TYPICAL PATHOGEN SURVIVAL TIMES AT 20 TO 30°C IN VARIOUS ENVIRONMENTS

	Survival Time, Days		
Pathogen	**Fresh Water and Wastewater**	**Crops**	**Soil**
Bacteria			
Fecal coliforms[a]	< 60 but usually < 30	< 30 but usually < 15	< 120 but usually < 50
Salmonella (spp.)[a]	< 60 but usually < 30	< 30 but usually < 15	< 120 but usually < 50
Shigella[a]	< 30 but usually < 10	< 10 but usually < 5	< 120 but usually < 50
Vibrio cholerae[b]	< 30 but usually < 10	< 5 but usually < 2	< 120 but usually < 50
Protozoa			
E. histolytica cysts	< 30 but usually < 15	< 10 but usually < 2	< 20 but usually < 10
Helminths			
A. lumbricoides eggs	Many months	< 60 but usually < 30	< Many months
Viruses[a]			
Enteroviruses[c]	< 120 but usually < 50	< 60 but usually < 15	< 100 but usually < 20

a In seawater, viral survival is less and bacterial survival is very much less than in fresh water.
b *V. cholerae* survival in aqueous environments is a subject of current uncertainty.
c Includes polio, echo, and coxsackie viruses.

Source: Adapted from: Crites and Tchobanoglous, 1998.

https://www.epa.gov/sites/production/files/2015-06/documents/comp.pdf

- Temperatures >50°C- 56°C(122°F-133°F) for up to 3 days to kill pathogens
- Most compost facilities not set up to handle human waste
- Per MA DEP- can be buried on property at least 6” below ground
  - This cycles nutrients back into soils
  - Other option is removal by septic hauler

Materials disposal-Compost toilet effluent-(CTE)- AKA tea

- Harmful pathogens
- Insufficient N for fertilizer
- CTE- 98 % water

<u>Experiment related to Falmouth Eco-toilet Project</u>

- Sent samples to Maine School of Composting
- Added to 3 different feedstock for compost that are available on Cape
  - Oak leaves, horse bedding, wood shavings

Materials disposal

- Urine: use for fertilizer
  - Cost of transportation- 95% water
    - Research being done to dehydrate
  - Urine generally sterile but may be contaminated with feces
  - Contains pharmaceuticals
  - High rates of direct application of urine thought to increase salinity and conductivity in the soils

- Incinerating toilets
  - Significant volume reduction
  - Pathogens removed from waste product
  - Per manufacturer- discard with household trash

https://www.ancient-origins.net/history-ancient-traditions/medieval-sanitation-0010886

User feedback

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

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

- Incinerating toilets
  - Energy use- reported to be very low
  - Additives, foam, liners
- 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)

Uses and installation

- Areas requiring nutrient reduction
- Environmentally sensitive areas
- Reduce water usage
- Cabins, campers
- Areas of home or compound without ability to install flush toilet
- Local & State regulations may limit installation
  - Plumbing code- Does it count as a toilet fixture?
  - Health codes: Sanitation, disposal of end product
  - Building code
  - Fire code- Incinerating toilets

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

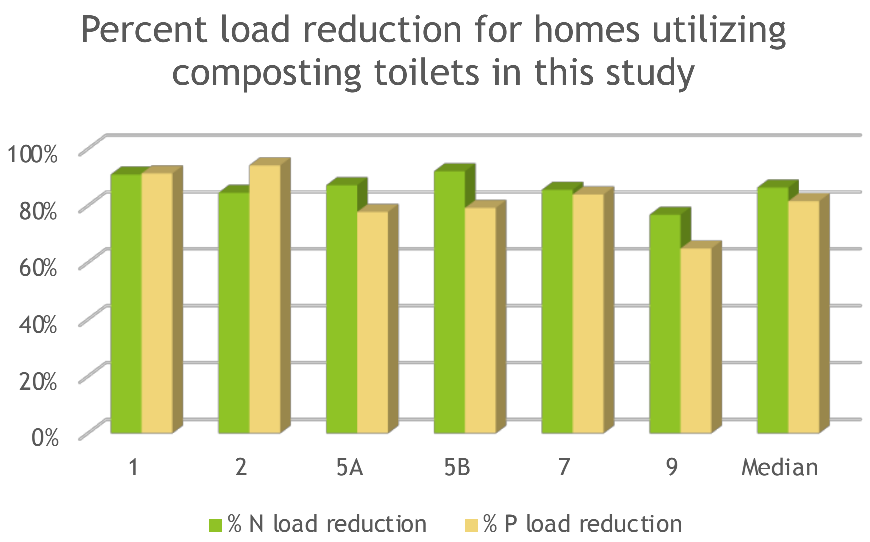
- **Water use**
  - Properties with no pre-installation sampling
  - Properties with erratic water use readings
  - Assumed 20% water use reduction from 55 gpd/person to 44 gpd/person
    - Gallons based on DEP Title 5
    - Percent reduction based on this study and EPA study showing toilets account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

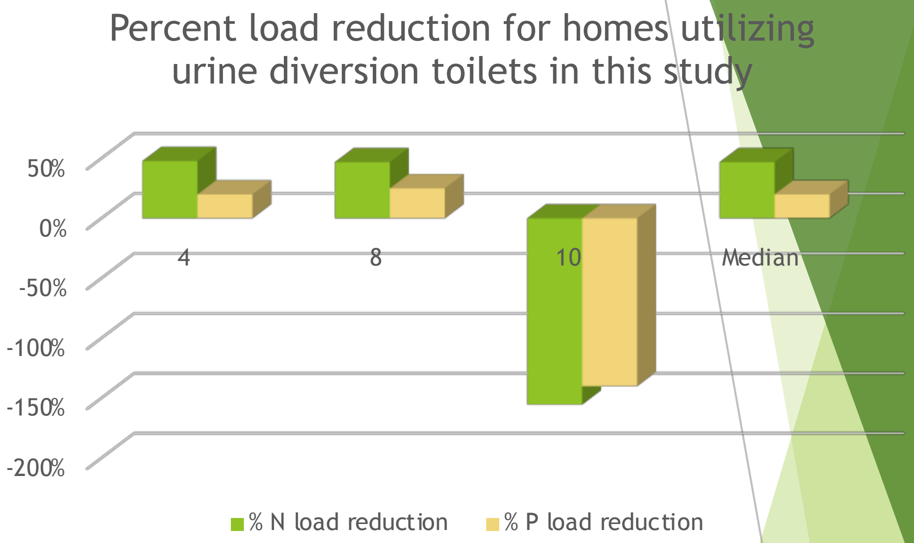
https://www.flickr.com/photos/koiquest10/8341564245

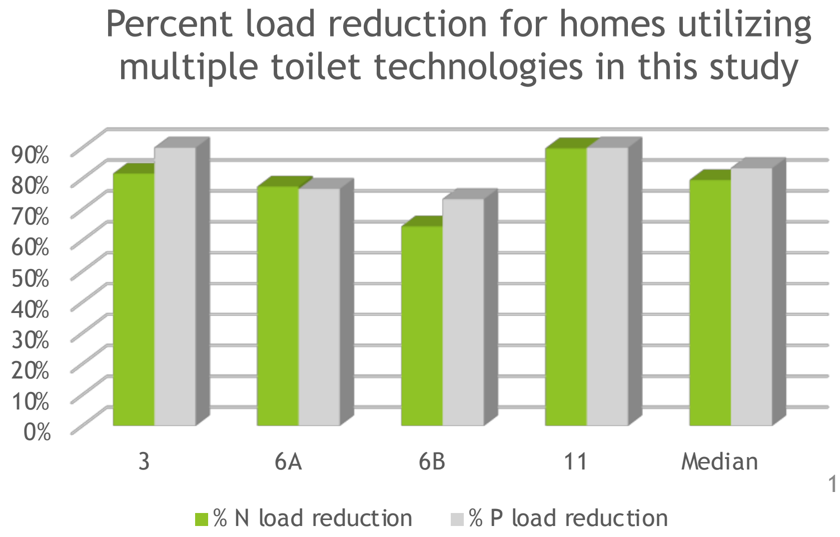
Results assumptions

- **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

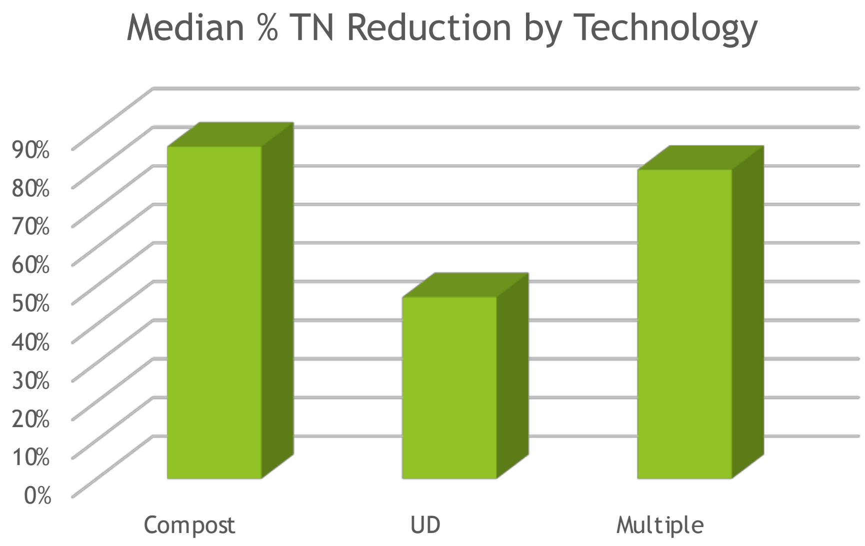
Percent load reduction for all properties

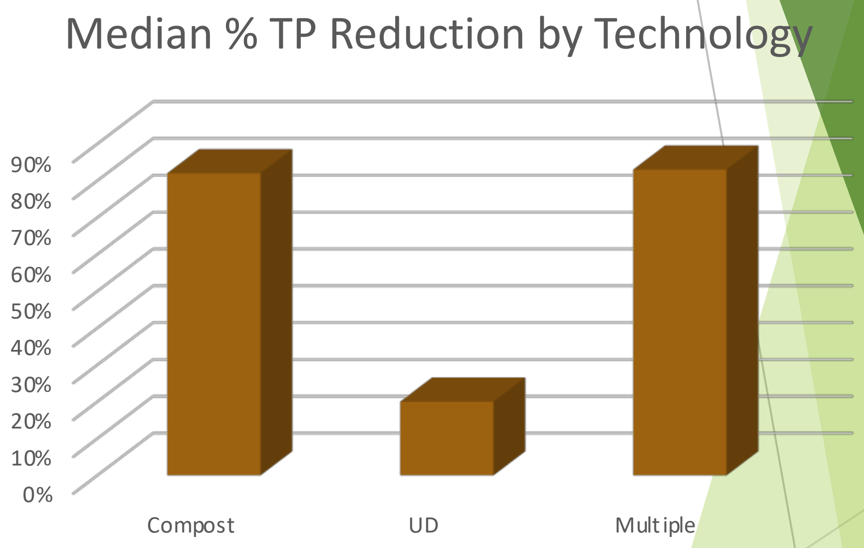






Side by side load reduction





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

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

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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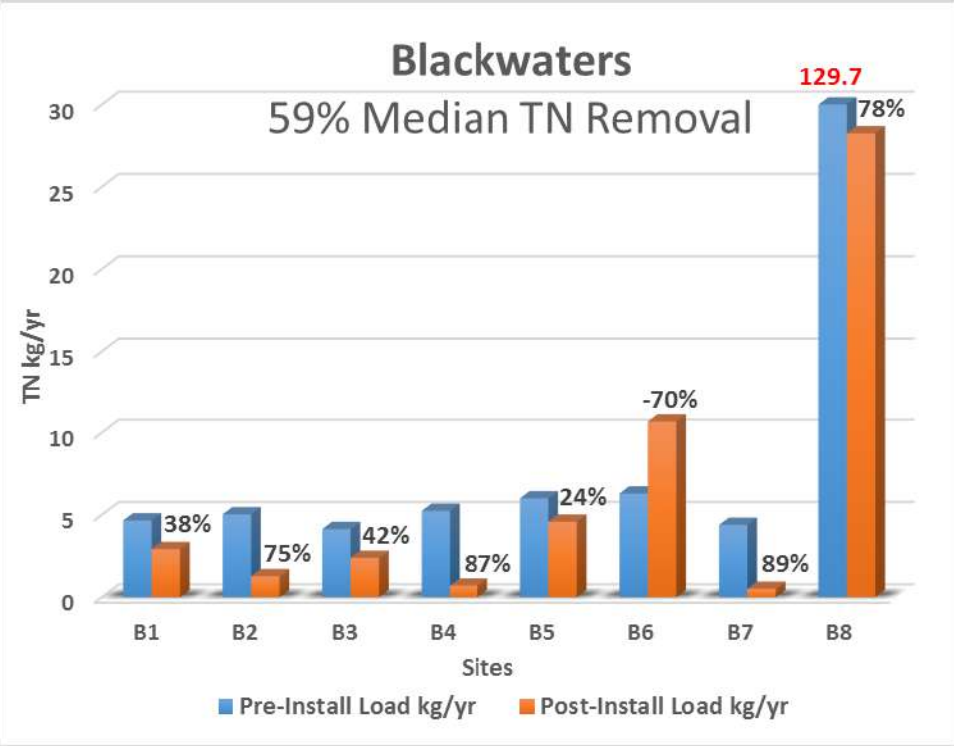
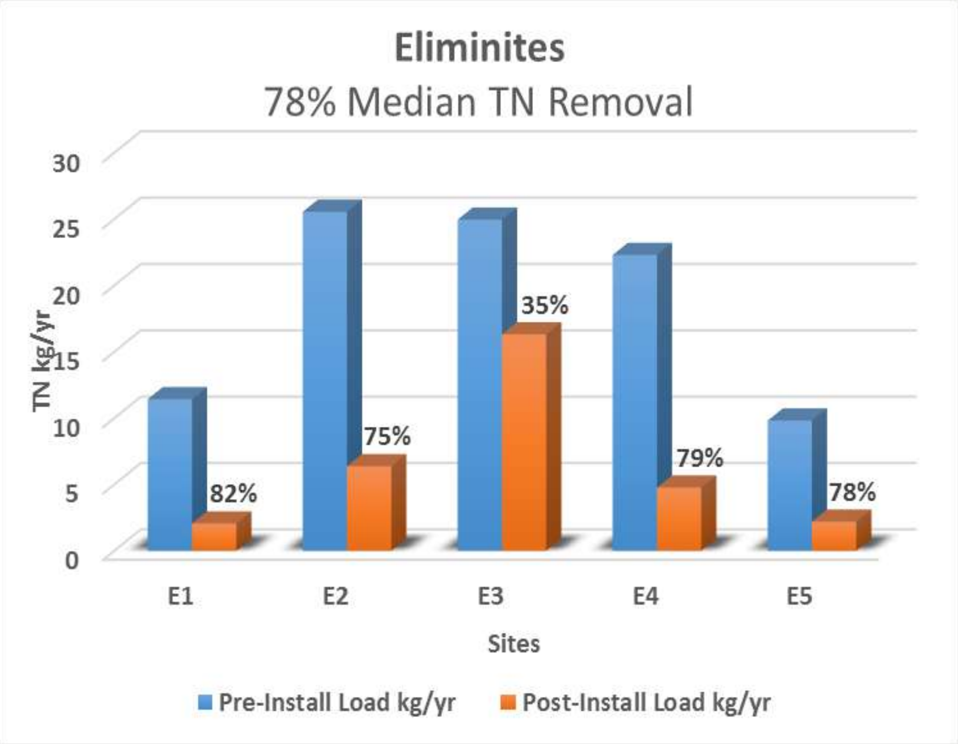
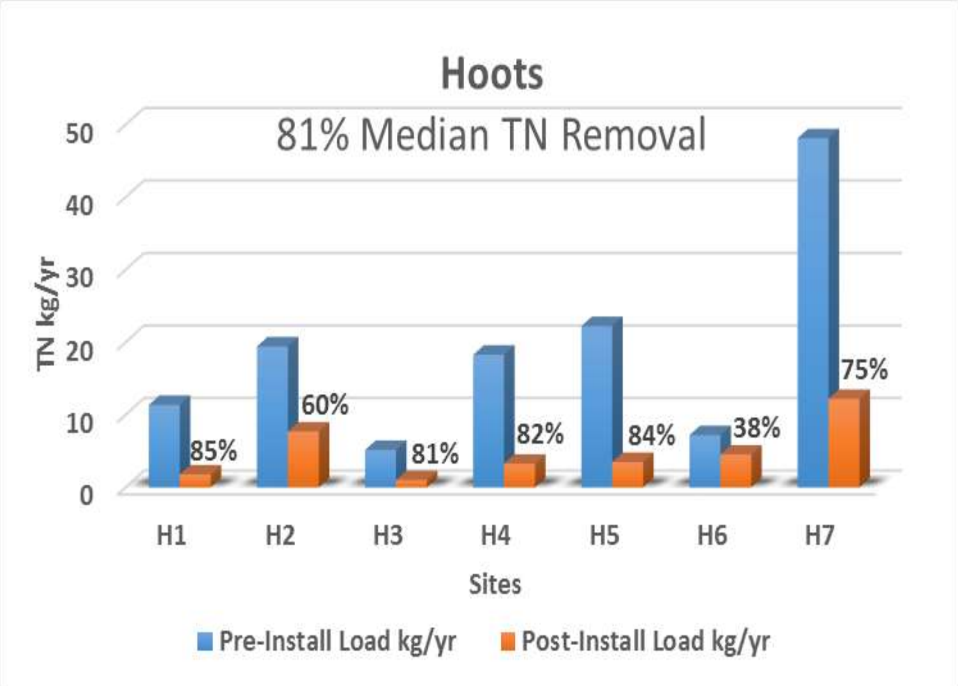
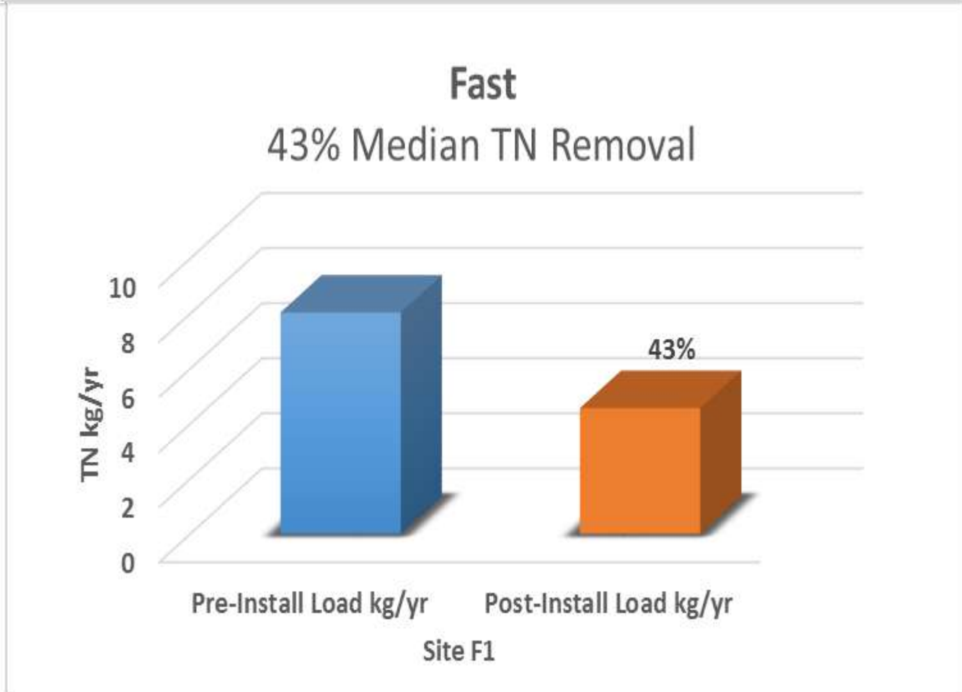

Blackwaters
59% Median TN Removal
129.7
TN kg/yr
0
5
10
15
20
25
30
38%
75%
42%
87%
24%
-70%
89%
78%
B1
B2
B3
B4
B5
B6
B7
B8
Sites
Pre-Install Load kg/yr
Post-Install Load kg/yr


Eliminites
78% Median TN Removal
TN kg/yr
0
5
10
15
20
25
30
82%
75%
35%
79%
78%
E1
E2
E3
E4
E5
Sites
Pre-Install Load kg/yr
Post-Install Load kg/yr


Hoots
81% Median TN Removal
TN kg/yr
0
10
20
30
40
50
85%
60%
81%
82%
84%
38%
75%
H1
H2
H3
H4
H5
H6
H7
Sites
Pre-Install Load kg/yr
Post-Install Load kg/yr


Fast
43% Median TN Removal
TN kg/yr
0
2
4
6
8
10
43%
Pre-Install Load kg/yr
Post-Install Load kg/yr
Site F1

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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Keys to Success

- Collaboration
- Funding
- Neighborhood Advocacy
- Results

QUESTIONS??

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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