To	Sarah Williams, Buzzards Bay National Estuaries Project
CC	Amy Lowell, Falmouth Wastewater Superintendent
Subject	FINAL REPORT for grant reporting; West Falmouth Harbor Shoreline Septic Remediation (WFHSSR) Project
From	Sia Karplus, Technical Coordinator, Science Wares, Inc. Korrin Petersen, Esq., Senior Attorney, Buzzards Bay Coalition
Date	07/25/16

Background

The town of Falmouth and the Buzzards Bay Coalition (Coalition), with the help of the West Falmouth Village Association, identified more than 20 homeowners within 300 feet of West Falmouth Harbor (WFH) willing to voluntarily upgrade or replace their existing Title 5 septic systems and cesspools with Innovative/Alternative (I/A) septic systems or eco-toilets (either composting or urine-diverting systems). I/A septic systems are referred to as nitrogen-removing systems in this Final Report. The installed nitrogen-removing systems reduce septic tank effluent to at least 12 mg/L nitrogen (N). This high level of *voluntary* participation by homeowners in a program where they incurred significant costs to install nitrogen-removing septic systems is unprecedented.

Moreover, with modest education and outreach by the Town and the Coalition, the number of homeowners and community leaders willing to invest in a nitrogen reducing septic solution soon surpassed the 20 subsidies provided by this grant. A waiting list has been developed with the hope that further grant funds will become available to continue this effort. It is clear that the West Falmouth community is committed to contributing to clean water in West Falmouth Harbor and quickly agreed to do their part in reducing nitrogen pollution. Homeowners contributed more than $275,000 dollars out-of-pocket over and above the $200,000 provided in the taxable government subsidy. We believe that this commitment and investment in improving water quality can be both continued in West Falmouth and replicated throughout southeastern Massachusetts.

Key program goals included:

- Reduce the amount of nitrogen pollution entering WFH;
- Validate the performance of best-off-the-shelf nitrogen-removing septic systems; and
- Demonstrates the benefit of targeting nitrogen-removing septic installations along the shoreline.

WFH fails to meet water quality standards due to nitrogen pollution. WFH is listed as a Category 4a water on the Final Massachusetts Year 2012 Integrated List of Waters. Originally listed as a Category 5 nitrogen impaired waterbody in 2002, a Total Maximum Daily Load, (TMDL) was approved by EPA in 2008 establishing a nitrogen concentration limit of .35mg/L at the sentinel station. Subsequent modeling was done by SMAST for a scenario that included (1) full build-out of the WFH watershed and (2) 0.5 million gallons per day of effluent from the Wastewater Treatment Facility (at the current enhanced level of treatment of 3 mg/L) discharging into this watershed. This scenario modeling found that the nitrogen concentration at the Sentinel Station for WFH would be significantly reduced due to improvements at the Wastewater Treatment Facility (WWTF), going from .464 mg/L to .364 mg/L. Thus, improvements to the WWTF that the Town of Falmouth has *already* implemented almost achieve the TMDL for this watershed, at full build-out. Thus, the actions planned in this Project contribute significantly to achieving the TMDL-compliance goals for WFH.

The best scientific understanding, as documented in the Massachusetts Estuaries Project (MEP) Reports for coastal communities throughout Buzzards Bay, is that wastewater from septic systems is the most significant contributor to nitrogen pollution. Collection systems associated with central sewers in low-density residential areas are costly, making this solution difficult for many towns to afford. Affordable, on-site septic systems and eco-toilets that remove a significant percentage of nitrogen are therefore seen as a critically important technical alternative. The concentration of nitrogen from septic system plumes is assumed to be approximately 35 mg/L. Based on water use data from town records, this septic effluent concentration translates into a household contribution of 13.23lbs N/year to WFH. These retrofits will meet a nitrogen limit of 12mg/L as opposed to the current 35mg/L. Nitrogen-removing septic systems that achieve 66% nutrient removal (to 12 mg/L) should reduce the mass of nitrogen from 6 kg/parcel/year (or 13.23lbs/year) to 2 kg/parcel/year (or about 4lbs/year) in WFH. **This will reduce the overall nitrogen load from 20 homes from ~265lbs/year to ~90lbs/year.**

The removal of approximately 175lbs of nitrogen is equivalent to removing 22% of the fertilizer load from the entire watershed, according to the MEP Report for WFH. It is also equivalent to removing the entire stormwater load from lower Mashapaquit Creek. Coupled with fertilizer reductions that are expected to be realized because of the passage and enforcement of a town-wide Nitrogen Control Bylaw for Fertilizer and the bottom planting of second-year oysters in Snug Harbor, the remediation of these harbor front septic systems may bring West Falmouth Harbor into TMDL-compliance. The ecosystems service that this reduction in nitrogen could accomplish also includes aesthetic improvements (fewer algae blooms), and increased water clarity leading to enhanced eelgrass restoration, which provides invaluable fisheries habitat.

Project Implementation

A number of steps were required to successfully complete this Project, including:

- Technology Evaluation
- Participant Selection and Enrollment
- Nitrogen-Removing Septic System Design
- Permitting
- Installation
- Monitoring

Technology Evaluation

A Working Group was convened to review nitrogen-removing septic technologies that qualified to participate in the WFHSSR Project. Members included: Gerald C. Potamis, Wastewater Superintendent; Sia Karplus, Water Quality Technical Consultant; John Waterbury, Ph.D, member Falmouth Board of Health and Water Quality Management Committee; George Heufelder, Director/Chief Health Officer of Barnstable County Department of Health and Environment (BCDHE); Dr. Rachel Jakuba, Science Director, Buzzards

Bay Coalition and Korrin Petersen, Esq. Senior Attorney, Buzzards Bay Coalition. To enable comparisons amongst nitrogen-removing septic systems, a vendor questionnaire was developed by the Working Group and sent to fifteen vendors. The questionnaire (Appendix A) asked for the following information; Cost (equipment and installation), Cost of Operation and Management, Monthly Energy Use, Warrantee, Number of Pumps, Ability to Retrofit to Existing Title V System, Components visible above ground.

Review of the vendor responses for single-family nitrogen-removing technologies was based on several criteria:

- Proven ability to achieve a discharge concentration of 12 mg/L N based on data submitted by the vendors; and
- Available third-party data.

Based on vendor responses to this questionnaire, a master list of recommended technologies was developed by the Working Group, and provided to property owners. All eco-toilets currently approved for use in the Town of Falmouth were also eligible for installation. This included both composting systems that have received Product Acceptance from the State Board of Plumbers and Gas Fitters as well as urine-diverting and composting systems that have received Test Site Status for installation in Falmouth.

Nitrogen-Removing Septic System Technology Descriptions

- Fifteen commercially-available systems qualified for the WFHSSR Project, including:
    - AdvanTex AX20RT (Orenco) Joseph Soulia 800-230-9580
      http://www.orenco.com/sales/choose_a_system/advanced_treatment_systems/index.cfm
    - Amphidrome - SBR Mollie Caliri 781-982-9300 x 33
      http://www.amphidrome.com/
    - Biobarrier MBR (Biomicrobics) Lauren Usilton 508-823-9566
      http://www.biomicrobics.com/products/bio-barrier-membrane-bioreactor/
    - Bioclere (Aquapoint) Mark Lubbers 774-930-3900 or 508-985-9050
      http://www.aquapoint.com/bioclere.html
    - BUSSE Green Tech Ingo Schaefer 708-204-3504
      http://www.busse-gt.com/
    - Eliminite +Puraflo Tom Kallenbach 406-581-1613
      http://www.eliminite.com/index-1.html#
    - GPC Mike McGrath 508-548-3564
      http://www.holmesandmcgrath.com/index.html
    - Hoot BNR Ron Suchecki 254-299-0821
      http://hootsystems.com/about-hoot-systems/
    - Nitrex (Lombardo Associates) Lombardo Associates 617-964-2924
      http://www.lombardoassociates.com/
    - NJUN Systems Duncan Corley 404-925-1289
      http://www.njunsystems.com/

- RUCK Mike McGrath 508-548-3564
  http://www.irucks.com/
- SepticNET Steve Anderson 406-498-6850
  http://www.septic-net.com/
- SES Environmental: Hydro-Kinetics Camel McGill 401-785-0130 or 508-406-8381
  http://www.seswastewater.com/hydro-kinetic.html
- Waterloo Biofilter Greg Corman 519-856-0757
  Chris James 519-830-1490 http://waterloo-biofilter.com/
- SeptiTech Lauren Usilton 508-823-9566
  http://www.septitech.com/staar-residential/

In addition, two non-proprietary technical solutions were developed as this Project progressed, a blackwater storage tank system and the Layer Cake system.

Participant Selection and Enrollment

To develop a list of priority properties within the WFH watershed, locations were ranked on a scale of 1 to 5 (with higher scores considered most advantageous) based on the following criteria:

- Proximity to Shoreline –Using mapping software, properties directly abutting West Falmouth Harbor and all septic systems within 300 feet landward of mean high tide were identified. Septic systems closer to WFH more directly impact water quality due to the short distance the nitrogen-rich effluent travels through groundwater before discharging to the harbor. Properties closest to the Harbor's edge will be ranked higher.
- Proximity to Sentinel Station – A primary goal of this project is to help achieve water quality standards in WFH and meet the TMDL nitrogen concentration limit of .35mg/L at the sentinel station, which is in the Snug Harbor subwatershed. Properties which abut the shoreline within the Snug Harbor subwatershed were ranked highest.
- Type and Age of Septic System – It is presumed that Title 5 septic systems and cesspools discharge approximately the same amount of nitrogen. However, cesspools located in saturated soils close to water bodies will discharge more nitrogen due to the lack of soil attenuation. For this reason, cesspools will receive a slightly higher priority ranking than Title V septic systems for this project. Furthermore, upgrading cesspools has the additional benefit of reducing bacteria and pathogen contamination with positive water quality and public health benefits. The type and age of system will be determined by reviewing Board of Health records for selected properties and through interviews with property owners.
- Annual Occupancy – In order to optimize the reduction of nitrogen currently discharged from properties within the WFH watershed, homes that are occupied year round received a higher rank than homes that are used on a seasonal basis. However, seasonally occupied homes were also selected in order to assess the performance of nitrogen-removing septic systems that are used on an intermittent basis.
- Willing Property Owners – As long as the property fell within 300 feet landward of mean high tide, a property owner's willingness to participate in the project became the ultimate determining factor.

To identify interested households, the Coalition, together with the leaders from the West Falmouth Village Association sent personalized letters and Fact Sheets (Appendix B) to the top sixty priority candidates. This first round of letters yielded 9 commitments to participate. A subsequent letter was sent to the entire list of 170 qualifying properties within 300 feet landward of mean high tide. Follow-up included numerous emails and phone calls as well as site meetings. In addition, the Coalition presented the project at the West Falmouth Village Association's annual meeting in July 2015.

A significant factor in enrolling participants was gaining the support of community leaders. West Falmouth is a close-knit community and once community leaders supported the project, many others residents agreed to participate. In this case it was critical to win the endorsement of a local property management company that many homeowners along WFH rely on for handling technical issues related to their property and to whom homeowners defer to with respect to septic system upgrades. Working in partnership with this property management company we were able to sign up many homeowners for upgrades.

Site Specific Technology Selection

It was not practical to present 15 different I/A systems and 10 different ecotoilet options without a way for the property owner to objectively evaluate each option. For those candidates committed to exploring an upgrade, the Town's Technical Coordinator and the Coalition created a Decision Support Tool (Appendix C) to help homeowners rank systems based on their preferences for such attributes as aesthetics, complexity, energy use, and cost. The town's Technical Coordinator and the Coalition then reviewed the top technologies for installation feasibility and reviewed the top qualified nitrogen-removing septic systems and ecotoilets with property owners. Each property had a unique set of site constraints such as space limitation, proximity to resource areas, depth to groundwater, and existing landscaping features. Therefore, not all of the qualifying systems were feasible to install.

To help property owners gain familiarity with different nitrogen-removing septic systems and their vendors, the Town and the Coalition held a workshop at the home of a WFH resident interested in participating in the project. Based on approximately 15 different homeowner interviews and the results of the Decision Support Tool, six different types of systems were the most popular and those those vendors were invited to present their systems. , Representatives of the Bioclere, Eliminite, Hoot, Nitrex, and NJUN systems attended. Over ten property owners attended this workshop, along with BCDHE, the Town's technical Consultant, staff from the Coalition and members of the Falmouth Water Quality Management Committee. Most of the homeowners who attended this workshop participated in the Project and those who did not participate are very committed to participating in a future phase. Homeowners top priorities for choosing a system were aesthetics (minimize visual impacts of components above grade), cost, and complexity (number of pumps required). Ultimately, four system types were selected by property owners for installation, and are described in the paragraphs below.

- Blackwater storage as part of a Title 5 system (for seasonal homes)
- Eliminite
- HOOT
- Layered Soil Treatment Area (STA)

Table 1 lists the twenty systems that were installed as part of this Project.

Table 1. System Types Installed and Replaced with Location by Case Study Number

Case Study #	System Type	System Replaced
BW1	Blackwater Holding Tank	Cesspool
BW2	Blackwater Holding Tank	Title 5
BW3	Blackwater Holding Tank	Cesspool
BW4	Blackwater Holding Tank	Title 5
BW5	Blackwater Holding Tank	Cesspool
BW6	Blackwater Holding Tank	Cesspool
BW7	Blackwater Holding Tank	Cesspool
BW8	Blackwater Holding Tank	Title 5
BW9	Blackwater Holding Tank	Title 5
BW10	Blackwater Holding Tank	Cesspool
EL1	Eliminite	Title 5
EL2	Eliminite	Title 5
EL3	Eliminite	Title 5
HO1	HOOT	Cesspool
HO2	HOOT	Cesspool
HO3	HOOT	Cesspool
HO4	HOOT	Title 5
HO5	HOOT	Cesspool
HO6	HOOT	Title 5
LSAS1	Layered SAS	Cesspool

Blackwater Storage

2,000 Gallon Blackwater Tank installed in parallel with an existing Title V systems at the location of Case Study BW9.

In WFH there are many homes that are only occupied eight to ten weeks out of the year. These homes are typically uninsulated and located on small lots in close proximity to wetlands. An innovative, non-proprietary, cost effective solution was developed to enable nitrogen-removing septic systems to be installed in these homes. This system adds a 1500 to 2000-gallon storage tank to a standard Title 5 septic system. Interior toilets are re-plumbed to divert into this holding tank. Sizing of the blackwater holding tank is calculated to require only one or two pump-outs per season. An alarmed float meter is installed to alert homeowners and property managers when the blackwater tank is 2/3 full and a counter is also installed to track the number of times the alarm is triggered. Figure 1 shows one of many possible configurations of this system. A total of 9 Blackwater tanks were installed.

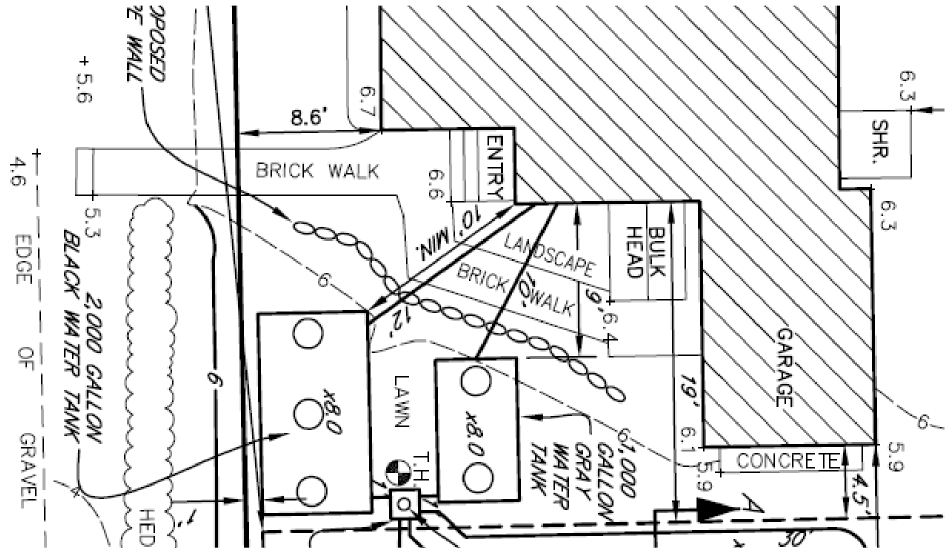


Figure 1. Blackwater Storage Tank Configuration

Eliminite

Eliminite is a fixed-film biological reactor with recirculation and alternating aerobic/anoxic treatment processes. While many models and configurations targeting a variety of wastewater constituents are available, the most basic configuration consists of a single primary tank (septic tank) and a single Eliminite treatment tank. The treatment tank houses the fixed-film bioreactor, recirculation/storage volume, level control and effluent pump(s).

Eliminite systems utilize patented, proprietary treatment media called MetaRocks. MetaRocks media represents a significant improvement over other types of trickling filter media common to the industry. Long-term use has proven that MetaRocks possess superior treatment characteristics which are absent from other types of fixed-film systems, including the following:

- High specific surface area in excess of 60 ft2/ft3 provides ample surface for microbial attachment and biofilm development.
- Large void volume exceeding 70% ensures low headloss for efficient air transfer through entire media bed.
- Large average pore diameter of 0.5 to 1.5 inch translates to nearly zero clog potential.
- Rough surface speeds time to maturation and enhances water holding characteristics.
- High hydraulic loading capacity, 250 gal/(min* ft2).
- Polar surface is hydrophilic and wets completely with water.
- Thin liquid surface film allows oxygen to penetrate into the full depth of the developed biofilm.
- Light weight at 7 lb/ft3 allows for deep media bed with no additional structural requirements imposed on the tank manufacturer.
- MetaRocks are free-flowing and take the shape of the vessel they occupy while retaining superior hydraulic and biological properties. This allows for their use in virtually any type of tank.

Eliminite Tank installed in parallel with an existing Title V systems at the location of Case Study EL3.

Eliminite was developed in Bozeman, Montana in 1994 in response to evolving water quality regulations developed by Montana Department of Environmental Quality (MDEQ). The new regulations identified nitrogen, due to its potential mobility in the vadose zone, as the contaminant of primary concern. Between 1994 and 2004, no formal classification for nutrient removal systems existed in Montana. However, early results from the Eliminite technology were so promising that MDEQ allowed them to be installed on a case-by-case basis until the formal rules were prepared. By the time MDEQ finalized the regulations, Eliminite systems had been in use in residential, commercial and community applications throughout Montana for 10 years. Eliminite are now used in hundreds of homes, businesses and government facilities in Montana, Colorado, New Mexico and California. Figure 2 is a technical drawing of the Eliminite System and Figure 3shows the Eliminite process. A total of 3 Eliminite Tanks were installed.

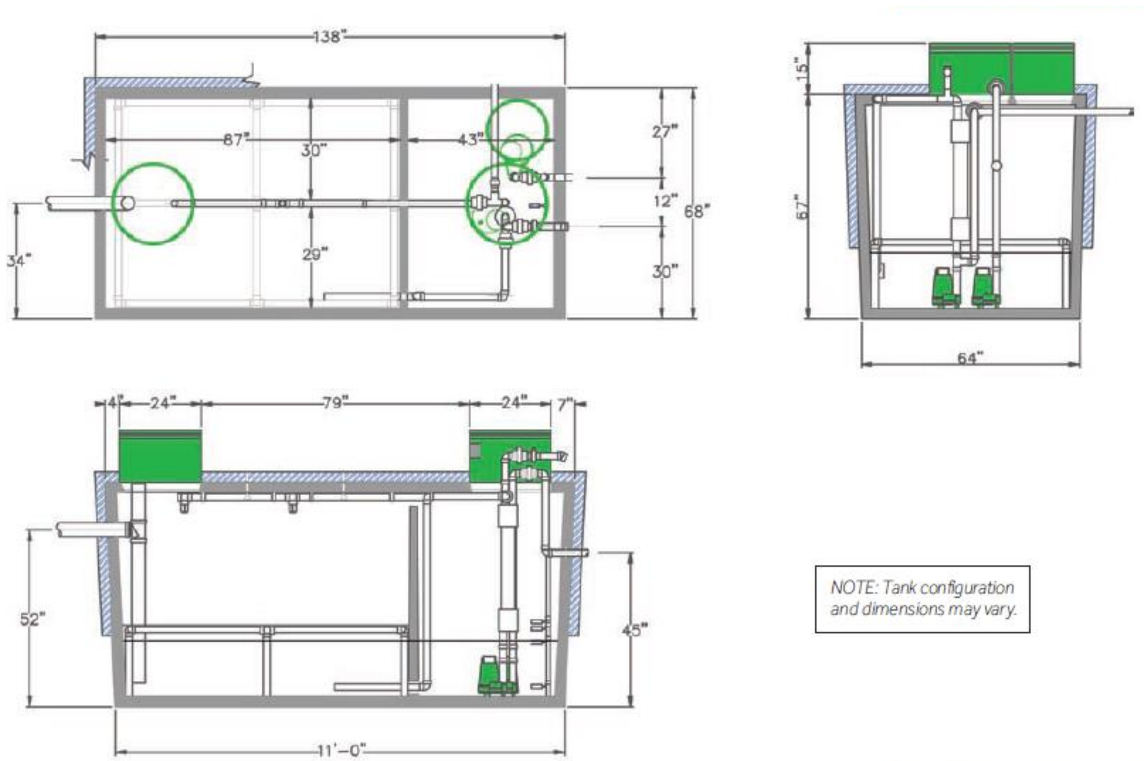


Figure 2. Eliminte Schematic

The Eliminite Process

1. Collection

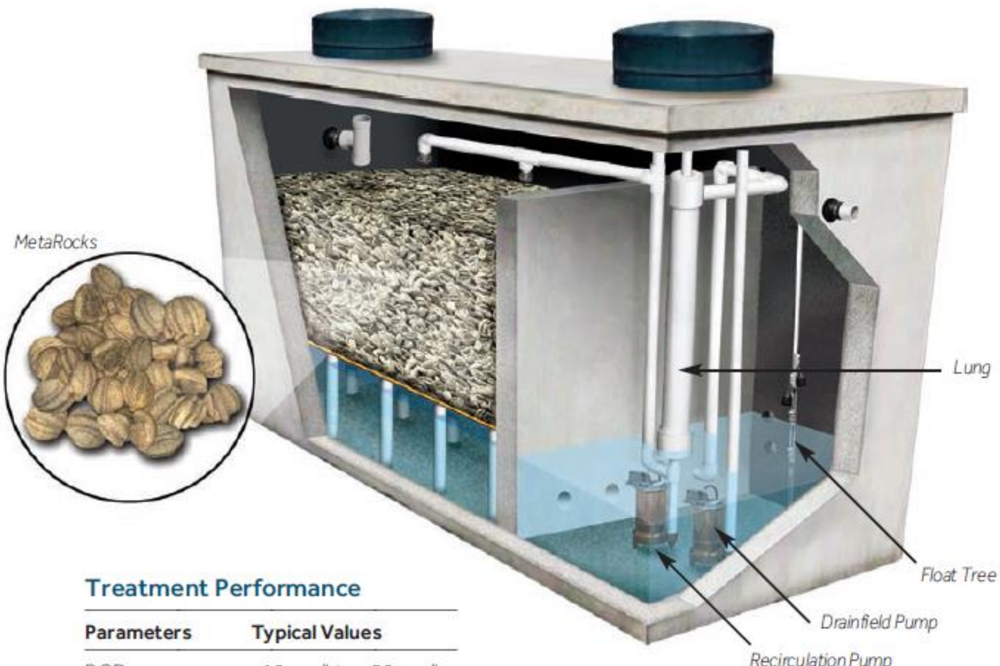
Sewage flows from the home or facility into a watertight primary tank or chamber. The solids settle and the liquid effluent flows by gravity through an effluent filter to the Eliminte system.

2. Treatment

The recirculating biofilter provides passive biological treatment through an active biofilm matrix. MetaRocks, suspended in the tank, provide large surface area for microorganisms to attach and grow. The Lung supplies additional oxygen to the biofilm through the action of the recirculation pump.

3. Dispersal

Treated effluent is pump dosed from the Eliminite recirculation chamber into gravel trenches, chambers, LPP, drip irrigation or other dispersal methods. Effluent is suitable for reuse. Chemical or UV disinfection may be required.



Treatment Performance

Parameters	Typical Values
BOD_5	<10 mg/l to <20 mg/l
TSS	<10 mg/l to <20 mg/l
Total Nitrogen	<10 mg/l to <15 mg/l

Figure 3. Eliminite Process and Performance

Hoot

The Hoot ANR Treatment System is comprised of five components, namely a pretreatment tank, aeration chamber, clarifier, media tank and final clarifier/pump tank.

The pre-treatment tank or trash trap contains the volume of approximately 1 day's system flow. The Pre-Treatment Tank, aids in the anaerobic decomposition of the influent by providing a storage area for non-biodegradables which are inadvertently added to the system. This tank functions like a septic tank, providing a space for components that are lighter than water to float (e.g. fats oils and grease - which should not be added to the system in the first place) and a place for other solids (e.g. hair, dirt and other non-biodegradble solids). to settle A reduction of up to 50% of the Total Suspended Solids (TSS) and approximately 25% of the Biochemical Oxygen Demand (BOD) occurs within this tank. This tank also contains a mid-level, baffled crossover by which the liquid waste enters into the aeration chamber.

The aeration chamber is the heart of the activated sewage treatment of the plant, using a Troy Air Blower to incorporate oxygen into the sewage. This introduction of oxygen is done to intimately mix the organics of the sewage with the bacterial populations in the aeration chamber. Reduction of the organics is accomplished by these organisms. Excess oxygen not needed for the organic decomposition is utilized by nitrifying bacteria to convert ammonia into the more stable form on nitrogen known as nitrate. Movement of sewage in the aeration chamber also causes the activated sludge that settled in the final clarifier to be re-introduced into the aeration chamber.

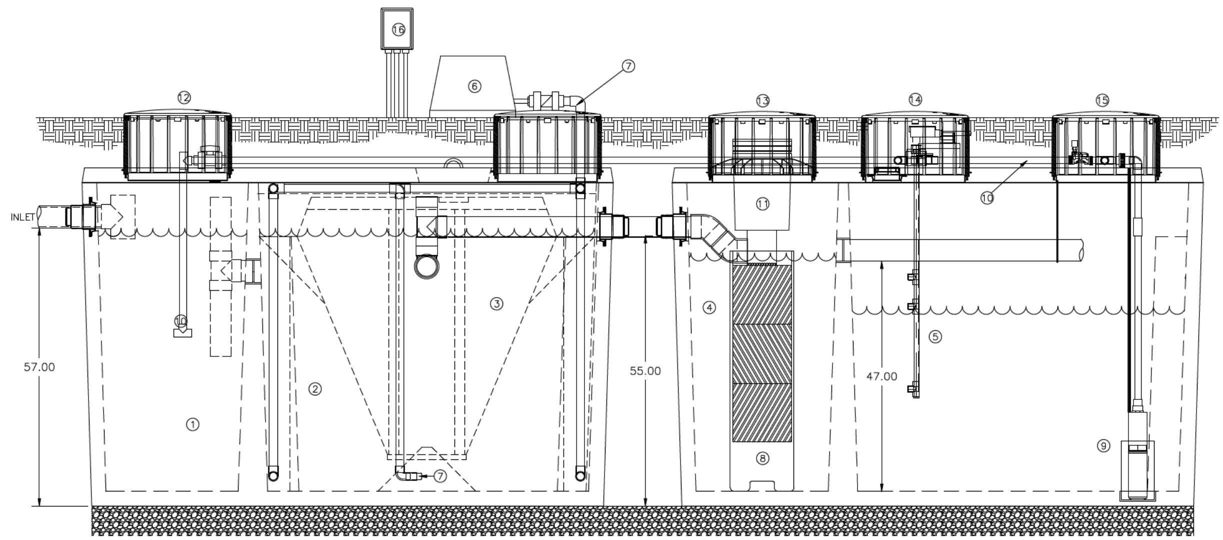
The clarifier is a still chamber located within the aeration chamber and provides a quiescent zone in where the clear odorless effluent rises through to the outlet, located 6 inches below the surface of the clarifier. This chamber holds approximately ½ day's capacity of effluent which passes from the clarifier into the media tank.

The media tank contains a fixed media surface. This fixed media is an environment optimized for the growth of denitrifying bacteria. A proprietary carbon source, HOOT-CS is added via a peristaltic pump to the wastewater in this chamber, providing the energy needed for nitrosomas and nitrobacter to convert nitrate into N_2, harmless airborne Nitrogen gas. Approximately 78% of the air we breathe is made up of odorless, colorless, Nitrogen gas. The chamber that holds the fixed media cell contains approximately a day's worth of flow volumetrically. From this media chamber, the effluent leaves and passes into an optional final clarifier/pump.

Hoot system installed as part of a full upgrade from cesspools at the location of Case Study HO2.

The final clarifier/pump tank is the last treatment component before release to the soil treatment area. This chamber contains a screening device that provides for storage of settled solids to be stored before the final discharge. This storage separates the solids from the pump so that pump will run cool and last longer. A calculated portion of the daily flow of the system is recirculated from this chamber back to the pre-treatment tank. The pump tank also serves as a storage chamber for holding the treated effluent for disposal at a later time.

All HOOT systems are designed to have a minimum of a 12 hours of flow above the alarm to give ample time for service personnel to arrive and correct any problem which may occur. Additional storage volume above the chambers in the air space provides approximately 2 days of additional emergency storage. ANSI/NSF Standard 40 and 245 requires a minimum removal for wastewater treatment systems. For a system to be certified as a Standard 40 Class I Treatment unit, the arithmetic mean of all effluent samples for Biological Oxygen Demand (BOD) collected in a seven-day period must be less than 45 mg/L. The HOOT ANR System had an average BOD of 6 mg/L with an average influent of 250 mg/L BOD and a Total Suspended Solids (TSS) average of 4 mg/L with an average influent of 300 mg/L, both averaging over a 98% removal efficiency. In Addition to the Class I performance for BOD and TSS, for the Standard 245, the System was sampled 3 times per week for Total Kjeldahl Nitrogen (TKN), nitrate and nitrite to determine Total Nitrogen (TN). The influent in TKN averaged 37.2 mg/L and effluent averaged 5.8, producing a nitrogen removal efficiency of 82%. If the HOOT ANR is properly installed, used and maintained, it is capable of producing similar of effluent quality in actual use conditions. Figure 4 shows a schematic of the HOOT system. A total of 7 Hoot Systems were installed.



1) PRETREATMENT TANK– WHERE ANAEROBIC DIGESTION OCCURS AND STORAGE FOR NON–BIODEGRADEABLE MATERIALS.

2) AERATION CHAMBER– WHERE AIR IS INTRODUCED INTO SEWAGE FOR DIGESTION.

3) CLARIFIER– A STILL CHAMBER WHERE SOLIDS SETTLE OUT AND THE CLEAR EFFLUENT RISES.

4) MEDIA TANK – CARBON LOADED MEDIA CHAMBER.

5) PUMP TANK – CONTAINS RECIRC PUMP, CAN PROVIDE PUMPED OR GRAVITY DISCHARGE.

6) TROY AIR LINEAR AIR BLOWER– LONG LIFE, EFFICIENT LINEAR BLOWER WHICH COMPRESSES ATMOSPHERIC AIR AND UNDER PRESSURE DELIVERS IT TO THE TANK. MUST BE LOCATED NO GREATER THAN 6 FEET FROM THE PANEL AND NO GREATER THAN 50 FROM THE TANK.

7) AERATION LINE– DELIVERS THE AIR FROM THE BLOWER TO THE MANIFOLD. CHECK VALVE INCLUDED, TERMINATED AT DIFFUSER INTO TANK.

8) MEDIA BLOCK – FIXED SURFACE AREA FOR FOR ANOXIC DENITRIFICATION TO OCCUR ON.

9) SUBMERSIBLE RECIRC/DISCHARGE PUMP – A SINGLE PUMP (OR MULTIPLE PUMPS) ARE USED FOR RECIRC. & EFFLUENT DISCHARGE.

10) RECIRC. LINE – A PORTION OF THE DAILY FLOW IS REPROCESSED THROUGH THE SYSTEM FOR ADDITIONAL TREATMENT (MIN. 50%)

11) HOOT CS CONTAINER – STORAGE CONTAINER PROVIDES CARBON SOURCE AND A LOW LEVEL INDICATOR.

12) PRE–TREAT/AERATION RISER – ACCESS THROUGH THIS RISER ALLOWS FOR OBSERVATION OF PRE–TREATMENT TANK, RECIRC. LINE, TRANSFER BAFFLE, AERATION CHAMBER & CLARIFIER. ALSO USED TO PUMP SYSTEM.

13) MEDIA CHAMBER RISER – ALLOWS ACCESS TO MEDIA BLOCK, REFILL OF CARBON SOURCE AND LOCATION OF PERISTALTIC PUMP.

14) MEDIA EQUIPMENT ACCESS – PROVIDES ACCESS TO PROBE, PERISTALTIC PUMP, WATER METER AND OPTIONAL UV DISINFECTION (IF EQUIPPED)

15) PUMP TANK/ SAMPLE PORT ACCESS – PROVIDES ACCESS TO PUMP TANK, RECIRCULATION & DISCHARGE LINES OR OPTIONAL GRAVITY FLOW OUTLET. ACCESS TO DISCHARGE EFFLUENT IN TANK OR FROM SAMPLE VALVE.

16) SYSTEM CONTROLLER – OPERATES BLOWER, PUMPS (DISCHARGE, RECIRC. AND PERISTALTIC) AND PROVIDES ALARM NOTIFICATION BY TRIGGERING AUDIBLE/VISUAL ALARM. MUST BE LOCATED NO GREATER THAN 6 FEET FROM THE BLOWER, AND 50 FEET FROM THE TANK.

Figure 4. HOOT systems configuration and component description

Layered Soil Treatment Area (Layered STA)

Layered STA installed as part of a full upgrade from cesspools at the location of Case Study #6.

With funding from various sources, staff at the Massachusetts Alternative Septic System Test Center (MASSTC), which is operated by BCDHE, have been experimenting with a simple, non-proprietary technique of layering soil mixed with wood byproduct (sawdust, woodchips) beneath a standard soil treatment area (STA; alternately known as soil absorption system or leaching field) in order to reduce nitrogen loading. The principle is fairly simple. Components of a standard STA generally convert the ammonia-nitrogen in septic tank effluent into nitrate, which is then leached into the groundwater where it contributes to the over-production of algae and consequent eutrophication of our bays and estuaries. If the percolating nitrate-laden effluent can be first directed through a layer of sawdust matrix and certain conditions are maintained before it reaches the groundwater, the nitrate can be reduced to harmless nitrogen gas (denitrification) and vented to the atmosphere. MASSTC has been studying simple and inexpensive ways to produce the sequential conditions necessary to complete the above-described process. Figure 5 shows the main components of this layered STA concept, which includes a septic tank, pump chamber, pressure dosing system, and 18-inch layer of sand and, 18-inch layer of sawdust matrix. Figure 6 shows the conceptual model that invites the name Layer Cake as well as results from one installation at MASSTC. One Layered STA was installed.

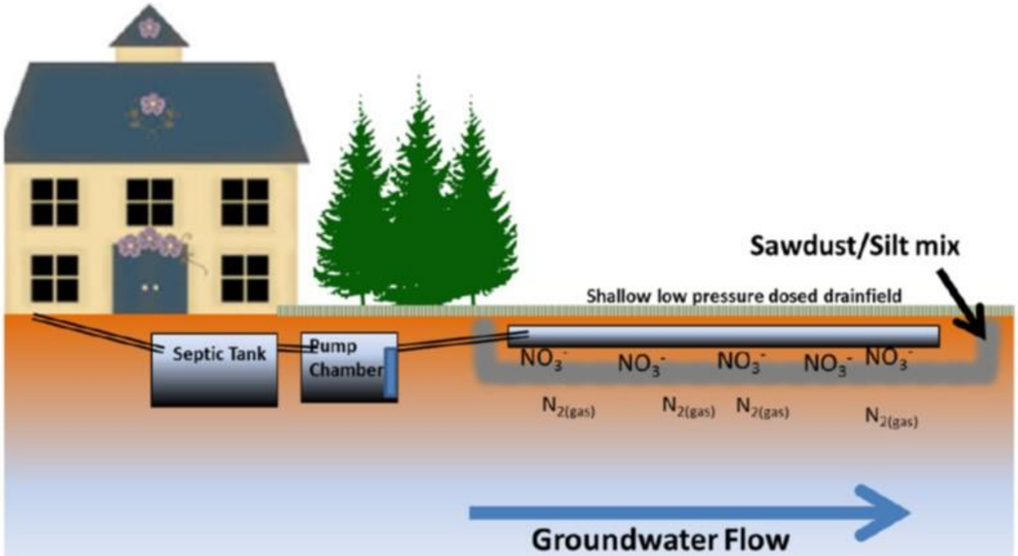
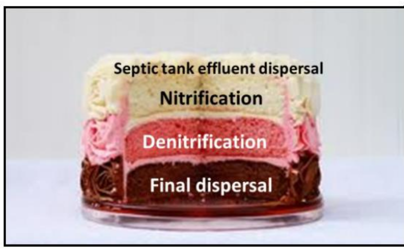
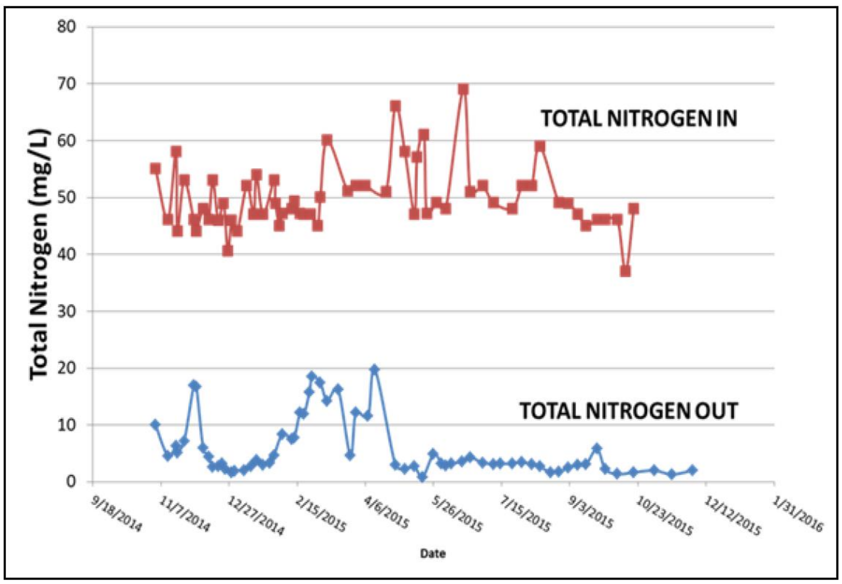


Figure 5. Layered STA Schematic



*The concepts detailed here could be described as a **layer cake,** where septic tank effluent passes sequentially through a layer for nitrification, denitrification and then final dispersal.*



Results from one of the three designs being tested at the Massachusetts Alternative Septic System Test Center

Figure 6. Layered STA Test Results

Design, Permitting and Installation

These systems were not only new to the homeowners but relatively new to the engineers and installers and therefore a steep learning curve existed for all stakeholders. It became evident early in the process that the Town Technical Coordinator and the Coalition would have to manage and ensure follow-through of the various steps required to design, permit and install a nitrogen-removing septic system. While property owners were willing to participate, given the timeframe of the grant, none were able to take on the responsibility of project management, which consisted of the following critical activities:

- Technology Selection
- Engineer of Record Selection
  - Coordinating engineering quotes for services
- System Design
  - Coordinating plan preparation with vendors
  - Coordinating location of system components with Conservation and Board of Health agent as well as property owners
- Permitting
  - Meeting with Board of Health and Conservation agents
  - Preparing permit applications
  - Attending hearings
- Installer selection
  - Coordinating installation quotes for services
  - Coordinate timing of installations
- Site management of installations

Once a technology was selected, an engineer of record was hired to prepare plans for the system for Board of Health approval and solicit quotes from qualified septic system installers. The Technical Coordinator and the Coalition worked with these engineers of record and coordinated with vendors and local regulators to ensure plans were prepared correctly. In several cases, percolation tests and site surveys were needed prior to plan preparation. Depth to groundwater, soil types, distance from wetlands and other siting information was specified on all engineered plans.

Town of Falmouth Technical Coordinator and Coalition interfaced with the Town Health Agent and Conservation Agent to identify and apply for all required permits. Review of draft engineering plans with these agents was often required. The Applications were prepared by Technical Coordinator in collaboration with the property owner and engineer of record, with the selected vendor providing technical information. The approval hearings with the Board of Health and Conservation Commission were attended by the Town's Technical Coordinator, who presented these plans, and the Coalition's Senior Attorney. Four installations required site-specific pilot approvals for technologies not yet approved for use in Massachusetts, the Eliminite system and the Layer Cake. The Town Technical Coordinator worked closely with MADEP to obtain these site specific pilot approvals.

The following list of permits were required for installations. Not all locations required all of these permits.

- Local Board of Health Approval for nitrogen-removing septic systems
- Local Conservation Commission RDA filing
- Massachusetts Department of Environmental Protection (DEP) Site Specific Pilot Approvals for system not already approved for use in Massachusetts

Once plans were prepared and approved, the Technical Coordinator and Coalition worked with participants to identify certified installers from which to request quotes and made these inquiries on behalf of participants. Once selected by participants, scheduling of installations was also coordinated for them.

Site Management of Installations

Participating homeowners relied on the Town's Technical Coordinator and the Coalition as the project manager. In most circumstances, the homeowners were not on-site for the installation and deferred to the Town's Technical Coordinator and the Coalition to be present on site during installation to ensure that the impacts to existing landscaping, and components are located in a way that is acceptable to property owners. Many decisions related to installing septic systems are made in the field. Engineering plans do not typically specify final locations of a number of components, and field conditions often require modifications to engineered plans. Installing the concrete tanks, blowers, pipes, and control panels associated with septic systems often present siting challenges on properties with mature landscaping. Installation requires digging large holes to accommodate tanks that are over six feet wide and ten feet long and digging long lengths of trenches for the piping that brings effluent from the home to these tanks. Delivering concrete tanks on trailers with booms large enough to move them can require moving smaller trees or even cutting larger ones. The disruption to existing landscaping is significant.

Other details of installations require careful management. Coordinating equipment purchase and delivery, as well as electrical and plumbing modifications were all necessary. Other details such as whether septic tank covers are exposed at grade to enable access to pumps and other system components for maintenance. These covers are twelve to thirty six inches in diameter and can present aesthetic challenges. In addition, control panels and blowers for aeration must also be carefully located to minimize both noise as well as aesthetic impacts. The importance of a knowledgeable person to oversee installations is critical.

Total Project Cost

The total project cost of different nitrogen-removing septic systems is shown in Table 2. Total project costs includes engineering, equipment, installation and restoring landscaping. While the range for the Eliminite and HOOT systems are modest, approximately $1000 and $6000 respectively, the range for the blackwater storage tank option is significant (approximately $15,000). This large range for costs can be explained by the difference in installation requirements. In some cases, existing Title 5 systems were in place and the addition of a blacwater tank and plumbing modifications were all that was required. In other cases, full Title 5 upgrades, including a soil absorption system (leachfield) were needed. The cost range for the HOOT system illustrates the significance of site conditions on installation costs. The low end of the installed costs was a case where there were minimal site constraints. The high end case had significant landscaping constraints, adding to the time required for installation and the extent of landscaping to return the property to existing conditions. For the Layered STA system, the costs associated with a deep excavation and fill were the cost drivers. A standard drainfield would have similar costs.

Table 2. Installation Costs by System Type

System Type	Average Total Installed Cost by System Type ($)	HIGH Total Installed Cost by System Type ($)	LOW Total Installed Cost by System Type ($)
Blackwater Holding Tank	$ 18,274	$ 32,327	$ 13,353
Eliminite	$ 20,760	$ 21,458	$ 19,523
HOOT	$ 34,581	$ 40,425	$ 28,158
Layered STA	$ 42,530 (please see note)	only one installation	only one installation
Layered STA NOTE:	The cost of this installation was dominated by the required 15-foot strip-out of the STA area.		
	The cost for a standard STA (drainfield) would have been comparable.		

Source reduction via nitrogen-removing septic systems will, by and large, require installing these systems on existing properties where there are numerous constraints that limit the area available tanks and STA (drainfield) siting, including:

- Lot size;
- Location of existing structures on the property;
- Proximity to wetlands;
- Soil types;
- Depth to groundwater; and
- Mature landscaping, including trees.

Installation costs will be significantly affected by these site-specific constraints.

Monitoring

Treatment system effluent samples are being taken on a monthly basis at locations just prior to discharge to the final disposal field. Assays for Total Kjeldahl Nitrogen (TKN) and nitrate-nitrite will allow for a computation of total nitrogen concentration. Measurements for Total Nitrogen were taken from septic tank effluents prior to nitrogen-removal septic system installation to estimate initial nitrogen concentrations and loading. Field measurements of temperature and pH will be taken coincident with sampling. As part of site specific pilot approval from MADEP, composite samples will be taken at these locations. All samples will be analyzed at the BCDHE Water Quality Laboratory or their subcontractors, all of whom are certified by Mass DEP to test wastewater.   Approved sampling and laboratory analysis protocols, as described in the Project Quality Assurance Program Plan (QAPP) for this Project will be used. BCDHE will provide an analysis of the sampling data in a separate report

In addition, data on occupancy will be collected and reported. All data is being collected using standard protocols currently in-place at the BCDHE and reported to the BCDHE Innovative-Alternative Septic Tracking System in accordance with Town of Falmouth Board of Health regulations, and data will be made available online. This tracking system provides an ongoing, long term reporting system for the performance results of the installed alternative systems. In addition, tracking of the operation and maintenance of these systems is accomplished through this well-established County system.

The Town of Falmouth Water Department installed radio read meters at all twenty properties to facilitate efficient collection of water use data.

Lessons Learned

Neighbors in Impaired Waterbodies Embrace Solutions

In addition to the 20 property owners who were the first to quickly agree to participate in the WFHSSR Project, there is now a waiting list of homeowners who would do the same. If grant funds were to become available to enable $10,000 subsidies to be offered, this effort could continue in West Falmouth. The West Falmouth community is committed to contributing to clean water in West Falmouth Harbor and continues to want to do their part in reducing nitrogen pollution.

Project coordination needed

Deeply engaged project management was key to successfully recruiting 20 participants and ensuring that installations happened appropriately and in a timely manner. The Town Technical Coordinator and Coalition's Senior Attorney coordinated myriad details during all phases of project implementation, including:

- Technology selection;
- Development of engineering plans;
- Design;
- Permitting; and
- Installation

The main reason a significant level of project management was required was that local engineers and installers were largely unfamiliar with the nitrogen-removing septic system technologies selected, and the fact that property owners generally did not have time to manage the project due to the seasonal nature of the community. A valuable outcome of this project was the education of engineers and installers with respect to the types of nitrogen-removing septic systems available and how to install them. Due to this investment in educating the stakeholders, it is expected that for future projects can be managed by the installer. To ensure that this responsibility is clearly understood, a clear and comprehensive specification sheet should be distributed to installation contractors as part of the request for installation quotations once the engineer of record has completed the site plan. This specification sheet would detail all aspects of the installation that are the installer's responsibility, which is critical for the installer to understand as part of the process of estimating the cost of a job.

Managing the execution of the installation process so that it runs smoothly from the perspective of the property owner is very important. Installation contractors are accustomed to managing the complete installation of standard title 5 components including the ordering of equipment and management of plumbers and electricians. An experienced installation contractor will be able to manage all phases of an installation of a nitrogen-removing septic system in a residential location.

While denitrification systems present new equipment or methodologies, installation contractors are able to be responsible and liable for the complete management of installation of these systems. Installation contractor should be able to work directly with equipment vendors to coordinate ordering of equipment, manufacturing of tanks, and installation of pumps, as well as all electrical and plumbing needs. As more nitrogen-removing septic systems are installed, installer as well as engineers will become familiar with the process. In cases where the selected installation contractor is uncomfortable or inexperienced, a dedicated project coordinator is needed to manage the project and address issues that arise in a timely manner, so that installations are done correctly, both technically and process-wise.

Estimated equipment and installation costs provided by venders were in some cases significantly lower than actual costs

Estimated costs for complete installations from selected vendors of proprietary systems, including labor and materials, averaged approximately $14,000 for the Eliminite system and almost $18,000 for the HOOT system. As shown in Table 2, actual costs averaged approximately $21,000 for the Eliminite system and almost $36,000 for the HOOT system. The key difference between estimated costs and installed was the actual cost of installation, which was affected significantly by site constraints and local installer costs. The Blackwater storage tank and Layered STA are non-proprietary systems that were estimated on a site-specific basis, with better local knowledge of installation costs.

Summary

This first-ever demonstration project to identify 20 homeowners to voluntarily install nitrogen-removing septic systems was a resounding success and warrants replication in other areas around Buzzards Bay and throughout Cape Cod. Nitrogen-removing septic systems that achieve the performance of the systems implemented as part of this Program are a critical solution in both seasonal and less densely developed watersheds with Total Maximum Daily Load (TMDL) requirements for nitrogen. The Town and the Coalition look forward to showcasing the success and lessons learned through this project to communities throughout Buzzards Bay and Cape Cod.

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APPENDIX A: Vendor Questionnaire

NAME OF I/A SYSTEM VENDOR:____

Innovative/Alternative (I/A) Septic System Questions - Single Family

Technical and Performance Questions:

- **Please provide a brief overview of the treatment technology and provide a schematic showing the placement of the system in context of a standard septic tank/leachfield (please provide approximate dimensions of components on the diagram and list all components necessary to achieve 12 mg/l at the discharge)**

- **Can the I/A system be retrofit to an existing septic tank-soil absorption system?**

- **List general requirements for installation, such as:**
    - **Must the installer be certified by the company?**
    - **Are there any site limitations?**
    - **Other general requirements?**

- **How long has the Company been in business?**

- **How many systems are installed in the ground (please specify how many in New England and how many in other states)?**

- **What is the expected system longevity?**

- **Are there data to support a claim that this system will achieve total nitrogen removal to 12 mg/L as measured prior discharging to drainfield? (Please supply data and source of data information):**

Permitting and Approval Questions

- **Does the system manufacturer hold proprietary patents or are there patents pending? Please list USPTO numbers:**

- **List state or provincial approvals held by the technology:**

NAME OF I/A SYSTEM VENDOR:______________________________________

- **If not approved in the Commonwealth of Massachusetts, is your company willing to file an application for a Site-Specific Pilot?**

- **List installation sites on Cape Cod (if any):**

- **Do you partner with specific engineering firms? If so, whom?**

- **What type of warranty do you offer?**

- **Please list three references that can be contacted (including 1 regulatory official) for their familiarity with your system performance and operation.**

Cost-Related Questions:

- **Equipment Cost:**

- **Estimated Single Family Installation Cost (average and range):**

- **Estimated monthly energy usage (kWh) including required pretreatment components:**

- **Typical long-term Maintenance Cost:**

- **Typical inspection and sampling cost (excluding analyses).**

APPENDIX B: Letter to Potential Participants

BUZZARDS BAY COALITION
WEST FALMOUTH VILLAGE ASSOCIATION

July 20, 2015

Dear ,

We hope you'll join us to help clean up West Falmouth Harbor.

Because you are someone who loves West Falmouth Harbor, the West Falmouth Village Association and the Buzzards Bay Coalition thought you might be interested in a **voluntary program** that will reduce nitrogen pollution, help improve the harbor's natural beauty, and protect the water for generations to come.

Nitrogen pollution is the greatest long-term threat to the health of West Falmouth Harbor. The town of Falmouth is reducing the amount of nitrogen coming from the wastewater treatment plant and great progress has been made in the past few years. More pollution reduction will restore our Harbor's health quicker. As a homeowner, there is something you can do to give the harbor a hand.

In the fall of 2014, the Buzzards Bay Coalition pursued a $200,000 grant to subsidize the **voluntary** replacement of 20 individual on-site septic systems around West Falmouth Harbor with a nitrogen-reducing solution. Homeowners who want to take advantage of this opportunity would **receive up to $10,000** to replace their septic systems and cesspools with a solution that can reduce nitrogen pollution to West Falmouth. (Please see the attached fact sheet for more detail about this program.)

How can you get involved?

As a West Falmouth Harbor property owner near the water with a septic system which causes nitrogen to flow into the Harbor, you have the opportunity to receive this subsidy and upgrade your system. Your property is among 170 homes that qualify for this subsidy. However, there are only 20 subsidies available. If you are interested in this opportunity, please contact Korrin Petersen at the Buzzards Bay Coalition as soon as possible at (508) 999-6363 ext. 206 or petersen@savebuzzardsbay.org. **There is no upfront commitment required.** Simply contact the Buzzards Bay Coalition to find out more and receive a no-cost evaluation. If you choose to take part in the program, the Coalition will assist you in selecting a solution, hiring an engineer, and completing the permitting process.

Thank you for making a difference to protect West Falmouth Harbor.

Sincerely,

John Weyand, President
West Falmouth Village Association

Mark Rasmussen, President
Buzzards Bay Coalition

APPENDIX C: Decision Support Tool Screen Shot

NAME:

WEST FALMOUTH PROPERTY ADDRESS:

DATE:

Please tell us how important the follow characteristics are to you based on the following scale:

First Cost (equipment and installation)		**1 = very important**
20 Year Present Worth (including O&M)		**2 = important**
Energy Use		**3 = somewhat important**
Aesthetics		**4 = not very important**
Complexity		**5 = not a concern**

Is there another criteria not listed here that is important to you?

Summary of top 7 systems to consider based on your weighting of the above criteria:

System Name Contact Website	Decision Tool Total Score	Average Estimated Installed System Cost	Annual Cost for Quarterly Inspections	Lab Costs after 1st year	Monthly Energy Use (kWh)*	20 year Present Worth for O&M**	Company Warrantee on System	Special Considerations	Number of Pumps