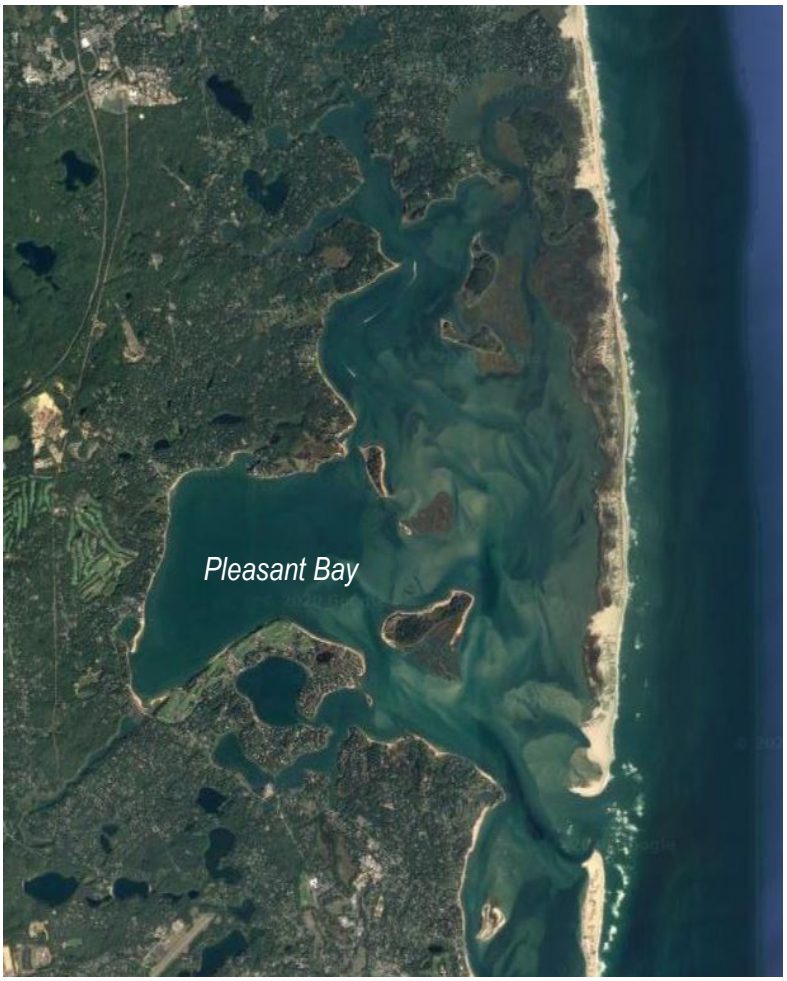
PLEASANT BAY ALLIANCE
Task 1A: On-Site Denitrification Systems Summary Report

Southeast New England Program (SNEP)
Grant - Regional Watershed Permit
Implementation Project for Pleasant Bay



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July 28, 2020

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Southeast New England Program (SNEP) Grant - Regional Watershed Permit Implementation Project for Pleasant Bay

Executive Summary

As part of the Southeast New England Program (SNEP) grant issued to the Pleasant Bay Alliance, the Town of Brewster evaluated the potential for using advanced septic systems to reduce the nitrogen discharged into its portion of the Pleasant Bay watershed. The goal was to evaluate the level of nitrogen reduction needed, the availability of technologies that could provide the necessary reduction, and the regulatory structure to be used to implement the program. In addition, the details of system operation, maintenance and monitoring, the level of municipal oversight, and the costs associated with the overall program were evaluated.

The Massachusetts Estuaries Program model used for the Pleasant Bay watershed assumes a nitrogen concentration of 26.25 milligrams per liter (mg/L) for effluent discharged from traditional onsite septic systems. This number is lower than the typical nitrogen concentration for septic tank effluent entering a leaching facility as it takes into account nitrogen removed in the leaching facility as well as in the underlying soil. Using this assumed concentration, it was determined that each septic system in the unattenuated watersheds in Brewster would have to use an advanced nitrogen removal system to meet Brewster's nitrogen reduction goals. Furthermore, these systems would have to meet a treatment level of 12 mg/L to be able to fully meet Brewster's remaining portion of the Total Maximum Daily Load (TMDL) for nitrogen for Pleasant Bay. Currently there are no systems with general approval from the Massachusetts Department of Environmental Protection (DEP) that can provide this level of treatment. There are a couple with pilot or provisional approval that might be able to meet a 12 mg/L threshold.

The key lessons learned from the project for Brewster and other municipalities considering the use of onsite system for nitrogen removal are summarized below:

- Based on discussions with DEP, regular monitoring will be required for all advanced systems including quarterly sampling for the first year, and annual sampling thereafter. Systems that do not have general approval from DEP will have to be sampled quarterly for up to three years.
- Also, according to DEP, each system will need to be inspected briefly on a monthly basis to ensure it is operating as intended.

- The cost for installing and operating an advanced onsite system will depend on the technology that is selected. The project estimated a capital cost for each system of approximately $33,900 and an annual operation and maintenance fee of about $2,360.
- Federal regulations governing the State Revolving Fund (SRF) program allow for loans to privately or publicly owned facilities, and Massachusetts dedicates $5 million a year for septic repair and replacement projects through the State Revolving Fund (SRF). MassDEP is in the process of providing guidance on how to access these loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install nitrogen reducing septic systems. Currently, the SRF program does fund a Community Betterment Septic Program that provides low interest loans to homeowners to upgrade or replace failed septic systems.
- The use of the systems can be mandated through a regulation passed by the Board of Health requiring their use. To increase public input and involvement in the decision, a town could consider adopting a General Bylaw with the details of how the program is implemented included in a subsequent Board of Health Regulation.

Introduction

The Town of Brewster evaluated the option of using on-site denitrification systems to satisfy portions of the Towns' Total Maximum Daily Load (TMDL) compliance responsibilities for Pleasant Bay. This work was conducted under Task 1A of the SNEP Grant issued to the Pleasant Bay Alliance.

The work for Task 1A involved five sub-tasks outlined in the SNEP grant proposal:

1. Establish the potential target effluent concentration for on-site systems;
2. Identify the best available technologies to meet the target concentration;
3. Discuss monitoring standards needed to document onsite system performance;
4. Evaluate the capital and O&M expenses needed to implement a municipal program; and
5. Develop an implementation framework for such a municipal program.

Brewster and Orleans plan to use this information to determine if an onsite septic treatment program is appropriate for meeting a portion of the TMDL for their portions of the Pleasant Bay watershed. As will be discussed further below, the level of treatment needed to comply with the TMDL is such that, at least for Brewster, the costs and implementation challenges may make this approach difficult, if not infeasible, and other options may need to be considered.

Task 1A-1. Establish the target effluent concentration

The Town of Brewster evaluated the number of septic systems that would need to be upgraded with nitrogen treatment systems to remove enough nitrogen to achieve compliance with the TMDL. This information was used as an example to help identify the types of systems that might provide the necessary removal and to evaluate the associated costs, monitoring, and implementation steps needed if an onsite program was established.

In Brewster there are 319 residential properties with onsite septic systems located in the portions of the Pleasant Bay watershed that are not subject to natural attenuation. Considering the nitrogen reductions already achieved at the Captains Golf Course, the Town needs to further reduce nitrogen inputs to the watershed by 982 kilograms of nitrogen per year (kg N/yr). With typical water use of 152 gallons per day (gpd) per home, the average effluent quality from on-site denitrification systems would need to be demonstrate a maximum value of 12 mg/L of nitrogen to achieve the removal goal. This is considerably less than the average effluent quality of 26.25 mg/L concentration of nitrogen attributed to standard onsite systems in the Massachusetts Estuaries Project model for Pleasant Bay. The effluent concentration used in the model assumes the nitrogen enters the septic system at approximately 35 mg/L. Nitrogen is then treated in the leaching facility and in the underlying vadose zone reducing the concentration by 25% to 26.52 mg/L. Further details on this assessment are provided in Appendix A.

Task 1A-2. Identify the best available technologies for onsite nitrogen removal

The April 17, 2020 report by the Barnstable County Department of Health and Environment presents a summary of performance data for thousands of homes using commercially available systems for on-site denitrification. The important conclusions of this report are:

- The average effluent nitrogen concentration for the surveyed systems ranges from 14 to 23 mg/L.
- None of the commercially available systems that have received general use approval from the Massachusetts Department of Environmental Protection (DEP) can reliably reach the 12 mg/L goal
- There are two emerging technologies that show strong promise for meeting the 12 mg/l goal.
- These systems will require up to three years of testing and evaluation before they achieve general use approval.

The report of the Barnstable County Department of Health and Environment is attached as Appendix B.

Task 1A-3. Establish monitoring standards

An initial program to monitor the performance of the onsite treatment systems was developed through conversations with DEP staff. This information was then used to inform the cost model prepared under Task 1A-4. It is assumed that effluent quality monitoring would be in four parts:

- Quarterly effluent sampling of each system for the nitrogen series compounds for the first year to confirm that each system is operating as expected. If the system(s) chosen by a town has not yet achieved general use approval from DEP, the quarterly monitoring may extend up to three years;
- Annual effluent sampling of all systems that have not been subject to quarterly sampling, with approximately 10% of the systems tested each month;
- Additional influent and effluent sampling of each system whose performance does not reach an established threshold (once to confirm non-compliance and to better determine the cause of non-compliance, and a follow-up sample to confirm that the remedial changes were effective).
- Monthly inspection of all systems by a certified operator.

As part of the SNEP project, the Pleasant Bay Alliance work group debated how the performance of the advanced systems would be evaluated and decided that the average effluent concentration of all the I/A systems is most important target to achieve. This average best reflects the amount of nitrogen ultimately entering the Bay and impacting coastal water quality. Some systems may achieve a nitrogen treatment concentration lower than 12 mg/L and others may not reach the target concentrations. Appendix C provides further details on the monitoring needs discussed above and Appendix D summarizes input from DEP on this monitoring program

Task 1A-4. Prepare a cost model

The Wright-Pierce technical memorandum dated July 21, 2020 presents a cost model that predicts capital and O&M costs for a municipal program for on-site denitrification. This model takes into account information from DEP on monitoring requirements and cost information from the Barnstable County Department of Health and Environment.

Using typical values for key cost items, a “base case” estimate was prepared and includes costs as follows for the average system in the program:

- Capital cost $33,900
- O&M cost $ 2,360 per year
- Debt Service $2,540
- Equivalent annual costs $ 4,900 per year

These costs are based on available information for the two systems that might meet the 12 mg/L nitrogen effluent standard needed in the Brewster example discussed above. The capital cost includes the design and construction costs as well as estimates for landscaping needs to rebuild the property after construction. The main cost is for the purchase of the system itself, estimated at $17,500. The O&M costs are based on an average cost over 20 years. It is important to note that during the first year, the O&M costs would be higher because quarterly sampling will be conducted for the year after a system is installed. If a town chooses to use a system that has not achieved general use approval, the additional costs could extend up to 3 years.

The cost model is attached to this Task 1A report as Appendix C.

Task 1A-5. Develop the implementation framework

The implementation of an onsite program would require oversight and management by the Town. Based on discussions with DEP it is clear that a town using such a program would need to be active in ensuring the onsite systems are maintained and monitored and would need to prove that the systems are meeting the performance goals required under the Bay's TMDL.

As part of this Task, Brewster evaluated how such a program would be implemented as discussed in Appendix E. The key issues addressed in the evaluation included:

- The development of a regulatory program to require the use of the advanced onsite treatment systems. The adoption of a general bylaw was recommended, accompanied by a regulation passed by the Board of Health that would provide the details of the design, maintenance and monitoring requirements for systems as they were installed. The two-pronged approach allows for greater public input to the process as the Board of Health can adopt a regulation with minimal public input, while a general bylaw must be approved with a majority vote at town meeting.

- The evaluation of options for managing town oversight of the maintenance and monitoring of individual systems. The Town would need to document each system's performance to confirm compliance with the TMDL and would therefore need to have oversight of the ongoing maintenance and monitoring. This is beyond the level of oversight typically provided for onsite systems which involves the review of the system design and confirmation that it was installed according to the approved plans. The details of such a program would depend on the system(s) selected for use and the specific maintenance requirements associated with them.

- The methods for financing the implementation of the plan. Currently, DEP is in the process of providing guidance on how to access SRF loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install privately-owned nitrogen reducing septic systems.

Conclusions

The information discussed above provides an overview of what will likely be needed to implement a town-managed advanced onsite septic system program using Brewster's nitrogen reduction goals for its portion of Pleasant Bay watershed as a model. The information shows that onsite systems would need to achieve a very strict nitrogen reduction target of 12 mg/L or less to remove the remaining nitrogen that is Brewster's responsibility under the TMDL. A similar level of nitrogen treatment would likely be needed for subwatershed areas in Orleans as well. There are currently no systems with General Use Approval in Massachusetts that meet this goal. A few systems with pilot or provisional status could achieve this level of nitrogen reduction however, the cost and oversight requirements for using these systems are significant. Each town will have to decide if this is an appropriate approach moving forward. While it may be challenging for a larger area of the watershed, it might be useful in a specific subwatershed or neighborhood.

Appendices

Appendix A: Horsley Witten Group, Inc. Memorandum Evaluating Level of Nitrogen Removal Needed for Brewster properties

Appendix B: Barnstable County Department of Health and the Environment Advanced Septic System Performance Memorandum

Appendix C: Wright Pierce, Inc. Technical Memorandum on Onsite System Installation and O&M Cost Evaluation

Appendix D: Memorandum from DEP on Monitoring Requirements of Onsite Treatment Systems Used to Treat Nitrogen to Meet TMDL Standards

Appendix E: Horsley Witten Group, Inc. Memorandum on Municipal Implementation of an Onsite Treatment Program.

Appendix A - Residential Septic System Treatment Analysis

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MEMO

TO: Ryan Bennett and Chris Miller

FROM: Mark Nelson, Geraldine Camilli

RE: Evaluation of the Number of Homes in the Pleasant Bay Watershed that will Require an Advanced Septic System to Meet the Nitrogen Reduction Goals for the Watershed.

DATE: December 31, 2018

The Horsley Witten Group, Inc. (HW) has evaluated how many septic systems within the Pleasant Bay watershed will need to be upgraded with an advanced, nitrogen reducing septic system to meet the Town's portion of the nitrogen reduction goal for Pleasant Bay. This was done as part of HW's initial assessment of the implementation steps needed to comply with the nitrogen reduction specified in the Pleasant Bay Watershed permit and as established by the Massachusetts Department of Environmental Protection (MassDEP) in the issuance of the Total Maximum Daily Load (TMDL) for the Bay.

Methodology

Under the watershed permit, Brewster has agreed to remove 2,262 kg/year of nitrogen to meet its TMDL requirements. To date 56 percent of this load reduction has been achieved through reductions in fertilizer use and through the recapture of nitrogen through the irrigation well at the town-owned Captains Golf Course. The Town currently plans on removing the remaining load (979 kg/year) through the advanced onsite program.

Septic system effluent concentration

The load from onsite septic systems within the watershed is based on an assumption in the University of Massachusetts School for Marine Science & Technology (SMAST) model that the nitrogen concentration in septic system effluent that reaches the embayment is 26.25 mg/L. Therefore, the load reduction provided by an advanced onsite system will be based on the difference between 26.25 mg/L and the effluent concentration provided by the advanced system, assuming the water use on the property does not change.

Each advanced onsite technology has its own capacity to reduce nitrogen and the Town is working with the other communities in the Pleasant Bay Watershed to evaluate technologies that may be appropriate for application in Brewster. At the same time, it is worthwhile to

evaluate how many homes may require an upgrade based on the treated effluent concentration that could be provided by an advanced system.

Using the original SMAST model, HW calculated the load reduction that could be provided by advanced systems meeting a series of nitrogen treatment goals. The following four scenarios were evaluated reflecting the expected range of nitrogen treatment that could be expected from advanced systems:

- Scenario 1: Nitrogen rate in the septic system effluent is reduced from the current rate to 19 mg/L.
- Scenario 2: Nitrogen rate in the septic system effluent is reduced from the current rate to 15 mg/L.
- Scenario 3: Nitrogen rate in the septic system effluent is reduced from the current rate to 12 mg/L.
- Scenario 4: Nitrogen rate in the septic system effluent is reduced from the current rate to 10 mg/L.

Parcel Locations

In conducting the evaluation, HW focused on the sub-watersheds to Pleasant Bay with parcels in Brewster where there is little to no attenuation of nitrogen in groundwater before it discharges to Pleasant Bay. This is because some Brewster properties are in areas where there is significant attenuation of nitrogen before it reaches Pleasant Bay. This occurs in areas where nitrogen from septic systems enters groundwater and then flows to a pond and then back into groundwater before it discharges to the Bay. This process removes approximately 50% of the nitrogen contained in the groundwater that enters a pond. In some areas in Brewster groundwater flows through multiple ponds before entering the Bay. It may not be worthwhile to install nitrogen treatment systems in areas where this attenuation is taking place.

As part of the original modeling conducted by SMAST to determine the nitrogen reduction goals for the Bay, the Pleasant Bay Watershed was divided into 18 major sub-watersheds (including one also called “Pleasant Bay”), and 95 smaller sub-watersheds. Eight of the major sub-watersheds, and 34 of the smaller sub-watersheds overlap with the Town of Brewster (i.e., they are located in whole or in part within town boundaries). The Pleasant Bay major sub-watershed is the largest in Brewster, contains the most properties with septic systems and has the least attenuation to account for. Therefore, these preliminary calculations focused solely on this major sub-watershed. In the future, as more details become available regarding advanced systems that might be used in Brewster, an evaluation of the other sub-watersheds can be conducted to determine if it is cost-effective to incorporate them into the program.

Estimate N Loads from Selected Parcels

In order to estimate the number of septic systems in each sub-watershed of interest, HW used GIS information to identify developed residential parcels in Brewster that overlap the sub-watersheds of interest. Some parcels overlap multiple sub-watersheds, so HW conducted the

analysis for parcels that are wholly located within the sub-watersheds of interest, and re-ran the analysis for parcels for which most of the area is located within these sub-watersheds.

The original SMAST model estimated wastewater load by small sub-watershed, rather than by Town, and relied on water use information for individual parcels. In order to evaluate Brewster's load, HW averaged the water use for each sub-watershed across all parcels, and assumed that water use in Brewster is on average the same as water use for all parcels within the sub-watershed. Using the original SMAST model, HW calculated the nitrogen load to Pleasant Bay for the properties described above under the four scenarios, and compared the results to the original model output using the effluent concentration of 26.25 mg/L. For each scenario, HW calculated an average nitrogen load reduction per property for all sub-watersheds. This average reduction was then used to convert a nitrogen reduction for each sub-watershed into a number of properties.

Results

The table below shows the amount of nitrogen removed under the four nitrogen treatment scenarios that were evaluated. There are 319 residential properties either fully within the watershed or with more than 50% of their land area in the watershed. Septic effluent needs to be treated to 10 mg/L (Scenario #4) to fully remove the 979 kg/year needed to meet the TMDL goal. If effluent is treated to 12 mg/L (Scenario #3), the total nitrogen removed is very close the goal (960 kg/year versus 979 kg/year). Under this scenario an additional seven homes in other unattenuated watersheds would require an upgrade to meet the TMDL goal. If commercial or industrial properties are included in the analysis, it is likely the goal will be met under the 12 mg/L treatment scenario and this will be evaluated further in the near future.

This analysis will be updated as further information is available on the treatment capabilities of onsite technologies that may be considered by Brewster, and as SMAST runs new modeling scenarios for the watershed taking into account current and proposed efforts to remove nitrogen from the watershed.

Nitrogen reductions provided by Onsite System Upgrades in the Pleasant Bay Subwatershed

Scenario	Nitrogen Reduction kg/year	TMDL Goal kg/year	Amt Over/Under TMDL Goal kg/year
#1: 19 mg/L	487	979	492
#2: 15 mg/L	752	979	227
#3: 12 mg/L	960	979	19
#4: 10 mg/L	1,096	979	-117

Appendix B - Barnstable County IA Septic Performance Assessment

Assessment of the potential role of alternative onsite septic systems in the nutrient management of the Pleasant Bay Watershed area located in Brewster.

Barnstable County Department of Health and Environment herein assesses the potential use of alternative onsite septic systems (herein referred to as "I/A technology") to meet the TMDL goals for the Town of Brewster portion of the Pleasant Bay Watershed. The premise of this assessment is based on work done for the Town of Brewster by the Horsley Witten Group which stated in their summary of December 2018:

"There are 319 residential properties either fully within the watershed or with more than 50% of their land area in the watershed. Septic effluent needs to be treated to 10 mg/L (Scenario #4) to fully remove the 979 kg/year needed to meet the TMDL goal. If effluent is treated to 12 mg/L (Scenario #3), the total nitrogen removed is very close the goal (960 kg/year versus 979 kg/year)."

An extensive database that is continuously compiled by the Barnstable County Department of Health and Environment and surveils maintenance and performance of residential onsite advanced treatment units from over 20 towns in the Commonwealth of Massachusetts was used in part for this assessment. These data include all systems approved and in use in the Commonwealth. In addition, we report on efforts from Suffolk County, Long Island which is engaged in an aggressive program to replace standard systems to address nutrient loading in Long Island Sound. Finally, data from selected demonstration projects such as Maryland's Bay Restoration, Falmouth Massachusetts West Falmouth Harbor Demonstration Project, LaPine Oregon Demonstration Project, New Jersey Pinelands and smaller grant and demonstration projects were used. Total nitrogen discharge values from single family residences across all projects were averaged for instances where data from at least 20 sites were available from single family residences. In some instances where large datasets were available from different locations and showed significant differences in performance for a particular technology or model, datasets were separated and where possible, manufacturers' different models were analyzed separately. A list of treatment technologies considered is provided below.

Authors' note

Projections of I/A performance expressed herein are based on the data which are dynamic in nature. Performance features of any technology are driven, in part, by regulatory requirements, expectations and market competition. As I/A technologies are increasingly used and performance results publicized, we expect that there will be performance improvements in some cases as product manufacturers modify their products in response to market and regulatory pressures. Accordingly, the assertions regarding performance expressed herein should be considered as of the date of this report and subject to need for regular updates.

The reader is also reminded that in the most regulatory settings where I/A systems are applied, a discharge concentration of 19 mg/L is expected or required. The lack of regulatory pressure and the general increase in cost to achieve levels < 10 mg/L in onsite setting has caused only a few technologies to be developed that can meet the requirements of many TMDLs.

For this analysis, a threshold discharge level of 12 mg/L Total Nitrogen (TN) is used (Scenario #3 -see above and Horsley Witten Group's final report for the Town of Brewster and the Pleasant Bay Alliance) as an indicator that the widespread use of I/A technology could meet the goal of removing 960 kg/year of nitrogen from the Brewster portion of the Pleasant Bay Watershed.

Results

A comprehensive review of field and research data indicate four commercially available technologies and two non-proprietary strategies can meet the above-referenced 12 mg/L total nitrogen removal threshold. The reader should understand that the data reviewed were obtained from systems in the single-residence configuration. As such, to the knowledge of these authors, these systems were not configured with an external carbon source to support denitrification. Some of these technologies can be supplied with an external carbon source and have been shown in cluster systems, serving more than one residence, to be able to achieve better treatment that is not represented in this analysis. Some models of certain products may include carbon additions in their single-family models, however information regarding which models were so equipped was unavailable.

Among the technologies which have smaller datasets (<20 sites), two commercially available technologies bear consideration. The Nitrex™ system employs a pretreatment unit from various treatment technology vendors (to nitrify the ammonia in the wastewater) and a container of cellulosic material (woodchips) configured as an upflow reactor. This system performed well in demonstration projects and data from various sources including the vendor website indicate and average TN of 2.5 mg/L (2.9 – 3.3 mg/L, p=.05). This system has Provisional Approval in the Commonwealth of Massachusetts.

List of onsite innovative advanced (I/A) treatment units investigated.

Amphidrome™
Amphidrome™(Pinelands)
AquaKlear™
Bioclere™ (Pinelands)
Bioclere™ 16 Series
BioMicrobics Biobarrier™
BioMicrobics MicroFAST™ .5
BioMicrobics STARR™
BUSSE GT(membrane bioreactor)
EcoFlo™ Coco Filter (also with denite filter)
Eliminite™
FAST™ 0.9
FugiClean™
HOOT™ (various models)
Hydro-Action™
Layered System Unlined
Layered System Lined
Lined Nitrification area to Woodchip Bioreactor
Nitrex™
Nitroe™
Norweco™ Hydro-Kinetic
Noweco™ TNT
Orenco Advantex™ AX-20
Orenco Advantex™ AX-RT
Pugo™
RUCK
SeptiTech™
SeptiTech™ M400N
SeptTech™ (Pinelands)
SeptTech™ 400
Waterloo Biofilter™

The Nitroe™ (KleanTu, LLC, 300 Old Pond Rd.,STE 206, Bridgeville PA) is a newly developed system with at least 10 installations on Cape Cod and Martha's Vineyard. Monthly samples show an average discharge TN of 10.8 mg/L (8.6 - 13.0 mg/l, p=.05). Nitroe™ is a single tank and can be retrofitted into an existing septic system that contains a septic tank and a Soil Treatment Area (STA). It can be configured for passive flow if the elevation difference between the existing septic tank and the soil treatment area inlet exceeds 3

inches and components are horizontally proximate (John Smith, Corporate Environmental Solutions, personal communication). The Nitroe™ has provisional approval in Massachusetts.

Two additional commercially available technologies, the data from which is emerging from extensive testing in Long Island as part of the "Reclaim Our Water" initiative, also show promise to meet the 12 mg/L treatment level maximum. Hyro-Action™ (https://www.hydro-action.com/) developed by an Indiana-based company was reported to produce an average TN in the discharge of 10.6 mg/L over 76 samples taken from 20 systems. FugiClean™(https://www.fujicleanusa.com/) similarly showed comparable treatment in this same demonstration project (11.4 mg/L TN in the discharge of 83 samples taken from 20 systems). These averages have changed slightly but not significantly since the October 2019 (2018 Annual Report) of that project. These two technologies remain the best performing of the field of the commercially available single-family home technologies advancing through the Suffolk County New York permitting process as of March 2020.

Finally, three experimental configurations of non-proprietary nitrogen removal systems bear mention since they have been the subject of study at the Massachusetts Alternative Septic System Test Center and have been advanced in Long Island Suffolk County, New York through the Clean Water Center of Stony Brook University. As of February 2020, these systems remain in the "experimental" stage in Long Island and in the Site-specific Pilot Approval stage in the Commonwealth of Massachusetts. The three configurations are discussed separately below.

Simple Layered Systems

The simple layered system involves layering a mixture of 50% sand and 50% sawdust (by volume) beneath a nitrifying layer of sand situated directly beneath the septic-tank dispersal system unit in a soil treatment area. In Massachusetts ten such systems have been installed, with only four installed at year-round residences and only two of these have sufficient data on which to base conclusions. Collectively, data suggest that although removal rates exceed 85% in warmer months, performance decreased significantly below this value when septic tank effluent temperatures are less than 10^{o} C (generally January – April in any year). Generally, however even at these colder temperatures the TN removal is greater than 50% of the influent TN. The diminished cold-temperature performance was also noted in one of the two systems installed in Long Island receiving septic tank effluent within the TN concentration range expected for normal households (>60 mg/L). The other of the two systems in that project exhibited little if any diminishment of treatment during periods of low temperature. A third system in Long Island received unusually low influent nitrogen (less than 20 mg/L) and was not considered in this analysis as a valid example. Simple layered systems in the Massachusetts Alternative Septic System Test Center (MASSTC) venue perform similarly to field installations, exhibiting decreased performance at temperatures below 10^{o} C (generally January – April). We conclude that this technology will not support the need for TN levels < 10 mg/L on a consistent basis. We note, however, that in the test center venue where hydraulic loading rates are measured with precision, two simple layered systems exhibited TN levels averaging < 10 mg/L over the year particularly when a hydraulic loading rate of 0.6 gal/sq. ft./day were applied every day.

Lined layered Systems

Lined layered systems are characterized by having an impervious liner beneath both the nitrification layer (18" of sand alone) and denitrification (18" of a sand mixed with sawdust). The collected percolate

is collected and directed toward an area for final disposal. This is opposed to simply allowing the percolate to move downward into a native soil horizon as above. The advantage of this type of system is that the sand/sawdust denitrification layer is maintained in a saturated condition, ensuring longer useful lifespan of the cellulosic material by preventing its aerobic decomposition. Two such systems in operation at MASSTC exhibited discharge concentrations of 7.2 and 7.1 mg/L over three and four years of operation, despite some diminished performance in winter months. Two of the three installations at residences in Long Island showed similar performance following in one instance a three month start up. The remaining system was installed in late autumn- early winter and hence no warm weather data are available.

The disadvantage to this configuration is the need for a final disposal area. Based on the greater performance stability of this configuration during colder periods, we conclude that this system could however meet the requirement for an overall average TN level of 10 mg/L. In addition, questions regarding the longevity of the cellulosic media are addressed in part by maintaining saturation in the media. There is general agreement that maintaining saturation will prevent the carbon exhaustion for decades.

"Box" Type Wood-Based Systems

This non-proprietary configuration involves a lined nitrification bed of 18" of sand with the collected percolate directed to a box of woodchips that is piped for upflow passage of the percolate prior to discharge. The system is much like the commercially available Nitrex™ but uses a slow rate sand bed sized as to receive septic tank effluent and act as a nitrifying reactor. A system installed at MASSTC and operated for three years has an average TN discharge concentration of 6.0 mg/L (excluding three dates in April 2018 when rainwater was inadvertently entering the pump chamber). A single installation in Long Island and operated for seven months exhibited a final TN concentration of 3.2 mg/L.

Similar to the lined layered system described above, this system requires an addition area for disposal. We believe, however that this system could consistently achieve TN discharge < 10 mg/L very similar to its commercial analogue, the Nitrex™ system. In addition, replacement of the woodchip carbon source upon its exhaustion would be simplified by the ready access.

The Path Forward

The information above suggest at least three paths forward for Brewster to satisfy its obligation for nutrient limitation in the Pleasant Bay Watershed using advanced onsite septic system treatment units (Innovative/Alternative Systems - I/A).

Path 1 - Pursue the installation of the four technology types and non-proprietary methods indicated at the 319 residences in the watershed.

Four commercially available technologies have a high or moderately high probability of meeting the discharge limit of < 12 mg/L TN. Two of these technologies involve lignocellulosic (wood based) denitrification systems. The Nitrex™ system has limited single-family installations in the Commonwealth. Nevertheless, data from the LaPine Demonstration Project, earlier testing of the commercial unit at the Massachusetts Alternative Septic System Test Center(MASSTC), two installations on Cape Cod and extensive experimentation of a generic version at MASSTC suggest that this system type is a viable

alternative which can achieve average TN levels in the discharge of < 10 mg/L. In its generic form, an estimated costs for this system is $22,000 based on an assumption that a small leaching system can be installed following the discharge from the woodchip reactor. A quote from the vendor of the Nitrex System™(the proprietary version) indicates a $30,000 cost, which might benefit by a price reduction due to an economy of scale (Pio Lombardo, Lombardo Associates, Inc., personal communication January 6, 2020). The Nitrex™ has a Provisional Approval in the Commonwealth while the generic version would require a review from Massachusetts DEP and possibly require a progression through an extended approval process.

Another candidate system is a new development from a newly formed company – KleanTu™. The unit name is NitROE™. It has been the subject of a Clean Energy Center Grant and has 11 installed systems. KleanTu™ is presently seeking Provisional Use Approval in the Commonwealth based on favorable results from the Pilot Approval systems. The equipment and engineering support cost of this unit is $12,250. With the additional cost of a soil treatment area and attendant engineering costs, a conservative total cost estimate in situations where a new system is being installed approximates $22,000. This unit can be retrofitted onto an existing septic system provided that the elevation between the septic tank and distribution box exceeds ~3 - 4 inches. The retrofit would reduce overall costs and reuse existing infrastructure.

Two additional commercially available candidate technologies are emerging based on the extensive sampling program and reporting of results from the "Reclaim Our Water" Program in Suffolk County New York. The FugiClean™ and Hydro-Action™ are mechanical units that occupy the top two performance rankings in that program and demonstrate the ability, on average, to approximate the 12 mg/L limit on TN Discharge concentration. FugiClean™ presently has a Provisional Use Approval in the Commonwealth of Massachusetts and could be used in part (and in accordance with the 50-system limit imposed under that approval) to meet the loading limitations in the watershed. The Hydro-Action™ system could be installed in a similar manner in the watershed if the company met the requirements for a similar approval. Costs of system installation for these two technologies is difficult to estimate but in Suffolk County New York, the costs for installing a FugiClean™ system ranged from $13,900 – $19,800 in situations where an existing soil treatment area (aka "leach field") could be used. Under this same scenario the costs of installing a Hydro-Action™ unit was $14,700 - $19,670. In both instances, the costs of design and engineering is not included.

Path 2 – Review selected assumptions of the TMDL modelling for appropriate assignment of credits for higher performing I/A systems as well as reviewing the required discharge concentration that is required for I/A to still meet the TMDL.

Under this path we would request that the MEP team consider a re-evaluation of selected model assumptions that fail to appropriately "credit" the removal capability of advanced treatment units that have discharge concentrations <10 mg/L. A chief deterrent of further development, advancement and deployment of onsite septic system treatment is due to the lower "credit" and the resulting propagation to a higher cost/per/pound estimate for nitrogen removal. Certain assumptions are questioned such as concentration of septic tank effluent applied to the soil treatment area (which we and the literature support as being 60-65 mg/L TN), attenuated concentration reaching the ground water beneath the system (which is assumed to be 26 ± mg/L), and TN removal in the vadose zone subsequent to I/A application. These authors believe that the demonstrated removal rates possible in selected

technologies, where actual load reductions calculated contrast with those levels assigned in computer model runs and assumptions, do compel a review of these assumptions for the purpose of proper assignment of advanced I/A credits.

This re-evaluation may also open up opportunities for using other I/A treatment technologies that approach 14 – 18 mg/L TN discharge concentration and others yet to be identified. In short, the range of options for the Brewster portion of the Pleasant Bay Watershed may expand and offer economic advantages for I/A use following any revisions of the model.

This path should also include discussions with permitting authorities regarding treatment technologies not yet approved in the Commonwealth and their allowance for installations in context of the watershed permit. Many of the treatment units showing better performance (i.e. Hydro-Action™) in Long Island presently have limited or no approvals in the Commonwealth. Their pursuit of the Massachusetts market is overshadowed by the large market incentive in Long Island and the perceived difficulty and length of the Massachusetts approval process. An expedited review process of data from other active and credible demonstration efforts might be warranted and an adjusted permitting process might be considered based on performance data collected from highly credible sources.

Path 3 – Estimate nitrogen trading possibilities with adjacent watershed towns and determine whether, in combination with these trades, a higher onsite septic system effluent TN concentration could still meet the TMDL.

This path is a blending of two strategies. If some nitrogen reductions are assumed by a trading partner, this could adjust the necessary nitrogen reductions (and hence the required nitrogen concentration in the effluent) for each lot. Higher allowed nitrogen reductions from each I/A system translates to a higher probability of treatment level compliance and possible cost savings.

Again, the use of adaptive management could also be applied here. Any broadscale use of I/A technologies will be monitored for compliance. Should the monitoring reveal higher than expected treatment levels the scaling of nitrogen trading as well as the required number of I/A systems can be adjusted.

Appendix C - Wright-Pierce IA Cost Memo

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	Carole Ridley---PBA	DATE:	21 July 2020
FROM:	Mike Giggey	PROJECT NO.:	13351D
SUBJECT:	Pleasant Bay Watershed Permit Implementation Elements and Costs for an On-Site Denitrification Program		

Wright-Pierce's scope of work for Task 1A of the SNEP project (Subtask 4) includes the development of a cost model to predict the capital and O&M costs for municipal on-site denitrification programs. The intention is to develop cost data that will help one or more towns refine their TMDL compliance plans. This information will also provide a basis for comparison of this technology with other nitrogen control approaches, to serve as input into our recommendations related to nutrient trading.

This memo first discusses the appropriate approach to TMDL compliance using on-site systems, based on recent discussions with DEP staff. It then lays out the likely components of a municipal program. Cost estimates are then presented for those components.

SUMMARY

To be approved by DEP, and to gain credit for TMDL compliance, the use of individual on-site denitrification systems must be within a town-managed program, with the town acting as the responsible management entity.

Principal cost elements of a municipally-managed program include:

Initial costs	Recurring costs
Program implementation	Routine inspection, maintenance. and testing
Surveys, permits and easements	Electricity
Equipment purchase and installation	Septage pumping
Site restoration	Non-compliance inspection and testing

For the assumptions presented in this memo, the costs are predicted to be:

Capital cost	$33,900
O&M costs	$ 2,360 per year
Debt service	$ 2,540 per year
Equivalent annual cost	$ 4,900 per year

FUNDAMENTAL APPROACH TO TMDL COMPLIANCE

A town should select one or more nitrogen control approaches (e.g., sewers, PRBs and shellfish aquaculture) and then set target nitrogen removal goals for each approach. For the purposes of this analysis, I have assumed that a town has identified 300 homes where individual on-site

denitrification systems would be installed. The nitrogen removal goal would be established utilizing water consumption data for the homes, assumptions on consumptive use, and a target effluent concentration that is sufficiently below the 26.25-mg/l MEP-assumed groundwater impact of conventional septic tank and leachfield systems.

Historically, on-site denitrification systems have been required by town boards to address nitrate loading concerns or to protect nearby sensitive receptors. These systems are typically purchased and installed by the homeowner, who also is responsible for system monitoring and repair. Typical town involvement is to require the installation of such systems, arrange for performance data to be entered into the County database, and then nominally follow up on systems that fall into disrepair, or fail to perform according to standards.

In a municipal program aimed at TMDL compliance, a significantly more robust approach is needed. In this setting, the town's involvement might include:

- owning and operating the denitrification systems, or
- overseeing privately-owned and operated systems, or
- overseeing privately-owned systems with municipal O&M and sampling.

It is DEP's stated position that the use of on-site denitrification for TMDL compliance will require municipal oversight. Accordingly, this memo assumes that the town must be the managing entity, not the individual homeowner.

Historically, in order for on-site denitrification systems to be eligible for DEP SRF financing, the systems must be municipally owned and must be maintained by the town or by the town's contract operator. While SRF financing is attractive, municipal ownership of wastewater treatment equipment located on private property imposes legal and logistical hurdles. For the purposes of this analysis, it is assumed that the town would forego SRF financing in order to avoid those hurdles. Each town must weigh the advantages and disadvantages and make the decision that is appropriate to its circumstances. (Recently, DEP has begun discussion that may allow SRF funding for privately-owned systems. Further, the Community Betterment Septic Program, a part of the SRF program, could be amended to fund I/A systems, even if the Title 5 system has not failed.)

COST ELEMENTS

A municipal program for nitrogen reduction using on-site denitrification systems would entail both capital costs and operation and maintenance costs. This analysis considers all of those costs whether those expenses are incurred by the municipality or by the property owner.

Capital Costs

The initial administrative costs to put in place a DEP-approved management program would include:

- Setting up the program, including drafting and passage of enabling regulations
- Determining which properties would participate
- Establishing the target effluent concentration
- Obtaining blanket easements for system access and testing (not site-specific)
- Undertaking an equipment selection process to achieve the lowest reasonable cost with associated material and equipment specifications and performance assurances (the town would identify the one or two best systems that would then be purchased by the homeowners)
- Setting up a financial assistance program
- Selecting a contract operator to provide inspection, sampling and repair of all systems (the operator would be selected by the town and paid for by the homeowner)
- Orchestrating a remote monitoring system for early detection of equipment failures
- Gaining DEP approval of the program

Costs at each property would include:

- Completing site-specific survey and design activities
- Obtaining necessary permits
- Obtaining site-specific easements, if necessary
- Purchasing and installing the necessary equipment on each property
- Performing site restoration to accommodate the new equipment within existing backyard features such as decks, pools and landscaping
- Installing influent pumps at most homes
- Installing new leaching fields at some properties
- Upgrading of the electrical system at some homes
- Preparing as-built drawings
- Installing standby generators at some homes (homeowner decision)

The failure of a treatment system to achieve the target effluent nitrogen concentration is termed a "non-compliance event" for the purposes of this analysis. Instances of non-compliance may often involve failure of key equipment items such as pumps or blowers. Instrumentation could be included in the equipment package to sense basic system "trouble" conditions, with an alarm to notify the property owner, or (with telemetry or cellular system) to notify the town at a central location. In the latter case, there would be costs to install a telemetry/cellular alarm system at a central location.

O&M Costs

"Operations and Maintenance", as used herein, includes inspection, maintenance, sampling, laboratory analysis and equipment replacement, as well as associated oversight and management functions.

Recurring costs at the individual properties would include:

- Electricity
- Septage pumping
- Routine inspections
- Routine effluent monitoring
- Non-compliance inspections
- Non-compliance influent and effluent monitoring
- Chemicals (alkalinity adjustment may be needed for certain remedial actions)
- Repairs
- Periodic replacement of mechanical, electrical or instrumentation components.

Recurring costs borne directly by the municipality would include

- Compiling water use data for each property
- Overseeing contract operators
- Enforcing warranty provisions on system suppliers
- Reporting annually on the overall nitrogen removal achieved
- Maintenance of the central alarm system if used
- Ensuring compliance with DEP procedures for approval of I/A systems (could be as long as 3 years for new technologies that must gain General Use Approval)
- Overall management of the program

It is assumed that influent and effluent quality monitoring would be in three parts:

- Quarterly effluent sampling of each system for the first three years (or for as little as one year for systems that have General Use Approval)
- Annual effluent sampling of all systems that have not been subject to quarterly sampling (10% of all systems sampled each month)
- Additional influent and effluent sampling of each system whose performance does not reach an established threshold (once to confirm non-compliance and to better determine the cause of non-compliance, and a second sampling to confirm that the remedial changes were effective).

The current design life of an on-site denitrifying system is yet undefined in this municipally-managed approach. The design of typical off-the-shelf equipment and tankage may reflect market pressures to maintain costs at a low level and such systems would be expected to have a shorter

life than traditional public infrastructure. If a municipally-specified system is installed, then better-than-average quality might be expected, albeit at higher-than-market costs. Conversely, if low-first-cost equipment and tankage are installed, then it would be prudent to assume a shorter effective life, perhaps 15 years (compared to the traditional 20-year life). The frequency and intensiveness of periodic repairs must also be considered.

As part of the SNEP project, the Pleasant Bay work group has debated the target nitrogen concentration to be achieved and decided that the target is the average effluent concentration of all the I/A systems that is most important. The monitoring program should be flexible enough to identify those systems that are performing poorly so that action can be taken to improve their performance and reduce the average effluent concentration toward the target. It seems that the lower the effluent nitrogen target, the more systems will require added attention. Traditional use of on-site denitrification systems has been to install them and then "walk away and hope for the best". For TMDL compliance under a watershed permit, a hands-on proactive program is warranted.

A three-year start-up period is suggested in this analysis to accomplish three goals:

- Allowing time for new technologies to gain DEP General Use Approval;
- Addressing warranty problems with equipment and tankage; and
- Establishing a performance database to allow a cost-effective statistical approach to long-term monitoring.

If the selected technology already has General Use Approval, a shorter start-up period would be possible, perhaps as short as one year. The number of samples to be analyzed in a 300-unit program would be as follows, assuming that 30% of systems would require non-compliance actions:

Initial period of 1 year

Year 1	180 influent samples	1,380 effluent samples
Years 2 to 20	180 influent samples/yr	540 effluent samples/yr
Average year	180 influent samples/yr	582 effluent samples/yr

Initial period of 3 years

Year 1 to 3	540 influent samples	4,140 effluent samples
Years 4 to 20	180 influent samples/yr	540 effluent samples/yr
Average year	180 influent samples/yr	666 effluent samples/yr

Over the 20-year life of the project, the added initial sampling for yet-unapproved technology would add about 20% to the number of influent and effluent monitoring.

COST ESTIMATES

I set up a detailed spreadsheet to allow the calculation of costs for a program overseen by a town intending to reduce watershed nitrogen load and gain credit under the Watershed Permit, using I/A systems installed at individual homes or business. I have incorporated significant flexibility into this model to accommodate future decisions on the details of the specific municipal system and DEP's stance with respect to demonstration of actual removal. All costs are expressed in current (early 2020) dollars.

Results

Using typical values for key cost items, a "base case" estimate was prepared and is summarized in Table 1. The base case includes costs as follows for the average system in the program:

Capital cost	$33,900
O&M cost	$ 2,360 per year
Equivalent annual costs	$ 4,900 per year

These O&M costs are the average over 20 years. It is important to note that during the first three years (for new systems without General Use Approval), the O&M costs would be higher ($2,840 per year) due to more frequent inspections and effluent monitoring. (These costs would apply for only one year for systems with General Use Approval.)

Assumptions Related to Capital Costs

1. Blanket easements would be granted to cover public access to most systems. Site-specific easements ($4,000) would be needed in some cases, assumed to be 10% of all lots.
2. All lots would have new treatments systems installed at $17,500 and 80% of the systems would require influent pumping at $3,500.
3. New $10,000 leaching fields would be needed at 20% of the homes; the remainder would have Title-5-compliant systems with at least 15 years remaining life and would not be replaced at the time of installation of the I/A system.
4. Basic site restoration would cost $2,000 per home, and 15% of the homes would have special sitework needs at $6,000 per home.
5. It would be a homeowner decision on whether to install a standby generator, and 15% of the homes would do so at $5,000.
6. Some homeowners would require a $3,000 upgrading of the home's electrical system.
7. The town's overall DEP-approved management program would cost $180,000 to set up and those costs would be shared equally by all properties at $600 per lot.

Assumptions Related to O&M Costs

1. A one-hour inspection of all systems would be conducted each month throughout the program.
2. During the first three years of the program (or just the first year for systems with General Use Approval), quarterly effluent sampling would occur at all systems, with laboratory tests including BOD, TSS, nitrogen species, pH and alkalinity. After the initial period, systems would be sampled annually (10% sampled each month) and tested for nitrogen species only.
3. About 30% of all systems would require resampling due to failure to meet the established threshold effluent nitrogen concentration. Those system would be visited by the contract operator to determine the cause of the non-compliance, and there would be influent and effluent sampling of BOD, TSS, nitrogen species, pH and alkalinity. While some systems might experience more than one episode of non-compliance, those have not been considered.
4. Treatment system repairs would cost $500 every 5 years.
5. The town would have routine responsibilities of oversight and reporting that would cost $66,000 per year and spread equally to all properties at $220 per year,

Assumptions Related to System Replacement

It is assumed that not all of the new I/A systems will last for 20 years. About 10% percent of all systems will require replacement (at 70% of original equipment cost) in 15 years. The present worth of those future costs is about $6,800 for those systems that do not last 20 years.

SENSITIVITY ANALYSIS

Given the uncertainty associated with certain assumptions, it is appropriate to see how varying assumptions change the overall average cost. Looking at annualized costs (O&M costs plus debt service), the most important cost components are:

Capital cost of treatment system and pump	30% of total annualized coats
Routine maintenance, inspections and testing	27%
Design, permitting, easements and as-builts	11%
Electricity	7%
Program costs	5%
Non-compliance inspection and testing	4%

About 85% of the overall cost is associated with these 6 cost categories. Note that non-compliance inspection and testing comprise only 4% of the total annualized costs.

The base case has an equivalent annual cost of $4,900. Changes in some of the assumptions yields other estimates:

Cost increases		
1. 10% higher equipment costs	$5,050 per yr	($150 more than base)
2. 15% more frequent monitoring	$5,100	($200 more)
3. Fewer homes covering program costs (150)	$5,160	($260 more)
4. Items 1, 2, and 3 combined	$5,510	($610 more)
Cost reductions		
5. 10% lower equipment costs	$4,750 per yr	($150 less than base)
6. 30% lower site restoration costs	$4,800	($100 less)
7. 20% less routine monitoring	$4,630	($270 less)
8. 40% less non-compliance monitoring	$4,810	($ 90 less)
9. Municipal financing (2%, 20-yr)	$4,470	($430 less)
10. Items 5, 6 and 7 combined	$4,380	($520 less)
11. Items 7, 8 and 9 combined	$4,110	($790 less)

The various scenarios identified above show a cost range of $4,100 per year (16% less than the base case) to $5,500 per year (12% higher than the base case). The cost model is configured to rapidly estimate costs for other potential changes in the key assumptions.

The base case assumes a 3-year start-up period, in part to accommodate new technologies that have not gained DEP General Use Approval. If approved technologies were used, and the start-up period could be reduced to 1 year, then there would be about 20% less routine monitoring costs and the overall equivalent annual cost would be close to the $4,630 figure shown above for Item 7.

This memo reports “all-in” costs, regardless of the party who pays those costs. Various cost recovery scenarios are possible, just as they are for any technology. If the town were to make a $18,100 grant to each participating homeowner (to cover equipment costs and initial program costs), the remaining annualized cost for each homeowner would be about $3,600, or $1,300 less than the base case. If the town were to cover the debt service on the grants and the on-going program costs with property taxation, the tax levy would increase by $400,000 per year for this 300-home scenario (a small fraction of which would be paid by the 300 homeowners).

The cost analysis reported here is consistent with the approach that towns take in their comprehensive wastewater management plans (CWMPs). “All-in” costs are reported, then refined by considering how those costs will be allocated (to users, put on the overall tax base, etc.) The readers of this memo should be careful to compare the “all-in” costs reported here with the “all-in” costs typically reported in CWMPs for other technologies. A second comparison could include

the costs after grant and loans, reflecting all available funding sources. Traditionally, funding entities expect the applicant to demonstrate that the selected program has the lowest cost of available options, based on the total costs, before grants and loans.

Table 1
Costs for a Municipal On-Site Denitrification Program

	Costs for One Home	Percent Applicable	Avg Cost for All Homes
Capital Costs			
Survey and design	5,000	100	5,000
Permitting	1,000	100	1,000
Site-specific easements	4,000	10	400
Purchase/install I/A	17,500	100	17,500
Purchase/install infl. pump	3,500	80	2,800
Upgrade leaching field	10,000	20	2,000
Site restoration--routine	2,000	85	1,700
Site restoration--special	6,000	15	900
Emergency generator	5,000	15	750
Upgrade electrical service	2,500	10	250
As-built drawings	1,000	100	1,000
Program costs	600	100	600
Total			33,900
O&M Costs			
Electricity	360	100	360
Septage pumping	450	25	113
Routine inspections	1,080	100	1,080
Routine laboratory analysis	261	100	261
Non-compliance inspections	360	30	108
Non-compliance lab analysis	370	30	111
Chemicals	50	10	5
Repairs	500	20	100
Program costs	220	100	220
Total	6,802		2,358
Replacement Costs			
Present worth of equipment	6,802	10	680
Summary			
Capital Cost			33,900
Present Worth of Replacement			680
Total			34,580
Debt Service 4%, 20 yr	CRF= 0.07358		2,544
O&M Cost			2,358
Equivalent Annual Cost			4,902

All cost expressed in early 2020 dollars 21-Feb-20

Appendix D - MA DEP Memo

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Appendix D
Sampling and Monitoring Requirements for I/A Systems

Introduction

The proper management of on-site denitrifying systems is essential in insuring that a community can meet its nitrogen reduction goals if it intends to use these technologies in pursuit of Total Maximum Daily Load (TMDL) requirements. This includes operation and maintenance and sampling and monitoring. This document provides a protocol for the management and monitoring of on-site denitrifying systems that has been reviewed and accepted by the Massachusetts Department of Environmental Protection.

The use of Innovative/Alternative (I/A) systems as part of a comprehensive nitrogen management plan requires municipal oversight. MassDEP has long held the position that given that critical importance of insuring proper operation under these circumstances, I/A operation and management cannot be left to the individual homeowner. In that regard, communities will need to maintain a management program staffed by appropriately certified wastewater treatment plant operators. Communities have the option of using municipal staff or contract operators overseen by the municipal government.

It is important to note that this protocol differs from the sampling and monitoring requirements for I/A systems regulated under Title 5 of the State Environmental Code (310 CMR 15.000). Any measures implemented to meet TMDL compliance on a watershed wide basis require strict oversight and comprehensive management. I/A systems are no different, and the operations, monitoring and management protocols described herein are necessary to assure that these systems are meeting the performance standards required to achieve the ultimate goal of habitat restoration.

Sampling and Monitoring Protocol

This protocol seeks to strike an appropriate balance between compliance monitoring and cost. Considering that communities will likely require several hundred system installations, it is not practical to sample each system every month. Accordingly, the protocol strives to attain a statistically significant monthly sampling schedule where 10% of the systems are randomly sampled each month, ensuring, however, that every system is sampled at least once per calendar year. In addition, each system will be inspected monthly to insure that it is operating properly.

The sampling, monitoring and management protocol will follow these steps:

1. a. For the first year of operation, all systems shall be sampled and tested quarterly for 5-Day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and Total Nitrogen (the sum of Total Kjeldahl Nitrogen, Nitrite-Nitrogen and Nitrate-Nitrogen) to insure proper installation and operation.

b. After the first year of installation systems for sampling and testing shall be selected randomly and sampled as follows:

i. For systems with General Use Approval, 10% of the total number of systems installed shall be sampled and tested for 5-Day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and Total Nitrogen (the sum of Total Kjeldahl Nitrogen, Nitrite-Nitrogen and Nitrate-Nitrogen) every month.

ii. For systems with Provisional Use Approval, quarterly testing shall be required in accordance with the system's Provisional Use Approval certification.

Random system selection will be done such that any system previously tested shall be removed from the sampling population until all systems have been tested after which the entire population shall once again be pooled for random selection.

2. Every system shall be inspected a minimum of once a month to insure that all mechanical components are operational.

After the first two (2) years of inspections the municipality may submit a request to meet this requirement through remote monitoring. MassDEP will consider the request depending upon how robust and reliable the remote monitors are.

<u>Noncompliance</u>

For any system that fails to meet required effluent limits, resampling will be required within thirty (30) days and monthly thereafter until two consecutive samples meet effluent limits. During this period of increased sampling, the operator shall evaluate the performance of the system and provide MassDEP with a report describing the findings of that evaluation including, but not necessarily limited to, the cause of effluent violations, corrective measures taken and operational considerations to prevent future violations.

Appendix E - Implementation Memo

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
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MEMORANDUM

To: Chris Miller, Natural Resource Director
Ryan Bennett, Town Planner

From: Mark Nelson, Jane Estey

Date: December 31, 2018, Revised July 30, 2020

Re: Implementation of an Onsite Septic System Treatment Program for the Pleasant Bay Watershed

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The Horsley Witten Group, Inc. (HW) has evaluated Brewster's requirements and options for the implementation of a program to install, operate and monitor advanced onsite septic systems for nitrogen removal within the Pleasant Bay watershed. The goal of this program is to remove the remaining nitrogen from sources within the watershed to meet the Total Maximum Daily Load for Brewster's portion of the Pleasant Bay Watershed.

This report has been prepared to identify the issues involved in establishing the program and to provide some initial recommendations on how to move forward. It is anticipated that the implementation process will be refined over the next one to three years with significant input from the Select Board, the Board of Health and town residents. Funding for this project was provided by the Department of Housing and Community Development's District Local Technical Assistance program through the Cape Cod Commission. This funding was applied as a match to the Southeast New England Program grant issued to the Pleasant Bay Alliance. The initial work on this memo was completed in December 2018 and has been updated now to reflect more recent evaluations and discussions as the work in Task 1A of the SNEP grant, of which this has been a part, has been completed.

Background

Pleasant Bay is impacted by excessive nitrogen coming from sources within its watershed; that area which contributes groundwater to the Bay. Septic system discharges are the largest source of nitrogen in the watershed, followed by fertilizers, road runoff and agricultural sources. Approximately 25 percent of the Pleasant Bay watershed is located within Brewster, with the remaining watershed areas in Orleans, Harwich and Chatham (Pleasant Bay Alliance, May 2018).

The Massachusetts Department of Environmental Protection (MassDEP) has established a TMDL for the Bay (Mass DEP, May 2007) based on a model developed by the University of Massachusetts School for Marine Science & Technology (SMAST, May, 2006). Based on this information, Brewster has partnered with the other towns within the watershed to develop a Targeted Watershed Management Plan to restore Pleasant Bay. The plan is the foundation for the watershed permit between the four Pleasant Bay towns and the MassDEP issued in August, 2018 to manage the towns' actions to achieve TMDL compliance for Pleasant Bay over the next 20 years. The permit identifies the steps each town will take to meet the TMDL over the next 20

years and allows them to utilize non-traditional options for nitrogen removal, like the onsite systems proposed for Brewster.

Under the watershed permit, Brewster has agreed to remove 2,262 kg/year of nitrogen to meet its TMDL requirements. To date 56 percent of this load reduction has been achieved through reductions in fertilizer use and through the recapture of nitrogen through the irrigation well at the town-owned Captains Golf Course. The Town is evaluating the possibility of removing the remaining load through an advanced onsite program.

Implementation Goals

The goal of Brewster's advanced onsite treatment program is to upgrade enough onsite systems within the watershed to remove the remaining nitrogen needed to meet Brewster's TMDL requirement for Pleasant Bay. Approximately 980 kilograms of nitrogen need to be removed through the onsite program under current conditions. Additional nitrogen removal may be needed to accommodate future development within the watershed.

The planning for a successful advanced onsite system program requires consideration of several issues to ensure it is successful and will be in compliance with the TMDL and the watershed permit. They include:

- Development of a regulatory program to implement the advanced onsite system program;
- Selection of the appropriate nitrogen removal requirements for the proposed onsite systems to ensure the TMDL goal is met;
- Selection of the appropriate advanced onsite systems to incorporate in the program, or the selection of performance standards for the systems to be used, to allow for the inclusion of new technologies over time;
- Determining the number and location of properties where the use of an advanced system will be required;
- Development of an operation and maintenance program with clear oversight by the Town to ensure the systems that are installed and operated properly to meet their nitrogen reduction requirements; and
- Development of monitoring programs under the Town's supervision to confirm that the advanced systems are in compliance with the state's septic system regulations (Title 5, 310 CMR 15.00) and DEP's monitoring requirements to confirm TMDL compliance.

HW has conducted an initial analysis of these issues as discussed below

Regulatory Approach

A regulation requiring the use of advanced onsite systems in the Pleasant Bay watershed will be needed to implement the program. There are two regulatory mechanisms that could be used: the adoption of a general bylaw or the adoption of a Board of Health regulation. HW recommends a combination of both. A general bylaw will require the use of the advanced onsite systems in the watershed with the appropriate number and treatment capability to meet Brewster's portion of the TMDL. The general bylaw will also mandate that the Board of Health

develop regulations that provide the details of how the program will be implemented and administered over time with authority for enforcement with the Board of Health.

A general bylaw must be adopted by a simple majority at Town Meeting. Using this approach, the Town is given the opportunity to review and approve the proposed program and make an affirmative vote to adopt it. Board of Health regulations are adopted by a simple majority of the Board. This process doesn't provide for the same level of involvement for Town residents. However, having the Board adopt the implementation regulations allows opportunities to change or update the requirements over time, without the need to return for a Town Meeting vote. This will be helpful if new technologies are identified, or if there are other changes that warrant updates to the regulations.

This hybrid approach provides the benefits of both approaches; input from all Town residents in the approval of the bylaw, and flexibility to implement the program and adapt to changing circumstances through the proposed Board of Health regulations. The general bylaw could incorporate provisions for how the program will be financed, if the Town agrees to fund a portion of the costs (see the Financing section below).

A draft General Bylaw is attached to this memo in preliminary form. Additional detail will need to be added as the decisions on how the program will be implemented are made.

Advanced System Selection and Treatment Requirements

Information on the advanced systems that Brewster might consider for use is currently being developed by the Pleasant Bay Alliance through the Southeast New England Program (SNEP) grant it received to help implement the Pleasant Bay watershed permit. This analysis will review the available technologies to rank them based on performance, reliability, and cost for installation and annual operation and maintenance.

There are two approaches for selecting which systems should be used in Brewster. Specific technologies could be approved for use, or a specific nitrogen removal concentration could be established and systems that are proven to meet this requirement could be chosen by the property owner with approval by the Board of Health.

The factors that need to be considered in selecting an approach include:

- The nitrogen removal capability of the systems selected for use in the program. The nitrogen reduction provided by an advanced system directly impacts how many systems must be upgraded. Fewer systems must be upgraded to meet the TMDL if the systems provide a higher level of nitrogen treatment. Further discussion on the number of systems requiring treatment is provided in the next section.

- The reliability of the chosen systems over the long term. The Town is responsible for ensuring that the TMDL nitrogen reduction goals are met and will need to have oversight of system performance. If the Town chooses to only allow the use of one or more systems, there may be issues if the systems do not provide the expected level of nitrogen treatment. If systems are operated and maintained properly, then the owners of the systems would likely not be liable for not meeting a nitrogen compliance goal as they

installed the system the Town required them to install. One way to manage this concern might be to obtain a performance guarantee from the system manufacturer that states they will guarantee compliance with the nitrogen reduction levels set by the Town. In addition, if the Town decides to select specific systems for use, there will likely need to be a proposal process to properly establish which systems will be used and what price will be provided.

- The cost for system installation, operation and maintenance. The cost for a system that provides a higher level of treatment may be more, and this could play into how many properties will be required to upgrade their system. There will be tradeoffs between cost and performance that the Town will need to consider as the program moves forward.

- The market for nitrogen reducing septic technologies is advancing and there will be changes over time. Therefore, selecting specific technologies may limit the Town from utilizing new technologies that may perform better or offer a cheaper alternative in the future. Establishing a set nitrogen reduction limit would avoid these types of complications.

Number of Properties Requiring and Advanced Onsite System

The level of nitrogen treatment provided by an advanced onsite system and the location of a property in the watershed both factor into how many systems must participate in the program. Some properties are in areas where there is significant attenuation of nitrogen before it reaches Pleasant Bay via groundwater. This occurs in areas where nitrogen in groundwater flows to a pond and then back into groundwater before it discharges to the Bay. This process removes approximately 50% of the nitrogen contained in the groundwater that enters a pond. In some areas in Brewster groundwater flows through multiple ponds before entering the Bay. It may not be worthwhile to install nitrogen treatment systems in areas where this attenuation is taking place.

HW has analyzed how many properties may need to participate in the program based on the level of nitrogen reduction that is needed. This is summarized a memorandum developed by HW (HW, Dec 31, 2018) which shows that most, if not all, of the homes in the subwatersheds where there is no attenuation will need to be upgraded to meet a nitrogen effluent standard of 12 mg/L to comply with the Pleasant Bay TMDL requirements.

Operation and Maintenance (O&M)

The performance of the advanced onsite systems is directly tied to the way they are operated and maintained. Based on conversations with MassDEP, the Town must have oversight of the O&M program to ensure systems are working sufficiently to meet the nitrogen reduction goals of the TMDL. Oversight will likely include monthly visits to confirm the system is operating per the manufacturers' guidelines. These requirements should be incorporated into the General Bylaw and the Board of Health regulation. The details on the required O&M practices will depend on the systems selected for use. The Town could:

- Hire a certified wastewater operator that works for the Town and is responsible for operating all systems upgraded under this program. The value of this option may

depend on how many properties are included in the program and whether there are too many or too few systems for a Town staff person to manage. The financing for this approach could be provided by property owners who pay the town for the O&M of their system.

- Establish a program to review and approve certified operators that contract with property owners to operate and maintain their systems. Under this approach, the Town would need a program to review the O&M work conducted by the approved operators and likely conduct some spot checks to verify systems are operating properly.

- Work with other communities and possibly Barnstable County to establish a regional approach to O&M management. It might be possible to have the County establish a certified operator program that works on behalf of the Town, and other communities on Cape Cod to provide O&M for advanced onsite systems.

Further discussions in Brewster, with Barnstable County and with neighboring Towns are needed to develop and adopt an appropriate O&M process that provides the proper oversight and control by the Town. However, the process is conducted, the Town will require access to each property to inspect and possibly manage the O&M of the systems. The draft General Bylaw incorporates language to address this issue.

Monitoring

Monitoring of all systems that are upgrades will be needed to confirm compliance with the nitrogen reduction goals in the TMDL. HW has discussed the monitoring requirements under the TMDL with MassDEP and the Pleasant Bay Alliance. In the first year, each system will likely need to be monitored quarterly to insure it is operating as intended. In subsequent years, each system will need to be tested annually with effluent samples analyzed for total nitrogen concentrations. Mass DEP recommends that at least 1/12th (approximately 10%) of the systems installed in the watershed be tested each month. In the first month a random selection of system representing 1/12th of the total would be tested. In month two a second round of systems would be tested. Over a year all the systems would be tested in this fashion. The nitrogen reduction documented in the monitoring plan will be compared to the TMDL goal to confirm the program is working. It is anticipated there will be some variability in the performance of the systems, and it is anticipated that an average nitrogen reduction across all the systems will be used to compare to the TMDL goal. However, data showing a system isn't meeting its performance goal should also be flagged so an operator can inspect the system and bring it into compliance.

In addition, many systems will require additional testing based on the innovative and alternative system regulations in Title 5 (310 CMR 280). New technologies must be approved following these regulations and there are monitoring requirements established by MassDEP for these systems. Depending on the systems used in Brewster there will be a need to evaluate how to incorporate this testing into the TMDL monitoring discussed above.

The Town will be responsible for overseeing the monitoring of the advanced systems to ensure compliance with the TMDL and a program to oversee this work will need to be established. There may be opportunities for collaboration with the Barnstable County Department of Health

and Environment in the collection, recording and evaluation of this data, options the Town should explore.

Annual Watershed Permit Reporting

The implementation of the program will need to be documented in the annual reports that are required under the Pleasant Bay watershed permit. A framework for the annual report should be developed that includes:

- Updates on the adoption of, and any changes to, the regulatory program;
- Reporting on the number of systems installed and their locations in the watershed;
- A summary of the O&M activities during the reporting period; and
- A summary of the monitoring conducted, including calculations of the amount of nitrogen removed relative to the TMDL nitrogen reduction goal.

Financing

As this program is developed there will also need to be discussions within Brewster on how it will be financed. Federal regulations governing the State Revolving Fund (SRF) program allow for loans to privately or publicly owned facilities, and Massachusetts dedicates $5 million a year for septic repair and replacement projects through the State Revolving Fund (SRF). MassDEP is in the process of providing guidance on how to access these loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install nitrogen reducing septic systems. Currently, the SRF program does fund a Community Betterment Septic Program that provides low interest loans to homeowners to upgrade or replace failed septic systems. An in-depth discussion of an equitable financing program should take place at the same time the implementation plan is developed and should involve extensive input from Town Boards and residents.

Next Steps

The implementation plan will evolve as more information on potential advanced systems is available and as the Town Boards and residents get involved in the discussion. The following next steps are recommended based on the information gathered to date:

- Continue to evaluate existing and new advanced nitrogen reducing septic systems, focusing on their performance, reliability, and cost.

- Select an approach for choosing which systems will be used in Brewster. The Town could decide to require new systems to meet a specific performance standard or could select a suite of systems allowed for use under the program based on their performance and reliability.

- Determine an effective approach to oversee the operation and maintenance program for the selected systems to insure they are functioning properly. The Town could run this program themselves, contract out for the services needed or set specific requirements in the approval of each system. However, it is done, the Town must have oversight of how the systems are maintained to insure they meet their performance goals.

- Finalize the monitoring program based on the specific requirements for the technologies chosen for use in the program.

- Incorporate a strong public participation program in the implementation planning. Regular meetings with the Select Board and Board of Health will be important as well as other outreach activities including public meetings and meetings focused on the property owners affected by the program.

- Continue discussions on how best to finance this program, evaluating public and private funding approaches. This evaluation should be concurrent with the rest of the implementation planning, especially as decisions on the technologies chosen and on the oversight of operation and maintenance will affect the overall project cost.

Pilot Program

If the Town decides to move forward with an onsite septic system program, then they should begin a pilot program to test out the performance of the selection of systems, and the ongoing operation, maintenance and monitoring practices that will be needed. Five to ten sites should be chosen for the installation of pilot systems, with the systems chosen based on the information provided through the Pleasant Bay Alliance SNEP grant analysis. The Town should solicit volunteers to allow the installation on their property. This will give valuable information on installation costs. It will also provide worthwhile experiences with operation and maintenance to guide how this process can best work moving forward. It will also be useful in evaluating the mechanisms for ongoing monitoring of the systems. The Town could begin with an installation at a Town property such as with an upgrade of the septic system at the Captains Golf Course.

References

Horsley Witten Group, Inc. December 31, 2018. Evaluation of the Number of Homes in the Pleasant Bay Watershed That Will Require an Advanced Septic System to Meet the Nitrogen Reduction Goals for the Watershed.

Massachusetts Department of Environmental Protection, May, 2007. Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Final Report # 96-TMDL-12, Control #244.0).

Pleasant Bay Alliance, May 2018. Pleasant Bay Targeted Watershed Management Plan http://pleasantbay.org/programs-and-projects/watershed-planning/pleasant-bay-watershed-permit

University of Massachusetts Dartmouth, School of Marine Science and Technology, May 2006. Massachusetts Estuaries Project, Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts

Attachment: Draft General Bylaw for Using Innovative/Alternative Septic Systems to Meet the Pleasant Bay TMDL

Attachment: Draft General Bylaw for Using Innovative/Alternative Septic Systems to Meet the Pleasant Bay TMDL

DRAFT
Town of Brewster, MA
General Bylaw (for Town Meeting approval)

Regulation of Sewage Disposal Systems to Protect Water Quality in Pleasant Bay

This is a preliminary draft of the proposed bylaw developed for discussion purposes. Reader's notes are provided in specific sections to identify issues that need further evaluation and discussion.

1. Purpose and Authority

1.1 This chapter is adopted to comply with the Town of Brewster's obligations pursuant to the Pleasant Bay Watershed Permit, issued by The Massachusetts Department of Environmental Protection (MassDEP) on August 3, 2018 (the "Permit"). The Town has concluded that it is necessary to reduce nitrogen in effluent from on site wastewater disposal systems in order to comply with the Town's obligations under the Permit. These requirements supplement and are in addition to those found in the *State Environmental Code Title 5* (310 CMR 15.00) ("Title 5").

1.2 The Brewster Board of Health is authorized to enforce this chapter and to adopt implementing regulations pursuant to M.G.L. Chapter 111, Section 31 and 127A, as amended to supplement its existing regulations.

The Board of Health will be asked to develop implementing regulations to oversee the upgrade of septic systems in the Pleasant Bay watershed, providing details on the performance of the systems that are installed, the operation and maintenance requirements and monitoring schedules. These regulations can be updated over time based on lessons learned or to incorporate new technologies for nitrogen treatment.

2. Applicability

This regulation shall apply to all existing and proposed subsurface sewage disposal systems located in Subwatershed _____, as shown on Map entitled _____ (the "Map") below. A copy of the Map is on file at the Brewster Board of Health Office at 2198 Main Street, Brewster, Massachusetts

Further work is needed to determine the number and location of properties that will be required to update their septic system. This will depend primarily on the level of nitrogen treatment that can be provided by the advanced systems that will be used.

3. Definitions

Enhanced nitrogen removal system: An alternative or innovative septic system that is approved by MassDEP for general, pilot or provisional use.

Person: An individual, owner, firm, corporation, company, parent company, subsidiary, limited liability company, entity, trust, joint venture, partnership, legal representative, agent or other form of doing business or any other group of individuals or entities and includes the plural as well as the singular.

4. Effluent Treatment Requirements for Septic Systems in Subwatershed _____.

All existing septic systems and any proposed septic systems associated with new construction or expansion of existing development with Subwatershed _____ must be upgraded to comply with these requirements. Existing septic systems shall be upgraded at the time of any transfer in title of the property. All such upgrades, as well as construction of new septic system or expansion of all septic systems with Subwatershed _____ must incorporate an advanced nitrogen removal system approved for use by the MassDEP that will treat septic system effluent to a standard of _____ mg/L of total nitrogen or below. Compliance with the _____mg/L standard must be measured in the effluent after treatment is conducted and before it is discharged into the ground below the leaching facility. All systems must be designed and installed with accessible monitoring ports.

5. Monitoring Requirements

Monitoring must be conducted according to the requirements for the innovative and advanced onsite treatment systems as approved by the Massachusetts Department of Environmental Protection (310 CMR 15.280) and the Board of Health. Monitoring for compliance with the Pleasant Bay Watershed Permit is also required according to requirements that will be established by the Board of Health. Monitoring will be conducted by _____ and all results shall be submitted to the Board of Health.

The Town reserves the right to take over monitoring for any or all systems installed pursuant to this chapter and to assess a fee to property owners to cover the costs of the same.

Monitoring is required to prove that the advanced nitrogen treatment systems are meeting the required performance standards for compliance with the Pleasant Bay Watershed Permit. The Town needs to determine who will be responsible for taking samples, reporting results and paying for the ongoing testing.

6. Operation and Maintenance Requirements

The property owner shall hire a person or firm who is approved by the system manufacturer and the Board of Health to operate the system and perform routine maintenance in accordance with the manufacturer's guidelines along with any additional requirements of MassDEP or the Board of Health. The property owner shall file documentation in the form or reports or receipts of routine maintenance or any repairs with the Board of Health.

The Town reserves the right to take over operations and maintenance for any or all systems installed pursuant to this chapter and to assess a fee to property owners to cover the costs of the same.

The Town needs to decide if Town staff will conduct the system O&M, or if they will approve certified operators that will do the work on behalf of the property owner. There may also be options for regional coordination on system O&M that can be explored.

7. Easements

At the time of system approval by the Board of Health, a property owner must grant an easement to the Town in a form approved by Board of Health to conduct any required monitoring and/or operation and maintenance. All such easements shall be recorded against the property title at the Barnstable County Registry of Deeds or Land Court and shall be structured to allow Town staff and approved system operators to access the property.

8. Enforcement

8.1 The Board of Health, its agents, officers and employees shall have the authority to enter upon privately owned land for the purpose of performing their duties for the administration and review of this regulation and may make or cause to be made such examination, operation and maintenance, surveys or sampling as the Board deems necessary.

8.2 The Board of Health shall have the authority to enforce these regulations by violation notices, administrative order and civil and criminal court actions.

8.3 Any person who shall violate any provision of this regulation for which a penalty is not otherwise provided shall be subject to a fine of not more than $200. Each day or portion thereof during which a violation occurs or continues shall constitute a separate offense.

9. Severability

Each section of these rules and regulations shall be construed as separate and to the end that if any section, item, sentence, clause or phrase shall be held invalid for any reason, the remainder of these rules and regulations shall continue in full force and effect.

10. Effective Date