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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 10.1.B - NT Demonstration Projects** **Draft Deliverable 10.1.B.3 – Layered Soil Treatment Area Candidate Sites**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
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Approvals	Date	Signature / Initials
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1. Introduction

The Orleans Water Quality Advisory Panel, or OWQAP, was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. The panel consisted of stakeholder representatives (Orleans Selectmen and representatives of engaged citizen constituencies) and liaisons from key town boards and commissions, organizations, neighboring towns, and regional, state and federal partners. The OWQAP met for twelve half-day meetings starting in July 2014, all of which were open to public attendance and comment.

Potential alternative planning scenarios to meet water quality standards were developed for the OWQAP and presented at meetings and workshops. A Hybrid Plan was developed through an iterative process and included specific sites for the use of NT nitrogen removal technologies, including FCW, permeable reactive barriers, aquaculture and coastal habitat restoration. Once the feasibility of using NT technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Plan would not specify exact site locations but instead focus on overall quantities of NT technologies needed to remove the appropriate mass of nitrogen at the watershed level.

Nitrogen Reducing Barriers were included in the toolbox of NT technologies that would be implemented in order to achieve water quality goals. Nitrogen Reducing Barriers are also referred to as a Layered Soil Treatment Area (LSTA). AECOM has been working with the Orleans Board of Health (OBOH) to identify the locations of potential LSTA demonstration sites. AECOM has also been coordinating with the Barnstable County Department of Health and Environment (BCDHE) with regard to the design, permitting and implementation of the LSTA demonstration projects. This Technical Memorandum outlines the present status of the program.

2. Goals and Objectives of LSTA Demonstration Project

The goal of this demonstration project is to evaluate the potential to use of LSTA to:

- Reduce nitrogen discharge to the environment at its source;
- Determine if an LSTA can function as a viable, maintenance free, component of an onsite sewage disposal system;
- Assess local ground water quality and ecological benefits; and
- Provide a case study to guide siting, design and monitoring of future projects.

The pilot projects will be built as repairs to existing failed sewage disposal systems and will be monitored for five years from the date that the system is placed into service.

The immediate objectives of the proposed LSTA demonstration project are to:

- Realize associated ecological and socioeconomic benefits;
- Install the LSTA as an integral component of an upgraded sewage disposal system;
- Monitor the performance of the LSTA to reduce nitrogen discharged to groundwater; and
- Evaluate uncertainties associated with the local climate and environmental conditions;
- Infer quantitative decisions about the value of LSTA at meeting the long term goals of the Town of Orleans in reducing nitrogen in its water resources.

3. Site Characterization Evaluation

A. General

The Site Characterization and Evaluation documents the process that will be used to identify, evaluate, rate, and rank demonstration sites to test the efficacy of LSTA to remove nitrogen from sewage disposal system discharges within the Town of Orleans. This Memorandum includes the following:

- Description of the proposed site identification plan that is based on coordination between AECOM and the OBOH in order to identify up to four potential demonstration sites;
- The steps taken in the process of evaluating the demonstration sites;
- Review of available data to understand current site conditions and evaluate potential demonstration sites; and
- Methods that will be used to evaluate and choose potential sites for LSTA installations Evaluation, rating and ranking of sites based on the site selection matrix and criteria.

In addition, key terms are defined including the categories of data that were evaluated. The site selection criteria and rating system used to assess potential demonstration sites are also explained.

The purpose of this documentation is to provide a transparent and objective assessment of the methods that will be employed to identify possible locations in Orleans to site LSTA Non-Traditional technology demonstration projects. The assessment will be used to select the best possible sites for preliminary engineering, which will include drawings, preliminary specifications, cost estimates, funding sources and monitoring plans.

B. Key Layered Soil Treatment Area Design Features

To establish a consistent meaning of LSTA in the context of this Technical Memorandum, this term is defined as follows: An LSTA is constructed as part of a sewage disposal system soil absorption field and is comprised of a sand based "nitrification layer" underlain by a "denitrification layer" of sand mixed with finely ground wood.

The LSTA is implemented following a conventional septic tank and a pump chamber. Effluent from the septic tank flows by gravity to a pump chamber that will intermittently dose the Soil Absorption field with a low pressure distribution system or drip dispersal system. The LSTA is incorporated into the design and implementation of the soil absorption field. As Septic tank effluent passes through the LSTA, the nitrogen in effluent discharged from the system is substantially reduced.

The following core design principles that will be followed in the design of the LSTA systems are to:

- Utilize natural treatment technologies where possible;
- Minimize energy use and mechanical system complexity;
- Incorporate the LSTA into sewage disposal systems that are upgrades to existing systems that are determined to be in a state of failure.
- Incorporate educational and interpretive value into the system; and
- Develop systems that are easy to maintain and operate to enhance long-term viability.

LSTA typically consist of a layer of sandy soils overlying a layer of mixed with finely ground wood that is dosed by a low pressure distribution system. LSTA remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, LSTA have shown an ability to achieve a high percentage of nitrogen removal (up to 90 percent), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a LSTA involves two steps: (1) a nitrification step in which ammonia and reduced organic nitrogen is septic tank effluent is converted to nitrate in an unsaturated, oxygen (O_2) rich sand layer; and (2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O_2-limited sand plus lignocellulose (wood chips or sawdust) layer.

The LSTA will be constructed as a horizontal layer in a multi layered soil absorption field system.

C. Site Identification Methodology

AECOM has been coordinating with the Orleans Health Agent to identify up to four sites that would be candidates for installing an LSTA as an integral part of a sewage disposal system upgrade. The following criteria are being used to help choose the candidate sites:

- The sewage disposal system that serves the facility shall be considered failed under State and local regulations (310 CMR 15.303, and Chapter 185, Article III, § 185-17.2 Definitions, of the Orleans Board of Health Regulations;
- There is no proposed increase in the number of bedrooms or the tabular sewage flow from the facility that will be served by the sewage disposal system upgrade;
- The sewage disposal system will not need variances from the required groundwater separation requirements under local and state regulations;

- The proposed sewage disposal system upgrade site will be greater than 100' from wetlands as identified under the MA Wetlands Protection Act and the Orleans Wetlands Protection By-Law;
- A substantial five foot "Soil Removal" and replacement will not be required for implementation of the LSTA;
- The proposed site will be located outside of a FEMA mapped 100 year flood zone;
- The property has sufficient area to install the sewage disposal system upgrade without dimensional variances from Title 5;
- The property is located outside of a Zone 2 of a public water supply well, or not located within a Nitrogen Sensitive Area. (as defined under State regulations);
- The site and property owner comply with the requirements of the Approval Letter issued by MassDEP for Piloting of the Non Traditional technology; and
- The property owner agrees to allow access to the site for sampling and monitoring purposes.

D. Definition of Failure of a Septic System under the Town of Orleans Board of Health Regulations (Chapter 185, Article III, §185-17.2 Definitions)

Any Septic System shall be considered to be failed when any of the following are met:

- Any component does not function as intended;
- The system causes effluent to be discharged to the surface of the ground, stream, or other watercourse;
- Any component is pumped to remove septage more than twice in any 12 month period except grease traps which may be pumped in accordance with Title 5, 310,15.351 (2) and systems serving laundromats, restaurants, food service or other establishments determined to be a high water user by the Board of Health and which is pumped frequently. Septic Systems serving high water uses shall be reviewed on a case by case basis with respect to its failure criteria;
- Any of its components consist of a privy, cesspool, or a converted cesspool, which has been identified during an inspection for the sale of the property, a change of use, or for a building permit resulting in an increase in flow, increase in square footage, or a change of footprint;
- The Soil Absorption System lacks a two foot protective zone between the bottom of the system and the maximum groundwater elevation; and
- A system has any other problem as defined by the Board of Health or it's agent which fails to protect the public health and safety and the environment.

4. LSTA Work Plan Status

A. Purpose

The LSTA Work Plan sets forth the preliminary design of the LSTA, including the project components, sequencing of subtasks, the equipment, labor and other resources required to implement the LSTA, and a preliminary cost estimate. The LSTA Work Plan also sets forth a draft monitoring and maintenance plan, along with potential regulatory requirements and funding sources.

The purpose of the LSTA work plan is to provide to the Town available information about LSTA to aid in the decision making process about whether or not to undertake the next steps towards the implementation of the demonstration projects.

B. LSTA Attributes

LSTA are a horizontal Permeable Reactive Barrier that typically consist of a layer of sandy soils overlying a layer of sand mixed with finely ground wood that is dosed with septic tank effluent by a low pressure distribution system. LSTA remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, LSTA have shown an ability to achieve a high percentage of nitrogen removal (up to 90 percent), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a LSTA involves two steps: (1) a nitrification step in which ammonia and reduced organic nitrogen is septic tank effluent is converted to nitrate in an unsaturated, oxygen (O_2) rich sand layer, followed by (2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O_2-limited sand plus lignocellulose (wood chips or sawdust) layer.

Under certain conditions, LSTA have been shown to meet the following core design principals:

- Utilize natural, biological treatment technologies;
- Minimize energy use and mechanical system complexity; and,
- Incorporate educational and interpretive value into the system.

The key feature of LSTA is that they can easily be incorporated into the design of a sewage disposal system soil absorption area. With the exception of the need to pressure dose or dip irrigate the soil absorption area, no complex mechanical components are required for the LSTA system.

C. Information Gaps to be addressed in Spring/Summer 2016 prior to full scale implementation.

To implement the LSTA Demonstration Project and allow for the most effective siting, the following additional data and permits will need to be acquired in order to supplement the initial research:

- Coordinate with the OBOH to help identify up to four properties with failing on-site sewage disposal systems that are candidates for the demonstration project.
- Research and coordinate with the Barnstable County Department of Health and Environment (BCDHE) relative to LSTA design and specifications;
- Coordinate with the OBOH and Barnstable County Department of Health and Environment (BCDHE) relative to the application for grant monies for financial assistance in implementing the LSTA Demonstration Projects;
- Prepare and file an application with Mass DEP for Piloting Approval for each of the LSTA Demonstration Project sites;
- Apply to the OBOH for approval of each installation; and
- Prepare and file a Disposal Works Construction Permit for each site with the OBOH.

The BCDHE is in the process of implementing several demonstration projects on Cape Cod and additional performance and design data is expected to be available in the spring of 2017.

D. Program Status

AECOM has been meeting and coordinating with the Orleans Health Agent to identify up to four sites that would be candidates for implementing a LSTA demonstration project as an integral part of a sewage disposal system upgrade. On 12/22/16, 1/11/17, and 3/28/17, Martin R. Donoghue P.E. of AECOM met with Robert Canning, the Orleans Health Agent, in order to review candidate sites for implementing a demonstration project. An initial review of a list of properties that had recently filed with the Board of Health for a Disposal Works Construction Permit for approval to install a sewage disposal system, or sewage disposal system component(s) was completed.

At the January 11, 2017 meeting between AECOM and the Orleans Health Agent, the following criteria were used for an initial review of the list of properties and to identify sites that may qualify for participation in the program.

- The property needed to be outside of the proposed Downtown Orleans and Meetinghouse area sewer service area.
- The property needed to be located outside of a Zone 2 of a public water supply well or not located within a Nitrogen Sensitive Area. (as defined under State regulations).
- The level of Groundwater, or potential high groundwater, identified in the soil evaluation data on the sewage disposal system design plan needed to be greater than nine feet below the ground surface at the site of the soil absorption area.
- The system had not already been installed or the Disposal Works Construction Permit was for a minor repair of the system.

On February 28, 2017, the Orleans Health sent letters to six candidate property owners inquiring if they were interested in participating in the program.

At a March 28, 2017, meeting between AECOM and the Orleans Health Agent, more recent Disposal Works Construction Permit Applications were reviewed to identify additional potential demonstration project sites. As a result of the review, three additional sites were identified. The Orleans Board of Health will be sending letters of interest to the owners of the three identified candidate properties.

When a property owner responds that they are interested in participating in the program, the following criteria will be used to help choose the candidate sites:

- The sewage disposal system that serves the facility shall be considered failed under State and local regulations (310 CMR 15.303, and Chapter 185, Article III, §185-17.2 Definitions, of the Orleans Board of Health Regulations;
- There is no proposed increase in the number of bedrooms or the sewage flow from the facility that will be served by the sewage disposal system upgrade;
- The sewage disposal system will not need variances from the required groundwater separation requirements under local and state regulations;
- The proposed sewage disposal system upgrade site will be greater than 100' from wetlands as identified under the MA Wetlands Protection Act and the Orleans Wetlands Protection By-Law;
- The proposed site will be located outside of a FEMA mapped 100 year flood zone;
- The property has sufficient area to install the sewage disposal system upgrade without dimensional variances from Title 5;
- The site and property owner comply with the requirements of the Approval Letter issued by MassDEP for Piloting of the Non Traditional technology; and
- The property owner agrees in writing to allow access to the site for sampling and monitoring purposes.

On January 6, 2017 Martin R. Donoghue, P.E., of AECOM, met with George Heufelder, Director of the Barnstable County Department of Health and Environment (BCDHE) in order to review the status of BCDHE efforts to install LSTA and review the design and permitting requirements for implementation of a LSTA demonstration site. The following is a summary of the meeting:

- At the time of the meeting, the BCDHE had one site in the ground and four to six sites in the cue. Two are in Westport. Two are on Martha's Vineyard. One has been permitted and one is in design in Falmouth.

- Presently the LSTA specifications are included on the design plans. The BCDHE is working with the University of Rhode Island to prepare a LSTA design manual.
- Mr. Heufelder is working with Dan Ottenheimer of Oakson relative to using a Perc-Rite drip dispersal system as an alternative LSTA dosing method.
- Mr. Heufelder was concerned about quality assurance for system monitoring and sampling. He recommended having BCDHE perform the system sampling. At a minimum he would like to have the samples processed at the BCDHE Laboratory.
- Using a drip pan lysimeter for collecting effluent samples was discussed. Typically a relief hole is provided in the sampling chamber below the drip pan so that effluent does not back up. For sampling, the chamber is purged the day before sampling so that the effluent collected in the chamber is fresh. Mr. Heufelder is still working out the details of what works best. Mr. Heufelder was assured that AECOM would follow the BCDHE protocol for sampling.
- Mr. Heufelder will provide AECOM with a sample plan and permit application. He also has some CAD details that AECOM can use.
- BCDHE has been using George Bothello from Falmouth for installation of the LSTA systems. He suggested using F.L. Quinn Construction, a local Orleans contractor, for the demonstration project implementation in Orleans.
- Mr. Heufelder warned that AECOM may be a target for suppliers of similar technology. Since BCDHE's work is for research, they do not need to be concerned.
- Performance data from LSTA systems will soon be posted on the BCDHE website.
- Mr. Heufelder stated that staying away from groundwater was an important consideration in design of the systems. He recommended a minimum nine foot separation between the surface and High Groundwater elevation at the site of the LSTA.
- BCDHE is sampling the systems monthly for two years. They have been experimenting with using a vacuum to help with sampling. The vacuum can break the pausing of the effluent at the soil textural interface above the drip pan lysimeter. They are still experimenting with the sampling methodology.

E. Site Specific Assessment for Preliminary Design

Site specific conditions will be taken into consideration for the preliminary design of the LSTA demonstration projects. Sewage flows, soil conditions, groundwater elevations, available undeveloped site area, and other site specific conditions will be used as a basis for the preliminary design of the demonstration projects.

F. Preliminary Design

1) Site Configuration

The system configuration will be site specific and will be determined once the candidate sites have been chosen.

2) Project Components

- Septic Tank - The existing septic tank, if possible, will be utilized in the design of the sewage disposal system upgrade. If the existing septic tank is found to be structurally sound and meets code requirements relative to tank capacity, it may be retained for the upgrade. New inlet and outlet tees, and a gas baffle, may need to be fitted to the tank. If it is determined that a new septic tank is required, the precast concrete tank will be sized in accordance with code requirements. If determined appropriate for the design, a two compartment tank may be utilized. The second compartment would be used as a dosing tank for the low pressure distribution system.

- Dosing Tank – If not incorporated into the design of a new septic tank, a separate precast concrete tank will be required for the placement of a pump(s) for the low pressure dosing of the soil absorption area. The tank will house the pump(s) and control floats. The pumps will be installed with a timed dose control system in order to meter the effluent flow to the LSTA. Drip dispersal systems may also be employed as an alternate method of dosing the LSTA.
- Soil Absorption Area and Nitrogen Reducing Biofilter – The soil absorption area will be designed to incorporate an LSTA into the system. A typical residential soil absorption area is constructed with ¾" to 1-1/2" stone and is gravity dosed. The soil absorption area that includes an LSTA is comprised of a sand based "nitrification layer" underlain by a "denitrification layer" of sand mixed with finely ground wood. The system is installed following a standard septic tank and pump chamber that intermittently doses a low pressure distribution system that includes a GeoMat system above the sand layer to ensure even distribution of the effluent over the entire soil absorption area. A drip dispersal system may also be used for effluent dosing.
- Monitor Wells – Monitor wells will be installed up gradient and down gradient from the LSTA site in order to determine groundwater flow direction and baseline groundwater quality information. The wells will also be used for sampling the groundwater over a period of five years from when the system is put into service.

3) Sequencing of Subtasks

To continue the implementation the LSTA demonstration projects, the following tasks will be undertaken:

- Coordinate with property owners, the OBOH, and the BCDHE;
- Preliminary design for siting of the proposed demonstration projects;
- Topographic survey of the area of the proposed sewage disposal system upgrade and LSTA sites;
- Premark the work area for Dig Safe and contact Dig Safe for utility marking;
- Completion of the required soil evaluations at the site of the proposed Soil Absorption Systems;
- Prepare Soil Evaluation Reports and file the reports with the OBOH;
- Install monitor wells for water quality testing and to determine groundwater flow direction;
- Design of the sewage disposal system upgrades that include an LSTA component;
- Meet with BCDE to review the details of the LSTA system designs;
- Design and CAD drafting services for plan preparation;
- Professional oversight and plan certification;
- Prepare and file permit applications for OBH and MassDEP approval, and
- Implement the LSTA demonstration project.
- Perform construction inspections and system certification.

4) Labor resources needed to implement the LSTA demonstration project:

Construction activities will be managed to limit disturbance to the project site and surrounding properties. A licensed firm, including an equipment operator and laborer(s) will be required for the LSTA system installation. The implementation of the system will need to be inspected by the design engineer during installation.

5) Issues considered during preliminary design:

- What is the sewage flow for the installations;
- Is there sufficient area for installation of the soil absorption area;
- What relief, if any, will be required from local and state health regulations; and
- What are the soil and groundwater conditions.

5. Monitoring and Maintenance

A. General

The specific objective of this study is to evaluate the effectiveness the LSTA demonstration projects in reducing the amount of nitrogen discharged to the environment. The monitoring and maintenance plan will include the following:

- Quarterly septic tank effluent and monitor well sampling and sample testing for a period of five years from the date of implementation of the systems;
- Quarterly measure temperature and pH of the septic tank effluent;
- Review test results and prepare an annual report on the performance of the systems;
- Attend an annual meeting with the Orleans BOH to report on the performance of the Demonstration Sites; and
- Any other testing required by the OBOH or the MassDEP Piloting Approval.

B. Water Quality Analysis

Water quality will be sampled using grab samples that are then sent to the BCDHE laboratory for analysis. Testing and monitoring will be in compliance with BCDHE protocols, and MassDEP requirements.

Effluent grab samples will be taken at monthly intervals. Grab samples will be taken from a drip pan lysimeter installed under the soil absorption area. The pH of the effluent will be recorded and the samples will then be sent to the BCDHE laboratory for analysis of the following constituents: total N, BOD5 TSS and NO3 or as required by the MassDEP Piloting Approval letter and BCDHE.

Grab samples will be taken from the monitor wells and tested for total N and N03, or as required by the MassDEP Piloting Approval letter and BCDHE.

C. Maintenance Requirements

Visual inspection of each LSTA site will occur on a quarterly basis. The main purpose of the maintenance inspections will be to confirm that the system is functioning as intended and to document any changes to the system or discharges to the surface. Maintenance activities will include the following:

- Inspect the site around the soil absorption area for signs or breakout of effluent to the surface;
- Measure the depth of ponding within the soil absorption area at the soil absorption area inspection port;
- Test the pump system alarm and log the reading on the pump run meter; and
- Perform the required effluent and groundwater sampling.

6. Project Cost Estimate

The estimated cost of the LSTA is approximately $30,000 per demonstration site. The cost estimate is based on the conceptual design, does not include maintenance and monitoring, and will be refined after additional engineering analyses are conducted. The cost estimate includes the following elements:

- Planning;
- System Design;
- Permitting; and
- Implementation.

7. Regulatory Considerations

The LSTA Demonstration Project would require the approval of the Orleans Board of Health and Piloting Approval from MassDEP for each demonstration site. In addition, a Disposal Works Construction Permit will be required from the OBOH for the implementation of the demonstration projects. After completion of the system, the designer will need to certify that the installation is in conformance with the design plans and specifications. After inspection of the system installation by an agent of the Board of Health and receipt of the certification from the designer, the OBOH will issue a Certificate of Compliance for the system.

8. Potential Funding Sources

Deliverables include an evaluation of general funding mechanisms for the overall wastewater management project, including options such as SRF funding, MassDEP 604b/319 grants, and USDA rural development grants.

Potential funding sources available specifically for Layered Soil Treatment Areas were researched. Availability of these funding sources would be dependent on a successful application process, and also on application submittal deadlines as compared to the LSTA DP schedule.

The potential funding sources and websites with additional information on each funding opportunity are listed in Table 1.

Table 1 - Potential Funding Sources for Nitrogen Reducing Biofilter Demonstration Projects

Grant Title	Website
MA Governors Budget Funds for Septic System Alternative Technology – Cape Cod Water Protection Collaborative	http://www.ccwpc.org/
604(b) Water Quality Management Planning Grant USEPA and MassDEP	http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#2
319 Nonpoint Source Competitive Grant Program USEPA and MassDEP	http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#3

9. Summary and Next Steps

Based on research and monitoring of in the ground installations, LSTA systems can reduce the amount of nitrogen entering the environment. The results from test sites recently implemented by the Barnstable County Department of Health and Environment will help provide guidance for the design of the demonstration projects. The implementation and monitoring of LSTA demonstration sites will provide valuable data and, if proven successful, become another tool in the nitrogen reduction toolbox.

The next step before implementation of the LSTA demonstration projects is to review and choose up to four candidate sites for implementing and LSTA system. When the sites have been chosen, the systems will need to be designed, permitted and implemented

10. References

Stony Brook University, June 2016. Nitrogen Removing Biofilters for Onsite Wastewater Treatment on Long Island: Current and Future Prospects. The New York State Center for Clean Water Technology.

Barnstable County Department of Health and Environment (Heufelder), 2016. Does Sawdust Have a Role In Saving Cape Cod's Bays?

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