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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 8 - NT Demonstration Projects** **Deliverable 8.1.2.A – Draft Nitrogen Reducing Barriers Feasibility**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	October 6, 2016

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. As discussed in further detail below in Section 2c, 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.

The resulting map entitled "Conceptual Approach to Meet Orleans Water Quality Goals (March 2015)" shows the agreed upon water quality management plan. Since the preparation of the map, Nitrogen Reducing Barriers (NRBs) were included in the toolbox of NT technologies that would be implemented in order to achieve water quality goals. The locations of the NRB demonstration sites have not yet been identified.

This Technical Memorandum outlines the proposed Site Characterization Evaluation and Work Plan for determining the feasibility of NRBs.

2. Goals and Objectives of NRB Demonstration Project

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

- Reduce nitrogen discharge to the environment at its source;
- Determine if an NRB 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 NRB demonstration project are to:

- Realize associated ecological and socioeconomic benefits;
- Install the NRBs as an integral component of an upgraded sewage disposal system;
- Monitor the performance of the NRBs to reduce nitrogen discharged to groundwater; and
- Evaluate uncertainties associated with the local climate and environmental conditions;
- Infer quantitative decisions about the value of NRBs 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 NRBs 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 will be based on coordination between AECOM and the Orleans BOH in order to identify up to four potential demonstration sites;
- Next 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 NRB 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 NRB 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 Nitrogen Reducing Biofilter Design Features

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

The NRB is implemented following a conventional septic tank. 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. The NRB is incorporated into the design of the soil absorption field. As Septic tank effluent passes through the Soil treatment area the nitrogen in the system effluent is reduced.

The following core design principals that will be followed in the design of the NRBs are to:

- Utilize natural treatment technologies where possible;
- Minimize energy use and mechanical system complexity;
- Incorporate the NRBs 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.

NRBs 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. NRBs remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, NRBs have shown an ability to achieve a high percentage of nitrogen removal (up to 90%), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a NRB 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 (O2) rich sand layer; and (2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O2-limited sand plus lignocellulose (wood chips or sawdust) layer.

The NRB will be constructed as a horizontal later in a multi layered soil Absorption field system.

C. Proposed Site Identification Methodology

AECOM will coordinate with the Orleans Health Agent to identify up to four sites that would be candidates for installing an NRB as an integral part of a sewage disposal system upgrade. 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 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;

- 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 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. NRB Work Plan

A. Purpose

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

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

1) Recommended Site Location

AECOM will coordinate with the Orleans Health Agent to identify up to four sites that would be candidates for installing an NRB as an integral part of a sewage disposal system upgrade. 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.

2) NRB Attributes

NRBs 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. NRBs remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, NRBs have shown an ability to achieve a high percentage of nitrogen removal (up to 90%), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a NRB 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 (O2) rich sand layer, followed by 2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O2-limited sand plus lignocellulose (wood chips or sawdust) layer.

Under certain conditions, NRB 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 NRBs 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 the soil absorption area, no complex mechanical components are required for the NRB system.

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

To implement the NRB 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 NRB 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 NRB Demonstration Projects:

- Prepare and file an application with Mass DEP for Piloting Approval for each of the NRB Demonstration Project sites;
- Apply to the OBOH for approval of each installation;
- Prepare and file Disposal Works Construction Permits 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.

B. Site Specific Assessment for Preliminary Design

Site specific conditions will be used for the preliminary design of the NRB 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.

C. Preliminary Design

1) Site Configuration

The site configuration 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 soil absorption area.

- Soil Absorption Area and Nitrogen Reducing Biofilter – The soil absorption area will be designed to incorporate an NRB into the system. A typical residential soil absorption area is constructed with ¾" to 1-1/2" stone that is gravity dosed. The soil absorption area that includes an NRB 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.

- Monitor Wells – Monitor wells will be installed in order to determine groundwater flow direction and baseline groundwater quality information, as well as for sampling the groundwater over a period of five years from when the system is put into service.

3) Sequencing of Subtasks

To implement the NRB 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 NRB sites;
- Premark the work area for Dig Safe and contact Dig Safe for utility marking;
- Completion of 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 NRB;
- Meet with BCDE to review the details of the NRB system designs;
- CAD drafting services for plan preparation;
- Professional oversight and plan certification;
- Prepare and file applications for OBH and MassDEP approval, and
- Implement the NRB demonstration project.

4) Labor resources needed to implement the NRB 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 NRB 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
- Soil and groundwater conditions.

5. Monitoring and Maintenance

A. General

The specific objective of this study is to evaluate the effectiveness the NRB 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 a lab for analysis.

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 a qualified lab for analysis of the following constituents: total N, BOD_5 TSS and NO_3 or as required by the MassDEP Piloting Approval letter.

Grab samples will be taken from the monitor wells and tested for total N and $N0_{3,}$ or as required by the MassDEP Piloting Approval letter.

C. Maintenance Requirements

Visual inspection of the NRBs 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 NRBs 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;
- Implementation;
- Maintenance (not included); and
- Monitoring – Lab and In-Situ (not included).

7. Regulatory Considerations

The NRB 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.

8. Potential Funding Sources

Deliverables developed under Task 5 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.

In addition to the funding sources discussed as part of Task 5, potential funding sources available specifically for Nitrogen Reducing Biofilters 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 NRB DP schedule. Deadlines for many grants have passed or are imminent for the current calendar year, although submitting an application for a 2017 project might be feasible.

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
US EPA Coastal Watershed Grants- Association to Preserve Cape Cod.	http://www.capecod.com/newscenter/coastal-watershed-grants-from-epa-to-benefit-4-cape-projects/ http://www.apcc.org/
MA Governors Budget Funds for Septic System Alternative Technology – Cape Cod 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

The next step recommended before implementation of the NRB demonstration project is to conduct additional research regarding potential nitrogen removal rates that can be achieved by NRBs and design specifications. 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 project.

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?