Water Quality and Wastewater Planning

Preliminary Amended Comprehensive Wastewater Management Plan

Prepared For:

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1.0 Executive Summary

The Town of Orleans is continuing to build on efforts to improve water quality in its coastal estuaries and freshwater ponds by amending the previous Comprehensive Wastewater Management Plan (CWMP) based on additional studies, wastewater engineering and planning decisions that have occurred since publication of the CWMP/Environmental Impact Report in 2010 (Wright-Pierce, 2010). Since the CWMP was approved in 2011, the Town has allocated funds each year through the Town meeting process in order to advance the planning and implementation of agreed upon solutions and projects. Input gathered from stakeholders over the years has produced a range of information, suggestions and opinions regarding types and quantities of Traditional sewering technologies to use and where they would be most appropriate and effective. In addition, these discussions have identified the potential for using additional Non-Traditional technologies mentioned but not developed in the 2010 Plan, and further expanded upon during subsequent planning efforts, including the use of Permeable Reactive Barriers, floating constructed wetlands, shellfish aquaculture/coastal habitat restoration, and on-site Innovation Alternative systems including Nitrogen Reducing Biofilters to reduce nitrogen loads to receiving waters. Several boards, subcommittees and working groups have been formed, and have met over the years with various consulting firms to guide the process, in order to achieve consensus on a plan that would be approved by residents. Much progress has been made since 2011, and this document reflects the modifications that have been made to the CWMP since 2010.

The Orleans Water Quality Advisory Panel (OWQAP) was formed in 2014 in order to:

- Consolidate the information being provided to the Town through the various studies being performed;
- Provide a forum for obtaining information, advice, and opinion from the businesses, residents and advocacy groups of the town;
- Assist in reporting to the broader voting public on the results to date and plans for future actions with respect to water quality and wastewater planning; and
- Achieve consensus upon which the water quality and wastewater management plan may move forward.

In 2015, this process resulted in a Consensus Agreement, including a hybrid approach combining both Traditional and Non-Traditional nutrient management technologies. The agreement led to development of a plan for implementation. This plan continues to be refined to reflect the current status of planning and implementing water quality and wastewater management in the Town.

The technologies (both traditional and non-traditional) proposed in the 2015 Consensus Agreement to remove target nitrogen load in each watershed to meet Massachusetts Estuaries Project requirements are summarized in Section 2. Also shown are any modifications made in proposed technologies since 2015 as a result of ongoing engineering studies. As the preliminary design work proceeds through spring 2017, the proposed plan and associated reductions in watershed nitrogen loads will be confirmed.

Facilities Engineering

Conceptual design tasks were done that advanced the traditional engineering tasks pertaining to discharge sites, facilities (wastewater treatment and disposal), Downtown Area planning, Tri-Town Septage Treatment Facility transitioning, and cost estimates. Two areas were identified for traditional sewering: Downtown and Meetinghouse Pond.

Downtown planning tasks were undertaken to develop a Town Center (business districts and some residential lots along the Route 6A and Old Colony Road corridors) plan appropriate for the more densely developed commercial and mixed use areas of the Town. An updated build-out analysis and study of land use, market conditions and development constraints were performed, along with projection of future growth scenarios and their implications for management of Downtown Area wastewater flows and biosolids. As part of the Downtown evaluation, verification of existing flows was completed using actual water records from a two year period between 2014 and 2015, which indicated that flows were higher than originally believed.

Several build-out scenarios were developed. Two Downtown Planning Workshops were held in winter 2016 to gain citizen input and gain consensus that the future needs of the Town are best met under the future build-out scenario which reflects higher residential density in the Village Center. Recommendations for zoning and regulatory changes required to achieve the strategies and objectives of the scenario were also identified.

Two new wastewater treatment facilities are proposed: a 250,000 gpd wastewater treatment facility at Overland Way, the site of the existing Tri-Town Septage Treatment Facility, and an 110,000 gpd wastewater treatment facility at a site to be determined in Meetinghouse Pond service area. Treated effluent from the Overland Way site is proposed to be discharge to groundwater at Site 1/1A, located at the existing Tri-Town Septage Treatment Facility and/or at one of four to five alternative sites located in the Downtown Area. The discharge of treated effluent from the wastewater treatment facility serving the Meetinghouse Pond Area would be at 223 Beach Road.

The conceptual sizing and layout of the collection systems were completed after a preliminary evaluation and screening process which included site suitability, as well as environmental, financial, maintenance and other considerations. Conceptual system layouts and costs were developed for both the Downtown and Meetinghouse Areas. Based on these evaluations a "hybrid" wastewater collection system consisting of both gravity and low pressure components was recommended for both areas. More detailed information, including survey and geotechnical data, is being collected as part of the preliminary design work for the Downtown Area and will allow for a more detailed evaluation of possible alternatives for the collection system and for final recommendations. Preliminary design of the Meetinghouse Pond Area will occur in a later phase of project development.

Wastewater flows and residuals/septage treatments were evaluated based on anticipated volumes for each area. For the Downtown Area, four modular membrane bioreactor treatment trains were recommended initially with accommodations for a fifth to be added in the future. The number and potential phasing of units will be confirmed as part of preliminary design as future flows and phasing of the collection system is confirmed. For Meetinghouse Pond Area, two membrane bioreactor treatment trains would be needed. Capital, operation and maintenance, replacement and monitoring costs of the systems are included in the cost estimates.

Advantages and disadvantages of water reuse systems were identified as were potential sites for possible use in Orleans. The incorporation of a reclaimed water system at the proposed WWTF site would increase the capital, operation and maintenance, replacement and monitoring costs at the WWTF. Additionally, because there are no large scale users of irrigation water in immediate proximity to the proposed WWTF site, there is considerable capital expense associated with a distribution system to bring reclaimed water to potential points of use. Lastly, there is some uncertainty on whether or not some of the identified points of use would be viable due to watershed concerns and/or public perception issues.

At a time when implementation of different elements of the Town's Water Quality and Wastewater Program is subject to limited revenues, it is not recommended that water reclamation not be included in the Program at this time. The currently recommended treatment process for the proposed Overland Way WWTF lends itself well to being modified for water reclamation in the future should water reclamation prove to be more viable at a later date, but items such as storage, color treatment, and most importantly a distribution system are not recommended at this time.

Tri-Town Septage Treatment Facility Transition Requirements

The existing Tri-Town Septage Treatment Facility has reached the end of its useful life and the Board of Managers voted not to fund interim improvements and to cease receipt of septage on June 1, 2016 due to concerns about staff departures and aging equipment that might fail leading to more expensive repairs. AECOM has estimated costs to decommission and demolish the existing facility, and at the request of the Town prepared design plans and specifications to allow for decommissioning and demolition. Decommissioning is complete and demolition bids will be in hand in sufficient time to approve at the May 2017 Town Meeting.

Non-Traditional Technologies

The Non-Traditional technologies proposed in the Consent Agreement included Shellfish Aquaculture, Permeable Reactive Barriers, and Floating Constructed Wetlands. Shellfish aquaculture is a first step in coastal habitat restoration and thus attention is being given to locations for shellfish aquaculture demonstration projects. During the evaluation process it was determined that, there is insufficient data available to verify the effectiveness of Floating Constructed Wetlands for nitrogen removal in estuarine environments; thus this technology is not further considered for implementation in the estuaries and embayments. However, Floating Constructed Wetlands will be considered as a potential remediation technology in the freshwater ponds of Orleans which are proposed to be evaluated in greater detail in the winter and spring of 2017. A replacement non-traditional technology to address nitrogen reduction in the embayments and estuaries is an Innovative Alternative Technology for on-lot systems. The technology called Nitrogen Reducing Biofilters is proposed to be piloted on several lots in Orleans.

The three selected Non-Traditional technologies are being implemented initially in relatively small-scale demonstration projects in order to determine overall feasibility, siting issues, specific rates of nitrogen removal and other critical information. This information will then be utilized in determining engineering details for full-scale implementation meeting nitrogen removal goals that meet TMDL requirements. The information will also be used to compare costs for implementation of Non-Traditional versus Traditional technologies; as well as to assess overall acceptance of these technologies by abutters. Several potential sites were or are being reviewed and ranked for each type of Non-Traditional technology in site selection processes with a goal of demonstration project success, including for the monitoring program to be able to quantify nitrogen removal and water body impacts.

Shellfish/Aquaculture

Four shellfish demonstration projects have been developed and are now in various states of implementation. These projects are listed below, and additional detail on each of these demonstration projects follows:

- Oysters in floating bags have been installed at Lonnie's Pond;
- A quahog population survey and consideration for additional quahog propagation in Town Cove is on schedule for implementation in the late 2016 and early 2017;
- A demonstration project of oyster bed planting is planned for Kent's Point (in place of Quanset Pond due to concerns about predators and sedimentation); and
- Efforts to work closely with existing aquaculture growers in Pleasant are underway.

A total of 200,000 larger oysters (1 and 2-inch) were deployed in floating bags in Lonnie's Pond in June 2016. Baseline water quality monitoring was performed by SMAST prior to deployment, and a monitoring program designed to determine the nitrogen removal rates is currently on-going. The data will be compiled during the winter of 2016 and 2017 a report will be prepared that will enable the determination of the engineering parameters required for full-scale implementation using oysters to meet TMDL limits.

Prior to implementing any additional quahog propagation efforts in Town Cove, a baseline determination and assessment of the existing quahog population needs to be done by conducting a shellfish survey. Working with the Town Department of Natural Resources staff, the appropriate areas for survey work will be determined, and the survey will, be performed during early 2017. It is estimated that 10 acres will be surveyed, beginning with the area near the Orleans Yacht Club. Additional funding will be requested at the spring 2017 Town Meeting to facilitate planting an additional 100,000 quahogs.

Plans to install an oyster bed demonstration project in Quanset Pond were reevaluated in the summer of 2016 due to concerns about predation and sedimentation that would threaten the oysters. A number of sites were evaluated and a location just offshore of Kent's Point was selected by the Shellfish Working Group. Oyster bed installation will begin with growing remote set oysters in trays and/or floating bags for an initial growing period (likely eight weeks) and then bottom planting them in the same area. The plan for 2017 involves developing a scope of work for baseline water quality monitoring and initiating water quality monitoring within the proposed growing area. In addition, an engineering design for a 2017 installation will be prepared.

The Little Pleasant Bay demonstration project includes three components: developing and disseminating a questionnaire to determine whether growers are interested in working with the Town to expand shellfish propagation for the purpose of water quality improvements; working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate; and evaluating areas in Town Cove for expansion of shellfish leases. In late 2016 the survey will be developed and disseminated, with results compiled and discussed with the Shellfish Working Group.

Permeable Reactive Barriers

Permeable Reactive Barriers will provide data to assess the effectiveness and applicability of this technology as a viable alternative for the Town to use in the nitrogen reduction efforts. Eight sites were evaluated and ranked to determine potential for Permeable Reactive Barrier demonstration project and monitoring success. Results of the evaluation ranking narrowed the list to four potential sites; Main Street and Tonset Road; South Orleans Road at Tonset/Eldredge Park Way ; Town Cove Gibson Road; and at the Town Landfill. A groundwater investigation was completed at all four sites in 2016 to further assist in site selection. The prioritized list of two recommended sites was proposed as Eldredge Park Way and Town Landfill.

The Permeable Reactive Barrier demonstration project at Eldredge Park Way was initiated in summer and early fall 2016 with the installation of injection and monitoring wells and injection of emulsified vegetable oil. Monitoring of the Permeable Reactive Barrier will continue throughout the fall of 2016 and early winter of 2017. Data collected will include the lateral and vertical movement of the emulsified vegetable oil through the ground, the extent of nitrogen reduction in the groundwater, and the migration path location of the groundwater plume. The results of the monitoring will provide the data necessary to detail the full-scale design parameters required to meet TMDL goals for nitrogen remediation in the receiving waters in combination with other technologies being employed in the watershed.

A second permeable reactive barrier demonstration project is being considered for the landfill to remediate nitrate as well as 1,4 dioxane. Groundwater data has been collected to confirm nitrogen levels as well as 1,4 dioxane, and contaminate discharged from the landfill. Changes by MassDEP in reporting concentrations have raised the presence of 1,4 dioxane as a serious concern to the Town. Field investigations are proposed. They will include groundwater monitoring upstream and downstream of the landfill to confirm concentration and flow path of the 1,4 dioxane. Groundwater data will be obtained during the winter of 2016 and recommendations as to the appropriateness of a permeable reactive barrier to control the nitrate and the 1,4 dioxane will be developed. Regardless, the Town is proceeding to investigate connecting downstream properties to public water supply.

Nitrogen Reducing Biofilters

Nitrogen reducing biofilters was evaluated and selected as a non-traditional technology that would reduce nitrogen load from on-site sewage disposal systems. The system is effectively an Innovative Alternative for septic systems to reduce nitrogen concentrations from wastewater discharge. The system consists of a horizontal layer of sandy soils overlying a layer of sand mixed with finely ground wood that is dosed with septic tank effluent using a low pressure system. The technology has been initially piloted at the Barnstable County Test Center and site specific testing at individual lots was determined to be warranted.

A site characterization and evaluation technical memorandum was prepared in the fall of 2016 and it was recommended that up to four sites be considered for demonstration in 2017 in Orleans. The team will work with the Orleans Board of Health to screen potential sites and select up to four sites for implementation. Design documents will be prepared with collaboration with the Barnstable County Department of Health and Environment. A monitoring program will be developed to provide information on installation and subsequent water quality effects.

Adaptive Management Plan

The Adaptive Management Plan was initially described in the 2010 CWMP/Environmental Impact Report and identified and explained that the Town's approach to managing wastewater and stormwater would be evaluated for effectiveness based on water quality monitoring, nitrogen removal effectiveness and updates to the Massachusetts Estuaries Project. Because the Town is now planning to implement a hybrid approach utilizing both Traditional and Non-Traditional technologies, a more robust adaptive management plan has been developed. The updated Adaptive Management Plan includes monitoring of baseline and operational monitoring of the demonstration projects, expanded monitoring of the Pleasant Bay and Nauset Estuary systems, and remodeling of portions of the Massachusetts Estuaries Project model. The adaptive management plan will continue to take into account cost, environmental impact considerations, and acceptability to the residents and businesses of Orleans. The Adaptive Management Plan represents the tool to allow for continued refinement of the water quality and wastewater management plan to optimize the individual components of the plan (specific type, size, and location of control technologies) to contribute to cost effective achievement of nutrient reduction goals.

The update to the Adaptive Management Plan involved assembling existing water quality data into a single database and comparing and contrasting the data to determine data gaps and to recommend additional monitoring required to meet future monitoring goals. Once the data were assembled, trends were identified for each parameter as applicable. Based on data results, water quality stations were then assigned to one of three action items: confirm system health, determine why inconsistent, or treat as impaired. The baseline data review concluded with recommendations for improving the long-term monitoring program going forward. Additional studies were recommended to fully understand the cause of the anomalies in trends for some parameters. Responsible parties and next steps are identified. As new data become available, the selected technologies to address nitrate reduction in each watershed will be modified as needed to adjust type, size, design, and location of recommended technologies. The Massachusetts Estuaries Project model and studies were evaluated, and it was determined that due to changes in conditions that the model is based on (updated water usage rate, the 2007 breach at Nauset Beach, additional water quality data available, and need for updating land use and watershed boundary mapping, etc.) it is appropriate to recommend an update to both the model as well as the studies for both Nauset Harbor and Pleasant Bay.

There are several actions underway regarding stormwater and fertilizer management to protect water resources. AMEC Foster Wheeler will be providing a dynamic planning tool that will provide information needed to design and install stormwater Best Management Practices to provide benefits to water quality as well as drainage volume. The NPDES Phase II Small MS4 General Permit requires that Towns address the contribution of pollutants in stormwater discharged to municipal systems. The Town's Annual MS4 Report to EPA in April 2016 states that the Town is using resources to develop a Stormwater Management Plan. Several key activities were listed in the annual report. The stormwater planning tool that is soon to be completed will facilitate identification of measures to reduce nutrients in stormwater runoff where appropriate, and these will be incorporated into the Stormwater Management Plan.

The Town continues to implement Best Management Practices (to reduce the use of fertilizers and pesticides after passing a Fertilizer Nitrogen Control bylaw at the April 2014 Annual Town Meeting. The Orleans Pond Coalition implemented a public education campaign in 2015 to inform residents and businesses about the proper use of and alternatives to fertilizers, and provide brochures about fertilizer and pesticide use at Town Hall. In 2015, SMAST partnered with the Town to update the previous 2005 study on nitrogen loading from lawn fertilizer, and the results of the investigation were issued in early 2016. Additionally, SMAST updated the fertilizer model inputs based on the assessment of the 260 parcels that have been developed in Orleans since the original Massachusetts Estuaries Project model runs.

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2.0 Background and Purpose of Amended Comprehensive Wastewater Management Plan (ACWMP)

2.1 Background

The Town of Orleans (Town) prepared a Comprehensive Wastewater Management Plan (CWMP) and Single Environmental Impact Report in December 2010. The 2010 CWMP/Environmental Impact Report proposed a new centralized sewer system to reduce nitrogen loads to coastal bays and estuaries in Orleans. Major watersheds evaluated in the 2010 CWMP/Environmental Impact report included Pleasant Bay, Nauset Harbor, and Cape Cod Bay as well as sub-watersheds identified by the Massachusetts Estuaries Project for Pleasant and Cape Code Bays.

The 2010 proposal included 74 miles of new sewer, 63 sewer pump stations, and a new wastewater treatment and groundwater disposal facility at the existing Tri-Town Septage Treatment Facility site, which would have treated up to 0.64 million gallons per day of wastewater. In addition, the 2010 CWMP/Environmental Impact Report identified non-structural controls to further reduce nitrogen loading, including fertilizer use controls, stormwater management, land use controls, water conservation, and enhanced embayment flushing.

The Cape Cod Commission held a joint hearing with the Massachusetts Environmental Policy Act staff on January 18, 2011 on the Environmental Impact Report, and the Cape Cod Commission voted to submit comments to the Massachusetts Executive Office of Energy and Environmental Affairs for Massachusetts Policy Act review. On January 28, 2011, the Executive Office of Energy and Environmental Affairs issued a Certificate on the revised CWMP /Environmental Impact Report (Appendix A) stating that the project complied with the Massachusetts Environmental Policy Act, which started the clock for the Cape Cod Commission to hold a public hearing to review the project within 45 days of the certification. Several hearings were held, between March 1, through October 13, 2011 when the full Cape Cod Commission voted unanimously to approve the project and issued an approval for the project as a Development of Regional Impact with conditions (Appendix B).

The Orleans CWMP Development of Regional Impact approval included conditions regarding the potential of operating the Orleans Wastewater Treatment Facility as a shared municipal facility, but also allowed Orleans to proceed with a single town facility if no agreement with the other Towns could be reached. The Development of Regional Impact decision also capped the amount of assimilative capacity in the Nauset Marsh system that Orleans could use through the Wastewater Treatment Facility discharge.

Since the CWMP was approved in 2011, the Town has allocated funds each year through the Town meeting process in order to advance the planning and implementation of agreed upon solutions and projects. Input from stakeholders has produced a range of information, suggestions and opinions regarding types and quantities of Traditional sewering technologies to use and where they would be most appropriate and effective. In addition, these discussions have identified the potential for using Non-Traditional technologies to reduce nitrogen loads to receiving waters, and evaluated types and locations of Non-Traditional technologies. Several boards, subcommittees and working groups have met over the years with consulting firms to achieve consensus on a plan that would be approved by the Town.

2.2 Cape Cod Commission 208 Plan Update Recommendations

In 2013, due to the impairment of water quality in coastal waters as a result of excess nitrogen, MassDEP directed the Cape Cod Commission to develop an update to the 1978 Water Quality Management Plan for the region in accordance with Section 208 of the federal Clean Water Act. The Cape Cod Commission issued the updated plan, and it was approved by MassDEP and US EPA in 2015. The 208 Plan Update identified a number of recommendations to improve water quality in coastal waters surrounding Cape Cod, which are designated into one of four categories: Information; Regulatory Reform; Support; or Cost. The full list of the recommendations is provided in Appendix C. The Information recommendations included a number of items regarding improvement of water quality monitoring and data management, implementation of Non-Traditional Technology, and evaluation of septage processing demands. The Regulatory Reform recommendations focused on the need for revisions to Cape Cod Commission and MassDEP procedures and guidelines for preparing and reviewing watershed management plans. The 208

Support recommendations recognized that communities needed additional tools and technical expertise from the Cape Cod Commission and recommended that the Commission provide additional guidance and resources to local planning efforts to assist in planning and implementing nitrogen reduction measures, including assistance with stakeholder consensus building. Finally, Cost category identified numerous recommendations regarding provision of additional funding from the Cape Cod Commission, as well as from the Commonwealth and federal government.

Specific recommendations to Orleans from the Plan published in 1978 included: (a) Title 5 enforcement in areas with difficult soils; (b) consideration of a regional septage treatment with Eastham and Brewster; (c) determination of the landfill plume; and (d) a coordinated land use analysis with Brewster to determine watershed protection needs. In the 208 Plan Update, the Cape Cod Commission identified a number of alternative technologies that should be considered to reduce nitrogen loadings from wastewater on the Cape, in addition to the consideration of traditional sewering, treatment, and effluent discharge approaches.

2.3 Consensus Agreement and Amended CWMP

In 2014, the Orleans Water Quality Advisory Panel (OWQAP) was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town. The panel consists 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, as summarized in Table 2-1 and Table 2-2.

Table 2-1 - Orleans Water Quality Advisory Panel (OWQAP) Members

Group Represented	Primary Representative	Alternate
Selectmen	David Dunford	---
Selectmen	Jon Fuller	---
Selectmen	John Hodgson	---
Selectmen	Alan McClennen	---
Selectmen	Sims McGrath	---
Former CWMP Committee	Judith Bruce	Bob Donath
Former Peer Review Committee	Paul Amman	Ed Daly
Orleans CAN	Dog Fromm	Paul Davis
Orleans Chamber of Commerce	Sid Snow	Todd Thayer
Orleans Community Partnership	Joy Cuming	Peter Haig
Orleans Pond Coalition	Jim McCauley	Jim Robertson
Orleans Taxpayer Association	Gordon Smith	Dale Fuller
Orleans Water Alliance	Gary Furst	Jeff Eagles

Table 2-2 - Orleans Water Quality Advisory Panel (OWQAP) Liaisons

Group Represented	Primary Representative	Alternate
Cape Cod Commission	Patty Daley	---
MassDEP	Brian Dudley	---
US EPA	Rob Adler	Karen Simpson
Orleans Board of Health	Robin Davis	Davie Currier
Orleans Conservation Commission	Joshua Larson	---
Orleans Shellfish and Waterways	Suzanne Phillips	Judy Scanlon
Orleans Water and Sewer Board	John Meyer	Robert Rich
Orleans Water Quality Task Force	Judy Scanlon	Carolyn Kennedy
Pleasant Bay Alliance	Carole Ridley	---
National Seashore	Sophia Fox	---
Town of Brewster	Sue Leven	Pat Hughes
Town of Eastham	Sandy Bayne	Charles Harris
Tri-Town Board of Managers	John Kelly	---
Brewster Conservation Commission	Virginia Iannini	James Gallagher

The OWQAP met for twelve half-day meetings between 2014 and 2016, all of which were open to public attendance and comment. The goals of the OWQAP were as follows:

- Consolidate the information being provided through the various studies being performed;
- Provide a forum for obtaining information, advice, and opinion from the businesses, residents and advocacy groups of the town;
- Assist in reporting to the broader voting public on the results to date and plans for future actions with respect to water quality and wastewater planning; and
- Achieve consensus so that water quality and wastewater management plan may move forward.

Potential alternative planning scenarios to meet water quality standards were developed for the OWQAP and presented at meetings and workshops. During a day-long OWQAP public workshop on December 17, 2014, the “Hybrid Plan” was presented, screened, and evaluated. This plan described a combination of Traditional and Non-Traditional technologies that meet the Massachusetts Estuaries Project load-reduction targets for nitrogen in each impaired waterbody. The OWQAP then formed three subgroups to discuss, evaluate and revise the Hybrid Plan. The graphic in Figure 2-2 illustrates the working group process of evaluation. To assist in the evaluation process, the OWQAP received a Technology Evaluation Decision Support Tool that allowed risks and benefits of each technology to be evaluated by subwatershed based on a number of parameters that were ranked for each technology. Preliminary comparative costs were also presented on a relative dollars/kilogram of nitrogen removed basis. The result was a Site Evaluation Matrix that summarized the risks and benefits of each technology.

Figure 2-1 – Conceptual Approach to Meet Orleans Water Quality Goals

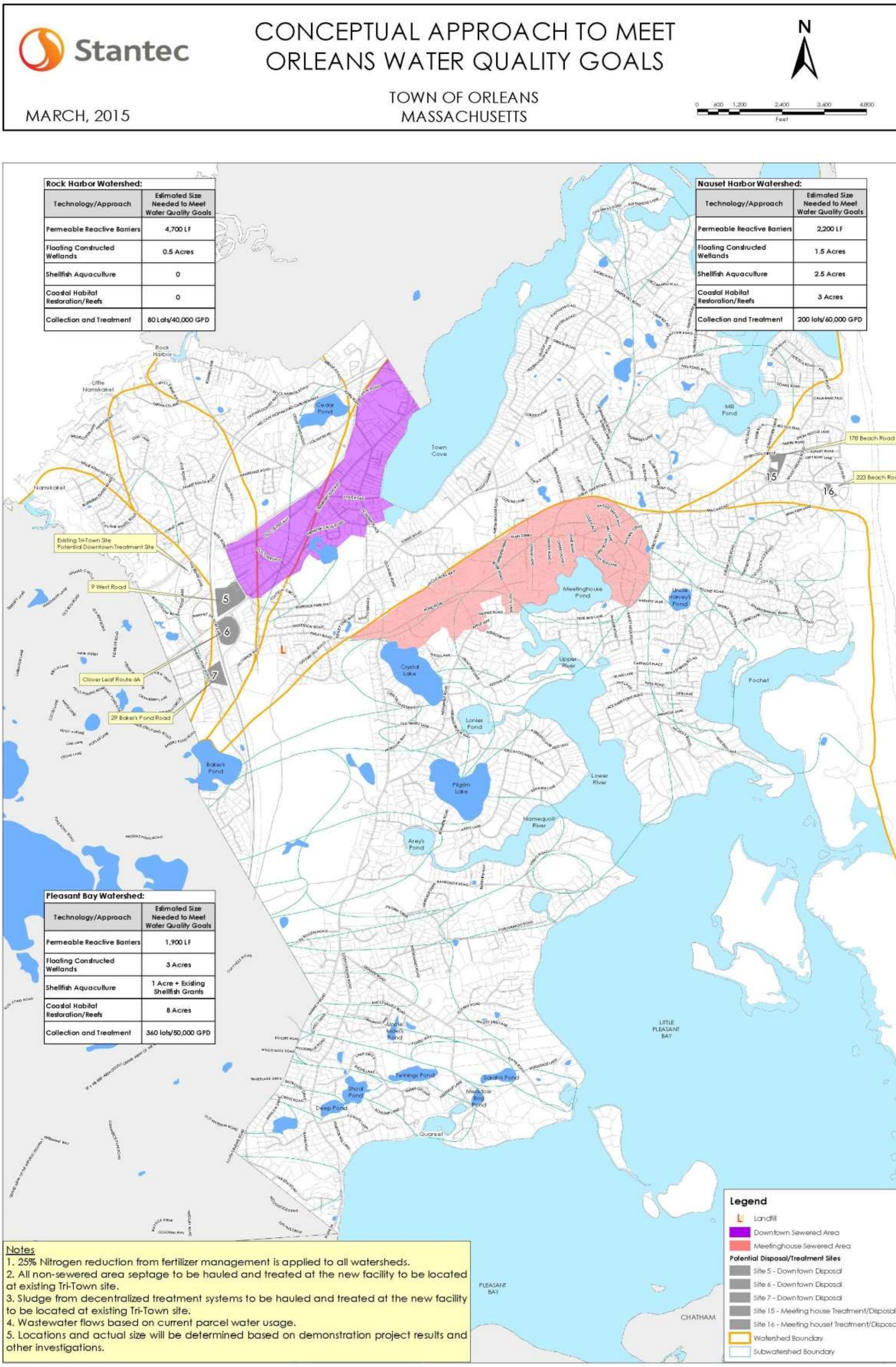
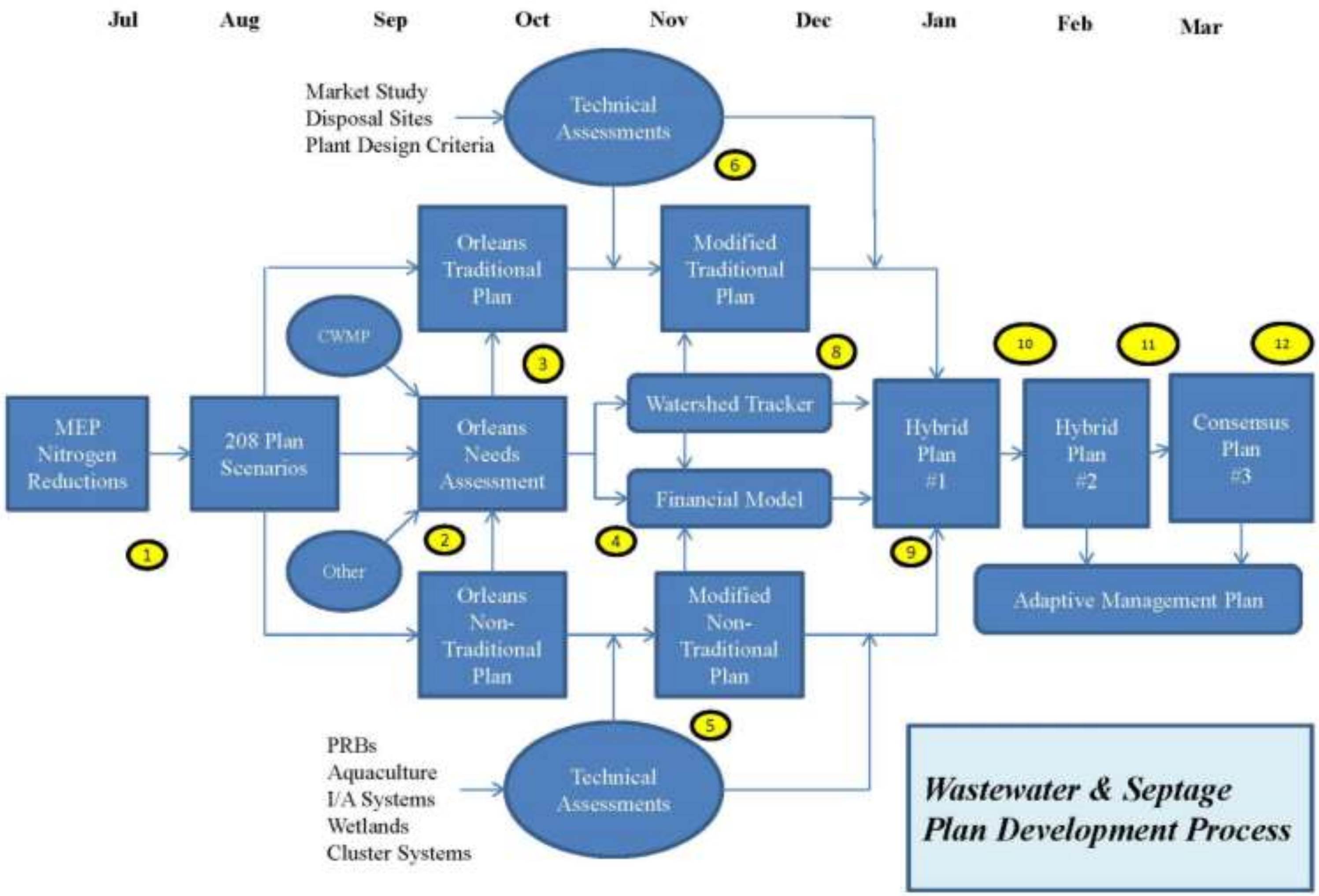


Figure 2-2 - Working Group Process of Evaluation



The Matrix is included as Appendix D, and includes the following ranked categories:

- Nutrient removal certainty: nitrogen (saltwater), phosphorus (freshwater);
- Implementation certainty;
- Other benefits: ecosystems, economic, social;
- Adaptability to uncertainty in nutrient-reduction goals and build-out;
- Contaminants of emerging concern (CEC) removal; and
- Overall cost.

The resulting revised Hybrid Plan described two general areas for sewers: the first area included approximately 270 parcels encompassing Downtown Orleans, which were estimated to generate approximately 100,000 gpd of wastewater to be treated at a facility and groundwater effluent disposal area; the second area included approximately 286 parcels within the Meetinghouse Pond subwatershed, which were also estimated to generate 50,000 gpd, to be treated at a new satellite treatment facility and groundwater effluent disposal area. The Hybrid Plan also listed specific sites for potential use for Non-Traditional technologies to remove nitrogen, including aquaculture and coastal habitat restoration, Permeable Reactive Barriers, and Floating Constructed Wetlands. The number of acres of shellfish growing area, linear feet of Permeable Reactive Barriers and square footage of Floating Constructed Wetlands were quantified to achieve specific nitrogen-removal targets. This exercise was undertaken to confirm that the quantities of all Non-Traditional technologies proposed were feasible to install. These specific locations became the basis for potential demonstration site locations for aquaculture/Coastal Habitat Restoration, Floating Constructed Wetlands and Permeable Reactive Barriers moving forward into late 2015 and 2016.

The Hybrid Plan was vetted through the OWQAP during three meetings, including a day-long workshop. This iterative process resulted in a draft Consensus Agreement that included a combination of Non-Traditional and Traditional technologies. Once the feasibility of using Non-Traditional technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Agreement would not specify exact locations for these technologies, but instead focused on the overall area needed to remove the appropriate mass of nitrogen at the watershed level. The resulting map (Figure 2-1), entitled *Conceptual Approach to Meet Orleans Water Quality Goals* dated March 2015 shows the components of the agreed upon water quality management plan at that time, and the final Consensus Agreement dated March 16, 2015 details the agreed water quality goals, objectives, water quality management plan approach and key elements.

The March 2015 Consensus Agreement was confirmed again by the OWQAP in a June 2016 document entitled *Status Report on the 2015 Orleans Water Quality Advisory Panel Consensus Agreement*. The 2016 OWQAP Status Report confirms the goals of the 2015 Consensus Agreement, documents progress made between 2015 and 2016, and outlines goals and implementation steps for 2016 and 2017 to advance recommended approaches to reducing nitrogen loading in Orleans.

2.4 Amended CWMP

This current document is an amended Comprehensive Wastewater Management Plan (CWMP). It is not intended that the Amended CWMP will represent a re-issuance of the previously published CWMP. Instead, this document builds upon previous studies and data collection completed for the CWMP, and provided an update on additional planning and engineering efforts completed over the last five years.

In response to comments on the CWMP, the Town of Orleans has re-evaluated its previously recommended approach to nitrogen control, which focused on installation of an extensive sewage collection system and new treatment facility and discharge at the Tri-Town Septage Treatment Facility site. Comments received on the 2010 CWMP are summarized in Appendix C, which also includes responses to each comment. Although Massachusetts Environmental Policy Act, MassDEP, and Cape Cod Conservation Commission comments on the 2010 CWMP were generally in favor of the plan, concerns were identified regarding the need for additional monitoring and characterization of the Tri-Town Septage Treatment Facility site groundwater plume and the current and future effects on Little Namskaket marsh, as well as the need to further evaluate the Massachusetts Estuaries Project reports for Nauset Marsh and Town Cove. The agencies also identified the need to further evaluate water quality issues at Cedar Pond and whether cluster systems to treat wastewater discharges for nitrogen removal were appropriate for this area.

In addition to agency concerns, a number of residents raised concerns regarding cost of the proposed centralized collection and treatment system and whether this was the most beneficial approach to managing nitrogen loading in the Town of Orleans. As a result of comments on the CWMP/Environmental Impact Report, as well as recommendations in the 208 Plan, the Town of Orleans has evaluated the potential benefits of Non-Traditional Technologies for lowering nitrogen loading to coastal receiving waters, and considered where these Non-Traditional Technologies might be beneficial as opposed to Traditional collection, treatment, and discharge. In addition, an extensive evaluation of the downtown area current and future wastewater loads was conducted in order to better identify the need for sewers in critical areas where Non-Traditional Technologies would not be appropriate. The initial result was a Consensus Agreement (discussed above) which formed the basis of a wastewater management plan including both Traditional and Non-Traditional approaches to reducing nitrogen loading in Orleans' subwatersheds, The Consensus Agreement has been further refined by work in 2015 and 2016, as summarized in Sections 5 through 9 of this Amended CWMP.

The scope of work contributing to this Amended CWMP performed from October 2015 through May 2016 included a series of deliverables, in the form of Technical Memoranda, covering the following a range of topics. The final recommendations from the Consensus Plan are summarized in Table 2-3. The topics addressed throughout the work to complete the Amended CWMP are identified below:

- Facilities engineering - the tasks required to advance the Traditional engineering design including Disposal Site Investigations; Facilities (Wastewater Treatment and Disposal) Conceptual Design; Downtown Planning and Cost Estimating;
- Downtown planning - planning goals; current economic conditions and market trend analysis; updated Town center study area build-out analysis; results of build-out scenarios; projections for wastewater flows and loads and projections for biosolids; other potential impacts associated with build-out scenario growth; and proposed zoning and regulatory changes to achieve strategies and objectives;
- Facilities conceptual design - collection systems; wastewater treatment, residuals, septage components, and effluent disposal transmission/pumping; groundwater disposal; water reuse systems; and cost estimating;
- Tri-Town transition requirements - interim use options; potential cost savings for doing demolition of existing facility and construction of new facility together; coordination with the MassDEP; and design criteria for demolition of the facility;
- Demonstration project design and implementation - Aquaculture/Shellfish propagation; Nitrogen Reducing Biofilters and Permeable Reactive Barriers;

Table 2-3 - Amended CWMP Summary of Final Recommendations

Watershed	Watershed Total Maximum Daily Load (TMDL) of Nitrate (kg/yr)	Subwatershed	Nitrate Load Removal Required to Meet Target based on MassDEP/MEP Developed TMDL - Orleans Only (kg nitrate/yr)	Proposed Nitrogen Reduction Tecnologies and Associated Nitrate Removals (kg nitrate/year) Identified in March 2015 Orleans Water Quality Advisory Panel Water Quality Management Plan		Proposed Nitrogen Reduction Tecnologies and Associated Nitrogen Removals (kg nitrate/year) Identified in Amended Comprehensive Wastewater Management Plan (CWMP)*	
Rock Harbor	1,358	Rock Harbor	**1,860**	Traditional WWTF	451	Traditional WWTF	451
				Fertilizer management	46	Fertilizer management	46
				PRB	634	PRB	634
				On-site I/A technology (NRB)	729	On-site I/A technology (NRB)	729
				Total	**1,860**	**Total**	**1,860**
		Cedar Pond	-	Traditional WWTF	976	Traditional WWTF	976
				Fertilizer management	2	Fertilizer management	2
				Total	**978**	**Total**	**978**
Nauset Marsh	10,736	Town Cove	**4,816**	Traditional WWTF	3,024	Traditional WWTF	3,024
				Fertilizer management	126	Fertilizer management	126
				Aquaculture	600	Aquaculture	600
				Coastal Habitat Restoration	500	Coastal Habitat Restoration	500
				PRB	566	PRB	566
				Total	**4,816**	**Total**	**4,816**
		Mill Pond	-	Fertilizer management	34	Fertilizer management	34
Pleasant Bay	29,577	Meetinghouse Pond	**1,876**	Traditional WWTF	1,841	Traditional WWTF	1,841
				Fertilizer management	35	Fertilizer management	35
				Total	**1,876**	**Total**	**1,876**
		Lonnie's (Kescayo Gansett) Pond	**284**	Aquaculture	274	Aquaculture	274
				Fertilizer management	10	Fertilizer management	10
				Total	**284**	**Total**	**284**
		Arey's Pond	**113**	Aquaculture	109	Aquaculture	109
				Fertilizer management	4	Fertilizer management	4
				Total	**113**	**Total**	**113**
		The River - Upper	**378**	Traditional WWTF	175	Traditional WWTF	175
				Fertilizer management	15	Fertilizer management	15
				On-site I/A technology (NRB)	188	On-site I/A technology (NRB)	188
				Total	**378**	**Total**	**378**
		The River - Lower	**524**	Fertilizer management	22	Fertilizer management	22
				Coastal Habitat Restoration	502	Aquaculture/ Coastal Habitat Restoration	502
				Total	**524**	**Total**	**524**
		Namequoit River	**348**	Fertilizer management	14	Fertilizer management	14
				On-site I/A technology (NRB)	334	On-site I/A technology (NRB)	334
				Total	**348**	**Total**	**348**
		Pah Wah Pond	**413**	Fertilizer management	11	Fertilizer management	11
				Coastal Habitat Restoration	80	Aquaculture/ Coastal Habitat Restoration	80
				On-site I/A technology (NRB)	322	On-site I/A technology (NRB)	322
				Total	**413**	**Total**	**413**
		Quanset Pond	**227**	Fertilizer management	7	Fertilizer management	7
				On-site I/A technology (NRB)	220	On-site I/A technology (NRB)	220
				Total	**227**	**Total**	**227**
		Round Pond	-				
		Muddy Creek Upper	-				
		Muddy Creek Lower	-				
		Ryder Cove	-				
		Crows Pond	-				
		Bassing Harbor	-				
		Frost Fish Creek	-				
		Pochet	**1,569**	Fertilizer management	55	Fertilizer management	55
				Coastal Habitat Restoration	780	Aquaculture/ Coastal Habitat Restoration	780
				On-site I/A technology (NRB)	734	On-site I/A technology (NRB)	734
				Total	**1,569**	**Total**	**1,569**
		Pleasant Bay (including Little Pleasant Bay)	**1,257**	Fertilizer management	68	Fertilizer management	68
				Aquaculture	500	Aquaculture/ Coastal Habitat Restoration	950
				Coastal Habitat Restoration	450	On-site I/A technology (NRB)	239
				On-site I/A technology (NRB)	239		
				Total	**1,257**	**Total**	**1,257**
		Chatham Harbor	-				
Namskaket	16,750	Namskaket Main	**(8,110)**	Traditional WWTF	451	Traditional WWTF	451
				Fertilizer management	69	Fertilizer management	69
				Total	**520**	**Total**	**520**
		Namskaket Creek	**(4,010)**	Fertilizer management	**31**	Fertilizer management	**31**
Little Namskaket	4,650	Little Namskaket Marsh	**(1,808)**	Traditional WWTF	976	Traditional WWTF	976
				Fertilizer management	35	Fertilizer management	35
				Total	**1,011**	**Total**	**1,011**
		Little Namskaket Creek (freshwater)	**(27)**	Fertilizer management	**4**	Fertilizer management	**4**

* These nitrate reduction goals are preliminary and may be adjusted pending water quality monitoring results to confirm removal efficiencies of the demonstration projects.

- Adaptive management plan implementation - identification of tasks necessary to support and refine the program moving forward; development of a long-term water quality monitoring program; development of a water quality monitoring program for demonstration projects to evaluate performance and consideration in light of other system-wide water quality monitoring; and recommendations for Massachusetts Estuaries Project study update monitoring;
- Financial evaluation – review and modification to the preliminary financial evaluation completed during 2015 including evaluation of revenue generating options; financing options; program cost impact assessment and affordability; and public private partnership options; and
- Regulatory review and coordination – No formal MassDEP or Massachusetts Environmental Policy Act review required to prepare the Amended CWMP, but coordination efforts with CCC and informal coordination with MassDEP was required during this scope of work. MassDEP and the Conservation Commission participated in the semi-monthly OWQAP meetings. Both agencies understood and supported the process followed to reach consensus on nitrogen reductions, and agreed with the conclusions and ultimate recommendations summarized in this Amended CWMP.

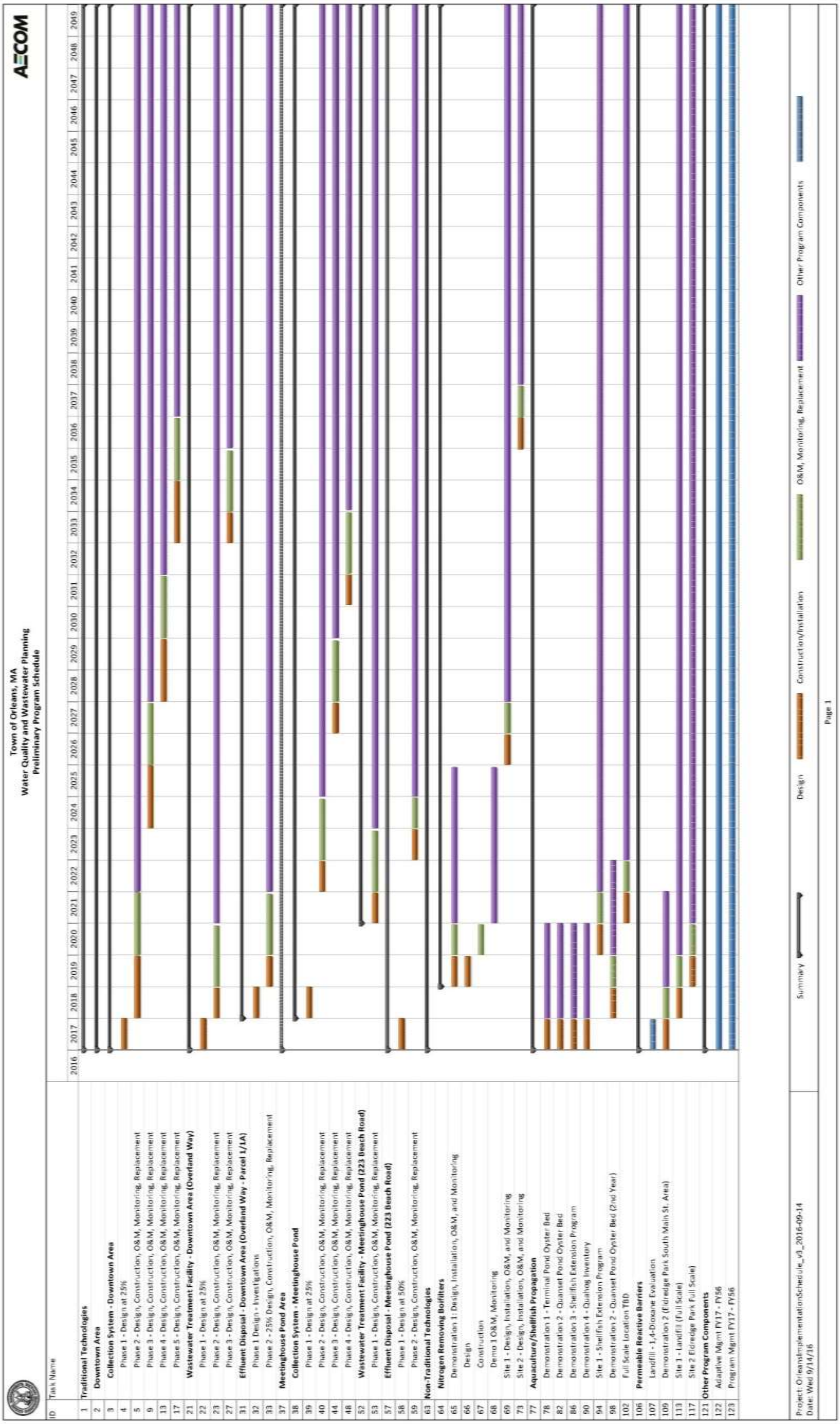
This Amended CWMP summarizes each of these Technical Memoranda, providing an overview of the contents of each. All of the Technical Memoranda are attached as Appendices (E through ##), and provide full details on each of the topics. In some cases the Technical Memoranda were prepared simultaneously with ongoing discussions and meetings with the OWQAP and subcommittees as well as with the Board of Selectmen, Finance Committee and Town Planner. Thus, the Technical Memoranda in the appendices represent considerations and recommendations at various points along the planning and design process. The text within the Amended CWMP represents the final recommendations, which are also summarized in Table 2-4. The current implementation schedule is provided in Figure 2-3.

Table 2-4 – Summary of Amended CWMP Final Recommendations

Traditional Wastewater Management Components	Consensus Agreement map, entitled *Conceptual Approach to Meet Orleans Water Quality Goals* March 2015)	Amended CWMP Recommendations	Comments
Downtown Parcels Sewered			
Meetinghouse Pond Parcels Sewered			
Wastewater Flows			
Septage Treatment			
Effluent Disposal			

Upon review and agreement by the Orleans Board of Selectmen, this updated Draft Amended CWMP will be provided to the Cape Cod Commission and MassDEP for preliminary review and informal concurrence with the Town's comprehensive planning and 208 water quality planning processes to address water quality concerns. Representatives from the Board of Selectmen have been participating in the monthly OWQAP meetings and are familiar with recommendations that have been made throughout the OWQAP process, as documented in this Draft Amended CWMP. Work to advance preliminary wastewater collection and treatment design and Non-Traditional technology implementation will be ongoing throughout the winter and spring of 2017. Results of that work will be incorporated into this Draft Amended CWMP and the Final Amended CWMP will be finalized in June 2017 for official submittal to the Cape Cod Commission and MassDEP in accordance with the Commission's Development of Regional Impact review procedures and MassDEP's guidelines for review of and updates to Comprehensive Wastewater Management Plans.

Figure 2-3 – Preliminary Implementation Schedule



3.0 Facilities Engineering

3.1 General

This section discusses the tasks undertaken to advance the Traditional engineering design including Disposal Site Investigations, Facilities (Wastewater Treatment and Disposal) Conceptual Design, Downtown Planning and Cost Estimating. The Consensus Agreement developed by the OWQAP determined that Traditional wastewater collection, treatment, and disposal was appropriate for the Downtown and Meetinghouse Pond sub-watersheds, as shown in Figure 3-1. Since the 2010 CWMP/SEIR, the following activities have occurred to advance the Traditional facilities engineering for these areas, and are described in the subsections that follow:

- Investigations have occurred to characterize a variety of groundwater disposal site alternatives for treated wastewater in terms of hydrogeology, effluent quantity, effluent quality, depth to groundwater, sensitive environmental conditions, etc. The results of these studies as well as recommendations for disposal sites are summarized in Section 5.1.
- An evaluation of build-out conditions in the densely developed Town Center has been conducted both under current conditions relying on septic treatment and zoning controls to limit development, as well as future conditions with a centralized collection system. These evaluations have provided a framework for identifying potential future wastewater flows requiring treatment during initial phases of centralized collection and treatment and are summarized in Section 5.2.
- Based on the projected wastewater flows in the Downtown Area and Meetinghouse Pond Area, alternatives for wastewater collection, treatment, and disposal technologies were evaluated and recommendations were developed based on cost, feasibility, and effectiveness. The results of these evaluations are summarized in Section 5.3.

The facilities engineering tasks described below have resulted in refinements to the Consensus Agreement in regard to boundaries of the Downtown Area and Meetinghouse Pond Area recommended for centralized collection as well as potential groundwater discharge disposal sites, as shown in Figure 3-1.

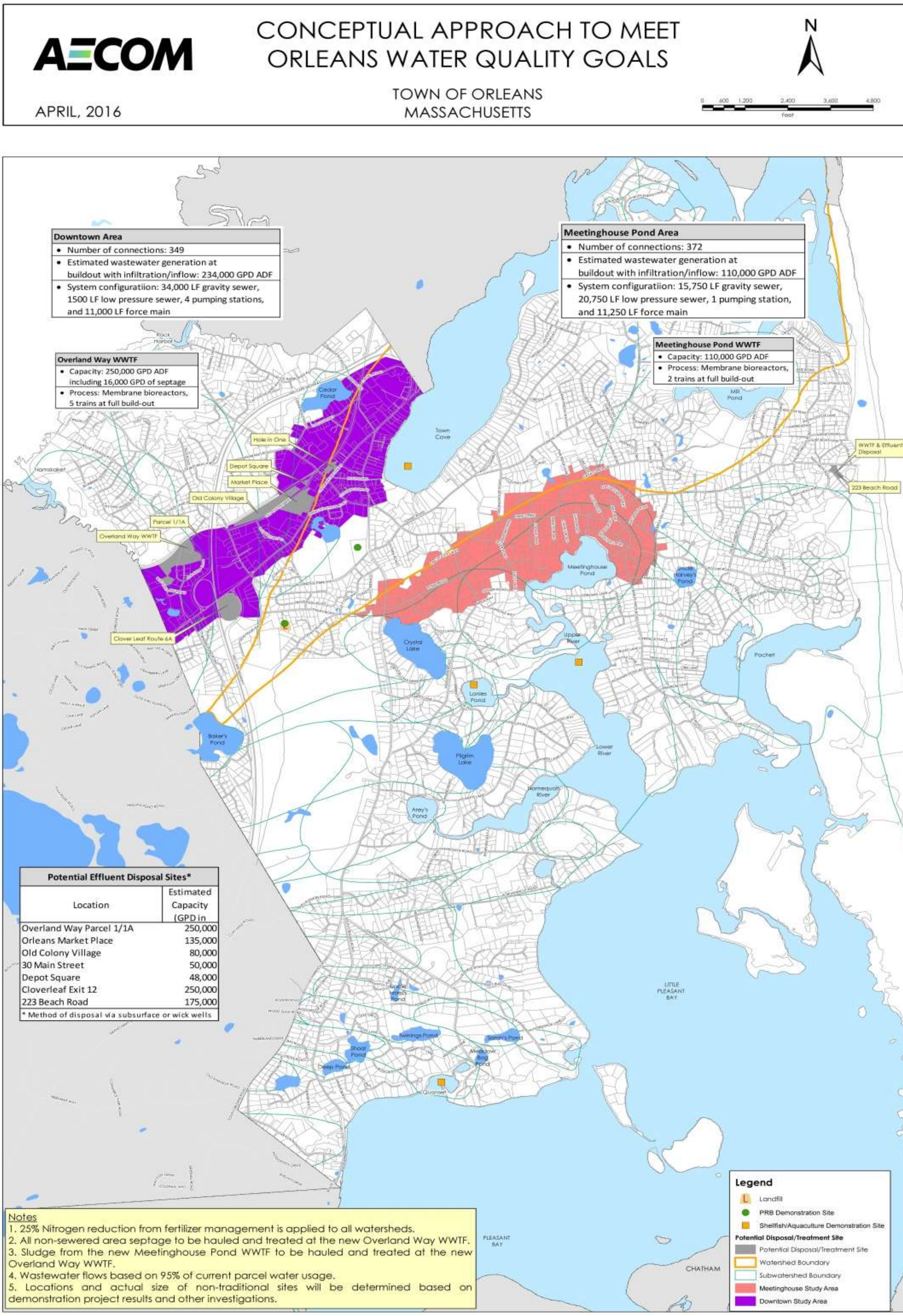
3.2 Disposal Site Investigation

3.2.1 WWTF Groundwater Discharge Site Investigations

Each of the two areas proposed for sewering (Downtown Area and the Meetinghouse Pond; Figure 3-1) will require wastewater treatment and a site for the discharge of the WWTF effluent.

A groundwater discharge site for each sewershed was selected for initial hydrogeologic evaluation: two discharge sites are under evaluation for the Downtown Area is and the site for Meetinghouse Pond is 223 Beach Road. The Hydrogeologic Evaluation is part of the MassDEP Groundwater Discharge Permit (GWDP) application process and evaluates each site for its suitability for groundwater discharge. A summary of the evaluation at each follows, and details are provided in the Groundwater Discharge Permit Hydrogeologic Study Technical Memorandum in Appendix E.

Figure 3-1 - Potential Groundwater Discharge Disposal Sites



3.2.2 Downtown Area - Disposal Site Investigations

The town is currently investigating Site 1/1A at the former Tri-Town septage site on Overland Way for groundwater disposal for the Downtown Area flows. A number of alternative sites are also currently being evaluated to select a second site for additional hydrogeologic investigations.

A number of alternative groundwater discharge sites are also under consideration by the Town for effluent disposal. The sites considered were preliminarily evaluated for a groundwater discharge. To date the evaluations included reviewing existing Health Department records and estimating an approximate groundwater discharge area and discharge rate based on existing data. Table 3-1 summarizes the sites investigated including the site name, street address, estimated discharge area and estimated groundwater discharge rate for each site.

The additional sites are currently being screened to select one for additional detailed Hydrogeologic Evaluation. The detailed Hydrogeologic Evaluations at both Parcel 1/1A and one additional site from Table 3-1 are planned to be complete by spring 2017.

Table 3-1 - Potential Groundwater Discharge Locations

Site	Street Address	Potential Area for Groundwater Discharge (sqft)	Potential Groundwater Discharge Rate (GPD)
Depot Square	8 Old Colony Way	24,000	48,000
Hole in One Restaurant Parking Area	Off Cranberry Highway and Main Street	25,000	50,000
Old Colony Apartments	Old Colony Way	40,000	80,000
Thayer Property Orleans Market Place	130 – 136 Old King Hwy	67,500	135,000
Overland Way (Parcel 1/1A)	29 Overland Way	125,000+	250,000+
Route 6 Interchange (Exit 12)	Route 6A	125,000+	250,000+

3.2.3 Downtown Area - Overland Way (Parcel 1/1A)

Site 1/1A at the former Tri-Town septage site on Overland Way is shown in Figure 3-2 Parcels 1/1A are located in the northeast corner of the 26-acre site on Overland Road, in the Town of Orleans.

The geology and hydrogeology of the Overland Way site, outside of Sites 1/1A is well known and documented through several studies including several US Geological Survey (USGS) reports. Parcel 1 and Parcel 1A are approximately 6.23 acres in size. Preliminary modelling has been conducted to evaluate groundwater flow paths at the site. Flow from a potential groundwater discharge from Parcels 1/1A sites was simulated using a modified version of the US Geological Survey Monomoy Lens groundwater Model. Using the groundwater model's particle tracking module, flow paths were used to illustrate the path of an effluent discharge through the groundwater, to where it discharges to surface waters.

Figure 3-2 - Proposed Groundwater Discharge Site at Overland Way (Parcel 1/1A)

Additional detailed hydrogeologic evaluation of the Parcel 1/1A site is ongoing over the winter of 2015/2016 in accordance with MassDEP requirements. The evaluation will include additional subsurface investigations, data analysis, model updates, model calibration, and more detailed model simulations. As part of evaluation, the US Geological Survey groundwater model will be updated to incorporate local and regional hydrogeologic conditions estimated through the hydrogeologic evaluation. At that time, the nitrate load to each subwatershed and quantity of freshwater flow to each watershed could more accurately be estimated.

Currently the site is used for the Tri-Town Septage Treatment Facility. The Tri-Town Septage Treatment Facility was constructed between 1985 and 1987, and underwent facility upgrades/modifications in 1995. The Tri-Town Septage Treatment Facility has now reached the end of its useful life and is scheduled to be demolished between October 2017 and April 2018. The hydrogeologic investigations would be performed to evaluate the site for a groundwater discharge for a potential wastewater treatment facility (WWTF) that would serve the Downtown Area of Orleans. The WWTF and groundwater discharge would improve water quality by lowering the nitrate load to nitrate impacted estuaries.

The evaluation will include the installation of approximately four monitoring wells and approximately 6 test pit excavations. Each groundwater monitoring will be constructed using 2-inch diameter PVC pipe to depths of approximately 60 to 80 feet below the ground surface. Each test pit will be excavated to a depth of approximately 15 feet and are typically 5-feet wide and 10 feet long.

3.2.4 Downtown Area – Route 6, Exit 12 Cloverleaf

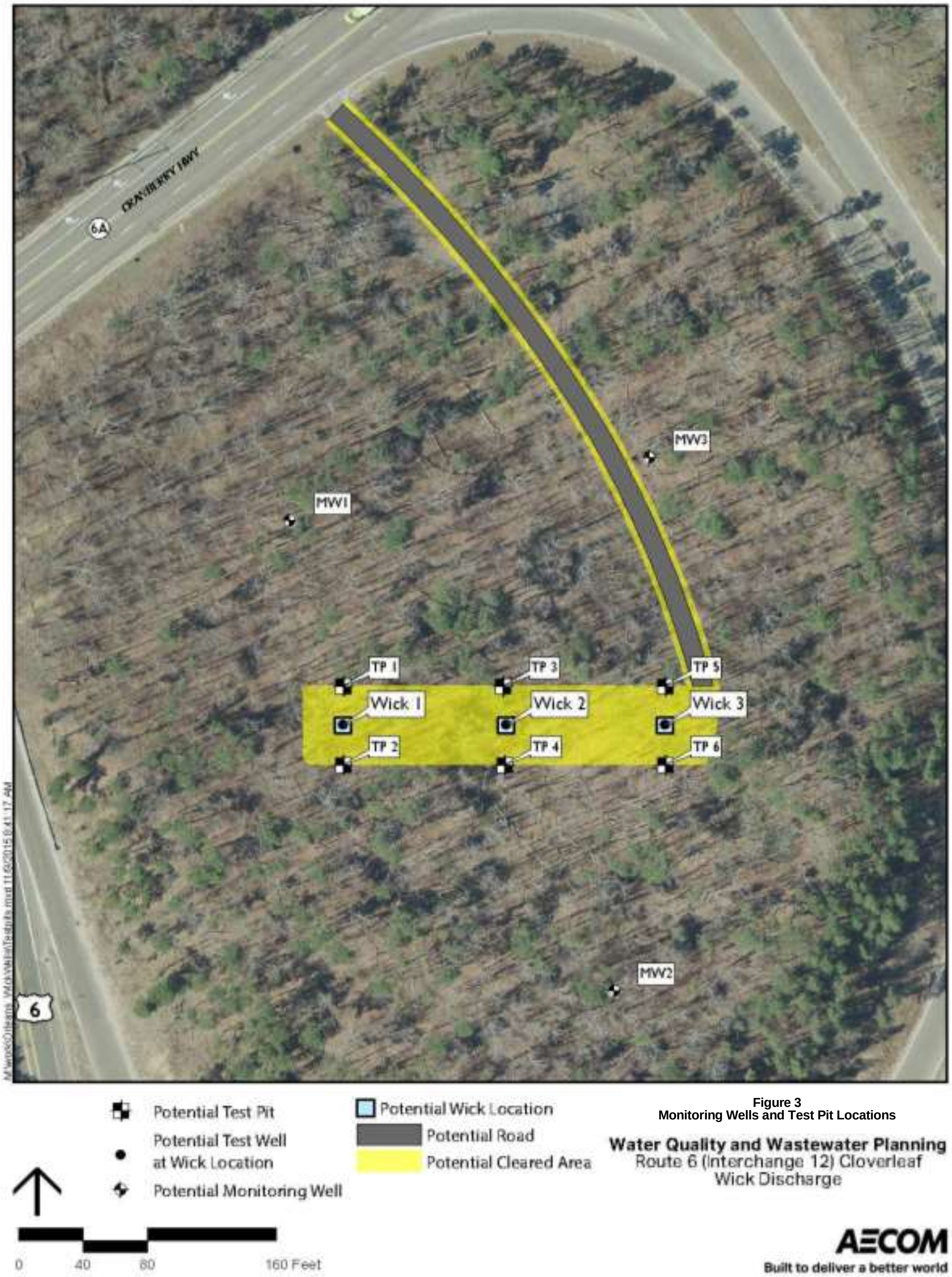
The location of the proposed discharge site for the Downtown Area collection area is the southeast quadrant of the clover leaf at the intersection of Route 6A with Route 6 (Figure 3-3 and Figure 3-4). The area within the cloverleaf is approximately 8.75 acres and is owned by MassDOT. Approval for site access by the Town of Orleans and their consultants to conduct a hydrogeological evaluation of the site as a discharge location is being recently been granted. At this time, the Town is preparing the necessary permits with MassDOT to perform a hydrogeologic evaluation at the site.

The elevation of the proposed discharge is approximately 80 to 100 feet above mean sea level (msl). The depth to groundwater is expected to be in excess of 60 feet. Preliminary modelling has been conducted to evaluate groundwater flow paths at the site. Flow from a potential groundwater discharge site was simulated using a modified version of the US Geological Survey Monomoy Lens groundwater Model. Using the groundwater model's particle tracking module, flow paths were used to illustrate the path of an effluent discharge through the groundwater, to where it discharges to surface waters. Groundwater below the site flows in a northerly direction towards Little Namskaket Marsh. Therefore the preliminary investigation indicates that the effluent does not recharge the Namskaket Marsh watershed and thereby reduces the freshwater impacts into the Marsh. The upper reaches of Little Namskaket Marsh are approximately 4,000 feet to the north-northwest of the proposed discharge. Soils underlying the site are mapped as outwash sands and gravel.

The evaluation will include the installation of approximately three monitoring wells and approximately 6 test pit excavations. Each groundwater monitoring will be constructed using 2-inch diameter PVC pipe to depths of approximately 60 to 80 feet below the ground surface. Each test pit will be excavated to a depth of approximately 15 feet and are typically 5-feet wide and 10 feet long.

Figure 3-3 - Proposed Groundwater Discharge Site at Route 6 Exit 12 Cloverleaf

Figure 3-4 - Proposed Groundwater Discharge Site at Route 6 Exit 12 Cloverleaf



3.2.5 Meetinghouse Pond Area - 223 Beach Road

The location of the proposed discharge site for the Meetinghouse Pond collection area is at 223 Beach Road in east Orleans near Nauset Beach, and is shown on Figure 3-5. The Beach Road site was considered for two primary reasons. First, the site is owned by the Town. Second, the site is located outside the Meetinghouse Pond Watershed and discharges to the Atlantic Ocean and not to an estuary where the nitrate in the effluent could be a potential issue. The Town also plans to use the site for Nauset Beach parking. Installation of a subsurface discharge at the site would not interfere with these plans.

On November 30, 2015, a proposed scope of work to conduct a Hydrogeologic Site Evaluation was submitted to MassDEP for review and comment as required by MassDEP (BRP WS 83) for a Groundwater Discharge Permit (GWDP) Application. The Proposed Hydrogeologic Site Evaluation was approved by MassDEP on January 19, 2016 after receiving no public comments. Copies of the proposed Hydrogeologic Evaluation scope of work, Environmental Monitor Notification and MassDEP approval letter are provided in the Technical Memorandum (Appendix E). The investigations included the excavation of test pits, performing Title 5 percolation tests, the installation of soil borings and monitoring wells, grain-size analysis of soil samples, and the performance of slug tests. The data obtained were used to evaluate subsurface conditions, estimate the groundwater flow direction, and estimate aquifer characteristics. Results of the field investigations and data analysis were incorporated into a numerical groundwater flow model to simulate groundwater flow across the site and estimate groundwater mounding under various discharge scenarios.

The potential discharge area at 223 Beach Road is approximately 140,000 square feet (sqft). At this time the projected flow and location of the primary and reserve discharge areas within the 140,000 sqft area has not been determined. However, at a flow of 110,000 gpd, approximately 55,000 sqft would be required for the primary discharge with the reserve located between the primary discharge laterals.

Geologic conditions found at the Beach Road site consist of silty sands underlain by relatively clean medium sands with varying amounts of fine and course sand and trace amounts of gravel and silt. The percolation rate of the medium sands was less than 2 minutes per inch indicating that the underlying sands are suitable for a groundwater discharge system. The depth to groundwater under the proposed discharge area is approximately 40 feet. Aquifer characteristic were estimated through laboratory grain-size analysis and analysis of slug test data.

A calibrated groundwater flow model was used to simulate a groundwater discharge. Several discharge scenarios were performed to estimate groundwater mounding and flow direction. The scenarios simulated discharge rates between 25,000 and 500,000 gpd under high water table conditions. Groundwater mounding at 500,000 gpd was approximately 3.5 feet; approximately 35 feet below ground surface.

According to Town records, there are no public water supply wells and six potential private water supply wells within 2,500 feet of the discharge. Only one private well is located within the influence of the discharge according to the groundwater model simulations. All of the properties with private wells could connect to the existing Orleans public water supply system located adjacent to their properties.

Figure 3-5 - Proposed Groundwater Discharge Site at 223 Beach Road

Based on the groundwater mounding analysis, discharge from the Beach Road site generally flows east and discharges directly to the Atlantic Ocean, a waterbody with no nitrate TMDL. At flows between 200,000 and 500,000 gpd, the model simulations indicate that a portion of the discharge flows to Pochet Neck, a sub-estuary of Pleasant Bay which has a nitrate TMDL. If the discharge at the Beach Road site were to exceed 200,000 gpd, measures to reduce or offset the nitrate load entering Pochet Neck would need to be considered.

A detailed description of the Hydrogeologic Evaluation, groundwater modeling, potential environmental impacts, results, conclusion, and recommendations are summarized in the Hydrogeologic Evaluation Technical Memorandum found as Appendix E. The purpose of the technical memorandum is to provide a transparent and objective assessment of the 223 Beach Road Site for the discharge of WWTF effluent. The Hydrogeologic Evaluation was submitted to the MassDEP for review in June 2016.

3.3 Downtown Planning

This section discusses the Downtown Planning tasks undertaken to develop a Town Center plan that will support water quality and wastewater planning on a sub-watershed basis. The area addressed in this task is the Town Center Study Area, which includes the business districts along the Route 6A corridor as well as some residential use (Figure 3-6). The Downtown Planning task work is summarized in the following Technical Memoranda:

- Updated Downtown Build-Out Analysis and Land Use / Market Conditions and Development Constraints (Appendix F);
- Downtown Future Growth Scenarios, Strategies to Limit Growth, Draft Regulations to Obtain Zero Interest Financing, and Implications for Wastewater Loading Impacts and Other Community Impacts in the Downtown (Appendix G); and
- Management of Future Downtown Wastewater Flows and Biosolids (Appendix H).

Highlights from these Technical Memoranda are provided below, and the complete documents are located as Appendices F through H.

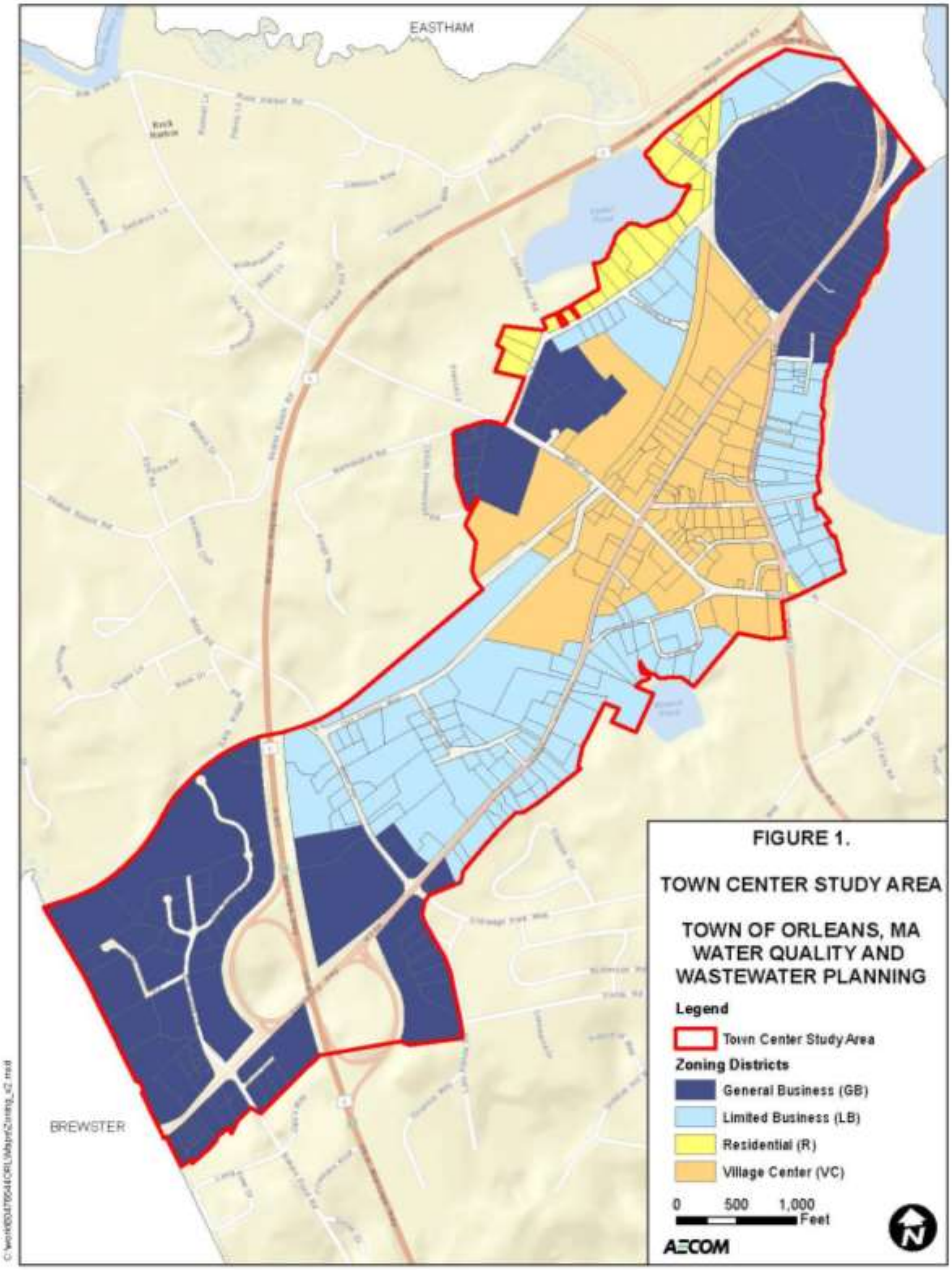
3.3.1 Updated Downtown Build-Out Analysis and Land Use / Market Conditions and Development Constraints

Appendix F provides the Technical Memorandum presenting the results of an updated economic conditions and market trend analysis for the Town Center Study Area, as well as the methodology and results for an updated build-out analysis of the Town Center Study Area based on existing Town regulations and zoning. The information in the Technical Memorandum is summarized below in two sub-sections that address the two components of Updated Economic Conditions and Build-Out Analysis.

3.3.1.1 Updated Economic Conditions and Market Trend Analysis

In 2010, FinePoint Associates conducted an economic analysis of the Orleans Village Center and worked collaboratively with the Planning Department, Planning Board, Chamber of Commerce, and interested citizens to develop a set of 24 strategy recommendations along with potential action steps to consider. Many of these recommendations have since been implemented or are underway. In 2015 FinePoint Associates, as a subcontractor to AECOM, conducted an updated economic analysis for the Town Center Study Area, which incorporates the Village Center. This analysis resulted in the production of an Orleans Town Center Economic Analysis Primer, which provided information and analysis pertaining to economic conditions and other factors that informed the Town and appropriate Boards or Committees as they reassessed/ reconfirmed the vision for the Town Center and the 2010 strategy recommendations, which particular focus on those recommendations that impact future development and therefore wastewater planning.

Figure 3-6 - Downtown Center Study Area



The Economic Analysis Primer is comprised of three parts:

- Real Estate and Business Conditions;
- Understanding of the Year Round and Seasonal Retail Market; and
- Other Conditions Pertinent to Town Center Planning.

The Primer is included in its entirety in Appendix F.

3.3.1.2 Updated Town Center Study Area Build-out Analysis

The Town Center Study Area build-out analysis was initiated by reviewing previous relevant planning studies and build-out analyses for the Town. Following review and organization of available information, the Orleans Downtown Planning Workshop No. 1 was convened with the BOS and other invited stakeholders on December 15, 2015. The purpose of this workshop was to: confirm the vision for the Downtown as stated in the 2006 Orleans Comprehensive Plan; confirm the 2009 vision statement for Village Center; and review/revisit the recommendations from the 2010 Economic Analysis of the Village Center prepared by FinePoint Associates and modify as needed based on findings of the updated economic analysis.

After Workshop No. 1, AECOM utilized output from the workshop and coordinated with the Town's Planning Department and subconsultant FinePoint Associates to develop an updated build-out for the Town Center Study Area and a range of future growth/build-out scenarios. Then, the Orleans Downtown Planning Workshop No. 2 was convened with the Board of Selectmen and other invited stakeholders on February 4, 2016. The purpose of this workshop was to: summarize input and key takeaways from Workshop No. 1; present assumptions and results for the Town Center Study Area build-out scenarios; and conduct a group discussion to obtain input on the build-out scenarios.

The Workshop No. 2 participants reconfirmed the Town Vision Statement and the Village Center Vision Statement. The key items discussed related to the vision statements and included: prioritize year-round residents and uses, reverse decline of year-round population and youth, target increased growth and higher density of residential uses, and target lesser increase in non-residential square footage. It was also noted that it is important to maintain continuity of non-residential space in the Town Center Study Area and avoid dead space in between non-residential uses.

2015 Existing Conditions for the Town Center Study Area were initially determined to provide a baseline from which to develop potential growth scenarios. Baseline values for the number of dwelling units, non-residential development (i.e. non-residential square footage), and wastewater generation within the Town Center Study Area were developed.

Following completion of the 2015 Existing Conditions analysis, an updated build-out scenario assuming no change to land use patterns or zoning regulations was developed. The scenario was then evaluated in light of three options:

- **Scenario Option 0a: Full Build-out under Current Zoning with Existing Wastewater Limitations**. This scenario assumes on-site wastewater management continues to be required and a variance would not be issued by the Board of Health to allow construction of new or expanded Title 5 systems under parking areas.

- **Scenario Option 0b: Full Build-out under Current Zoning with Existing Wastewater Limitations and Title 5 Septic Systems Constructed under Parking**. This scenario applies the same approach / assumptions as used for Scenario Option 0a, except it assumes a variance would be issued by the Board of Health to allow construction of new or expanded Title 5 systems under parking areas. This scenario was created as a result of input received at Orleans Downtown Planning Workshop No. 2.
- **Scenario Option 0c: Full Build-out under Current Zoning with Wastewater Limitations, Title 5 Constructed under Parking, and Local Nutrient Management Regulations Removed**. This scenario applies the same approach / assumptions as used for Scenario Option 0b, except it assumes the Town's Nutrient Management Regulations would not be applicable to any parcel in the study area. This scenario was created as a result of input received at Orleans Downtown Planning Workshop No. 2.

The Technical Memorandum summarizing the predicted number of dwelling units is provided as an Appendix, and the resulting future predicted flows for all build-out scenario options are presented in Table 3-2.

3.3.2 Downtown Future Growth Scenarios, Strategies to Limit Growth, Draft Regulations to Obtain Zero Interest Financing, and Implications for Wastewater Loading Impacts and Other Community Impacts in the Downtown

This Technical Memorandum presents the methodology and results of future build-out scenarios for the Town Center Study Area (see Figure 3-6), as well as strategies to manage growth, draft regulations to obtain zero Interest financing through the MassDEP Clean Water State Revolving Fund (MassDEP CWSRF) program, and implications for wastewater loading impacts and other community impacts in the Town Center Study Area. The sub-sections that follow summarize each of these components of the Technical Memorandum.

3.3.2.1 Future Build-out Scenario Development

A range of future build-out scenarios for the Town Center Study Area was developed based on input received from the two Downtown Planning Workshops held on December 15, 2015 and February 4, 2016; consideration of market demand conditions; and coordination with the Town. Five future build-out scenarios were developed over the course of the project. Ultimately, the following three scenarios were selected for water quality and wastewater planning purposes:

- **Scenario 1 – Full Build-out Under Current Zoning without Wastewater Limitation.** This scenario utilizes the same underlying approach and assumptions as used for Scenarios 0a, 0b, and 0c discussed in Section 5.2.1.2, except the on-site wastewater limitation (e.g. Title 5 sizing and setback requirements, Title 5 and the Town's Nutrient Management Regulations wastewater flow limits) that was applied for Scenario 0 is eliminated due to the assumed future provision of sewer to the Town Center Study Area. As a result, additional land area is available for future development and higher densities can be achieved.

Table 3-2 - Orleans Town Center Study Area Wastewater Flows by Sub-watershed (gpd)

Sub-watershed	2015 Existing Conditions	Scenario Option 0a[1]	Scenario Option 0b[1]	Scenario Option 0c[1]
Town Cove	61,178	66,268	66,312	66,312
Boat Meadow River	837	837	837	837
Rock Harbor Stream	53	53	53	53
Cedar Pond	26,277	31,086	31,407	32,579
Rock Harbor Main	29,705	29,749	29,783	29,783
Boland Pond	2,603	2,603	2,603	2,603
Little Namskaket	21,699	43,670	49,704	61,050
Namskaket Main	5,252	15,381	18,140	18,140
Namskaket Stream	4,252	13,456	15,790	15,790
Total	*151,855*	*203,102*	*214,628*	*227,146*

Notes:

1. Scenario 0 descriptions:

- Option 0a: Full Build-out under Current Zoning with Existing Wastewater Limitations
- Option 0b: Full Build-out under Current Zoning with Existing Wastewater Limitations and Title 5 Septic Systems Constructed under Parking
- Option 0c: Full Build-out under Current Zoning with Wastewater Limitations, Title 5 Constructed under Parking, and Local Nutrient Management Regulations Removed

- **Scenario 2 – Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center.** This scenario utilizes results from Scenario 1 as a starting point and incorporates changes to increase residential density in the Town Center. In addition to a currently proposed large-scale mixed use development in the Village Center, several trends – low vacancy rates, high housing costs, decreasing household size and aging population – point to the need to expand the variety of housing options in the community. It appears there may be a need for maintenance-free homes in close proximity to services that could serve an older population looking for smaller units, less maintenance, and less driving. There also appears to be a need for lower-priced homes that could serve a young workforce population. The Downtown Planning Workshops also indicated strong support to expand the variety of housing in the town center. It was assumed that there were 48 parcels in the "Downtown Core" area (i.e. vicinity of the Main Street / Route 6A intersection) that could support a future mixed use based on application of the following ratios, which were derived from values provided by the Town for a proposed large-scale mixed use development in the Village Center district:
    - **Residential use: 9 dwelling units / acre; and**
    - **Non-residential: 9,000 square feet (s.f.) / acre.**

- **Scenario 3 – 2050 Planning Horizon.** This scenario utilizes the 2015 Existing Conditions results for the Town Center Study Area as a starting point and applies residential and non-residential growth rates for a 2050 planning horizon. The growth rates are applied at the study area-wide level and not by individual parcel. The planning horizon was determined based on an assumed 2020 construction date of a new wastewater facility and a 30 year estimated useful life. This scenario includes two options:
  - Scenario Option 3a: Historical Growth Rate; and
  - Scenario Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer.

The residential and non-residential results for all future build-out scenarios are presented in Table 3-3.

The Orleans Planning Board issued a memorandum to the Orleans BOS on February 26, 2016 regarding downtown growth and development. In the memorandum, the Planning Board states that based on the outcome of the Downtown Planning Workshops, it is their opinion that there is general consensus regarding the future of the downtown area as expressed in the Town Center and Village Center Vision Statements that were reviewed. The memorandum also states that the Planning Board agrees that the future needs of the Town are best met under the future build-out Scenario Option 3.b, which reflects higher residential density in the Village Center. This memorandum is included as Appendix G.

Wastewater flows and load associated with the future build-out scenarios were estimated for each scenario using approaches as detailed in the Technical Memorandum. The wastewater flows and loads results for each future scenario are presented in Table 3-4.

3.3.2.2 Coordination of Future Growth with the Orleans Comprehensive Plan

As noted in the 2006 Orleans Comprehensive Plan, growth and development continue to create challenges for the Town, including increased traffic congestion and nitrogen pollution of local waters. Per the Comprehensive Plan, the Town's growth policy is to "ensure that future growth is at a level and in such a manner that will have no or minimal adverse effect upon semi-rural character and environmental integrity of the Town." The Comprehensive Plan also states that future business activities should be oriented primarily in village areas and strip commercial development prevented. This approach is consistent with the growth policy of the 2012 CCC Regional Policy Plan, which is to "guide growth toward areas that are adequately supported by infrastructure and away from areas that must be protected for ecological, historical, or other reasons."

High septic system replacement costs and Title 5 restrictions currently limit the ability of the Town to direct future growth to the Village Center and the two major commercial nodes (Skaket Corners and the Orleans Rotary area). Also, businesses with high sewage volume are significantly constrained from locating in the downtown area, as any business generating in excess of 15,000 gpd of wastewater would require an advanced septic treatment facility, which comes with additional costs and regulatory requirements.

Table 3-3. Orleans Town Center Study Area Future Build-out Scenario Results by Sub-watershed

Sub-watershed	Scenario 1[1]		Scenario 2[1]		Scenario 3[1]			
					Option 3a[1]		Option 3b[1]	
	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)
Town Cove	448	1,328,796	545	820,417	296	768,828	322	781,796
Boat Meadow River	8	---	8	---	6	---	6	---
Rock Harbor Stream	2	---	2	---	1	---	1	---
Cedar Pond	181	987,366	276	431,436	154	365,687	167	382,215
Rock Harbor Main	390	191,769	436	83,439	389	80,856	394	81,505
Boland Pond	5	34,635	24	20,594	8	18,839	10	19,281
Little Namskaket	163	635,984	163	289,074	139	253,627	142	262,538
Namskaket Main	22	217,306	22	113,067	14	101,294	15	104,253
Namskaket Stream	26	169,582	26	91,892	14	70,946	15	76,211
Total	*1,245*	*3,565,437*	*1,502*	*1,849,919*	*1,021*	*1,660,078*	*1,073*	*1,707,800*

Notes:

1. Scenario descriptions:

- Scenario 1: Full Build-out Under Current Zoning without Wastewater Limitation
- Scenario 2: Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center
- Scenario 3: 2050 Planning Horizon
    - Option 3a: Historical Growth Rate
    - Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer

Table 3-4. Orleans Town Center Study Area Future Wastewater Flows and Loads

Parameter	Scenario 1[1]	Scenario 2[1]	Scenario 3[1]	
			Option 3a[1]	Option 3b[1]
Wastewater Flow (gpd)	337,013	233,730	183,150	190,815
Septage Flow (gpd)	16,000	16,000	16,000	16,000
I/I Flow (gpd)	22,501	22,501	22,501	22,501
Total Flow (gpd)	375,514	275,231	221,651	229,316
BOD Loading (lbs/d)	1,002	727	592	612
TSS Loading (lbs/d)	940	681	555	574
TN Loading (lbs/d)	188	136	111	115
Effluent BOD Load (lbs/d)	94	68	55	57
Effluent TSS Load (lbs/d)	94	68	55	57
Effluent TN Load (lbs/d)	31	23	18	19
Waste Biosolids (lbs/d)	1,018	863	788	799

Notes:

1. Scenario descriptions:

- Scenario 1: Full Build-out Under Current Zoning without Wastewater Limitation
- Scenario 2: Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center
- Scenario 3: 2050 Planning Horizon
  - Option 3a: Historical Growth Rate
  - Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer

The proposed sewering of the Town Center Study Area will aid in attainment of the Town's growth policy by eliminating current on-site wastewater limitations and enabling denser development and redevelopment within the three commercial nodes targeted to receive future growth. The sewering will also eliminate nitrogen loading from wastewater in the Study Area and aid in restoring the health of local water bodies.

Potential growth must be managed in light of other demands that new growth would place on the Town in terms of other utilities, traffic and transportation, and services (police, fire, etc.). Relevant goals from the Comprehensive Plan related to the additional demands posed by potential future growth were detailed in the Technical Memorandum.

Meeting these demands will need to be coordinated with the goals and policies included in the Town's Comprehensive Plan. The primary infrastructure improvement in the Town Center Study Area required to support the preferred build-out scenario is provision of a wastewater collection system and treatment facility. Without this wastewater infrastructure in place, the desired density and type of development in the Study area as reflected in the preferred build-out scenario (Scenario Option 3b) could not be achieved.

3.3.2.3 Zoning and Regulatory Changes Needed to Achieve Strategies and Objectives

Focusing development in the specified nodes in the Town Center Study Area will reduce the potential for undesired strip commercial development and other types of development sprawl. Implementation of the Town's proposed amendment to Section 164-31 Apartment Development of the Zoning By-laws or similar amendment would allow for and encourage the higher residential density that is desired in the Village Center. The Town could also consider implementing a zoning amendment that requires all (or selected types) new housing developments to contribute to the Town's affordable housing stock.

Also, in order for the Town to be eligible to receive zero percent financing through the MassDEP Clean Water State Revolving Fund program (described in detail in Appendix G), the Town must adopt land use controls that would limit increase in wastewater flows as a consequence of changed land uses or increased density allowed if sewers are installed. The Planning Board has continued to discuss planning for future growth in the Downtown and has been evaluating several rezoning proposals. It is expected that the Planning Board will make a recommendation on proposed rezoning in winter 2017 so that land use considerations can be accounted for in the Final Amended CWMP. The Planning Board is working under the understanding that there may be a limit on future development that can occur and still qualify for 0 percent financing. Finalization of the zoning modifications will consider these limitations as they evaluate various options available for implementation.

3.3.3 Management of Future Downtown Wastewater Flows and Biosolids

Appendix H includes the Technical Memorandum that describes the proposed methods to manage future downtown wastewater flows associated with the preferred build-out scenario (i.e. Scenario Option 3b – Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer) and allocate sewer capacity, as well as management of future downtown wastewater biosolids. As discussed in greater detail in Section 5, it is recommended that the proposed Overland Way WWTF be constructed at the existing Tri-Town Septage Treatment Facility on a 26-acre parcel to the northwest of the Exit 12 cloverleaf. Because of the planned decommissioning of the facility, and the proximity of this location to the Downtown Area, it is a logical choice for siting a proposed Overland Way WWTF to receive flow from the Downtown Area.

Phasing of the proposed Overland Way WWTF and Downton Area collection system is a key component of the overall Project Plan. It is proposed that the Overland Way WWTF and Downtown Area collection system be constructed in at least two phases with the first phase occurring within the next five years and the second phase occurring within the next ten years. Additional detail regarding recommendations for treatment of wastewater flows and biosolids is provided in Section 5.

3.4 Facilities Conceptual Design

This section discusses the tasks undertaken to advance the conceptual design of the wastewater collection, treatment, and discharge facilities. The Facilities Conceptual Engineering design work is summarized in the following Technical Memoranda:

- Collection System Technologies and Evaluation Technical Memorandum (Appendix I);and
- Wastewater Treatment Facility Liquid Train (Appendix J).

Highlights from these Technical Memoranda are provided below.

3.4.1 Collection System

A *Collection System Technologies and Evaluation Technical Memorandum was prepared (*Appendix I) to identify the types of collection system technologies and to evaluate each of the technologies in order to develop a cost-effective alternative for the proposed Downtown Area and Meetinghouse Pond Area wastewater collection areas of Orleans. The Collection System Technologies include:

- Gravity Sewers (GS);
- Low Pressure Sewers (LPS);
- Septic Tank Effluent Gravity (STEG);
- Septic Tank Effluent Pumping (STEP); and
- Vacuum Sewers (VS).

Design description, considerations and criteria, advantages and disadvantages of each of these collection systems are included in the Technical Memorandum in Appendix I.

3.4.1.1 Collection System Alternatives Evaluation

A technology evaluation and screening criteria for the proposed Collection systems are discussed in detail in the Technical Memorandum (Appendix I), and included the following categories:

• Site Suitability	• Land Ownership • Constructability (Method of Installation)
• Environmental Considerations	• Permittability • Extent of Dewatering • Sustainability
• Financial Considerations	• Construction Costs • Operation and Maintenance Costs
• Maintenance Considerations	• Level of Maintenance, Homeowner • Level of Maintenance, Town
•	•
• Other Considerations	• Reliability • Ability to Accommodate Expansion • Area of Disturbance • Duration/Schedule • Aesthetics

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: Good = 1 point; Neutral = 0 points; and Poor = -1 point.

An overall rating for each technology was completed based on the criteria and weights assigned to each of the individual criteria. It is noted that septic tank effluent pumping and low pressure sewer are ranked the most favorable with very close criteria points and thus considered essentially equivalent in this analysis. Vacuum sewers were ranked the least favorable for both areas mainly because they are most beneficial in flat terrain. Gravity sewers were ranked at 3 of 5, and septic tank effluent gravity systems ranked at 4 of 5.

However, the criteria points for gravity were more significantly favorable in the Downtown area due to the emphasis on reliability and minimal maintenance required by the owner at the property level. In addition, gravity sewers offer flexibility for phased development as they are able to adapt to future increases in flows, whereas low pressure and vacuum sewers offer little if any capability to accommodate future increased flows. For both collection system areas, low pressure sewers and Septic Tank Effluent Pumping systems are ranked essentially equivalent with one point difference in total criteria points.

In this analysis, key differentiators were construction impacts related to cost, environmental considerations and restoration of temporarily disturbed areas such as driveways and landscaping to pre-construction conditions. This focus highlights the benefits of utilizing smaller pipes from low pressure and septic tank effluent pumping systems to collect and transmit sewage flows at a lower cost of construction per service connection. However, these systems are most suitable to small communities with an established year-round residential service area and are less able to provide future expansion capacity within the same collection area. For this reason, a hybrid system is recommended that takes advantage of the newer collection system design strategies to provide services to the individual properties where appropriate, with a limited Traditional gravity sewer system that can collect the flows and provide the capacity for long-term expansion. In this manner, additional phases, or neighborhoods can be added to the system without impacting the existing infrastructure. The gravity sewer would be installed in the public right of ways and designed to eliminate deep excavations and the need for pumping stations as much as possible, by relying on pressure service connections where required.

While low pressure sewers and Septic Tank Effluent Pumping collection systems were comparable in this analysis, the low pressure sewer system is determined most favorable for use in the hybrid plan mainly due to the additional cost and maintenance burden on the homeowner related to the septage management requirements of the Septic Tank Effluent Pumping system. Additional factors include the higher potential for corrosion and odors from the septic conditions of the Septic Tank Effluent Pumping system at the property as well as increase in difficulty in the biological process of the septic effluent at a wastewater treatment facility. Both systems require nominal cost to the homeowner related to operation and maintenance of the effluent service pumps. The analysis assumed 100 percent septic tank replacement based on other municipality experience with implementation of Septic Tank Effluent Pumping systems.

3.4.1.2 Collection System Layout and Cost Estimates

A conceptual system layout (plan and profiles) was developed for both the Downtown Area and Meetinghouse Pond Area. Refer to the Technical Memorandum (Appendix I). The development of the plan and profiles for each area system was based on existing information as follows: (a) Town of Orleans Assessors Records; (b) Town of Orleans topography survey from the stormwater project for part of the Downtown Area; and (c) USGS topographic survey.

The conceptual system layouts were developed in accordance with the New England Interstate Water Pollution Control Commission - TR-16, Guides for the Design of Wastewater Treatment Works, 2016 Edition.

The conceptual system layouts are currently undergoing additional refinement based on various site factors as defined by obtaining detailed topographic survey; performing subsurface investigations (i.e. soil types, and depth to groundwater); acquiring land and/or easements; and investing of existing utilities. Additional topographic survey data will be used to supplement existing documentation (prepared by SMC Consultants) to confirm utility locations and obtain sill elevations of structures as well as to cover the entire Downtown Area.

Preliminary cost estimates were developed based on the conceptual system layouts and included Project Costs; Annual Operation and Maintenance Costs; Replacement Costs; and Annual Monitoring Cost, and is included in the following sections. These are summarized in the Technical Memorandum and also described in more detail in Section 5.

The details for the operation and maintenance, replacement and monitoring costs are included in the Technical Memorandum (Appendix I) and are included in the Life-Cycle Costs. Based on the estimated quantities developed from the conceptual system layouts, estimated Program Costs and Life-Cycle Cost Analysis Assumptions a Life-Cycle Cost was developed for each of the technologies (Gravity Sewers; Low Pressure Sewers; Septic Tank Effluent Gravity; Septic Tank Effluent Pumping; and Vacuum Sewers). The results of the Life-Cycle Cost Analysis are presented in Table 3-5 and Table 3-6 for the Downtown Area and Meetinghouse Pond Area, respectively.

The "Life-Cycle Cost Analysis" is very cost sensitive to revisions to the system layout, components utilized, changes in unit prices, etc. To understand this sensitivity by the changing system layout the following example is utilized. In the Downtown Area Hybrid (GS and LPS) alternative, once the detailed topographic survey and subsurface investigations are complete, the conceptual system layout will be reviewed and adjusted. If the revised layout results in 3 pump stations, the capital cost, associated O&M, Replacement and Monitoring Costs for a Hybrid System will be reduced and would result in a Present Value of $29.38 million or 10.4 percent reduction over the Present Value shown in Table 3-6.

Table 3-5 - Downtown Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Present Value	$38.22	$40.43	$26.96	$41.08	$28.23	$32.81

Note: Costs in Millions of Dollars

Table 3-6 - Meetinghouse Pond Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Present Value	$51.01	$53.37	$30.72	$56.73	$32.08	$27.93

Note: Costs in Millions of Dollars

3.4.1.3 Collection System Recommendation

Based on the technical evaluation and economic evaluation (Life-Cycle Cost Analyses) it is recommended that a “hybrid” wastewater collection system be carried forward to preliminary (25 percent) design in both the Downtown Area and Meetinghouse Pond Area. The “hybrid” configuration is recommended because of its ability to accommodate changes in wastewater flows particularly with the Downtown Area caused by zoning changes and business dynamics; ability to phase the design, construction and operations; proven long term reliability; generally a higher public acceptance; and ease of permitting.

The recommendations include the following:

- Utilize similar collection system alternatives in each of the proposed service areas and standardize design details/configurations since this reduces overall project costs;
- Develop 20 to 25 percent planning documents for the Downtown Area and Meetinghouse Pond Area Collection Systems;
- Determine the preferred method of implementation – design-bid-construction; design-build, etc.;
- Utilize the updated information to engage in Public-Private-Partnerships negotiations; and
- Utilize the updated information to prepare funding applications in order to obtain grants and loans.

In addition, as part of the inputs to the Financial Model, the Program Costs need to be inflated to the year anticipated for implementation. The ENR Cost Index History Tables can be used for estimating inflation on future cost projections that are then used for development of Capital Improvement Plans and Financing Plans.

3.4.2 Wastewater Flows, Septage, Influent Pollutant Concentrations and Treatment

3.4.2.1 Wastewater Flows

Based on wastewater projections developed for both the downtown and Meetinghouse Pond areas of Town and provided projections for the current level of development, as well as a "future build-out" condition. The future build-out condition for the Downtown Area addressed possible re-zoning impacts and different property utilization scenarios. The future build-out condition for the Meetinghouse Pond Area was derived by simply assuming residential properties not currently developed might be so in the future. This analysis yielded the annual average flow projections listed in Table 3-7.

Table 3-7 - Initial and Future Build-out Flow Projections for Downtown and Meetinghouse Pond Areas

Downtown Area		Meetinghouse Pond Area	
Initial Design Flow	Future Build-out Condition	Initial Design Flow	Future Build-out Condition
153,000 gpd	250,000 gpd	70,000 gpd	110,000 gpd

Note: Future Build-out Condition for Downtown Area include 16,000 gpd of Septage

<u>Septage</u>

Even after the completion of a sewage collection and transmission system for these two areas, there will still be a significant amount of properties in Town that continue to rely on septic systems. In addition, there will continue to be a need for septage disposal capacity to service Orleans and the surrounding communities in the lower/outer Cape.

Based on a previous study, the existing Tri-Town Septage Treatment Facility has averaged in the order of 9 million gallons of septage annually over the past several years. The sewering of some parts of the Town will decrease septage generation within Orleans. In addition, some permanent loss of market might be expected from some of the communities proximate to the Yarmouth-Dennis facility, as it expands operations to fill the void left by the closure of the existing Tri-Town Septage Treatment Facility. AECOM has conservatively prorated the existing Tri-Town Septage Treatment Facility receiving rates on a town by town basis to what they might be expected to be in the future and has arrived at a projected "high-end" septage loading of 6 million gallons annually, or 16,000 gal/d. While this rate will depend on how the Town chooses to operate the proposed Overland Way WWTF, this is considered a reasonable assumption with which to estimate loadings to the facility.

Influent Pollutant Concentrations

Typical wastewater pollutant concentrations need to be adjusted to account for septage. To address what impact septage receiving would have, actual annual average data from the existing Tri-Town Septage Treatment Facility was used. It was assumed that septage would be received only at the proposed Overland Way WWTF servicing the Downtown Area. Additionally, it is assumed that it will be processed with biosolids from the facility, so that only septage filtrate would be mixed with raw sewage influent to reduce solids loadings on the biological process. The resulting blended influent, as well as the influent characterization for the proposed Meetinghouse Pond WWTF is as shown in Table 3-8.

Table 3-8 - Assumed WWTF Influent Pollutant Concentrations

Constituent	Downtown Area	Meetinghouse Pond Area
BOD, mg/l	340	270
TKN, mg/l	60	55
TSS, mg/l	300	310

Evaluation

The existing Tri-Town Septage Treatment Facility was previously located on a 26-acre parcel to the northwest of the Route 6 Exit 12 cloverleaf. A decision had been made to close the facility because the equipment is outdated and an upgrade would be prohibitively costly. The decommissioning schedule was accelerated due to anticipated departure of staff that would have made ongoing operation logistically challenging, and the facility was closed June 1, 2016, prior to the originally anticipated closure date. Due to the proximity of this location to the Downtown Area, it is a logical choice for siting a proposed Overland Way WWTF to receive flow from the Downtown Area. The Meetinghouse Pond Area however would require a force main several miles long to bring flow from the eastern edges of town to either the proposed Overland Way WWTF site or the proposed Downtown Area collection area. For the purpose of this evaluation, it was assumed that a proposed smaller, satellite WWTF would be dedicated to this service area, located on the Town owned property at 223 Beach Road. The higher degree of neighborhood sensitivity associated with the Beach Road site requires as small and unobtrusive a facility as possible. This combined with the economy of scale of providing biosolids/septage processing capacity at one location led to the decision that the Beach Road site would not receive septage, and that any WWTF residuals generated would be trucked to the proposed larger Overland Way WWTF located at the existing Tri-Town Septage Treatment Facility site.

Downtown Area

Liquid Train - With the site selected and flow/loadings to the facility defined, AECOM used its experience with similar projects to define a list of applicable technology options for the proposed Overland Way WWTF. A list of attributes important in the selection of an appropriate liquid train treatment technology was developed, and weighting factors applied to reflect the importance of each attribute to the overall selection process. Lastly, AECOM's wastewater process team ranked each technology selection on how well it met the requirements of each attribute. A weighted ranking was then totaled for each technology.

A technology evaluation and screening criteria for the proposed wastewater treatment facility Liquid Train are discussed in detail in the Technical Memorandum (Appendix J), and included the following categories:

- Project Evaluation
  - Energy/GHG Footprint
  - Capital Cost
  - LCC
  - Operational Complexity
  - Degree of Preliminary Treatment Required
  - Expansion Capability (flow/load)
  - Biosolids Production
  - Ability to Achieve Potential Stricter Limits (P, lower N)
  - Ability to Process Septage Filtrate
  - Compatibility with Wick Well for Effluent Disposal
- Site Suitability
  - Footprint Required
  - Impact on Neighbors (odors, noise)
- Other/Overriding Considerations
  - Proven acceptance by MassDEP
  - Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Conventional Activated Sludge (CAS);
- Sequencing Batch Reactor (SBR);
- Integrated Fixed Film Activated Sludge (IFAS);
- Membrane Bioreactor (MBR); and
- Rotating Biological Contractor (RBC).

MBR achieved the highest weighted score by a fairly large margin. In this particular analysis, key differentiators were the low degree of operational complexity, expansion capability, the ability to reach potential lower permit limits in the future, and compatibility with the possible use of a Wick Well for effluent disposal, all of which MBR received higher ratings on.

Residuals/Septage Treatment - For reasons of economy of scale, impact to neighbors, and site constraints, it is anticipated that all treatment plant residuals from the proposed Meetinghouse Pond WWTF will be trucked to the proposed Overland Way WWTF site and co-processed with residuals there. Similarly, it is anticipated that septage receiving will occur only at the proposed Overland Way WWTF. AECOM would recommend that septage be processed directly with WWTF residuals to avoid the solids loading to the biological process that would result if it was introduced directly to the liquid train. An estimate of average solids generation from each source is summarized in Table 3-9.

Table 3-9 - Estimate of Average Solids Production from WWTF and Septage Receiving

Item / Constituent	Meetinghouse Pond WWTF Residuals	Overland Way WWTF Residuals	Septage Receiving at Overland Way WWTF	Combined Totals
Gal/d	1,157	2,625	16,000	19,782
TSS, percent	1.80	1.80	0.36	0.64
TSS, lb/d	174	394	480	1,048

A similar process to what was used to evaluate the liquid train options was conducted for residuals/septage treatment.

With the site selected and projected residuals/septage quantities defined, AECOM used its experience with similar projects to define a list of applicable treatment technology options. While dewatering is usually a two-step process requiring thickening first, there are a few technologies available that allow dewatering to acceptable solids levels with one device. Two thickening technologies, two dewatering technologies, and two combined thickening/dewatering technologies were selected for evaluation. A list of attributes important in the selection of an appropriate septage/residuals treatment technology was developed, and weighting factors were applied to reflect the importance of each attribute to the overall selection process. AECOM's wastewater process team ranked each technology selection on how well it met the requirements of each attribute. A weighted ranking was then totaled for each technology. A technology evaluation and screening criteria for the proposed wastewater treatment facility Residuals/Septage Treatment are discussed in detail in the Technical Memorandum (Appendix J), and included the following categories:

- Project Evaluation
  - Operating Cost
  - Capital Cost
  - LCC
  - Operational Complexity
  - Transportation Costs
  - Solids Quality
- Compatibility with Site
  - Footprint Required
  - Impact on Neighbors (odors, noise)
- Other/Overriding Considerations
  - Proven acceptance by MassDEP
  - Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Gravity Belt Thickener (GBT);
- Rotary Drum Thickener (RDT);
- Belt Filter Press (BFP);
- Rotary Press;
- Belt Filter Press w/pre-Thickening Zone; and
- Screw Press.

The screw press achieved the highest weighted score by a fairly large margin. A key differentiator in this analysis was the fact that the screw press didn't require a separate thickening step, which reduced the overall capital cost and footprint required for solids processing. Another category that set it apart was that because it is an enclosed system, control of odors and housekeeping are significantly less of an issue than with belt types of processes where the product is open to the ambient.

Overall Site Layout and Costs - AECOM estimates that if some of the existing tankage is utilized to mitigate hourly fluctuations in flow, four modular MBR treatment trains would be needed to satisfy initial design conditions. A fifth treatment train would be needed to accommodate future build-out conditions. Although AECOM would recommend the installation of only four treatment trains is currently recommended, the concrete pad, piping and connections should be designed to accommodate the fifth future train should the full build-out condition materialize.

With the assumption that all of the structures to the project north side of the road adjacent of the Chemical Feed Building are retained at the Tri-Town site, the total estimated project capital cost was estimated at $16.5M as in detail in the Technical Memorandum (Appendix J).

Annual Operation and Maintenance (O&M) Costs were estimated at approximately $972,000/year using the key assumptions detailed in the Technical Memorandum (Appendix J). Septage receiving revenue was estimated at $600,000, leaving the net estimated annual O&M costs $371,900.

<u>Meetinghouse Pond Service Area</u>

Liquid Train - A very similar evaluation of options for technologies was conducted for the proposed Meetinghouse Pond WWTF intended to service the Meetinghouse Pond service area. The same technologies evaluated for the proposed Overland Way WWTF were evaluated, with some minor changes to criteria and weighting. The primary changes were the addition of a selection criterion that favored commonality with the technology choice at the proposed Overland Way WWTF, and a stronger weighting for the impact on surrounding neighbors to reflect the more residential nature around the Beach Road site.

A technology evaluation and screening criteria for the proposed wastewater treatment facility Liquid Train are discussed in detail in the Technical Memorandum (Appendix J), and included the following categories:

- Project Evaluation
  - Energy/GHG Footprint
  - Capital Cost
  - LCC
  - Operational Complexity
  - Degree of Preliminary Treatment Required
  - Expansion Capability (flow/load)
  - Biosolids Production
  - Ability to Achieve Potential Stricter Limits (P, lower N)
  - Ability to Process Septage Filtrate
  - Compatibility with Wick Well for Effluent Disposal
- Site Suitability
  - Footprint Required
  - Impact on Neighbors (odors, noise)
- Other/Overriding Considerations
  - Compatibility with proposed Overland Way WWTF
  - Proven acceptance by MassDEP
  - Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Conventional Activated Sludge (CAS);
- Sequencing Batch Reactor (SBR);
- Integrated Fixed Film Activated Sludge (IFAS);
- Membrane Bioreactor (MBR); and
- Rotating Biological Contractor (RBC).

As was the case for the proposed Overland Way WWTF, and for similar reasons, MBR achieved the highest weighted score by a fairly large margin. Again, key differentiators were the low degree of operational complexity, expansion capability, the ability to reach potential lower permit limits in the future, and compatibility with the possible use of a Wick Well for effluent disposal, for all of which MBR received higher ratings. Factors favoring MBR specific to the proposed Meetinghouse Pond WWTF were lower impact on neighbors and compatibility with the technology selection for proposed Overland Way WWTF.

Overall Site Layout and Costs - AECOM estimates that if upstream flow equalization is employed to mitigate hourly fluctuations in flow, two modular MBR treatment trains would be needed to satisfy initial design conditions, but would also have sufficient spare capacity to accommodate future build-out conditions. Flow equalization to mitigate hourly peaks would require a tank in the order of 65,000 gallons in volume. Waste sludge storage capacity is also needed and estimated at approximately 10,000 gals, which would supply about seven days of storage under future build-out conditions.

Because the proposed Meetinghouse Pond WWTF site is in a more residential/recreational area, it is assumed that measures will need to be taken to minimize the impact on the neighborhood from both the standpoint of odors, noise and visual aesthetics. AECOM recommends that the MBR modules and their ancillary equipment be housed in a building designed to match the visual appearance of the surrounding area to the extent possible. Similarly, the storage tanks can be located mostly below grade. AECOM estimates a building with a footprint of 45-feet x 65-feet will be required to house two MBR units and have additional lab and maintenance space. The equalization and storage tanks will be adjacent to the building along one of the 65-foot walls, projecting 15-feet from the wall, and having a total depth of 12-feet (10-below grade).

As previously indicated, capital costs assumed the proposed Meetinghouse Pond WWTF would be housed inside a building to lessen aesthetic and odor impacts on the surrounding neighborhood. Below grade storage tanks were included for both influent flow equalization, as well as waste biosolids storage. All biosolids processing was assumed to take place at the proposed Overland Way WWTF.

The total estimated project capital cost was estimated at $8.1M as in detail in the Technical Memorandum (Appendix J). Annual Operation and Maintenance (O&M) Costs were estimated at approximately $300,000/year using the key assumptions detailed in the Technical Memorandum (Appendix J).

AECOM would recommend that these costs and the pros/cons of modular construction be revisited during the design phases, but believes the concepts developed herein provide a sound strategy and planning level costs for consideration and funding allocation as the Town proceeds with its Water Quality and Wastewater Planning efforts.

3.4.3 Water Reuse Systems

3.4.3.1 General

The use of treated wastewater, also known as reclaimed water, recycled water, or effluent reuse water, is a supply of water for use in non-potable applications, including irrigation, industrial uses, toilet flushing, and aquifer recharge. The use of reclaimed water can satisfy many water demands but in many cases requires an enhanced or higher level of treatment where there is a greater chance of human exposure.

Reclaimed water can provide many advantages, particularly for locations where raw water supplies are limited, water infrastructure does not exist, and water quantity is not available. In addition, in many cases, cost effective water reuse systems allow business and industry to operate and expand at lower cost, and reduced water demand results in healthier rivers, streams, and lakes for recreation and wildlife.

An integral part of any Water Quality and Wastewater Planning program that includes the collection, treatment and disposal of wastewater effluent is the consideration of including effluent reuse. The reuse of treated wastewater requires a higher level of treatment but results in a reduced demand on municipal water supply systems and can enhance recycling of the nutrients remaining after treatment. Although reuse offers an alternative approach to effluent disposal current MassDEP rules and regulations requires that the groundwater discharge location(s) be able sized for the full design flow.

A Technical Memorandum (Appendix K) was prepared to discuss the current MassDEP Reuse Regulations; Advantages and Disadvantages of effluent reuse; Examples of Reclaimed Water in Massachusetts; Potential of Reclaimed Water Use in Orleans; and Conclusions and Recommendations. As explained below, the incorporation of a reclaimed water system increases costs and does not result in a reduction of effluent disposal capacity. Furthermore, preliminary investigations did not identify users for large scale re-use. Therefore, it is not recommended that water reclamation be included in the Program at this time.

3.4.3.2 Regulations

The MassDEP regulates the use of reclaimed water under 314 CMR 20.00: Reclaimed Water Permit Program and Standards. The regulations were established to regulate and permit reclaimed water systems and include requirements for the use, sale, and distribution of reclaimed water. In general, the regulations allow for reclaimed water reuse for the following uses:

- Irrigation as a source of water for recreational use;
- Industrial or commercial cooling, air conditioning, or boiler feed;
- Toilet and urinal flushing;
- Agricultural use;
- Creation of wetlands;
- Commercial (i.e. laundries, carwashes, snowmaking);
- Miscellaneous (i.e. fire protection, dust control, soil compaction, street cleaning); and
- Aquifer recharge.

The regulations do not allow for reclaimed water to be used as follows:

- Used or distributed in a manner within the Zone I of a public water supply well, the Zone A of a surface water source for a public water system, or within 100 feet of a private water supply well.
- Used or distributed in a manner that will cause or contribute to violations of the Massachusetts Surface Water Quality Standards, or impair the use of the ground water as an actual or potential source of potable water.
- Used or distributed in a manner that affects the water quality of any public source of potable water or private source of water used for drinking, domestic or culinary purposes.

MassDEP reclaimed water regulations state that in order to meet the EPA Class I Reliability Standards (EPA-430-99-74-001 – Design Criteria for Mechanical, Electrical, and Fluid System and Component Reliability), the wastewater treatment facilities have to be designed to include the following components:

- Two independent and separate sources of power, with the backup source sufficient to operate all vital components during peak flow conditions, together with critical lighting and ventilation;
- Unit redundancy;
- Additional storage or bypass to a discharge site; and
- Sufficient inventory of spare equipment and parts to minimize the time period that treatment facility operations are off-line.

The regulations establish three classes of reclaimed water reuse identified as Class A, Class B and Class C and are described in the Technical Memorandum (Appendix K). In general, Class C reuse is for reclaimed water with no potential for direct contact with people. Class A requires the highest level of treatment and allows for irrigation, cooling water and other uses where there is expected to be human contact with reuse water. Class B is for scenarios that are unlikely to result in human contact with reuse water, and an intermediate level of treatment is required.

3.4.3.3 Advantages and Disadvantages

The following summarizes some advantages and disadvantages of reclaimed water use.

<u>Advantages</u>

- Reduces demand on the municipal water supply system;
- Provides an increment of supply for growing communities in stressed basins;
- Provides a cost-effective supply for industrial users with large-scale demand for non-potable water, for industrial uses, cooling water, or toilet flushing;
- Reduces the impact of large developments;
- Decreases the diversion of freshwater from sensitive ecosystems;
- Reduces or eliminates treated wastewater discharges into sensitive water bodies;
- Creates or enhances wetlands and stream habitats; and
- Reduces reliance on commercial fertilizers to the extent that nitrogen and phosphorus in the reclaimed water can offset current uses on irrigated surfaces.

It should be noted that Item 3, Item 7 and Item 9 are the most relevant to the Town of Orleans.

<u>Disadvantages</u>

- Increased public education required;
- Increases capital costs since additional equipment (i.e. pumps, tanks, analyzers, etc.) as well as distribution piping are required for the reuse system and therefore increase capital costs above and beyond the typical WWTF;
- Increases operation and maintenance costs since additional equipment (i.e. pumps, tanks, analyzers, etc.) for the reuse facilities will increase O&M;

- Increases monitoring costs since MassDEP requires additional monitoring for reuse facilities above and beyond the normal WWTF monitoring and reporting process;
- Increases level of oversight to ensure that reclaimed water is not used for inappropriate purposes (MassDEP requires the monitoring occur so that the reuse that is permitted for a specific purpose is not used for another purpose without an increase in treatment {i.e. Class C – Boiler Feed and then used for Class A Snowmaking}); and
- Adds legal and administrative costs related to customer agreements.

3.4.3.4 Examples of Reclaimed Water in Massachusetts

Examples of Reclaimed Water in Massachusetts includ the following :

- Yarmouth-Dennis Septage Treatment Facility, Yarmouth, MA
- Wrentham Premium Outlet Mall, Wrentham, MA;
- New Seabury Properties, LLC, Mashpee, MA;
- EMC Corporation, Hopkinton, MA;
- Gillette Stadium, Foxborough, MA; and
- Linden Ponds Retirement Community, Hingham, MA.

3.4.3.5 Potential of Reclaimed Water Use in Orleans

Previous reports have been developed for the Town and have indicated that the use of reclaimed water should be considered as a viable enhancement to the Town's Water Quality and Wastewater Program for many of the reasons outlined above.

The most recent document (Conceptual Reclaim Water System Memorandum by Stantec dated October 17, 2014) indicates that the theoretical demand of reclaimed water for irrigation approaches 460,000 gpd (69 MG / 150 irrigation days). These potential irrigation sites included:

- Ocean Edge Golf Course – 15 MG annual demand;
- Captain Golf Courses (Port Course and Starboard Course) – 30 MG annual demand;
- Wequassett Resort and Golf Club - 15 MG annual demand;
- Orleans Cemetery - 3 MG annual demand;
- Orleans Athletic Fields on Eldredge Park Way – 3 MG annual demand; and
- Brewster Athletic Fields on Freemans Way (4 fields) – 3 MG annual demand.

The document indicated that a reclaimed water system sized to accommodate the above demand of 460,000 gpd or about 72 percent of the approved CWMP flow of 640,000 gpd, would include a pumping system, storage tank and distribution network and has an "order of magnitude" cost of about $12,000,000 as shown below.

Reclaim Water Pumping system	$100,000
Reclaim Water Storage Tank	$500,000
Reclaim Water Distribution Network (12 miles X 5,280 feet/mile = 64,000 lf at $180/lf)	$11,500,000

3.4.3.6 Conclusions and Recommendations

Discussions with the Town of Brewster on March 24, 2016 indicated that the use of reclaimed water would be limited since the sites are located in nitrogen sensitive areas. The incorporation of a reclaimed water system increases the capital, operation and maintenance, replacement and monitoring costs of the proposed WWTF. While the costs within the limits of the proposed WWTF are modest, the cost of the distribution system necessary to bring the treated wastewater to the various points of use would be substantial, as indicated by the $12 million estimate previously developed. AECOM has reviewed this estimate, and concurs that it is in the right order of magnitude.

The incorporation of a reclaimed water system does not result in a reduction of effluent disposal capacity since the current state rules and regulations require that an effluent disposal system be incorporated into the project plan in case effluent quality degrades to a level that is not acceptable for reuse.

Preliminary communications with the Town of Brewster and Brewster golf courses did not identify useful options, but that there are other private and public sites in Brewster that will be investigated during the next phase of planning/design, such as the Brewster Day Camp, Ocean Edge and Nickerson State Park, and the stone/concrete company.

In conclusion, the incorporation of a reclaimed water system at the proposed WWTF site would increase the capital, operation and maintenance, replacement and monitoring costs at the WWTF. Additionally, because there are no large scale users of irrigation water in immediate proximity to the proposed WWTF site, there is considerable capital expense associated with a distribution system to bring reclaimed water to potential points of use. Lastly, there is some uncertainty on whether or not some of the identified points of use would be viable due to watershed concerns and/or public perception issues. At a time when implementation of different elements of the Town's Water Quality and Wastewater Program is subject to limited revenues, AECOM recommends that water reclamation not be included in the Program at this time. The currently recommended treatment process for the proposed Overland Way WWTF lends itself well to being modified for water reclamation in the future should water reclamation prove to be more viable at a later date, but items such as storage, color treatment, and most importantly a distribution system are not recommended at this time.

3.4.4 Project Cost Estimates

A Project Cost estimate was prepared for each of the Traditional and Non-Traditional technologies. The details of these estimates are included in the various Technical Memorandums included in Appendices. This included estimates for the Non-Traditional Demonstration Projects, as well as best estimates for the full-scale implementation projects, assuming the technologies are cost-effective

3.4.4.1 Development of Program Costs

Cost estimating is a critical component of project evaluation in the early stages of planning and concept design, before selection of a definitive plan and commitment of any funds. The Program Costs were developed with AECOM in-house specialists who provide cost estimates for construction and operation using industry standards for materials and labor as well as actual bid tabs from a library of projects. Supplemented with information obtained from the Project's interactive workshops and a collaborative process to fully understand the cost implications of the various alternatives, these comprehensive costs allow for informed decision making.

The Program Costs include Capital Costs, Annual Operation and Maintenance Costs, Replacement Costs and Monitoring Costs. These costs obviously vary with the specific design considerations and layout configurations, etc.

The Program Costs presented are planning level costs and should be refined as additional informational details are identified and/or determined. This refinement to the project scope includes topographic survey, subsurface exploration, types of equipment, redundancy, and types of control systems. In addition, project constraints, project schedule, and overall project complexity will impact Program Costs if the program is phased. Although planning level Program Costs have been updated throughout the process of preparing this Amended CWMP, it is recommended that anticipated costs be updated again just prior to appropriation of funding for design and construction.

The Program Costs are preliminary in nature and contain construction cost, construction contingencies, administrative, legal, construction engineering, environmental and regulatory permitting. The Class 3 opinion of probable construction costs were developed in accordance with “AACE International Recommended Practice No. 18R-97 - Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries” as prepared by the Association for the Advancement of Cost Estimating (AACE) International (www.aacei.org) dated February 2, 2005. Refer to Table 3-10 for the AACE International Cost Estimating classification system.

AECOM has no control over costs of labor, materials, competitive bidding environments and procedures, unidentified field conditions, financial and/or market conditions or other factors likely to affect the opinion of probable project costs all of which are and will unavoidably remain in a state of change. It is further understood that the probable project costs are a “snapshot in time” and that the reliability of this opinion of probable project costs will inherently degrade over time. The probable project costs need to be indexed on a common “baseline”. The construction industry uses the Engineering News Record (ENR) Construction Cost Index (www.enr.com) that is based on construction and materials costs throughout the United States. Therefore, the probable project costs contained herein are based on an ENR Construction Cost Index of 10182 for February 2016.

3.4.4.2 Capital Costs

Capital Costs are those to construct any type of wastewater treatment system including Non-Traditional and Traditional technologies. Capital Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Capital Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources. Included in the Capital Costs were land purchases, at $250,000 per acre, required for locations of pumping stations that are not proposed on existing municipally owned land.

Table 3-10 - AACE International Cost Estimating Classification System

Estimate Class	Primary Classification	Secondary Classification			
	Level of Project Definition[1]	End Usage[2]	Methodology[3]	Expected Accuracy Range[4]	Preparation Effort[5]
5	0 to 2 percent	Concept Screening	Capacity Factored, Parametric Models, Judgment or Analogy	L: -20 to -50 percent H: +30 to +100 percent	1
4	1 to 15 percent	Study or Feasibility	Equipment Factored or Parametric Models	L: -15 to -30 percent H: +20 to +50 percent	2 to 4
3	10 to 40 percent	Budget Authorization or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10 to -20 percent H: +10 to +30 percent	3 to 10
2	30 to 70 percent	Control or Bid Tender	Detailed Unit Cost with Forced Detailed Take-off	L: -5 to -15 percent H: +50 to +20 percent	4 to 20
1	50 to 100 percent	Check Estimate or Bid Tender	Detailed Unit Cost with Detailed Take-off	L: -3 to -10 percent H: +3 to +5 percent	5 to 100

Notes:

1 Expressed as percent of Complete Definition

2 Typical Purpose of Estimate

3 Typical Estimating Method

4 Variation of Low and High Ranges. The state of process technology and availability of applicable reference costs data affect the range market. The +/- value represents percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope.

5 Typical Degree of Effort Relative to Least Cost Index of 1. If the range index value of "1" represents 0.005 percent of project costs, then an index value of "100" represents 0.5 percent. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

3.4.4.3 Operation and Maintenance Costs

Operations and Maintenance (O&M) Costs relate to the day-to-day running and upkeep of the Non-Traditional and Traditional technologies. O&M Costs include items such as labor, utilities, chemicals, etc. In order to achieve maximum asset life and reduce O&M costs, the establishment of standardized O&M procedures is critical. Standardized procedures help personnel operate all assets within acceptable operational levels and ensure that each person is following the same routines. Lack of regular maintenance may result in the deterioration of the system components and result in rapid failure and reduced nitrogen removal from the environment as well as the ability to meet operating permits. O&M Costs are an annual cost generally paid through fee or tax revenues as costs accrue. O&M Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

3.4.4.4 Replacement Costs

In addition to O&M Costs, components will malfunction or fail and therefore Replacement Costs, including Repair Costs, become a necessary part of the overall costs of the wastewater system. Replacement Costs are used to replace various pieces and parts of the Non-Traditional and Traditional technologies that have failed or malfunctioned such as the injection of liquid organic carbon (i.e. emulsified vegetable oil) for Permeable Reactive Barriers or to replace a broken pump bearing. As part of an Asset Management Program, a schedule of assets with their useful life should be developed since understanding the costs for partial replacement and full replacement of an asset will become necessary for sound financial planning. If more funding is spent on a repair to an asset, there will be a decreased need for the replacement of the asset. However, if greater funding is spent to replace the asset, therefore will be a decreased need for repairs to an asset. Overall there is a balance between how much to fund in each category in order to achieve the most efficient system. Like Capital Costs, Replacement Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Replacement Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources.

3.4.4.5 Monitoring Costs

Monitoring of the Non-Traditional and Traditional technologies is an essential component of adaptive management. Monitoring will assess the effectiveness of the different technologies to remove nitrogen from the environment. Monitoring for compliance with the Massachusetts Estuaries Project Total Maximum Daily Load of nitrogen is different than direct measurement of nutrients in a point discharge. Monitoring for compliance with the Total Maximum Daily Load requirements requires receiving water sampling to document changes in nutrient concentrations achieved through the range of technologies implemented for nitrate reduction. The results of monitoring will indicate which technologies are working and which are less successful. This allows adjustments in the phased approach to improve overall performance of the solution. Like O&M Costs, Monitoring Costs are an annual cost generally paid through fee or tax revenues as costs accrue. Monitoring Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

The Project Cost estimates for Traditional and Non-Traditional technologies are shown in Table 3-11.

Table 3-11 Project Cost Estimates for Traditional and Non-Traditional Technologies

Components	Capital Cost	Annual O&M Cost	Annual Replacement Cost	Annual Monitoring Cost
Traditional Technologies				
Downtown Area				
Collection System - Downtown Area	$ 20,725,100	$ 220,500	$ 27,200	$ 8,900
Wastewater Treatment Facility - Downtown Area (Overland Way)	$ 17,079,600	$ 952,600	$ 102,500	$ 16,900
Effluent Disposal - Downtown Area (Overland Way - Parcel 1/1A)	$ 2,702,200	$ 11,300	$ -	$ 10,800
	$ 40,506,900	$ 1,184,400	$ 129,700	$ 36,600
Meetinghouse Pond Area				
Collection System - Meetinghouse Pond	$ 21,253,500	$ 166,800	$ 32,800	$ 3,000
Wastewater Treatment Facility - Meetinghouse Pond (223 Beach Road)	$ 8,003,100	$ 284,300	$ 51,300	$ 16,900
Effluent Disposal - Meetinghouse Pond (223 Beach Road)	$ 1,189,000	$ 11,300	$ -	$ 10,800
	$ 30,445,600	$ 462,400	$ 84,100	$ 30,700
Non-Traditional Technologies				
Nitrogen Removing Biofilter				
Nitrogen Removing Biofilter - Demonstration 1	$ 178,900	$ 700	$ -	$ 28,500
Nitrogen Removing Biofilter - Demonstration 2	$ -	$ -	$ -	$ -
Nitrogen Removing Biofilter - Site 1	$ 5,501,800	$ 25,500	$ -	$ 89,100
Nitrogen Removing Biofilter - Site 2	$ 6,712,200	$ 25,500	$ -	$ 89,100
Nitrogen Removing Biofilter - Site 3	$ -	$ -	$ -	$ -
Nitrogen Removing Biofilter - Site 4	$ -	$ -	$ -	$ -
Nitrogen Removing Biofilter - Site 5	$ -	$ -	$ -	$ -
Aquaculture/Shellfish Propagation				
Aquaculture/Shellfish Propagation - Demonstration 1 - Terminal Pond Oyster Bed	$ 126,900	$ 143,800	$ -	$ -
Aquaculture/Shellfish Propagation - Demonstration 2 - Kent's Point Oyster Bed	$ 49,900	$ 216,400	$ -	$ 54,700
Aquaculture/Shellfish Propagation - Demonstration 3 - Shellfish Extension Program	$ 540,500	$ -	$ 48,000	$ 58,900
Aquaculture/Shellfish Propagation - Demonstration 4 - Quahog Inventory	$ 50,800	$ -	$ -	$ -
Aquaculture/Shellfish Propagation - Site 1 - Shellfish Extension Program	$ 432,300	$ 45,300	$ 87,843	$ 58,900
Aquaculture/Shellfish Propagation - Demonstration 2 - Quanset Pond Oyster Bed (2nd Year)	$ 756,700	$ -	$ -	$ 59,500
Aquaculture/Shellfish Propagation - Full Scale Location TBD	$ 1,080,800	$ 45,300	$ 51,300	$ 59,500
Permeable Reactive Barriers				
Permeable Reactive Barriers - Demonstration 1 - Landfill Focused Injection Test	$ 164,100	$ -	$ 8,700	$ 116,200
Permeable Reactive Barriers - Demonstration 2 (Eldredge Park South Main St. Area)	$ 593,800	$ -	$ 17,100	$ 244,300
Permeable Reactive Barriers - Site 1 - Landfill (1,500 L.F.)	$ 1,597,600	$ -	$ 70,040	$ 117,500
Permeable Reactive Barriers - Site 2 - Eldredge Park (3,500 L.F.)	$ 2,934,800	$ -	$ 71,896	$ 433,700
Permeable Reactive Barriers - Site 3	$ -	$ -	$ -	$ -
Permeable Reactive Barriers - Site 4	$ -	$ -	$ -	$ -
Permeable Reactive Barriers - Site 5	$ -	$ -	$ -	$ -
	$ 20,721,100	$ 502,500	$ 354,879	$ 1,409,900
Other Program Components				
Adaptive Management Implementation	$ -	$ 157,025	$ -	$ -
Program Management	$ -	$ 92,948	$ -	$ -
Miscellaneous	$ -	$ 5,313	$ -	$ -
	$ -	$ 255,285	$ -	$ -
Totals	**$ 91,673,600**	**$ 2,404,585**	**$ 568,679**	**$ 1,477,200**

	On-Site System Type		Wastewater Flow (gpd)	
On-Site Ownership Cost (Per year per On-Site System)	**Conventional**	**I/A**	**Range**	**Average**
Low Wastewater User	$ 800	$ 1,530	0 to 300	150
Medium Wastewater User	$ 1,270	$ 2,290	300 to 1,000	650
High Wastewater User	$ 2,770	$ 4,280	>1,000	1,000

Engineering News Record (ENR) = 10531 (December 2016)

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4.0 Tri-Town Transition Requirements

4.1 Background

The Orleans-Brewster-Eastham Groundwater Protection District (Tri-Town District) owns and operates the Tri-Town Septage Treatment Facility, located on Overland Road in Orleans, MA. The Facility was constructed over 30 years ago and is designed to treat up to 45,000 gallons per day of septage and grease. A document entitled “Tri-Town Septage Treatment Facility Decommissioning Action Plan”, dated October 18, 2013 was prepared by Stantec Consulting Services Inc. for the Tri-Town District. The purpose of the report was to develop an action plan to decommission and demolish the Tri-Town Septage Treatment Facility prior to May 30, 2015 (expiration date of the agreement). Following the preparation of the report, the Tri-Town District agreement and the Facility’s MassDEP Groundwater Discharge Permit were both extended until December 2016.

The Tri-Town Septage Treatment Facility has reached the end of its useful life and the Tri-Town Septage Treatment Facility Board of Managers voted not to fund interim improvements estimated at approximately $1,000,000 for a 5-year extended life and ultimately to cease receipt of septage on June 1, 2016.

4.2 Estimated Costs

AECOM’s estimated cost to decommission and demolish the Tri-Town Septage Treatment Facility including demolition, site restoration, engineering and contingencies is estimated at $2,025,000. The results are shown in the attachment following the Technical Memorandum (Appendix L). AECOM estimates that a savings of 10 to 20 percent ($200,000 to $400,000) can be realized if the decommissioning and demolition of the Tri-Town Septage Treatment Facility is included as part of the construction of a new Wastewater Treatment Facility at the site. The potential cost savings does not include the potential additional cost savings that might be achieved through repurposing some of the existing facility (e.g. – administration building) as part of the new Wastewater Treatment Facility. These potential cost savings were considered as the concept for the proposed new Wastewater Treatment Facility developed as part of Task No. 1 – Facilities Engineering, subtask C Facilities Conceptual Design.

4.3 Schedule

- Plant decommissioning took about 3-months and occurred between July 2016 and September 2016;
- Towns voted to extend 3-month salary retention offer to employees to stay at the facility to conduct plant decommissioning process;
- Design of demolition was procured and contracted on June 8, 2016 Town Meeting took about 5 months and occurred between June 2016 and October 2016;
- Bid in hand for demolition by March 1, 2017 to allow Town Meeting Appropriations (Brewster, Eastham, and Orleans); and
- Demolition to expect to start in September 2017 and be completed in March 2018.

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5.0 Demonstration Project Design and Implementation

The Consensus Agreement (Figure 4-1) recommended three Non-Traditional (NT) technologies for use in key locations in Orleans' sub-watersheds in order to reduce nitrogen loading in the Town's coastal estuaries: Floating Constructed Wetlands (FCW), aquaculture/shellfish propagation, and permeable reactive barriers. This section describes each of these NT tools, discusses site selection for demonstration projects for each NT, and describes the work plan associated with the demonstration projects. In addition, a Nitrogen Reducing Barrier (NRB) is a new, innovative NT technology that was not identified in the Consensus Agreement and is now under consideration for implementation in Orleans; this new NT technology is also discussed below.

5.1 Floating Constructed Wetlands

Floating Constructed Wetlands (FCWs) are one of the Non-Traditional technologies that have been considered to reduce nitrogen loads to receiving waters. The Site Characterization and Evaluation Technical Memorandum (Appendix M) documents the process used to identify, evaluate, rate, rank and ultimately recommend specific demonstration sites to test the efficacy of FCW for nitrogen removal and the Work Plan Technical Memorandum (Appendix N) sets forth the conceptual design of the FCW, including the project components, sequencing of subtasks, the equipment, labor and other resources required to construct the FCW, and a preliminary cost estimate. However, after review of the costs for implementing FCW as well as the uncertainty of nitrogen removal that could be achieved, the Town decided to curtail pursuit of FCW implementation and instead focus on other NT to meet nitrogen removal goals.

5.2 Nitrogen Reducing Biofilters

Nitrogen Reducing Biofilters are one of the Non-Traditional tools being tested by the Town of Orleans to determine the efficacy in managing nitrogen at its source. The intent of including the Nitrogen Reducing Biofilters as part of the nitrogen management solution is to reduce the amount of nitrogen entering the environment from the discharge from on-site sewage disposal systems by addressing it at its source.

The Site Characterization and Evaluation Technical Memorandum (Appendix O) documents the process used to identify, evaluate, rate, rank and ultimately recommend specific demonstration sites to test the efficacy of Nitrogen Reducing Biofilters to reduce the amount of nitrogen entering the environment from on-site sewage disposal systems. The Nitrogen Reducing Biofilters Work Plan Technical Memorandum (Appendix P) sets forth the conceptual design of the Nitrogen Reducing Biofilters, including the project components, sequencing of subtasks, the equipment, labor and other resources required to incorporate the Nitrogen Reducing Biofilters into at sewage disposal system upgrade and a preliminary cost estimate. The Nitrogen Reducing Biofilters Work Plan also sets forth a draft monitoring and maintenance plan, along with potential regulatory requirements and funding sources.

Description of a Nitrogen Reducing Biofilter - Nitrogen Reducing Biofilters can be constructed as a component of a sewage disposal system Soil Absorption Area with a horizontal layer of sandy soils overlying a layer of sand mixed with finely ground wood that is dosed with septic tank effluent using a low pressure distribution system. Nitrogen Reducing Biofilters can also be constructed as a separate sewage disposal system component that receives septic tank effluent and discharges to a Soil Absorption Area for disposal.

In the past, Vertical Permeable Reactive Barriers have been used to remove nitrogen from groundwater by placing a vertical column of woodchips as a permeable barrier that extends beneath the water table down gradient from a groundwater plume that contains nitrogen. This results in a reduction of nitrate to nitrogen gas as the groundwater plume passes through the barrier. The reactive zone containing woodchips provides carbon and the anoxic conditions necessary for denitrification.

Based on research performed at the Massachusetts Alternative Septic System Test Center, The New York State Center for Clean Water Technology, and the Florida Onsite Sewage Nitrogen Reduction Study. Nitrogen Reducing Biofilters have been found to significantly reduce the nitrogen discharge from sewage disposal systems into the environment. 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 would then discharge to a conventional soil absorption system for subsurface recharge of the treated effluent. (Heufelder, 2016) and (Stony Brook University 2016).

Up to 10 sites will be evaluated with the Orleans Board of Health and four sites will be selected to test the Nitrogen Reducing Biofilters.

5.3 Aquaculture/Shellfish Propagation

Orleans has chosen to include shellfish propagation as a means to reduce the amount of nitrogen entering watersheds where sewering is not currently planned. Four different demonstration projects are planned in order to obtain site specific information within Orleans’ waterbodies and the viability of pursuing any or all to full-scale implementation. The demonstration projects have been scaled in a way to allow meaningful monitoring and quantifiable results while expending only the minimal amount of necessary funds during this experimental phase. While all of the demonstration projects have been thoughtfully planned, it should be understood that there is a possibility that one or more may not prove to be successful to implement at a full-scale level.

The purpose of the Orleans shellfish demonstrations is to both locally measure the nitrogen-removal benefits of shellfish cultivation, as well as demonstrate the practical applications of shellfish propagation and aquaculture expansion within the Town of Orleans. A two-step approach to plan and design demonstration projects for Orleans has been taken. The first step is to review existing data and evaluate a number of potential sites for overall suitability using a variety of criteria. This siting evaluation provides a transparent and objective assessment of possible locations in Orleans for the installation of shellfish based Non-Traditional technology demonstration projects.

In Orleans, the most suitable shellfish species for aquaculture include American (or Eastern) oyster (*Crassostrea virginica*), hard clam (or northern quahog) (*Mercenaria mercenaria*), and blue mussel (*Mytilus edulis*). Shellfish aquaculture for Orleans involves growing single oysters and/or quahogs in gear such as bags, trays or cages until these shellfish reach a suitable size for bottom planting or harvest. Aquaculture systems that require supplemental feeding to support growth are not under consideration. Blue mussels were evaluated and rejected for a demonstration project due to the difficulty of growing this species at this time. Nitrogen-removal calculations are based on average shellfish uptake as demonstrated in published literature as well as through personal experience by the assembled Team.

The Aquaculture/Shellfish task work is summarized in the following Technical Memoranda:

- The Final Site Characterization and Evaluation TM (Appendix O); and
- Preliminary Engineering Design and Work Plan Technical Memorandum (Appendix P).

Highlights from these Technical Memoranda are provided below, and the complete documents are located as appendices.

5.3.1 Site Review and Validation

The Final Site Characterization and Evaluation Technical Memorandum is provided in Appendix O and presents the process used to identify, evaluate, rank and ultimately recommend specific shellfish demonstration sites. The Memorandum details: a description of the initial process that was employed to develop the Orleans Consensus Agreement and associated potential demonstration sites; next steps that have been taken in the process of evaluating demonstration sites; data that are available to help evaluate potential demonstration sites; evaluation and ranking of sites based on the site selection matrix and criteria; recommended demonstration sites paired with specific shellfish propagation approaches (such as bottom planting hard shell clams, oyster beds or oyster aquaculture), and rationale for selection.

Locations evaluated as potential sites for shellfish demonstration included those identified in the Consensus Agreement. As detailed in the Technical Memorandum in Appendix O, the Nauset harbor embayment and Pleasant Bay watersheds were also reviewed to identify potential demonstration locations that may not have been identified during development of the Consensus Agreement. The final list of sites evaluated for demonstration projects included the following:

- Little Pleasant Bay Existing Grants Quanset Oyster Bed;
- Pochet Oyster Bed Arey's Pond Oyster Singles in Floating Bags ;
- Town Cove quahog propagation Mill Pond quahog propagation; and
- Lower River Oyster Singles in Floating Bags.

5.3.2 Site Evaluation and Screening Criteria

To facilitate a systematic and objective evaluation of each of the potential demonstration sites, a Site Selection Matrix was developed. This Site Selection Matrix includes a number of criteria for Site Suitability, Permitting, and Project Evaluation. Site Suitability criteria address the environmental, land use and implementation characteristics of each proposed demonstration location. Permitting criteria assess the regulatory issues related to each proposed demonstration location. Project evaluation criteria estimate the likelihood of obtaining meaningful results from a proposed demonstration site. Other/Overriding Considerations refer to any threshold issue that precludes a demonstration at a given site.

These criteria were first presented as part of the process of developing the Orleans Consensus Agreement. The Shellfish Technical Team refined the criteria after reviewing the Site Ecology and Surrounding Environment data as described above. The Site Selection Matrix now includes the following criteria, which are described in detail in the Technical Memorandum (Appendix O):

Site Suitability: Available growing area/adequacy of acreage; water quality indicators; disease/predation; ease of access; aesthetic impacts; representativeness of the site (transferability); use conflicts; ability to co-locate with other Non-Traditional technologies.

Permitting: Abutter compatibility; wild harvest conflicts (Massachusetts Department of Marine Fisheries [DMF]); grow-out to harvest size allowed (DMF); and permittability.

Project Evaluation: Expected survival; and overall likelihood of monitoring plan to yield quantifiable results

5.3.3 Analysis: Evaluate and Rate Each Site Based on Criteria

To rank each criterion in the Site Selection Matrix, the Shellfish Technical Team assembled available data, and conducted a site visit. A ranking system was then developed to quantify how well each site met a specific criterion.

To apply the ranking system to each potential shellfish demonstration site, the Shellfish Technical Team held a day-long working session. At this session, the Team first reviewed and discussed all of the available information for each site: water quality data from the Massachusetts Estuaries Project Reports, Pleasant Bay Alliance data and reports, shellfish suitability and other Geographic Information Systems (GIS) maps from the DMF, preliminary grain size maps from Center for Coastal Studies and notes from site visits with the Assistant Harbormaster and Shellfish Constable/Harbormaster. The Team then evaluated each demonstration site and ranked the criteria for each site based on this available information.

The final step in site evaluations is to assign an overall rating to each site based on evaluation findings and criteria rankings. Findings/Recommendations: Summary of Site Selection Matrix/Site Screening Results.

The top two sites derived from both the Site Selection Matrix as well as Team deliberations were Little Pleasant Bay for shellfish aquaculture and Quanset Pond for a coastal habitat restoration oyster bed. These two sites were also recommended by the Shellfish Constable/Harbormaster and Assistant Harbormaster during the site visits.

To demonstrate the water quality benefits as well as implementation logistics and practical densities of oyster aquaculture, working with current shellfish grant-holders seems ideal. The expertise, gear and interest already exist. The plan for this option generally includes working with growers to optimize shellfish harvest numbers, identify the needs of this group, and design a monitoring plan that can capture water quality impacts. This work is planned for Pleasant Bay and Town Cove grant-holders.

To demonstrate an oyster bed, Quanset Pond was initially identified as having several advantages, including ease of access and patrol, suitable bottom and nutrients, and a reasonable expectation of monitoring yielding quantifiable results. Pochet was also identified as a favorable location for an oyster bed demonstration but access and patrol is more difficult, and therefore this site did not rank as highly as Little Pleasant Bay and Quanset.

Plans to install an oyster bed demonstration project in Quanset Pond were reevaluated in the summer of 2016 due to concerns about predation and sedimentation that would threaten the oysters. In a re-evaluation of the site selection process for the oyster bed demonstration project in summer and fall of 2016, additional sites were evaluated, rated and ranked (Appendix Q). In this evaluation process the Team also discussed whether any criterion was more important than another and determined that expected survival should hold a higher weight for the oyster bed demonstration project because the ultimate goal is to determine if an oyster bed can be successfully grown and sustainable in Pleasant Bay. For this evaluation, the expected survival criterion was weighted twice as high as all others (assigned a value of 2, with all others assigned a value of 1). As a result, the Shellfish Working Group identified a location just offshore of Kent’s Point as the preferred site for the oyster bed demonstration project. Kent’s Point has several advantages, including: it is situated in the section of Pleasant Bay that is more impaired/nitrogen-enriched, has good accessibility, good visibility for public education, recent designation by the Town as a “no wake” zone, and is a town-owned parcel with specific provisions in the deed for shellfish cultivation.

Pursuing a shellfish demonstration in Town Cove or Mill Pond was not recommended in the site selection process because (1) oyster propagation is precluded due to excessive oyster drill population (Massachusetts Shellfish Officers Association advises against oyster propagation where drills are prevalent as a Best Management Practice) and; (2) a population study for quahogs is necessary to establish a baseline before any new propagation can be quantified. Lonnie’s Pond had not been evaluated initially by the Shellfish Team during site selection due to it having been selected by the FCW team as the best alternative for Floating

Constructed Wetland implementation. Once the Town put implementation of the Floating Constructed Wetland technology temporarily on-hold until further refinement of estuarine nitrogen removal and costs were evaluated, Lonnie's Pond was identified as the preferred location for the town's first shellfish demonstration project. This selection was made based on two key factors: the town's strong desire to improve the environmental conditions in the town's terminal ponds, and the expected ability to monitor water quality and other impacts caused by shellfish in this semi-closed sub-embayment.

5.3.4 Discussion of Selected Shellfish Demonstration Projects

Once the specific locations for demonstrations were selected, the next step was to define the specific design parameters for each demonstration project site, including numerical targets for shellfish and nitrogen-removal. This detailed design and engineering including schedules of implementation is presented in the Preliminary Engineering Design and Work Plan Technical Memorandum (Appendix P) and contains a detailed monitoring plan for water quality as well as shellfish biomass, predators and diseases. The Technical Memorandum in Appendix P presents detailed preliminary designs for four different shellfish demonstration projects. To identify the sites included in this Technical Memorandum, an in-depth critique of the above Site Characterization Technical Memorandum was conducted, involving review and comments from several outside experts as well as several meetings with a Town of Orleans working group that consisted of the Shellfish Constable/Harbormaster and representatives from the Shellfish and Waterways Advisory Committee, Orleans Marine and Freshwater Quality Task Force, Orleans Pond Coalition, Citizens Peer Review Committee, and Orleans Water Alliance. The memorandum in Appendix P also identifies potential sources of grant funding for implementing the demonstration projects. The four selected demonstration projects are listed below and summarized in the following sub-sections.

- Propagation of oysters in Lonnie's Pond;
- Increased production of quahogs in Town Cove through additional seed planting;
- Formation of an oyster bed in Kent's Point; and
- Enhancing oyster aquaculture in Pleasant Bay and Town Cove by either working with existing growers to increase production and/or through the Town offering additional lease areas.

Complete details of each demonstration project, including proposed schedules, are included in the Technical Memorandum in Appendix P.

5.3.5 Lonnie's Pond Oyster Singles Installation

The first year plan for Lonnie's Pond was to grow between 170,000 to 340,000 oyster singles, starting at a size of at least ½ inch, in floating bags. Approximately 200,000 oysters were purchased from the Town of Falmouth and were installed in Lonnie's Pond in floating bags on 6/22/16 and 6/27/16. This demonstration design mitigates against the known issues with predation and siltation by maintaining the oysters in floating gear. Most of an oyster's nitrogen uptake occurs during the second year of growth. Therefore, to maximize the impact of this demonstration project on water quality parameters, oysters should be grown starting with the largest size seed available, with a minimum starting size of ½ inch. Based on the timing of decision making related to this demonstration, availability of seed was one critical factor that determined the final number of oysters and initial size that were grown during this demonstration project.

Monitoring of water quality, sediment and benthic impacts, and oyster growth and nitrogen content will provide critical evidence regarding the environmental aspects of shellfish cultivation. This information will help define future shellfish programming. In addition, operation and maintenance, actual costs and neighborhood responses will be documented to inform future decision making.

5.3.6 Increased Quahog Population and Propagation Planning

In Town Cove and parts of Pleasant Bay, expansion of municipal quahog propagation is recommended to establish maximum practical densities that can be grown and harvested in these areas, and to allow water quality changes to be correlated to numbers of new quahogs added to these systems. Quahogs have been grown successfully through the Town's propagation program, and there is suitable bottom in both Town Cove and Pleasant Bay for increased quahog planting. Based on site reviews, it was found that there are existing populations of quahogs throughout Town Cove and Pleasant Bay. Therefore, a quahog demonstration should only be pursued after a baseline quahog population has been established. This will provide an estimate of current quahog densities in specific areas where additional quahogs would be planted as part of a demonstration project.

Determining current populations before additional quahogs are added to these waterbodies is an important first step in evaluating survival, growth, and the impacts of additional quahogs on water and sediment quality. This survey is also critical to determining how many additional quahogs should be planted. In 2017 this demonstration project will begin in Town Cove. The specific areas in Town Cove to be surveyed, quantity of quahogs purchased, as well as the precise location where quahogs will be planted will be determined in close coordination with the Town Department of Natural Resources staff. The acreage that will be surveyed and the number of quahogs that are purchased for bottom-planting will be limited by available funding, final cost per acre for the survey, and the price of quahogs of field-plan table size (approximately 21 to 25mm).

Once the baseline population is established, the specific quantities and sizes of additional quahogs will be recommended as part of an expanded quahog propagation program for certain areas in Town Cove and Pleasant Bay. For planning purposes, the goal for 2017 is to survey at least ten acres, beginning with the area near the Orleans Yacht Club and plant at least 100,000 quahogs in this area.

5.3.7 Kent's Point Oyster Bed Installation

The Orleans oyster bed demonstration projects involve growing remote sets and planting them in suitable areas, resulting in bed-like grow-out under the diverse environmental conditions experienced over the course of a typical Pleasant Bay growing season. The waters of Pleasant Bay do not have a naturally-occurring oyster population that could spawn. To establish an oyster bed in areas where there is no natural set, remote set can be used to introduce oysters into the growing environment.

The technique for establishing an oyster bed in the Kent's Point area is similar to techniques used throughout Cape Cod, and recently implemented successfully in West Falmouth Harbor, MA. This technique begins with installing remote set in trays and/or floating bags for an initial growing period. In the Kent's Point area, remote set will likely be able to be bottom planted after approximately eight weeks. The remote set will likely be planted under the bags and trays in which they were initially grown. The significant benefit of planting remote set after a maturation period is that it allows the oyster spat to mature in a protected environment, thus reducing predation and mortality. Planting remote set when oysters have reached over 1.5 inches (38 mm) in size also reduces mortality caused by siltation. Harvest occurs by opening this area to recreational harvest.

Growing out remote set in both trays as well as floating bags with bottom-planting will enable an evaluation of the growth and survival rates of each technique. Moreover, evaluating the potential for bottom-planting oyster remote set at Kent's Point will help determine the feasibility of expanding oyster beds in other parts of Pleasant Bay where there is suitable substrate, such as areas along the Upper and Lower River, Quanset, Namequoit, and Pochet.

The plan for this demonstration project in 2017 involves developing a scope of work for baseline water quality monitoring and for SMAST to begin monitoring within the proposed growing area; prepare a draft engineering design for a 2017 installation; review the plan with the Shellfish Working Group; and finalize the engineering design for 2017 installation.

Shellfish Aquaculture The demonstration methodology proposed for Little Pleasant Bay involves working with the growers on the town's existing private shellfish leases. There are currently 12 leases with an average size of 1.75 acres. Typically, single oysters are raised from seed to harvest size in trays, bags and cages. In total, growers are harvesting approximately 1,000,000 oysters annually from these leases in Pleasant Bay. Working with growers can create opportunities to demonstrate the water quality benefits as well as implementation logistics and practical densities of oyster aquaculture.

The expansion of private leases for oyster aquaculture in certain areas of Town Cove is also an important option to pursue. Oyster aquaculture in gear, off the bottom would be the only method of growing oysters in this area due to the oyster drill population. The expansion of private grants requires several permitting steps beginning with a recommendation from the Board of Selectmen to the Massachusetts Division of Marine Fisheries. A study of the feasibility of expanding private aquaculture leases is needed to assess the Town's interest in this approach for shellfish propagation in Town Cove.

This demonstration will build on these established growing methods, and includes three components: developing and disseminating a questionnaire to determine whether growers are interested working with the town to expand shellfish propagation for the purpose of water quality improvements; working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate; and evaluation of areas in Town Cove for expanding shellfish leases.

Activities proposed for late 2016 through June 2017 include: developing a survey to gauge interest from Pleasant Bay growers in exploring an expanded production program in Pleasant Bay; disseminating the survey through the Shellfish Constable; aggregating and understanding the survey results; and discussing survey findings and grower interest in pursuing an enhanced aquaculture demonstration in Pleasant Bay with the Shellfish Working Group.

5.3.8 Detailed Assessment of Lonnie's Pond Monitoring Program

The purpose of implementing shellfish demonstrations in Orleans is to determine the extent to which shellfish can be grown to achieve water quality improvement goals as well as compliance with regulatory standards. Monitoring of both ecological parameters as well as implementation success will provide information that is needed to incorporate shellfish into the town's full-scale water quality improvement program. The SMAST Quality Assurance Policy Plan for water quality and benthic denitrification and infauna sampling will be followed during the monitoring of this demonstration project.

5.3.8.1 Water Quality Monitoring

To quantify any water quality changes that result from this demonstration project, twice monthly sampling from May to September will include the following parameters at both water surface and bottom locations (where depth is greater than 5 feet) at the sampling stations: Total Nitrogen (TN), nitrate + nitrite, ammonia, dissolved organic nitrogen (DON), dissolved inorganic nitrogen (DIN), particulate organic nitrogen (PON), Temperature, Chlorophyll a, Pheophytin a, PO4 (SRP), Salinity, Dissolved oxygen (DO), and Transparency (Secchi depth. Continuous monitoring of Chlorophyll a, DO and turbidity is being conducted at five locations from sondes installed approximately 30 cm off the bottom. Eight monitoring stations were established in order to determine the water quality changes due to the installation of the oysters: 1 sentinel (middle of Pond), 1 northern, 1 at the coast to the south (western), 1 in tidal river channel, and 4 around the oyster deployment area (1 east, 1 west, 1 outboard, and 1 within). SMAST sampled each location every other week, and asked for town volunteers to collect surface water inflows and obtain secchi disk readings at the sentinel station every other week. SMAST will be preparing a report at the conclusion of the monitoring program for the year, which will be submitted to the Town by January, 2017.

5.3.8.2 Measuring Changes in Sediment and Benthic Flux Associated with Oyster Aquaculture

Analysis of enhanced sediment denitrification that can be attributed to oyster aquaculture is critical to determining the impact of oysters on the estuary in which they are grown. This analysis includes collecting sediment core samples and incubating them under in situ conditions during the period of maximum denitrification rates in summer (July–September); and collecting time series measurements of total dissolved nitrogen, nitrate + nitrite and ammonium. The rate of oxygen uptake is also necessary in order to: (1) evaluate sediments relative to organic matter deposition rates; and (2) develop a general nitrogen model for oyster impacts to the nitrogen cycle in the sediments. This monitoring will happen in 2017 once the oysters are larger. A sediment sampling program was initiated during the 2016 growing season to understand the deposition from the oysters into the underlying sediments.

5.3.8.3 Monitoring Shellfish Growth and Survival at Lonnie's Pond

In addition to water quality sampling and sediment analysis, tracking the size of the shellfish population, as well as growth and survival rates is also recommended. Single oysters were randomly sampled from floating bags in different rafts, and measured every two weeks to establish growth rates. Survival within the floating bags was quantified monthly. Observations regarding predation and other stressors were recorded. Survival at the beginning of the second growing season should then be measured.

The oysters in the Lonnie's Pond demonstration project grew well during the summer of 2016, with several reaching 4-inch in size or larger. No mortality was recorded through September, and the oysters were still growing and doing well. During the first round of maintenance after installation, some oyster drill eggs were noted. After that initial observation, drills and drill eggs were not observed again.

Additionally, observations regarding increased biodiversity should be made and documented. A basic assessment of species (e.g., shrimp, crabs and fish) in the vicinity of the growing area was made prior to installing the demonstration. Observations of organisms in the water column during operations and monitoring were recorded. Sorting benthic sediments and identifying infauna in the laboratory will be conducted in 2017. Weekly observations of any species that were not initially present in the water column but have been attracted to the area because of oysters due to the structure created by the floating gear were recorded as observed.

5.3.8.4 Overwintering Plan for the Lonnie's Pond Oysters

At the end of the growing season the oysters in Lonnie's Pond will be removed from the floating bags and will be overwintered in the Pond within trays on footings that will keep them off the bottom. The trays will be placed in water deep enough to be below any ice that may form during the winter. This has been approved by the Conservation Commission, and complies with the original directive from them to remove the floating bags from the Pond at the end of the growing season.

5.4 Permeable Reactive Barriers

The Technical Memorandum *Site Characterization and Evaluation for Permeable Reactive Barriers (evaluation criteria and ranking)* (Appendix Q) describes in detail the process involved in identifying and evaluating potential sites for Permeable Reactive Barriers in order to select sites for Permeable Reactive Barrier demonstration testing. The selected locations were then used to develop a Preliminary Engineering Work Plan Technical Memorandum (Appendix R), which detailed designs, schedules, and costs for Permeable Reactive Barrier demonstrations. Strategies for performance verification through groundwater monitoring are included in the Work Plan.

Nitrogen loading from point and non-point sources in the watersheds is impacting surface water quality. Permeable Reactive Barriers can intercept and remove part of this nitrogen load from the groundwater system by enhancing the activity of naturally occurring denitrifying bacteria in the aquifer that consume nitrate in their respiration. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas (denitrification) and requires both anoxic conditions (dissolved oxygen less than 1 mg/L in groundwater) and sufficient food substrate for bacterial growth. Permeable Reactive Barriers provide the food substrate to deplete oxygen levels, resulting in conditions that favor denitrifying bacteria, and food substrate to promote their growth. The Permeable Reactive Barrier treatment zone is located in groundwater below the water table. Nitrate is removed in place in the ground (in-situ) as groundwater flows through the thickness of the permeable barrier.

The Demonstration Tests provide data from November 2016 through June 2017 to assess the effectiveness and applicability of Permeable Reactive Barriers as a treatment alternative for the Town. It is expected that the tests will demonstrate the level of nitrate removal that can be achieved with Permeable Reactive Barriers and provide data to prepare a full scale design. The Demonstration Tests were evaluated by the following performance objectives:

- Achieve satisfactory distribution of the carbon substrate solution into the subsurface;
- Establish and maintain necessary anaerobic (reducing) and groundwater flow conditions in the subsurface throughout the targeted treatment area;
- Demonstrate reduced nitrate concentrations and flux in groundwater through monitoring to extrapolate to reduction targets for full scale (total maximum daily load [TMDL]);
- Demonstrate performance, compliance monitoring, and assessment of treated water quality, including potential secondary water quality affects, through groundwater monitoring program;
- Evaluate time frame for technology performance;
- Evaluate potential impacts to sensitive receptors (surface water, private wells, etc.); and
- Obtain data for engineering evaluations and to optimize full scale design and implementation.

5.4.1 Site Selection

Potential Permeable Reactive Barrier locations identified on the Consensus Agreement Hybrid Map and additional locations were evaluated as potential demonstration sites. The specific methodology used for detailed site evaluations included reviewing potential Permeable Reactive Barrier locations developed through the Consensus Agreement process, review of other locations within the Town of Orleans to identify potential demonstration locations that may not have been previously identified, assess potential Permeable Reactive Barrier nitrogen reductions with the online Multi-variant Planning tool developed by the Cape Cod Conservation Commission (WatershedMVP), field visits to potential sites; review of existing soil and groundwater quality data, discussion of potential demonstration sites with Town of Orleans, officials; ranking of sites based on criteria using Site Selection Matrix; and recommending site locations for additional field investigation and Work Plan cost estimates.

Eight (8) potential locations for Permeable Reactive Barrier demonstration were considered in detail including:

- Main Street and Tonset Road (Main Street);
- South Orleans Road at Tonset/Eldredge Park Way Way (Route 28 site);
- Town Cove Gibson Road;
- Namequoit Road;
- Town Landfill;
- Paw Wah Pond;
- Rock Harbor Road Area; and
- Kescayo Gansett Pond (Lonnie's Pond).

Based on the eight (8) locations identified above, preliminary full scale Permeable Reactive Barrier scenarios were evaluated for nitrogen reduction with WatershedMVP to evaluate estimated nitrogen mass removal for various theoretical Permeable Reactive Barriers at full length based on land use in the watershed and hydraulic capture zone of a theoretical Permeable Reactive Barrier at each site.

A Site Selection Matrix was developed for objective evaluation of selected Permeable Reactive Barrier sites. The Matrix includes criteria for Site Suitability, Permitting, Project Evaluation and Other/Overriding Considerations. These criteria address environmental, land use and implementation features of the proposed demonstration locations. Permitting criteria assess regulatory requirements and potential conflicts related to the proposed demonstration locations. Project evaluation criteria evaluate the benefits gained from a proposed demonstration site. Other/Overriding Considerations refers to other superseding issues that support or prevent a demonstration at a given site.

The Permeable Reactive Barrier Technical Team collected site specific information, conducted site visits, and evaluated the potential performance effectiveness of selected Permeable Reactive Barrier locations with the WatershedMVP tool. A ranking system was then developed to quantify how well each site met a specific criterion.

Results of the evaluation ranking are presented in Table 2 of the Technical Memorandum (Appendix Q). The site suitability evaluation process narrowed the list of potential Demonstration Test sites to the following four locations:

- Main Street and Tonset Road (Site A);
- South Orleans Road at Tonset/Eldredge Park Way Way (Site B);
- Town Cove Gibson Road (Site C); and
- Town Landfill (Site E).

5.4.2 Hydrogeological Investigations

To support further evaluation of these sites and the preparation of a Preliminary Engineering Work Plan for Permeable Reactive Barriers, a groundwater investigation was completed by AECOM in 2016. The investigation included the installation of several groundwater monitoring wells, groundwater sampling, and data analysis on these four sites. Based on the 2016 investigation, a preferred Demonstration Test site at Eldridge Park (Site B) was selected. The Eldridge Park site (Site B) has sufficient groundwater nitrogen data (from AECOM in 2016 and data collected at existing monitoring wells within the areas of interest identified through records search) to support a demonstration project, and the results will be representative of other potential Permeable Reactive Barrier locations in Orleans. The Town-owned Eldredge Park Demonstration Test site is located in the parking lot area between the playing fields off Eldredge Park Way. This demonstration location supports full scale

Permeable Reactive Barriers that may be located in Eldredge Park, along South Orleans Road, Tonset Road, and Main Street or some combination of these options. Permeable Reactive Barriers at one or more of these locations would be designed to reduce nitrogen loading to Town Cove. One additional potential demonstration site, the Town Landfill (Site E) was identified as a test site option that may also be implemented with the preferred site, given sufficient funding. The landfill demonstration location is seen as highly advantageous, close in preference to the Eldredge Park location, and ideally would be implemented along with Eldredge Park Way..

AECOM completed hydrogeological investigations at selected sites in the Town (four locations that scored highest from the site suitability evaluation) to support the design of the demonstration tests. Demonstration tests and groundwater nitrate treatment in general would be most cost effective where the mass flux of nitrate in groundwater is high based on groundwater nitrate concentrations and groundwater flow velocity. The understanding of environmental conditions (the conceptual site model) developed for each of the potential sites was updated with the additional data from site specific investigations, including:

- Depth to groundwater;
- Groundwater flow direction;
- Soil type and groundwater flow velocity;
- Vertical nitrogen concentration profile; and
- General groundwater chemistry.

The potential Demonstration Test sites investigated included:

- Main Street and Tonset Road (Main Street);
- South Orleans Road at Tonset/Eldredge Park Way, near Eldredge Park Way and Orleans Police Station (Route 28 site);
- Gibson Road at Asa's Landing; and
- Orleans Town Landfill.

A summary of field and laboratory groundwater data is presented in Table 3 and Section 4.b.5) of the Technical Memorandum (Appendix R).

5.4.3 Demonstration Project Testing

A prioritized list of two recommended Permeable Reactive Barrier demonstration tests has been proposed – Eldredge Park and the Landfill. The proposed Permeable Reactive Barrier demonstration at the preferred locations will generally each include one line of injection points spaced 10 feet apart. The approximate locations of the proposed Permeable Reactive Barriers are shown on Figure 5-1. Proposed demonstration test Permeable Reactive Barrier lengths are 200 feet for Eldredge Park, and 200 feet and 50 feet for Landfill.

Future full-scale Permeable Reactive Barriers or sections of Permeable Reactive Barriers are anticipated to be longer (500 to 3,000 feet, depending on the location); however, demonstration test locations are proposed to be shorter distances to assess construction/implementation and allow adequate monitoring of groundwater conditions in the vicinity of the Permeable Reactive Barriers for initial demonstration.

For the demonstration test Permeable Reactive Barriers, a vertical treatment interval is anticipated from the top of the groundwater table to approximately 30 to 40 feet into the saturated soils. The total depth below land surface will also depend on the depth to groundwater at the location. Multi-level groundwater sampling events conducted on Cape Cod have identified bands of groundwater containing nitrate concentrations 25 to 40 feet thick (MT Environmental, 2015). The field groundwater investigation completed by AECOM in 2016 indicated that nitrate is present 30 feet below the water at concentrations similar to shallower groundwater supporting a vertical treatment interval of 30 to 40 feet for demonstration testing for the two proposed Permeable Reactive Barrier locations.

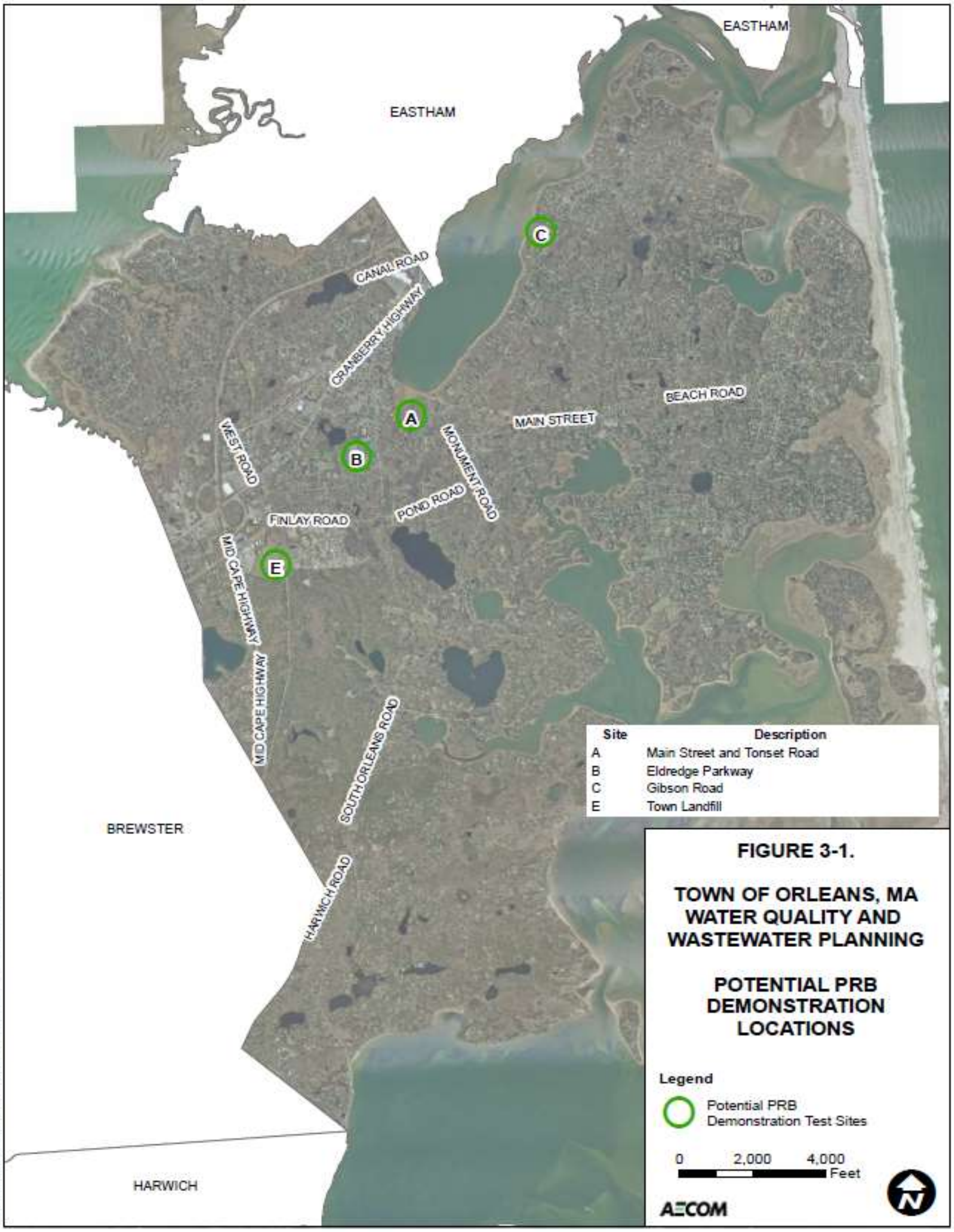
Based on numerous disadvantages and potentially unacceptable environmental impacts, trench installation was considered and ruled out for Permeable Reactive Barrier demonstrations in Orleans due to limited feasibility and prohibitive siting requirements. Due to shallow installation depth, trench-based Permeable Reactive Barriers would need to be located very close to surface water in resource areas, causing potential damage to natural resources and increasing permitting requirements and cost. Installation of trenches may cause significant disruption, and abutter concerns may be significant. In addition, trench locations would not provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water.

The most likely design will use soil borings for injection of slow-release organic carbon electron donor substrates, such as food-grade emulsified vegetable oil as carbon food source, to create a Permeable Reactive Barrier capable of stimulating denitrifying bacteria to remove nitrate. These soil boring Permeable Reactive Barrier installations would be located upgradient away from resource areas and could be installed with minimal impacts. For the Permeable Reactive Barrier demonstration test, emulsified vegetable oil is the recommended amendment based on the need to optimize Permeable Reactive Barrier longevity. Emulsified vegetable oil contains only non-toxic, food grade materials, primarily soybeans, and is widely used in enhanced bioremediation applications for groundwater. After injection, emulsified vegetable oil is relatively immobile in the subsurface and relies on the slow release of soluble compounds that are distributed by advection, dispersion, and diffusion in groundwater. Injection of carbon substrates is proposed to be completed using direct-push tooling (i.e., GeoProbe®).

The demonstration project at Eldredge Park Way was initiated in summer 2016 with installation of the monitoring wells and injection wells. The injection of emulsified vegetable oil occurred in late October 2016.The demonstration test will evaluate field implementation and observations, including range of observed injection flow rates, observed injection pressures and emulsified vegetable oil dilution rates and associated handling. Monitoring wells in proximity to the preliminary injection test points will be observed to measure how far emulsified vegetable oil emulsion travels downgradient and cross-gradient as a result of injection. A description of how the field injection activities are anticipated to be conducted is detailed in the Technical Memorandum (Appendix R).

A second permeable reactive barrier demonstration project is being considered for the landfill to remediate nitrate as well as 1,4 dioxane. Groundwater data has been collected to confirm nitrogen levels as well as 1-4 dioxane, a contaminate discharged from the landfill. Changes by MassDEP in reporting concentrations have raised the presence of 1,4 dioxane as a serious concern to the Town. Field investigations are proposed. They will include groundwater monitoring upstream and downstream of the landfill to confirm concentration and flow path of the 1,4 dioxane. Groundwater data will be obtained during the winter of 2016 and recommendations as to the appropriateness of a permeable reactive barrier to control the nitrate and the 1,4 dioxane will be developed. Regardless the Town is proceeding to investigate connecting downstream properties to public water supply.

Figure 5-1 - Potential Locations for PRB Demonstration Projects



5.4.4 Demonstration Project Monitoring

Performance monitoring of the Permeable Reactive Barrier demonstration project will be performed to assess nitrate transformation, concentrations of other key indicators, and the distribution of the injected reagents. Groundwater samples will be collected from both existing monitoring wells and additional monitoring wells. The monitoring well network for demonstration test performance monitoring is presented on Figure 5-2 and Figure 5-3 for the Eldredge Park Way and landfill Permeable Reactive Barriers, respectively. The monitoring well network for demonstration test sites includes monitoring wells upgradient, downgradient, and cross-gradient of the Permeable Reactive Barrier to evaluate changes to nitrate and groundwater quality or to aquifer permeability as a result of the injection of emulsified vegetable oil. Groundwater quality parameters will be measured in the field (pH, oxidation reduction potential (ORP), dissolved oxygen (DO), specific conductivity, temperature, turbidity), with particular attention to ORP (mV) and DO (mg/L) which will be used to evaluate the generation and distribution of reducing conditions. Laboratory analyses will be performed to quantify Total Nitrogen (TN), nitrate, nitrite, ammonia, total and dissolved metals (iron and manganese), dissolved organic carbon (DOC), sulfate, methane, and chloride. These laboratory analyses will support evaluation of Permeable Reactive Barrier performance as well as characterize the nitrate plume in groundwater vertically. Groundwater samples will be collected prior to initiation of in-situ treatment to provide a comparative baseline to evaluate performance of the demonstration test. Following completion of injections for the full demonstration projects, it is anticipated that groundwater sampling would be performed quarterly for a period of up to three years. Primary objectives of the post-injection sampling will be to:

- Demonstrate reduction in nitrate concentrations in groundwater in monitoring wells compared to baseline samples and/or wells upgradient of the Permeable Reactive Barrier;
- Identify distance traveled by emulsified vegetable oil emulsion;
- Identify extent of generated reducing conditions;
- Evaluate potential for reduction in aquifer permeability as a result of emulsified vegetable oil application;
- Evaluate persistence of emulsified vegetable oil emulsion and anaerobic conditions favorable for denitrifying bacteria after Permeable Reactive Barrier installation; and
- Assess changes in groundwater monitoring parameters as a result of the Permeable Reactive Barrier.

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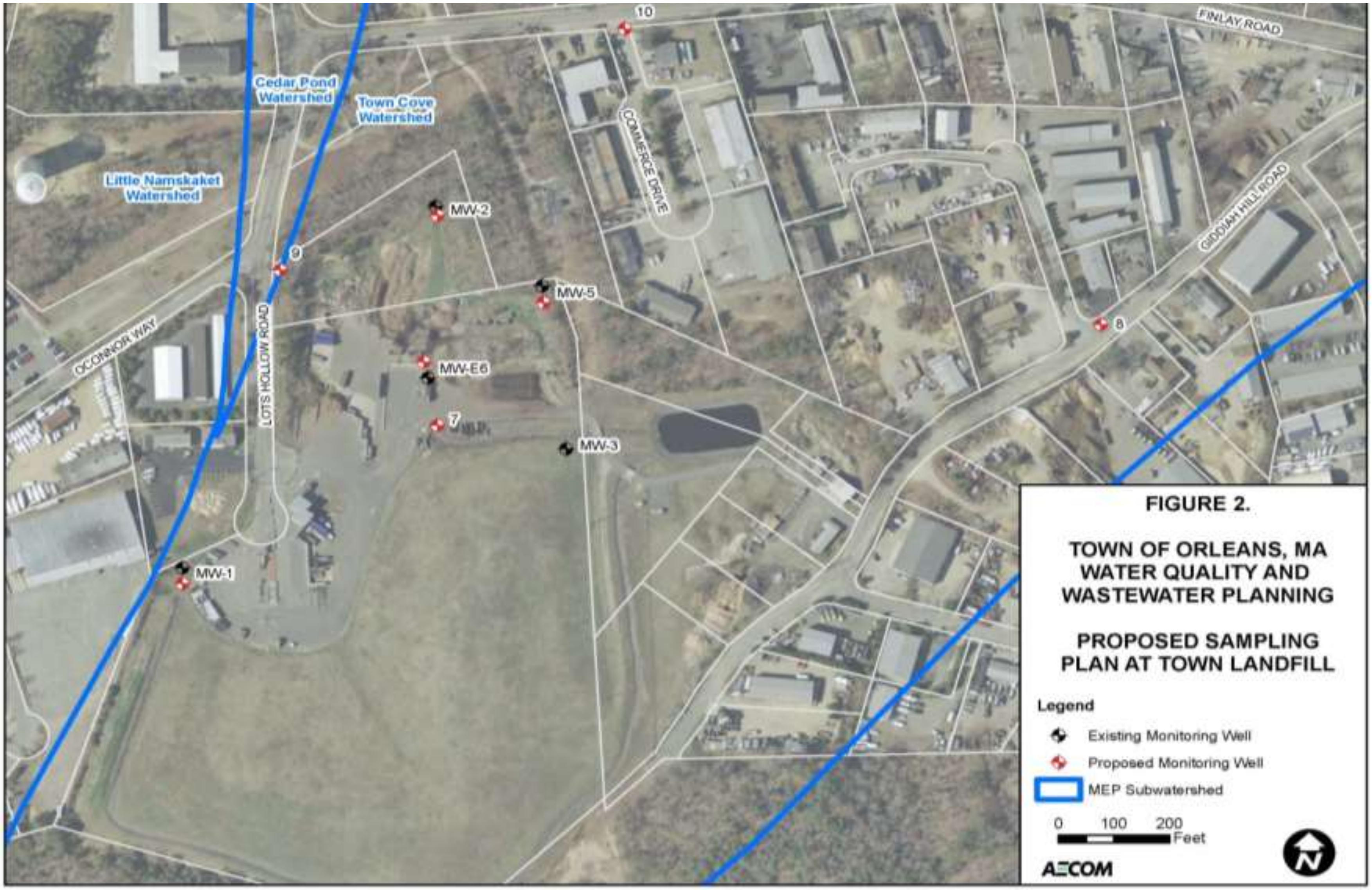
Figure 5-2 – Proposed PRB demonstration project at Eldredge Park showing locations of Monitoring Wells

Figure 5-3 – Proposed PRB Demonstration Project at the Orleans Town Landfill showing locations of monitoring wells



6.0 Adaptive Management Plan Implementation

The 2010 CWMP included an Adaptive Management Plan that outlined the process by which initial phases of the Town's proposed approach to managing wastewater and stormwater would be evaluated for effectiveness and modified as appropriate based on interim results. The 2010 Adaptive Management Plan included a Groundwater and Surface Water Quality Monitoring Plan and identified that the Town would prepare an annual TMDL Compliance Report. Since the Town has modified its approach to meeting nitrogen load reductions through a hybrid approach of Traditional and Non-Traditional technologies, modifications to the Adaptive Management Plan water quality program are needed. This section describes the baseline water quality data available, identifies data gaps, and identifies additional water quality monitoring needed in order to document the status of compliance with the TMDL.

Baseline water quality monitoring, data evaluation, plans for Massachusetts Estuaries Project model nitrogen threshold updates and other requirements for management of water quality in Rock Harbor Creek, Namskaket Creek and freshwater ponds watersheds are addressed below. These watersheds are being addressed as part of the Adaptive Management Plan because of either:

- Outstanding, more complex issues that must be resolved before realistic water quality management plans for the watershed can be developed or revised, or
- The watershed is not impaired by nitrogen and is not under planning requirements resulting from a nitrogen TMDL. However, the Town has determined that significant impairments prevail in the watershed and that these impairments are best addressed in an adaptive framework of monitoring, evaluation and implementation of remedial plans and further confirmatory monitoring. Management options for these watersheds may include rezoning, land use modifications, stormwater management and other non-structural, longer-term actions by Orleans in coordination with the neighboring towns of Brewster (Namskaket) and Eastham (Rock Harbor Creek).

6.1 Baseline Monitoring Data

The purpose of Technical Memorandum entitled *Final Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets* (Appendix S) is to evaluate the adequacy of sampling locations and sampling methodology (protocols and parameters) in order to accomplish the following monitoring objectives:

- Establish current baseline conditions for evaluating water quality improvements as the town's overall nutrient management program is implemented;
- Allow Massachusetts Estuaries Project model revisions where physical conditions and nutrient loads have changed; and
- Determine data gaps and recommend additional monitoring to meet monitoring goals.

To make this assessment, existing water quality data collected from 2000 to 2015 were consolidated and reviewed, and missing data have been identified. In addition, this water quality information is compared to baseline monitoring data from the Massachusetts Estuaries Project reports for Pleasant Bay and Nauset Harbor and trends have been documented.

Recorded water quality parameters contained in the data sets for Pleasant Bay and Nauset Harbor include: weather, wind force, wind direction, water condition, secchi depth, DI salinity, field corrected salinity, sample time, sample depth, in situ dissolved oxygen (DO), in situ DO (as percent saturation), in situ water temperature, laboratory salinities, laboratory conductivity, soluble reactive phosphate (SRP), ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), total dissolved nitrogen (TDN), particulate organic nitrogen (PON), total organic nitrogen (TON), total nitrogen (TN), particulate organic carbon (POC), chlorophyll a and pheophytin. Several of these parameters, including weather, wind force, wind direction, water condition, sample depth, and field temperature are recorded to characterize the conditions under which the water quality sample is taken.

6.1.1 Nauset Harbor Embayment

In terms of establishing baseline conditions, the Massachusetts Estuaries Project report for the Nauset harbor embayment includes fifteen monitoring stations, WMO-25 to WMO-40. However, the only stations that have a complete set of data from 2003-2014 are WMO-27 (the sentinel Station for the Nauset Harbor in Town Cove), WMO-34 (Mill Pond), and WMO-38 (Salt Pond). The remaining monitoring stations only have consistent data for 2003-2004, with sporadic data collected in 2005. These three stations do not provide sufficient spatial resolution within the sub-embayments of this estuary to establish a baseline to compare against demonstration monitoring data. To establish robust baseline conditions for Nauset Harbor, additional stations are recommended so that trends and values shown at the single stations in these sub-embayments can be compared to data from additional locations in the same system. Comparison of existing water quality parameters at these stations over the monitoring period of record is as follows:

- **Total Nitrogen (TN):** Since 2011, Town Cove has been consistently higher than the Massachusetts Estuaries Project baseline values; Mill Pond has been consistently higher than the Massachusetts Estuaries Project baseline values since 2010; and since 2011, Salt Pond has been consistently lower than the Massachusetts Estuaries Project baseline values, but has been rising towards the baseline since 2012.
- **Salinity**: Town Cove has been consistently lower than the Massachusetts Estuaries Project baseline value since 2009; Mill Pond has been consistently lower than the Massachusetts Estuaries Project baseline value since 2009, but in 2011 began approaching that baseline; and Salt Pond has been above and below the Massachusetts Estuaries Project baseline value since 2003, and in 2014 was essentially at that baseline.
- **DO**: Town Cove and Mill Pond have been consistently lower than the Massachusetts Estuaries Project data from the data sets from 2003; and Salt Pond has been higher than the Massachusetts Estuaries Project data from 2004.
- **Chlorophyll-a (Chl-a**): Town Cove has been consistently higher than the Massachusetts Estuaries Project data from the data sets for 2003 but is declining; Mill Pond has been oscillating above and below the Massachusetts Estuaries Project data for 2003 but was lower in 2014; and Salt Pond has been higher than the Massachusetts Estuaries Project data for 2004 since 2009, but in 2010 began to decrease and in 2014 was slightly lower relative to 2004. There is significant variation in the data, as shown by the standard deviation bars.

While the Total Maximum Daily Load (TMDL) for nitrogen has not yet been established by MassDEP/US EPA for Town Cove and Mill Pond, neither Town Cove nor Mill Pond meet the target load for nitrogen that is prescribed in the Massachusetts Estuaries Project Report, which is 58.718 kg/day and 9.219 kg/day respectively. In addition, TN concentrations are higher than the Massachusetts Estuaries Project recommended threshold of 0.45 mg/L at the sentinel station in Town Cove. Nitrogen concentrations are also higher relative to the 2003 reference point. Increasing DO and Chl-a echo this TN trend. Lower salinity may indicate an occluded inlet and shoaling relative to the 2003 value.

An analysis of the available data also highlights the importance of surface and bottom measurements to understanding water quality trends, as seen in Figures 5 and 6 in the Technical Memorandum (Appendix S). Differences in data values for surface and bottom sampling locations are apparent for all four parameters at both stations where data were available for comparison.

Another notable feature of the data was discovered when examining Chl-a for Mill Pond (WMO-34B) and Salt Pond (WMO-38B). Figures 4d and 5d in the Technical Memorandum (Appendix S) show very large standard deviation for the 2001 bottom Chl-a data. Plotting each measurement as a function of time suggests an exponential decline over the course of years. Note the logarithmic vertical scale of the graph. This may have been caused by an algal bloom occurring during the sampling time at Salt Pond (WMO-38B) in 2011, with the values in subsequent years showing a continuous declining trend. By 2014, values in Salt Pond had returned to typical pre-2011 levels. However, values in Mill Pond had decreased to near zero by 2014, possibly indicating a permanent change in this ecosystem. It should be noted that a change in the water depth from which the sample is taken can also impact results.

A brief review of the data sets provided to Orleans shows large anomalies in some of the data. These may be the result of sampling errors, an atypical event or natural temporal and spatial variations within a particular sub-embayment.

6.1.2 Pleasant Bay

The Pleasant Bay Alliance was formed in 1998 to oversee resource management planning for Pleasant Bay. For the past fifteen years, the Alliance has organized and trained volunteers to collect water quality data from sampling stations bay-wide, which are sampled two times per month during July and August and once in early September. Fourteen of these stations are in Orleans's waters, although volunteers from Orleans coordinate with Chatham to sample two additional stations.

In 2015, the Alliance contracted the Cadmus Group to analyze the monitoring data for statistical changes over time. In order to evaluate trends within all of Pleasant Bay, the Cadmus Report pooled water quality data from samples from all 34 monitoring stations (Cadmus 2015). The number and frequency of samples were considered adequate for establishing trends in overall data parameters.

Long term data sets from Pleasant Bay were investigated to determine whether current water quality data are sufficient to establish baseline conditions for evaluating Non-Traditional demonstrations in Orleans. The Cadmus report presents trend lines that were fitted to sampling data for each of 20 stations, including trends before and after the 2007 breach at Nauset Beach. The specific parameters include: dissolved inorganic nitrogen (DIN), bioactive nitrogen (BioN), total nitrogen (TN), phosphate (PO4), total phytopigments (pigments), dissolved oxygen (DO) and salinity. This trend analysis for Pleasant Bay monitoring stations includes the following stations in Orleans (Cadmus 2015):

- Meetinghouse Pond (PBA-16);
- The River at Rattles Dock (WMO-10);
- Namequoit South (PBA-12);
- Namequoit North (PBA-13);
- Namequoit Mid (WMO-6);
- Arey's Pond (PBA-14);
- Kescayo Gansett Pond (Lonnie's, PBA-15);
- Paw Wah Pond (PBA-11);
- Little Pleasant Bay near Quanset (PBA-8);
- Pochet Mouth (WMO-3);
- Pochet Upper (WMO-5);
- Quanset Pond (PBA-10); and

- Little Quanset Pond (WMO-12).

Stations in Orleans that were not included in this evaluation because of significant gaps in data include the following:

- Pochet (mid): WMO-4 which has not been sampled since 2004;
- The River (mid): WMO-8 which does not have data from 2005-2013;
- Namequoit River (mouth) WMO-7 which has not been sampled since 2004;

Table 6-1 summarizes the statistically significant and non-significant trends (at 95 percent confidence) for each parameter. Appendix F of the Cadmus Report presents graphed data for DIN, BioN, TN, SRP (PO4), Pigments, DO and salinity for all monitoring locations (Cadmus 2015). These data were also evaluated and are presented in Table 6-2. Black text, a black "X" or arrow "↑" indicate an improved water quality value; and red text, a red "X" or arrow "↓" indicate a degraded water quality value. When values are not statistically significant, they are shown in brackets:

Table 6-1: Water Quality Parameters with no statistically significant results at the 95 percent confidence intervals are indicated by an X. Boxes with a dash indicate statistically significant trends (based on Cadmus 2015).

		DIN	BioN	TN	SRP (PO_4)	pigment	DO	salinity
Meetinghouse Pond	(PBA-16)	X	-	X	X	-	X	X
Namequoit South	(PBA-12)	X	-	-	-	-	-	-
Namequoit North	(PBA-13)	-	X	X	X	-	X	X
Namequoit Mid	(WMO-6)	X	-	-	X	-	X	X
Pochet Upper	(WMO-5)	X	X	X	-	-	-	X
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	-	-	-	-	X	X
Paw Wah Pond	(PBA-11)	X	-	-	X	-	X	-
Pochet Mouth	(WMO-3)	X	-	-	X	-	X	X
Little Quanset Pond	(WMO-12)	-	-	-	X	X	-	-
Arey's Pond	(PBA-14)	X	X	X	X	-	-	X
Quanset Pond	(PBA-10)	-	-	-	-	-	X	X

Table 6-2: Water Quality Parameters with Action Items. Both statistically significant trends as well as trends that are not statistically significant are shown (based on Cadmus 2015)

		BioN Above TMDL (X) or Below/Near TMDL (X)	Pigments Below 5 µg/L or Decreasing	DO Increasing (↑) or Decreasing (↓) or Steady State below 6 mg/L (SS)	DIN Increasing (X) or Decreasing (X) or Steady State (SS)	ACTION
Meetinghouse Pond	(PBA-16)	X	X	[↓]	[SS]	Confirm System Health
Namequoit South	(PBA-12)	X	X	↑	[X]	Confirm System Health
Namequoit North	(PBA-13)	[X]	X	[↑]	X	Confirm System Health
Namequoit Mid	(WMO-6)	X	X	[SS]	[X]	Confirm System Health
Pochet Upper	(WMO-5)	[X]	X	↑	[X]	Confirm System Health
The River at Rattles Dock	(WMO-10)	X	X	↑	[X]	Determine Why Inconsistent
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	X	[SS]	[X]	Determine Why Inconsistent
Paw Wah Pond	(PBA-11)	X	above 5 µg/L	[SS]	[SS]	Determine Why Inconsistent
Pochet Mouth	(WMO-3)	X	X	[SS]	[X]	Determine Why Inconsistent
LPB Near Quanset (Big Bay NE)	(PBA-8)	[X]	X	↑	X	Determine Why Inconsistent
Little Quanset Pond	(WMO-12)	X	[X]	↓	X	Treat as Impaired
Arey's Pond	(PBA-14)	[X]	above 5 µg/L	↓	[SS]	Treat as Impaired
Quanset Pond	(PBA-10)	X	above 5 µg/L	[↑]	X	Treat as Impaired

The data summarized in Table 6-2 show that BioN is below or near TMDL for seven of 13 stations in Orleans, and pigments are either below an acceptable level of 5 µg/L or are decreasing with statistical significance at all stations that were evaluated except three. Neither DIN nor DO consistently follow the BioN and pigment trends for water quality improvement. DIN is increasing at both Quanset Pond and the Lower River, but only Quanset Pond shows a statistically significant increase in BioN.

These results are not surprising since in estuaries, N concentrations, especially the inorganic forms, typically vary widely seasonally and along salinity gradients. The timing of sample collection and macroalgae uptake and organic contributions may be impacting Dissolved Inorganic Nitrogen, Dissolved Organic Nitrogen and Particulate Organic Nitrogen concentrations. Systems may be achieving water quality standards based on N sampling, measures of algal biomass (e.g., chlorophyll a), water clarity (e.g., Secchi depth) or DO, yet still show inconsistencies in long term data sets because nitrogen fractions are cycling in new ways in response to environmental changes. For example, the concentration of the primary N variables may not correlate well with one or more response variables such as phytoplankton production. Physical factors such as salinity, pH and temperature gradients and input and outputs of fresh or salt water (e.g. flushing) play an important role in the N process and phytoplankton productivity.

As shown in Table 6-2, water quality data results were then assigned to one of three action items :

- Confirm system health;
- Determine why inconsistent; and
- Treat as impaired.

Confirming system health is recommended when the station is below the TMDL for BioN and other water quality parameters such as total pigments show improved conditions that reflect acceptable BioN concentrations. Five of thirteen stations are in this category. Determining why parameters are inconsistent is suggested for sites where either BioN is at or near the TMDL, but other parameters indicate impairment, or BioN is above the TMDL but other parameters seem to show that the system is in good condition. Five of thirteen sampling stations are in this category. Treating systems as impaired is designated for sub-embayments where the range of water quality parameters consistently show degraded conditions. Three of thirteen stations are in this category.

Water between Pleasant Bay and the Atlantic Ocean is currently exchanged through two tidal inlets. South Inlet was formed in 1987, and North Inlet was formed in 2007 when a breach occurred at the southern end of an unbroken, ten-mile stretch of barrier system known as “North Beach”. Geographically the breach is located in North Chatham in the vicinity of Strong Island and Ministers Point. The formation of this new inlet was expected to bring increased tides and flushing to the bay. Both before and after the 2007 breach, several bay-wide trends are evident.

The post-breach trends include:

- Increasing DIN, Bioactive Nitrogen (BioN);
- Decreasing Pigments;
- Increasing DO;
- Trends in TN, PO4 not considered statistically significant; and
- Increased salinity.

A Bay-wide analysis of the data shows several unexpected trends:

- DIN is increasing at a slower rate after the break, but particulate organic nitrogen and dissolved organic nitrogen are not changing in ways that are consistent with this trend;
- BioActive Nitrogen (dissolved organic nitrogen and particulate organic nitrogen combined) is increasing but pigments are decreasing;
- While Bay-wide trends show an increase in BioN, individual sampling station values increase at only two locations while eight show a decrease. Nine locations show no statistically significant difference;
- DO is higher at the bottom of the water column; and
- Temperatures are higher at the bottom of the water column

After the breach, DIN continued to increase, but at a significantly slower rate. A steady decline in PON was occurring before the breach. If increased flushing due to the breach was responsible for improving water quality, the expected drop in PON would be more pronounced after the break. Instead, PON started to climb slightly.

Dissolved organic nitrogen was also decreasing before the breach. This drop in dissolved organic nitrogen would also have been expected to accelerate after the breach, but the data show it is decreasing more slowly. Atmospheric trends should be expected to continue unaffected by the breach, but dissolved organic nitrogen from biological activity should be lower if there were increased flushing. Instead the rate of dissolved organic nitrogen decrease lessened. If this change in BioN were due to increased flushing, accelerated decreases in PON and dissolved organic nitrogen should be observed, but this is not the case.

There are several potential explanations for the seemingly contradictory bay-wide trend that BioN (DIN and PON) is increasing and pigments are decreasing. Pigment reductions may be explained by lower populations of phytoplankton and other microalgae, but BioN may also be stimulating the growth of macroalgae. Macroalgae populations can be promoted by nitrogen levels that are lower than optimal for phytoplankton, yet still elevated (Hein, 1995). Sampling during the summer may not measure DIN and PON accurately because DIN is consumed and PON is produced as part of macroalgae cycling. Summer sampling may be underestimating actual DIN inputs, and may not capture PON. Increased grazing by zooplankton may also be reducing phytoplankton populations. Pigments are the sum of Chl-a and pheophytin. It may be more accurate to track Chl-a alone for a more representative measure of microalgae.

6.1.3 Nauset Harbor and Pleasant Bay Baseline Data Review Conclusions

A review of data from monitoring programs in both Pleasant Bay and the Nauset Harbor embayment reveal a significant variability in water quality data. the standard deviation for annual average values in both Pleasant Bay and Nauset Harbor embayments ranges from 10 percent to over 50 percent. This indicates that there is a large range of values in the approximately five data points collected within a season. Averaging these data points to establish an annual value for a given parameter is the accepted practice of the Massachusetts Estuaries Project for overall water quality determination. This data set is valuable for long term study and gross comparisons within the watershed, however, in order to quantify a small change in nitrogen that is removed from a shellfish or floating wetland installation, pre installation samples taken in close proximity to the demonstration sites are needed to establish reference values at a given demonstration location.

There are several key implications of the analysis:

- Establishing current baseline conditions requires additional sampling locations in Nauset Harbor estuary, and additional study of the biogeochemical processes impacting nutrient cycling in select sub-embayments of Pleasant Bay;

- Establishing baseline conditions that will enable the effect of demonstration projects to be quantified requires site-specific monitoring with high spatial and temporal resolution to capture the localized range in values for water quality and benthic parameters; and
- A recalibration and rerun of the Massachusetts Estuaries Project model for Pleasant Bay and Nauset Harbor is warranted based on the changes in physical conditions and measured nutrient concentrations.

Recommended additional monitoring and evaluations include:

- Additional sampling dates (not through volunteer efforts);
  - Spring (March/April)
  - Fall (Sept/October)
- DIN and PON concentrations sorted by temperature, based on additional sampling;
- Macroalgae populations and nutrient flux;
- Dissolved organic nitrogen changes due to reduced atmospheric deposition;
- Pigment assessments based on Chl-a only; and
- Benthic assessments.

Although there are valuable data collection programs occurring across water bodies in Orleans, current data sets are not adequate for establishing a baseline to which the impact of demonstration projects can be compared. T Demonstration monitoring requires data collection at high spatial and temporal resolution. Standard deviation has implications for the number of sampling events that are needed for evaluating a demonstration project that removes modest amounts of nitrogen. A detailed description of the high resolution monitoring program for the oyster demonstration project in Lonnie's Pond can be found in Section 5. To maximize the benefit of these efforts, annual compilation, review and analysis is recommended.

6.1.4 Namskaket Creek and Little Namskaket Creek

The purpose of the Namskaket Creek and Little Namskaket Creek Monitoring is to establish water quality conditions for the preparation of a Massachusetts Estuaries Project report; establishment of TMDLs for development of Orleans Comprehensive Wastewater Management Plan.

6.1.4.1 Locations

Namskaket Creek

Years Sampled	Station Number	Site Description
2001-2016	WMO 22	Mouth of creek
2001-2004	WMO 23	Mid marsh
2001-2003	WMO 24	Bog side of stream leaving radio tower bog (FW outflow)
2001-2003	WMO 45	Bog side of stream leaving Hurleys Bog (FW outflow)

Little Namskaket Creek

Years Sampled	Station Number	Site Description
2001-2016	WMO 19	Mouth of creek
2001-2004	WMO 20	Mid marsh
2001-2003	WMO 21	Headwaters to marsh at Roadway

6.1.4.2 Monitoring

- Parameters: Current weather conditions, wind force and direction, visible water conditions, Secchi disk transparency, depth at station, sample depth, field DO and saturation, field temp at sample depth
- Frequency: Currently five times, two weeks apart in July, August, and Sept on early morning outgoing tide
- Duration: 2001-2015; ongoing
- Source and status of QAPP and Lab arrangements by SMAST

- Staff resources: Director of Planning Department; Marine and Fresh Water Quality Task Force and recruited volunteers
- Analyses: SMAST lab --Salinity, conductivity, PO4, NH4, Nox, DIN, DON, TDN, POC, PON, C/N ratio, TON, TN, Chl a, Phaeo, pigment ratio, total pigments
- Documentation of results: Yearly spreadsheet report. Linked Watershed Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Namskaket Marsh Estuarine System, Orleans, MA. Massachusetts Estuaries Project, Draft report June 2007
- Analyses and documentation of results: SMAST
- Database location: SMAST

6.1.4.3 Resources

Summary of 2004 Monitoring Results Namskaket Creek, Orleans, MA and Proposed future work. USGS, Weiskel, February 2005.

Update on USGS Monitoring Activities, Namskaket Creek, Orleans, MA . USGS, April 2011

Stability of Wetland Plant Communities in Upper Namskaket Marsh, Town of Orleans, MA. SMAST, January 2016.

6.1.5 Rock Harbor Creek

The purpose of the Rock Harbor Creek Monitoring is to establish water quality conditions for preparation of Mass Estuaries Project report on Rock Harbor; establishment of TMDLs for Town development of Comprehensive Wastewater Management Plan.

6.1.5.1 Locations

Years Sampled	Station Number	Site Description
2001-2004	WMO 14	Cape Cod Bay offshore, 100 Ft past last tree in channel
2001-2016	WMO 15	Rock Harbor, outer marina dock/Town Landing
2001-2004	WMO 16	Rock Harbor - mid
2001-2003	WMO 17	Upper Rock Harbor in marsh channel
2001-2003, 2005, 2012	WMO 18	Cedar Pond outlet; headwaters to Rock Harbor

6.1.5.2 Monitoring

- Parameters: Current weather conditions, wind force and direction, visible water conditions, Secchi disk transparency, depth at station, sample depth, field DO and saturation, field temp at sample depth
- Frequency: Currently five times, two weeks apart in July, August, and Sept on early morning outgoing tide
- Duration: 2001-2015; Ongoing
- Source and status of Quality Assurance Policy Plan and Lab Arrangement by SMAST
- Staff resources: Director of Planning Department; Marine and Fresh Water Quality Task Force, and recruited volunteers
- Analyses: SMAST lab --Salinity, conductivity, PO4, NH4, Nox, DIN, DON, TDN, POC, PON, C/N ratio, TON, TN, Chl a, Phaeo, pigment ratio, total pigments
- Documentation of results: Yearly spreadsheet report in Town computer files. Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Orleans, MA , SMAST, 2007.
- Analyses and documentation of results: SMAST
- Database location: SMAST

6.1.5.3 Studies related to Rock Harbor and Cedar Pond

2003 : *Cedar Pond Restoration of Herring Run*, Orleans Water Quality Task Force

2007: *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Orleans, MA.* This Massachusetts Estuaries Project report for Rock Harbor documented the groundwater basin and land use patterns in the watershed.

2007: *Review and Interpretation of Orleans Freshwater Pond Volunteer Monitoring Data,* documents the anoxia in the bottom waters of the pond while “the shallowest waters on average are supersaturated, which is usually indicative of extensive algal photosynthesis.” (pg. 66) The study recommends further analysis as part of the Massachusetts Estuaries Project.

2010: *Rock Harbor Creek, Restoration Feasibility Study,* Applied Coastal Research and Engineering. Documents the hydraulics and elevation of the creek from Rock Harbor to Cedar Pond.

2011: Cormorant population studies, Orleans Marine and Fresh Water Quality Task Force, 2011, 2012, 2015.

2013: *Cedar Pond Management Plan*, SMAST/UMASS Dartmouth.

2013: Documentation of Atlantic White Cedars adjacent to Cedar Pond, Orleans Marine and Fresh Water Quality Task Force.

2014: *CSP/SMAST Technical Memorandum: Board Height Recommendation for Cedar Pond Outlet: Task 1 of Cedar Pond Adaptive Management and Monitoring Program*.

6.1.5.4 Roadway Water Quality Improvements surrounding Cedar Pond:

2008: MASS-DOT installed leaching basins along Route 6 adjacent to north side of Cedar Pond.

2011: Stormwater drains along Locust Road (south side of Cedar Pond) were remediated with infiltration basins to eliminate direct roadway discharge and its associated nutrients from flowing into Cedar Pond.

6.2 Long-Term Water Quality Monitoring Program

The purpose of Technical Memorandum 4.a.2 – *Recommendations for Long Term Water Quality Monitoring Program* (Appendix T) is to provide the details for a monitoring program that can adequately quantify water quality and benthic conditions over the long term. This program includes locations of additional stations, as well as sampling points at different depths within the water column. The frequency of sampling, methodology and parameters for sampling, including benthic analysis are described. Recommendations for future data collection personnel (both volunteer and paid) as well as a system for long term coordination and management of all data sets generated for Orleans are also presented.

Orleans has successfully implemented and maintained a long-term program for water quality monitoring in both Town Cove and Pleasant Bay. Consistent data sets exist for Town Cove starting in 2003, and for Pleasant Bay starting in 2000. These data are collected and analyzed annually by the UMASS Dartmouth SMAST. In order to be able to utilize this data to meet regulatory standards it is recommended that future data sets utilize version-controlled standard operating procedures (SOPs) and include the following information:

- A notes page with GPS coordinates for all sampling stations, Definitions for all terms, and conversion of units from micro-Moles to milligrams per liter for relevant water quality data.
- Description of methodology for dissolved oxygen (DO) columns and a discussion of which columns, if any, can be used to analyze trends continuously from 2003 through 2014.
- Each year documentation should be provided with the data sets that describes key information regarding each parameter, such as measurement location and derivation.

6.2.1 Additional Station Locations and Frequency of Sampling

There are currently three monitoring stations in Nauset Harbor. Additional monitoring locations are recommended in order to accurately assess this estuary. The Massachusetts Estuaries Project Report included data from eighteen monitoring stations. This program recommends monitoring eleven of these stations: WMO Station Numbers 25, 26, 27, 29, 30, 33, 35, 37, 38, 39, and 40 (if accessible). Sampling would be performed twice a month from May 1 through October 15 and once in January though volunteers are not available during this timeframe.

There are currently twenty-four monitoring stations in Pleasant Bay. These station locations seem adequate for assessing overall water quality in Pleasant Bay. However, the stations in Orleans where different water quality parameters do not show consistent trends are recommended for further evaluation and additional stations may be required. This would require additional sampling and analysis at the existing water quality monitoring stations and/or the establishment of new water quality monitoring stations.

In addition to data collection and laboratory analysis of samples, a data analysis report should continue to be completed annually. Data evaluation should include sorting of DIN and PON concentrations by temperature, as well as pigment assessments based on Chl-a only.

To the extent that data values include data outliers, a discussion of these outliers should be included in these reports.

6.2.2 Additional Future Studies Recommended

To evaluate the possible explanation for reductions in DIN being due to macroalgae assimilation, a study of microalgae populations is recommended, along with a bethic assessment of infaunta and nutrient flux. ed into macroalgae. Macroalgae consume DIN but releases PON. Because pigments seem to be decreasing as DIN increases in some sub-embayments, macroalgae should be surveyed and quantified as a possible sink for DIN and a source of PON. Because taxa respond differently, identifying macrophyte (macroalgae and eelgrass) species can help evaluate changes in nitrogen regimes. Macroalgae may be impacting the nitrogen budget in ways that would otherwise seem contradictory by looking at water quality parameters alone. Therefore, water sampling should be supplemented with an assessment of macrophytes in the water column, as well as in bottom sediments in the following locations in Pleasant Bay and Nauset Harbor:

- LPB Near Quanset (Big Bay NE);
- Pochet Mouth;
- Meetinghouse Pond;
- The River at Rattles Dock;
- Kescayo Gansett Pond (Lonnie's);
- Paw Wah Pond; and
- Pochet Upper.

In addition, a baseline benthic assessment that includes both nutrient flux and infauna surveys should be completed for Pleasant Bay and Nauset Harbor. This will provide a baseline benthic habitat assessment that will aid in assessing overall ecosystem health and improvements after Nitrogen reduction methods have been implemented. SMAST will use previously collected data as baseline for the Lonnie's Pond demonstration project, and will monitor sediment nitrogen dynamics (including denitrification and recycling) for three years (2017 – 2019). A targeted infauna survey of not less than 25 sites with duplicates will be performed in 2018 in order to assess habitat health changes since the 2006 Massachusetts Estuaries Project analysis, and data will be incorporated into the updated Massachusetts Estuaries Project model. A sediment recycling survey of 64 sites will be sampled by SCUBA divers in 2019 in order to update the Massachusetts Estuaries Project model.

In addition to the macroalgae and benthic assessment study, an additional study to evaluate Dissolved Organic Nitrogen due to changes in atmospheric deposition is recommended. The Cadmus data analysis shows that since the breach in 2007, dissolved organic nitrogen has been decreasing at a significantly lower rate than before the break (Cadmus Group 2015). Based on the Waquoit Bay study there is reason to believe that contributions to Pleasant Bay from atmospheric sources were higher in previous years and have continued to decrease since 2007 (Valiela and Lloret, in press). The recommended study would entail a review of the literature and analysis of historical data from air quality stations in the area to confirm reductions in atmospheric deposition over time.

6.3 Water Quality Monitoring for Demonstration Projects

The main purpose of Technical Memorandum 4.c.3 *Final Technical Memorandum for Non-Traditional Technology Performance Analysis* (Appendix U) is to present a systematic program for monitoring three Non-Traditional water improvement technologies: Shellfish, Floating Constructed Wetlands (FCW), and Permeable Reactive Barriers (PRBs) in ponds and estuaries in the Town of Orleans. The monitoring plans are also discussed in the Technical Memoranda for engineering pertaining to each of the Non-Traditional technologies Preliminary Engineering Design and Work Plan for Preferred Sites which are found in Appendices N, P and R. Monitoring plans for the Shellfish and Permeable Reactive Barrier Demonstration Projects are also discussed in Sections 5.3.8 and 5.4.4, respectively for the Shellfish and Permeable Reactive Barrier Demonstration Projects. Floating Constructed Wetlands are not being proposed for implementation at this time. Section 5.2 currently discusses the plan to implement Nitrogen Removing Barriers (NRBs) instead of the FCWs.

6.4 Massachusetts Estuaries Project Study Update Monitoring

The original Massachusetts Estuaries Project model was set up, calibrated and verified using field data from 2001 through 2004. To accurately represent the impacts of nitrogen removal from different sub-embayments of the main estuarine systems in Orleans, the model should be based on current conditions, including the estimate of nitrate flux from the landfill. The purpose of the Technical Memorandum (Appendix V) is to confirm that the data that were consolidated and documented during baseline data review were applicable to updating the existing Massachusetts Estuaries Project model. Additional data that are required for the model to be parameterized, calibrated and verified are also identified.

The Massachusetts Estuaries Project model setup and requirements are discussed in detail in the Technical Memorandum (Appendix V).

To revise the hydrodynamic model (RMA-2) for Nauset Harbor and Pleasant Bay, there are a number of assessments required to enable recalibration. An updated bathymetric survey and tide gauge measurements are needed because the inlet conditions that established the model's grid and boundary conditions (respectively) have changed. Three surveys that include these parameters have been completed recently for Nauset Harbor and Pleasant Bay as noted:

- Dredging study of Nauset Harbor (Woods Hole Group, 2015, report pending);
- Sidescan sonar for bathymetry in Pleasant Bay and Nauset Harbor (Center for Coastal Studies/Cape Cod National Seashore, 2014 – 2015, report pending); and
- Tide monitoring including time series monitoring of the flood tide cycle at the Nauset inlet (SMAST report recently released).

Consideration needs to include existing data from previous barrier beach breaks as well as predications of future barrier beach changes on the water quality changes.

These data should be sufficient for generating an updated grid and boundary condition specification, but may need to be supplemented with updated tide gauge data at inland stations to recalibrate this model.

For the water quality model (RMA-4), it is expected that updated total nitrogen and salinity measurements from the 34 Pleasant Bay monitoring stations as well as the ocean reference station will be adequate for calibration and verification. In Nauset Harbor, only three of the 15 stations used for model calibration and verification have current data. Therefore, to calibrate this model, three years of data from ten additional monitoring stations are recommended. Updated values for the nitrogen concentration in the ocean reference station should also be used when the model is re-run.

Massachusetts Estuaries Project uses 26.25 mg N/l, and 90 percent of actual water usage from town records to predict the mass of nitrogen entering an estuary from an average single family residential property. To enable Massachusetts Estuaries Project model runs to more accurately verify the results of the amended Comprehensive Wastewater Management Plan, updated water use records and land use information should be used in order to revise the nitrogen load data for input to RMA-4. In addition, the concentration of TN below the soil absorption systems of a statistically significant number of septic systems should be measured. This will validate the foundational assumption that is used to calculate the nitrogen load input to RMA-4.

Although not evaluated as part of the Technical Memorandum in Appendix V, the model also needs to be updated to include Rock harbor and Namskaket sampling data. Nauset estuary sampling was re-established in the summer of 2016.

6.5 Massachusetts Estuaries Project Model Update and Implementation Analysis

Technical Memorandum 4.e.7 and 8 *Final Technical Memorandum on* Massachusetts Estuaries Project *Model Update and Implementation Analysis* (Appendix W) discuss the Massachusetts Estuaries Project model and a proposed update. In order to coordinate the Massachusetts Estuaries Project model update two workshops were held on April 1, 2016 and April 11, 2016. The purpose of the Technical Memoranda is to document the results of these workshops and provide an integrated work plan for monitoring, modeling and the analytical services needed to support the implementation of the Orleans water quality and wastewater program for the next 5 years.

Workshop agendas and a list of attendees are provided in Appendix A of the Technical Memoranda (Appendix W). The April 1, 2016 schedule included an overview of Orleans's water quality and wastewater planning program, and presentations on the broad range of water quality monitoring programs in Orleans. Representatives from the Orleans BOS, Town Staff, OWQTF, OWQAP, Pleasant Bay Alliance (PBA), AECOM and the UMass SMAST presented details of their monitoring programs. Appendix B of the Technical Memorandum provides copies of the PowerPoint presentations that were made. Discussion followed each presentation to address the following questions:

- Are modifications to existing monitoring programs needed?
- Is additional information needed to supplement current programs?

Prior to the second workshop, a summary of the recommendations from the first workshop was provided to attendees. These "key takeaways" are included as Appendix C to the Technical Memorandum. The second workshop provided time to thoroughly review these recommendations in order to finalize a list of action items and responsible parties. Action items included: the use of volunteers for data collection; continuation of the protocols, frequency and methods currently used for water quality sampling; water quality data base consolidation; Pleasant Bay Massachusetts Estuaries Project report (and linked model) update; Nauset Harbor Massachusetts Estuaries Project report update; Rock Harbor Creek water quality standards need evaluation; Namskaket Marsh watershed management plan, Cedar Pond Environmental Impact Report (EIR) preparation and continuation of monitoring; and preparation of a freshwater ponds management plan.

In addition, it was determined that SMAST would provide a detailed Scope of Work (SOW), schedule and budget for all analytical work required to continue water quality monitoring in Orleans, as well as update the Massachusetts Estuaries Project Reports for Pleasant Bay and Nauset Harbor. The following specific items were identified as necessary to include in the SMAST SOW, which has since been finalized:

- Revision of the assumption used for septic nitrogen load value as part of updating the land and water use analysis , including more accurate assumptions on nitrate load from the Orleans landfill based on the landfill Permeable Reactive Barrier studies;
- Meet with PBA to assist with the plan to re-run the Massachusetts Estuaries Project models for the Nauset Harbor embayment and Pleasant Bay;
- Update of watershed boundaries and land use (using data that was collected for amendment of CWMP);

- Conduct a preliminary re-run of the Massachusetts Estuaries Project model for the Nauset harbor embayment with revised hydraulic inputs to confirm existing nitrogen load reduction estimates;
- Determination of the adequacy of recently-completed bathymetric and tide surveys in Pleasant Bay and Town Cove from Cape Cod National Seashore/ Provincetown Center for Coastal Studies (CCNS/PCCS);
- Number and locations of monitoring stations needed in Nauset Harbor Estuary;
- Number of years of data needed from additional monitoring stations in Nauset Harbor Estuary;
- Need and locations of additional stations to acquire tide data on elevation, velocity and ranges; and
- Update and rerun the Pleasant Bay Massachusetts Estuaries Project Linked Model;
- Develop information, preliminary assessment of issues and approach with Brewster for development of integrated adaptive management plans for protection of the Namskaket and Little Namskaket watersheds and tidal marshes.

6.6 Rock Harbor Creek

The plan for the Rock Harbor Creek proposed in the 2010 CWMP included a conventional sewerage system to convey flow to the new wastewater treatment facility at the Tri-Town site. The on-site system nitrogen load accounted for 88 to 92 percent of the controllable nitrogen load to the Creek. The Massachusetts Estuaries Project Report concluded that a total nitrogen concentration of 0.50 mg/l at the sentinel station at the head of the Creek (WMO-17) would be required to restore infauna health of the Creek. The DEP has developed a draft TMDL for Rock Harbor Creek, pursuant to the SMAST Massachusetts Estuaries Project Report. The TMDL has not been issued pending resolution of the Cedar Pond flash board issue discussed above.

The Massachusetts Estuaries Project report also states that:

"... the analysis of future nitrogen loading to the Rock Harbor estuarine system focuses upon additional shifts in land-use from forest/grasslands to residential and commercial development. However, the MEP Massachusetts Estuaries Project *analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round usage and increasing use of fertilizers (presently less than half of the parcels use lawn fertilizers). Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP* Massachusetts Estuaries Project *analysis of the Rock Harbor estuarine system is that restoration will necessitate a reduction in the present nitrogen inputs and management options to negate additional future nitrogen inputs."*

Since the completion of the CWMP, several significant issues have arisen to warrant delay of the implementation of the CWMP until further resolutions and resulting reevaluation of alternatives are completed. These issues include:

6.6.1 Eversource Problem with Cormorants at Cedar Pond

The loitering of multitudes of cormorants on the overhead power lines above Cedar Pond owned and maintained by Eversource is well documented. This condition contributes substantial loads of bacteria and nutrients to the Pond causing severe impairment of the water quality of the water and violation of state and federal water quality standards. On November 12, 2015, the Orleans Conservation Commission issued an order requiring Eversource to file a plan in the form of a Notice of Intent to implement actions to bring the maintenance of the power lines into compliance with the Town's wetlands by-law and regulations. Discussions between the Town and Eversource have proceeded, albeit slowly, to the point at which currently a mutually-agreeable Eversource project to relocate the lines and remediate the problem is being defined. The timeframe for final agreement on the project and its financing remains somewhat uncertain. A solution to this problem needs to be agreed-upon, along with an implementation schedule to allow other remedial actions to be beneficial.

6.6.2 Disposition of Flash Boards at Cedar Pond

For some period of time the water surface elevation of Cedar Pond and the effects of the diurnal tidal cycle of Cape Cod Bay on the Pond were controlled by manually adjusted flash boards at the interface of Rock Harbor Creek near the mouth of Cedar Pond. This control protocol resulted in decreased tidal flushing and salinity of the Pond compared to conditions that would prevail without the flash boards.

The purpose, history and effects of the flash boards have been investigated extensively over the last several years. In an attempt to increase tidal flushing to improve water quality in the pond, the boards were removed sometime between 2004 and 2007. The original Massachusetts Estuaries Project studies and subsequent reanalysis of the impacts of the flash boards by SMAST has resulted in a decision by the Town to install the boards resulting in lower salinity of the Pond. Because the boards had not been in lace for more than 10 years, the town was required to file with the Orleans Conservation Commission for permission to return the boards. The Conservation Commission approved this action but a citizens group appealed the decision to DEP. On September 3, 2015, the DEP issued a requirement, along with request for other information, to file an Environmental Notification Form (ENF) under the Massachusetts Environmental Policy Act with the Secretary of Energy and Environmental Affairs. This ENF has resulted in the need to complete an Environmental Impact Report (EIR) addressing the impacts of removal of the flash boards. The completion of the EIR is expected in December 2016. The findings and recommendations of the EIR will be reviewed and acted upon by DEP to result in a final decision and action related to the management of the Pond. This decision will, in turn, affect the downstream requirements for nitrogen removal and, thus, the evaluation and design of programs to comply with Massachusetts Estuaries Project and TMDL requirements. One of the resulting effects of maintenance of the flash boards would produce some attenuation of nitrogen loads from Rock Harbor Creek, which flows through the Pond in the upper segment of the watershed thus reducing requirements for nitrogen reduction through other management controls.

Given the issues related to Cedar Pond, as well as the age of the data used in the original Massachusetts Estuaries Project study, it is planned that the Massachusetts Estuaries Project study and model runs will be updated with more recent water quality monitoring data and to reflect other changes in the watershed in addition to the cormorant pollutant load and flash board decisions driving salinity of the Pond.

6.6.3 Causes of Impairment in the Rock Harbor (Lower Basin)

The Massachusetts Estuaries Project report for Rock Harbor Creek includes the following statements:

- A habitat assessment was conducted throughout Rock Harbor system based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure.
- The Rock Harbor system is showing high habitat quality throughout its upper salt marsh reach (above WMO-17) and significant habitat impairment in its lower "embayment" reach (e.g. harbor portion, WMO-17 to inlet). The upper reach appears to be a fully functional tidal salt marsh with deeply incised narrow creeks surrounded by significant areas of emergent marsh. This reach is typical of New England "pocket" marshes, with smaller tidal creeks and a marsh plain dominated by low marsh and high marsh plant communities, along with patches of fringing brackish marsh vegetation.

- In contrast, the lower embayment reach, comprised primarily of the harbor basin, functions as a small open water cove or harbor. This basin is depositional by structure, collecting both algal and salt marsh organic matter with accumulation of anoxic organic-rich fine sediments (sulfidic); it is highly tidal, with sufficient light penetration to allow periodic development of benthic algal mats; and its tidal inlet is influenced by sand transport via near shore coastal processes associated with adjacent Cape Cod Bay. These features in combination with the observed levels of summer oxygen depletion (to 2 mg L-1), indicate a significantly impaired habitat. This assessment is supported by the impoverished infaunal animal community which is dominated by small opportunistic stress indicator species common to disturbed or organic matter enriched basins.

- Based upon all available information the present lack of eelgrass throughout the Rock Harbor System does not appear to be a response to watershed sourced nitrogen loading (e.g. changing watershed land-use). Instead, the absence of eelgrass habitat appears to result from the structure of the upper reach supportive of salt marsh and the lower reach being a maintained depositional basin. The absence of eelgrass within the harbor basin is likely the result of its configuration, in that it is a "relatively deep" depositional basin. In addition, in the lower reach, harbor activities also likely have limited the potential for colonization of this system. Most important relative to Massachusetts Estuaries Project nitrogen thresholds analysis, it does not appear that eelgrass beds have been present within the Rock Harbor System at any time over the past century, as indicated by MassDEP Eelgrass Mapping Program analysis and Massachusetts Estuaries Project Technical Team historical analysis. Therefore, nitrogen threshold development for protection/restoration of this estuarine system will necessarily focus on restoration of the impaired infaunal habitat within the harbor (embayment reach) and protection of the high quality infaunal habitat within the upper salt marsh reach."

These conclusions of the Massachusetts Estuaries Project Report call to question the validity of the state water quality standards for the Harbor reach of the watershed. The 1992 Clean Water Act envisions situations in which otherwise reasonable water quality designated uses may not be achievable due to circumstances such as natural hydrologic or geomorphic conditions in the watershed, anthropogenic water body uses that cannot (will not) be reversed, the affordability of extremely expensive solutions to attain and maintain water quality standards and other irreversible conditions. The ability to create and sustain infaunal habitats, eelgrass and associated water quality criteria (i.e. nitrogen concentrations) in the lower reach of the Rock Harbor in the face of natural littoral processes and anthropogenic conditions such as the marina with associated periodic dredging, boat traffic, scour and deposition and other influences cited by the Massachusetts Estuaries Project, may be one of the examples covered by the Use Attainability provisions of 40 CFR 131.10(g) (1-6) of the Clean Water Act. Appeal to the provisions of this section of the Clean Water Act could result in modification of the water quality standard for the lower segment of Rock Harbor Creek for various parameters that would mitigate the need to reduce nitrogen loads to this lower segment. Since, according to the Massachusetts Estuaries Project, 88 percent of the nitrogen load to the entire Creek enters in the Rock Harbor segment, this could results in a significant reduction in cost to the town, without compromising the health of the upstream segments of the Creek.

Discussion between the Town of Orleans representatives and the EPA to consider the applicability of the use attainment provisions indicated that this avenue may be appropriate, but only after all other alternatives, including control of stormwater and well as on-site systems and wastewater treatment plant discharges, have been explored and the affordability question resolved. It is noted that requirements technical information and evaluation, public involvement and regulatory review to enact a modification in the water quality criteria or use designation are very substantial and time consuming. For these and other reasons, the adaptive plan for the Rock Harbor Creek watershed is to complete the studies and evaluations outlined in this section, retaining the option of appeal to the MassDEP and EPA under the Clean Water Act use attainment provisions at a later date.

It is also noted that the Cape Cod Bay at the mouth of Rock Harbor Creek is under a MassDEP promulgated TMDL for bacteria due to unknown causes. This issue is one that would also be addressed in the adaptive management framework, and may be a contributing factor in water quality standards - use attainment analysis.

6.6.4 208 Management Plan Recommendations

Since issuance and DEP and Cape Cod Commission approval of the Orleans CWMP in 2011, the Cape Cod Commission has completed an update of the 1968 Area-wide Water Quality Management Plan required by the EPA. This update included recommendations for Cape Cod towns to consider a wide range of non-traditional technologies in development, or reevaluation in the case of Orleans, of their CWMPs. These 208 recommendations were incorporated by the Town into the reevaluation of the CWMP conducted over the last two years. This reevaluation has resulted in substantial modifications to the traditional technologies recommended for Phase 1 of the 2011 CWMP. Demonstration projects including projects for aquaculture, permeable reactive barriers and horizontal, on-site nitrogen reducing barriers are being implemented by the Town, with the hope that successful demonstrations will significantly reduce overall cost of the program.

Pending resolution of the other issues driving the Rock Harbor Creek plan (i.e. Cedar Pond status, Massachusetts Estuaries Project update), the nitrogen control options will be reevaluated in light of the results of the non-traditional demonstration projects. In addition, stormwater, fertilizer and growth management considerations will be incorporated into the reevaluation. The projected schedule for this reevaluation in included in the timeline included below.

6.6.5 Modification of the Amended CWMP

As a result of the above issues, the following activities are being completed. Upon resolution of these issues an Amended CWMP will be modified to include a revised management plan for Rock Harbor Creek.

Given that there is significant uncertainty with each issue, a best estimate of the schedule for the resolution of the above issues and modification of the ACWMP suitable for DEP review and approval and implementation is as follows:

- MassDEP decision on Cedar Pond flash boards (pond salinity): February 2017;
- Resolution of cormorant pollution source: April 2017;
- Update/confirmation of MEP thresholds and MassDEP TMDL: December 2017;
- Evaluation of traditional/non-traditional management options: July 2018; and
- Begin implementation (design/construction) of approved plan: May 2019.

In the meantime, it is the plan of the Town of Orleans to proceed with the implementation of components of the ACWMP in other watersheds of Orleans under the “Targeted Watershed Implementation” approach proposed and adopted by the MassDEP and Cape Cod Commission to promote substantive programs to remediate and protect water quality and meet regulatory standards. Certainly, progress on implementation of agreed-upon Traditional or Non-Traditional water quality management projects can proceed once an agreement between Eversource and the Town is reached without waiting for actual design and construction of the Eversource cormorant solution. It is also reasonable for the Town to proceed to evaluate alternative traditional and non-traditional technologies while the Massachusetts Estuaries Project /Total Maximum Daily Load process in progress with adjustment of the size, capacity and other design features of control options (e.g. length of PRB; capacity of treatment systems, etc.) to be adjusted to fit the final TMDL requirement.

As stated above, the option of customizing water quality standards for the Rock Creek Harbor segment, requiring substantial additional time and technical evaluation, regulatory review and public involvement, will be pursued, if deemed appropriate by the Town, after all other management approaches are proven infeasible or unaffordable through the above steps.

It is noted that it is also imperative that the Town of Eastham proceed with its water quality management planning to resolve the Eastham nitrogen contribution to Rock Harbor Creek.

6.7 Namskaket Marsh Adaptive Plan

6.7.1 Background

Namskaket Marsh is an 80 hectare (200 acre) salt marsh on the northeastern coast of Cape Cod, located within the Towns of Orleans and Brewster. The marsh has been designated by the state as an Area of Critical Environmental Concern (ACEC) because of the unique environmental resources of the marsh in need of special management attention. The Namskaket Marsh has also been designated as an Outstanding Resource Water (ORW) by the state because of their "outstanding socio-economic, recreational, ecological and/or aesthetic values". As such, these waters are given special protection under the Massachusetts Surface Water Quality Standards. Figure ## shows the approximate limits of the groundwater aquifer feeding the Namskaket Creek.

The watershed is bifurcated by an elevated bike trail, creating, in conjunction with other watershed changes, and upper and lower marsh with distinctively different characteristics. According to the Massachusetts Estuaries Project Report, the lower marsh is characteristic of *"...a typical New England salt marsh dominated by a central tidal creek and emergent marsh colonized by low marsh and high marsh with some more brackish marsh plants found in the upper most regions and limited bordering patches of Phragmites. Tidal exchange with the high quality waters of Cape Cod Bay is high, given the ca. 10 foot tide, which has also resulted in tidal creeks which are deeply incised, with near complete drainage at low tide. The result is the type of coastal system which has a relatively high tolerance for nitrogen inputs from its watershed.*" (UMass Dartmouth SMAST, 2008)

On the other hand, the upper marsh has been affected by urbanization, including significant commercial development, transportation systems, and utilities with attendant severe negative modifications to the stormwater drainage patterns and resulting groundwater recharge and pollutant loading to surface waters.

During the development of the CWMP the paramount concern was the potential for excessive enrichment of the lower marsh due to on-site wastewater discharges, the TTSTP discharge, stormwater runoff and other sources. Consequently, these issues were addressed in detail in the monitoring, modeling and resulting Massachusetts Estuaries Project analyses performed as part of the CWMP process.

6.7.2 Massachusetts Estuaries Project Report and CWMP

The Massachusetts Estuaries Project report (UMass Dartmouth SMAST, 2008), focusing on the areas downgradient of the bike path and the TTSTP discharge, concluded that Namskaket Marsh is significantly below the level of nitrogen loading that would cause impairment to its infaunal habitats (i.e. below its nitrogen threshold level). The threshold set by the Massachusetts Estuaries Project for the system would allow up to 3.6 times (261 percent increase) the present watershed loading. Nevertheless, the 2008 Massachusetts Estuaries Project Report stated:

"The overarching conclusion of the Massachusetts Estuaries Project *analysis of the Namskaket Marsh estuarine system is that protection of this currently healthy salt marsh system will allow for increased nitrogen loading from a variety of watershed sources, however, limits to nitrogen loading have been determined as detailed further in the report. This requires careful long term monitoring of conditions in the marsh system and watershed based management of present and future nitrogen inputs such that nitrogen concentration thresholds specified as supportive of health marsh habitat are not exceeded in the future."*

Because of the special protection warranted by the ACEC and ORW classification, the Town of Orleans opted to investigate alternative locations for discharge of the treated effluent from the new wastewater treatment plant proposed in the CWMP. The new WWTF would have discharged up to 640,000 gpd upon full implementation of the 6-phase wastewater management plan. The historic 20-year average discharge from the Tri-Town Septage Treatment Plant (TTSTP) located on Overland Way just north of the bike path was approximately 30,000 gpd.

During and after the development of the CWMP, additional concerns were raised regarding:

- The potential influence of the discharge of treated wastewater from the TTSTP. Specifically, the concern that the treated *freshwater* comprising the groundwater discharge had potential to upset the natural fresh-saline water balance in the estuary, affecting vegetation and aquatic habitat downstream.
- Alterations in vegetation patterns due to freshwater discharges from the existing TTSTP, as well as alterations in the hydrology of the watershed due to urbanization of the area up-stream of the bike path.
- The alterations in land use, vegetation, surface water quality and other environmental features resulting from commercial growth, transportation system modifications, stormwater practices, including modifications to the Namskaket Creek culvert at the bike path, and other land management conditions in the watershed above the bike path.

To address these concerns several additional studies were undertaken by the Town:

- A study by the USGS comparing the historic groundwater conditions, including nitrogen and salinity concentrations, with conditions 20 years after beginning of operation of the TTSTP;
- A salinity and vegetation survey of the marsh downstream of the bike path to define changes in the characteristics of the marsh with respect to those parameters, and
- Development of an Adaptive Management Plan to identify and implement management and remediation plans for the areas above the bike path and for protection of the lower Namskaket Marsh.

6.7.3 USGS Study

The USGS study report (USGS, 2016) concluded that:

"...the 2011 creek samples, collected approximately 8 years after the shallow plume segment was first detected beneath the marsh, do not show evidence of elevated nitrate or total dissolved nitrogen concentrations attributable to the discharge of the plume segments. The plume segments may be moving with the regional groundwater flow system below the marsh, toward downgradient discharge areas such as the Little Namskaket Marsh or Cape Cod Bay. Alternatively, the plume segments may be fully or partially discharging to creek reaches within the Inner Namskaket Marsh, and the nitrate and other dissolved nitrogen species in the plume segments are (1) being removed by the chemical and microbial processes during vertical transport through the creek-bottom and marsh boundary sediments or (2) diluted to such an extent in the creeks that changes in the concentration or nitrogen cannot be detected.

6.7.4 SMAST Vegetation and Salinity Study

The SMAST vegetation and salinity study report, also issued in 2016, updated the 1995 study and concluded that:

"It appears from both the salinity and vegetation surveys that Upper Namskaket Marsh is a dynamic system that has experienced changes over the past 2 decades. However, the direct measurements do not support the contention that the invasive plant Phragmites australis has increased its distribution and abundance within Upper Namskaket Marsh from 1995 to 2015. Comparing the surveys it appears that the specific areas colonized have shifted but that the total area covered has not changed significantly (780 m2 within a 56,000 m2 marsh). The changes, especially the spatial shifts, can be best seen in the simplified vegetation coverages showing areas of pure Phragmites and all other salt marsh vegetation combined (Figure 6). The results do show an increase in salt marsh vegetation, mainly resulting from the re-colonization of previously wrack covered marsh. Equally important to ecosystem health is that previously pure stands of Phragmites are becoming mixed stands due to the colonization by endemic (non-invasive) wetland species.

The vegetation results are consistent with the salinity data which showed a potential increase in pore water salinity or stable conditions. A freshening of the root zone of the marsh would be of concern relative to Phragmites expansion, but this was not the case in Upper Namskaket Marsh. The salinity results are consistent with the lack of significant new sources of freshwater inflow to the marsh over the past 2 decades (Tri-Town is a small discharge relative to the watershed recharge).

Given the results it appears that Upper Namskaket Marsh will continue to show cyclical vegetation shifts due primarily to periodic natural deposition of wrack and its subsequent natural removal on extreme tides and changes at the upland/marsh border due to sea level rise. These types of changes are typical of New England pocket marshes. It appears that this region of marsh will continue in its present state (as delimited by the 1995 and 2015 surveys) unless a major change in tidal exchange or within the upland occurs. Upper Namskaket Marsh continues to be a productive salt marsh and home to countless invertebrates, fish, and birds as a tributary to the larger Namskaket Marsh system."

Figure ## above are maps of vegetation patterns from the 1995 and 2016 studies depicting the conclusions outlined above.

6.7.5 Namskaket Marsh Adaptive Management Plan

In 2015, pursuant to the Consensus Agreement reached by the Orleans Water Quality Advisory Panel, the Town authorized the development of a long-term plan for remediation and protection of Namskaket watershed, including the protection of the lower marsh and remediation of the land use and environmental conditions in the upper marsh. The plan would be an Adaptive Management Plan (AMP), involving continuing monitoring, alternatives assessment, implementation of agreed-upon actions, follow-up monitoring and adjustment of next phases of the plan. Elements of this planning effort include:

- Cooperation and consultation with the Town or Brewster in development and implementation of the plan;
- Public engagement involving commercial, residential, regulatory, environmental advocacy groups, Town departments and other representatives;
- Generation of baseline information from existing and new studies related to land use, water quality, vegetation, wastewater systems, stormwater management, environmental resources, zoning and other information;
- Definition of impairments and threats to the health of the watershed;
- Identification and evaluation of remediation and protection options, including definitions of the actions, costs, time frames, implementation requirements and regulatory requirements;
- Coordination with Town Boards to support, approve and fund agreed-upon implementation activities; and
- Identification and solicitation of county, state and federal financial support for implementation of the plan.

As part of the on-going Adaptive Management Plan of the Town of Orleans, water quality monitoring is continuing to provide information adequate to track baseline conditions and inform future updates of the Massachusetts Estuaries Project analyses and other studies.

Through its Board of Selectmen, the Town of Orleans has funded in its FY 2017 budget the initial steps for development of this plan.

6.8 Freshwater Ponds

The Town of Orleans contains 60 named lakes and ponds within its borders. The 2010 Comprehensive Wastewater Management Plan (Wright-Pierce, 2010) included an evaluation of eight of the major ponds, including assessment of the water quality and trophic status of these ponds. The CWMP did not include an evaluation of alternatives for protection of these ponds or remediation of those ponds that are impaired and do not meet water quality standards. In 2007, the Cape Cod Commission completed a review and interpretation of the water quality data collected by the Town's Marine and Fresh Water Quality Task Force under the County's Pond and Lake Stewardship program (Cape Cod Commission, 2007).

In December 2016 the Orleans Board of Selectmen authorized and funded the development of a plan for further evaluation, protection and remediation of the freshwater ponds of the Town. This plan will build on the information and assessments completed under the CWMP. It will also incorporate the information developed in the ponds water quality monitoring program, continued by the Town's Marine and Fresh Water Quality Task Force since completion of the CWMP and the 2007 Commission report.

Elements of the freshwater ponds planning effort include:

- Creation of a Freshwater Ponds Work Group to oversee development and implementation of the plan;
- Development and contracting for the scope of services necessary to provide technical information, analyses and direction for the planning and implementation stages. This has been accomplished with contracting with SMAST;
- Update and analyses of the Town's water quality data base for freshwater ponds, including identification of water quality data "gaps" and adaptation of the monitoring program to reflect needs and ensure long-term sustainability. This task is currently underway and includes defining agreed-upon prioritization criteria;
- Completion of an data analyses, categorization and prioritization of the ponds to define agreed-upon priorities for development of management plans;
- Development of watershed assessments to determine the nature of impairment, sources of pollution and threats to future deterioration that need to be addressed;
- Evaluation of remediation and management alternatives to address impairments and threats, including regulatory requirements, costs, implementation roles and responsibilities and other requirements;
- Coordination with town and, in some cases, state departments such as the Board of Health, Department of Public Works, state DOT, Conservation Commission and other parties to develop integrated plans that include management of on-site systems, stormwater, fertilizer, agricultural practices and other potential causes of impairment;
- Coordination with regulatory agencies in development and implementation of the plan;
- Coordination with, and integration of, local pond and watershed advocacy groups, along with development of a broader public information and engagement process;
- Coordination and communication with the Board of Selectmen to develop short- and long-term plan for approval and funding of a sustainable plan;
- Identification and solicitation of county, state and federal financial support for the program;
- Implementation of adaptive planning principles that provides for monitoring management "projects", responsive adjustment of program priorities and actions, and further progress monitoring; and
- Reporting and tracking of the program.

The freshwater ponds management plan will be a continuing component of the Town's overall Water Quality Management program.

6.9 Integrating Stormwater and Fertilizer Management Programs

The Town has taken a proactive approach to implementing stormwater and fertilizer management for water resources protection as summarized in the Technical Memorandum in Appendix X. Two separate consultants are currently providing evaluations related to stormwater and fertilizer, including GHD, Inc., and AMEC Foster Wheeler. Both are expected to provide final deliverables by the end of 2016. In addition, Orleans submitted a NPDES Phase II Small MS4 General Permit Annual Report to the Environmental Protection Agency in April 2016, included as Appendix A to the Technical Memorandum (Appendix Y).

6.9.1 Stormwater

The annual NPDES report states that the Town has been evaluating program needs based on the draft 2014 Phase II Permit (which has since been issued in final form) and using these evaluations and other activities (e.g., CWMP and Best Management projects) to develop a Stormwater Management Plan. The following key stormwater management planning activities were listed in this annual report:

- Detailed mapping of the downtown area was conducted by SMC Engineering, Inc. to identify all municipal infrastructures with an emphasis on drainage and other utilities. This effort was coordinated with Greenseal Environmental, Inc. to complete the mapping of drainage systems through the remainder of the Town. The result of these efforts will be a field verified drainage map that identifies each structure, pipe and existing stormwater Best Management Practices. The mapping effort is substantially complete.
- As part of the 208 Plan Update for Cape Cod, the Town is required to establish watershed management teams. The Town began evaluating teams for specific waters to meet the requirements of the 208 Plan approval. The results of the above efforts are being incorporated into a stormwater pollutant load analysis and dynamic planning tool by Amec Foster Wheeler and will provide the following information: baseline stormwater pollutant loads; analysis of existing stormwater BMPs and benefits; prioritization of stormwater management basins (watersheds); and an evaluation of proposed Best Management Practices, benefits and costs. . This information will be used as the basis for future capital projects to design and install stormwater Best Management Practices for water quality improvement.
- There were several stormwater and water quality improvement projects designed:
  - Eldridge Playground Improvement Project – tree plantings and improvements were completed in April 2016 to infiltrate stormwater from the tennis courts;
  - Rock Harbor Dredging – completed in spring 2015;
  - Rock Harbor Parking Lot – stormwater improvement Best Management Practices were designed and construction will be completed in early 2017;
  - Portanimicut Road – design began for stormwater improvements (infiltration and erosion control);
  - Gibson Road – outfall improvements (infiltration) are under design for the direct discharge to Town Cove;
  - Best Management Practices Database – the Town began efforts to complete a comprehensive assessment of all stormwater BMPs (approx. 35) in Town to develop an operation and maintenance plan; Water Quality Monitoring – ongoing water quality monitoring was conducted between May 2015 and May 2016 at the creeks that enter Cape Cod Bay, Pleasant Bay (21 locations), and Nauset Bay (3 locations). The Town also increased funding for 2016 to include additional monitoring locations in Nauset Bay to support the Massachusetts Estuary Program (Massachusetts Estuaries Project) update; and
  - Rock Harbor Road – design began for multiple locations to provide stormwater treatment (infiltration) for direct outfalls.

- AMEC Foster Wheeler will be providing a dynamic planning tool that will provide information needed to design and install stormwater Best Management Practices to provide benefits to water quality as well as drainage volume. This stormwater planning tool will facilitate identification of measures to reduce nutrients in stormwater runoff where appropriate and these will be incorporated into the Stormwater Management Plan.
- The above efforts are reviewed on an ongoing basis by the Stormwater Team, which consists of the DPW and Natural Resources Director, DPW Manager, Town Planner, Health Agent, Conservation Officer and the Chairperson of the Marine and Freshwater Quality Task Force.

6.9.2 Fertilizer Program

In addition to the efforts to reduce nitrogen loading from stormwater, the Town of Orleans continues to implement BMPs to reduce the use of fertilizers and pesticides. The Pleasant Bay Alliance developed a fertilizer and pesticide use policy for municipal properties in April 2012. The Town developed a Fertilizer Nitrogen Control bylaw that passed at the 2014 Annual Town Meeting. The purpose of the bylaw is to restrict the use of nitrogen based fertilizers throughout Town and it includes the following provisions: no application of nitrogen between October 16 and April 14; no application before or during heavy rain; and no application within 100 feet of Resource Areas protected under the Massachusetts Wetlands Protection Act and Orleans Wetland By-law. In support of these efforts, the Orleans Pond Coalition maintained a robust public education campaign between May 2015 and May 2016 to inform residents and businesses about the proper use of and alternatives to fertilizers. Additionally, SMAST updated the fertilizer model inputs based on the assessment of the 260 parcels that have been developed in Orleans since the original Massachusetts Estuaries Project model runs. Brochures regarding proper fertilizer and pesticide use are available at the Town Hall. Orleans is one of four Massachusetts towns to have such a bylaw (the others are Falmouth, Mashpee and Nantucket).

6.9.3 Information Relevant to Adaptive Management Plan

Because these programs are scheduled for completion at the end of 2016, and Technical Memoranda have not yet been submitted to the Town, there is no new information on the nutrient - removal attributed to stormwater BMPs or fertilizer reduction available at this time.

7.0 Financial Evaluation

The goal of the Financial Evaluation task of the Town of Orleans Water Quality and Wastewater Planning project is to modify the financial model that was completed in 2015 to provide an updated model with greater functionality. The model has been updated to provide greater definition of revenue generating options, financing options, and program costs, to allow for an evaluation of impact on the residents and businesses of Orleans. The update also included a preliminary evaluation of the feasibility of a public/private partnership which would allow private developers to finance or contribute to costs of the wastewater management system. The Financial Evaluation task work is summarized in the following Technical Memoranda:

- Revenue Generating Options;
- Financing Options;
- Financial Model Update – Preliminary Analysis and Updated;
- Program Cost Impact and Affordability Assessment; and
- Public Private Partnership Options.

Highlights from these Technical Memoranda are provided below; the complete documents are located in Appendix Z.

7.1 Revenue Generating Options

Traditionally, wastewater programs have been funded by property taxes, betterments or other special assessments, connection fees, and user fees. Recently, the financing of wastewater and stormwater management programs has been funded by other sources including but not limited to regional or local options taxes (for example meals and/or lodging taxes), the water infrastructure fund which is a real estate tax surcharge generating additional tax revenue outside of Proposition 2 ½, septage revenues, and stormwater utility fees.

Attempts are also made by communities to offset charges through grants such as US Department of Agriculture (USDA), US Economic Development Agency (EDA), and Housing and Urban Development (HUD) block grants and EPA 319 Grants. In addition, there are opportunities to reduce costs of a program through alternative procurement methods such as design/build or design-build-operate or through a public private partnership in which private equity is introduced into a project. The Town of Orleans evaluated all of these options which are discussed in greater detail in the Final Technical Memorandum on Revenue Generating Options.

Orleans considered several key factors in looking at sources of revenue: equitable allocation of cost based on the watershed benefitting from the wastewater management method, and customer or user group (both residential and non-residential, and year-round customer versus seasonal or short-term visitor). The financial model was developed with the flexibility to handle a variety of revenue requirements so that the Town could evaluate implications for total costs and impacts to Town businesses and residents. The model initially included seven scenarios that contain different combinations of Revenue Generating Options and allows comparison among them. As the design of the project and the model itself has been refined, additional scenarios have been developed.

The revenue options evaluated in the model include:

- Special Assessments – The Town intends to rely on special assessments to recover most, if not all, of the project's capital and financing costs.
- Property Taxes – The Town intends to rely on special assessments to recover most, if not all, of the project's capital and financing costs, but may turn to an increase in property taxes if it chooses to split the funding of capital costs between special assessments and property taxes.
- Connection Charges – The Town does not intend to rely on connection charges to fund capital costs. Instead, the Town seeks to fund capital and financing costs via special assessments and/or property taxes.

- User Fees – The Town expects to rely on user fees to fund operating, maintenance, replacement, and monitoring costs, on an annual basis.
- Grants (or Principal Forgiveness) – The Town continues to seek revenue opportunities to help with the funding of the capital costs. The Town will consider all grant possibilities.
- Septage Revenue – The Town is interested in constructing the downtown plant such that it is a septage-processing facility. The Town can expect about $580,000 in annual septage revenue if it constructs such a facility. Constructing the facility to handle septage costs about $500,000 more than not constructing it to handle septage and the facility would require about $200,000 more in operating and maintenance costs. However, the Town could expect approximately $350,000 net revenue if it were to construct a septage-processing facility in the downtown area.
- Design/Build – Design/Build is a procurement method in which both the design and the construction contracts are bid and completed under one contract as opposed to the more traditional procurement method of design/bid/build. The Town could realize 21 percent savings in capital costs related to the wastewater treatment facilities if it were to construct them as design/build projects.
- Design/Build/Operate – In addition to savings on capital costs with a design/build project, the Town could realize 7 percent savings in operating and maintenance costs related to the treatment plants if it were to operate them as design/build/operate projects. The savings estimate is based on Design/Build/Operate projects with which the engineering firm of AECOM has been involved.
- Local Option Taxes – The Town is considering increases in existing local option taxes in order to bring in more revenue. An increase in the local option tax is an appealing option for the Town since it is the only revenue option listed here that brings in revenue from people that do not own property in Orleans, like seasonal and daily visitors.
- Public-Private Partnerships – The Town has convened a group of local businesses and condo associations to begin discussions regarding opportunities to leverage private investment to accelerate construction of an affordable treatment facility in the Downtown. This opportunity would lessen the burden of capital and financing costs on the Town. There are several forms such a private-public partnership could take, and these are discussed in greater detail below and also in Technical Memorandum on Public-Private Partnership Options.

7.2 Evaluation of SRF and Other Financing Options

The Financing evaluation considers financing available through the Massachusetts' Clean Water State Revolving Fund program and USDA and conventional financing. The State Revolving Fund (SRF) Program is the financial assistance program for water pollution abatement projects authorized under M.G.L. c21, S 27A and the Clean Water Act, including the Water Pollution Abatement Revolving Loan Program. Each of these programs is described in detail in the Final Technical Memorandum on Evaluation of SRF and Other Financing Options, provided in Appendix AA.

SRF financing includes an origination fee and administrative fees, but typically allows towns to finance projects at interest rates lower than those with conventional financing. Under the SRF program, certain nutrient management projects may receive an enhanced state-financed subsidy on the Interest rate. The amount of the subsidy varies depending on the financial status of the community.

The Town may receive:

- 0 percent financing on certain nutrient-management projects over a 20-year period;
- 2 percent financing on non-nutrient-management projects over a 20-year period; and
- 2.4 percent financing on non-nutrient-management projects over a 30-year period.

A nutrient-removal project is defined as a water pollution abatement project undertaken by the Town primarily to remediate or prevent nutrient enrichment of a surface water body or a source of water supply to comply with effluent limitations established under a NPDES permit or an EPA-approved TMDL or to otherwise implement a nutrient-management plan approved by Massachusetts Department of Environmental Protection (MassDEP). Nutrient-removal projects include those portions of such projects approved by the MassDEP as reasonably necessary for cost-effective nutrient removal or recovery, and as evidenced by the Town's CWMP or a corresponding engineering report. Specifically, projects that meet the following criteria are eligible for 0 percent SRF financing:

- The project is primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply;
- The applicant is not currently subject, due to a violation of a nutrient-related total maximum daily load standard or other nutrient based standard, to a MassDEP enforcement order, administrative consent order or unilateral administrative order, enforcement action by the United States Environmental Protection Agency or subject to a state or federal court order relative to the proposed project;
- The applicant has a Comprehensive Wastewater Management Plan (CWMP) approved pursuant to regulations adopted by MassDEP;
- The project has been deemed consistent with the regional water resources management plans if one exists; and
- The applicant has adopted land use controls, subject to the review and approval of MassDEP in consultation with the Department of Housing and Economic Development and, where applicable, any regional land use regulatory entity, intended to limit wastewater flows to the amount authorized under the land use controls that were in effect on the date the Secretary of the Executive Office of Energy and Environmental Affairs issued a certificate for the CWMP pursuant to the Massachusetts Environmental Policy Act, M.G.L. c. 30, §§ 61-62H, and the Massachusetts Environmental Policy Act regulations at 301 CMR 11.00. The Town of Orleans meets all the criteria to be eligible for 0 percent SRF Financing.

The other financing mechanisms evaluated include Conventional Financing and USDA Financing. The updated financial model allows flexibility to users to create scenarios based on the most appropriate financing tool for the type of activity (planning, design or construction) and based on the desired borrowing term. The financing options identified include both short-and long-term financing. Both Conventional and SRF Financing are believed to be appropriate tools for traditional sewering as well as the non-traditional technologies. All phases of planning through construction are eligible for conventional financing, however, SRF only considers planning and construction costs as eligible costs.

7.3 Final Financial Model Update – Preliminary Analysis

The model originally was developed to contain seven program cost scenarios that are displayed in an easy-to-compare format. The model has since been expanded to evaluate difference costs scenarios. The model shows the different financing options and costs offsets (for example, grants) for each scenario, which are identified as “Cases”, as well as the total program costs for each. Since costs for each scenario are easy to compare to those for other scenarios, it is straightforward to assess the impact different financing options and different costs offsets have on program costs. The updated Financial Model allows the user to generate borrowing schedules. The capital costs of the various elements of the program are input into the model, and multiple borrowings can be identified as needed. Having this ability has given the Town a tool to determine the combination of financing options, costs offsets, and revenue options most beneficial to the Town’s ability to finance the program

The new financial model is being refined to present program costs in two ways: (1) total program costs together as if the entire program were completed in the first year; and (2) program costs subject to phasing over a 20-year or longer period. The plan for phasing is being developed and will be finalized as part of preliminary design in early 2017.

7.4 Background and Framework for Assessing Affordability

Background and baseline information on the affordability of the Orleans water quality and wastewater management program was compiled to provide a foundation for more detailed evaluation of the impacts on residents and businesses. The United States Environmental Protection Agency (EPA) guidance on financial capability and affordability is used as one tool to conduct the analysis because it provides recognized benchmarks for community financial health and residential affordability. The EPA guidance does not address non-residential affordability; thus a separate discussion is provided to begin the discussion of the potential cost to the non-residential users in the Downtown. Wastewater management costs and wastewater management user charges in several other communities on the Cape that are also undertaking water quality and wastewater management programs are provided for information purposes. Direct comparison among communities is difficult because the communities may or may not include property tax charges, connection costs, or other charges in the annual user fees they report. The comparison is informative, although differences in the various elements and size of programs must be recognized. It is important to note that the costs of the Orleans program are still at a planning level at this time pending completion of the preliminary design which will occur in winter and early spring 2017.. This assessment provides a preliminary insight into the ability of Orleans to pay for the water quality and wastewater management program, but it will be refined as additional design information becomes available.

Baseline data show that while the Town has reasonably strong financial capability based on several of the EPA Financial Capability Criteria (debt, socioeconomic, and financial management indicators), the benchmark for the Residential Indicator (RI) at 2 percent of MHI ($58,235, 2010 ACS 5-year Estimate) would represent in excess of $1,100 per year. It is also important to note that the Town has a particularly large share of population over the age of 65 (41.2 percent compared to 14.4 percent for the State of Massachusetts according to recent Census data), many of whom may be on a fixed income and, thus, face even greater challenges in paying increased wastewater costs. The combination of the fairly strong Town Financial Condition and the anticipated heavy burden on the average residential household would result in an overall medium to high financial burden on residents of the Town, indicating that additional financial assistance and/or a longer program implementation are required.

Businesses and other non-residential users would be responsible to pay their fair share of the anticipated wastewater management costs. These non-residential users would pay any costs allocated through property taxes and would also pay for special assessment charges and annual user fees. Under several of the Cases, the costs of the downtown collection, treatment, and disposal system components of the project would be paid for solely by the downtown businesses.

For the purpose of establishing a baseline for evaluating affordability, the anticipated cost to maintain and/or replace their wastewater management systems was estimated. Restaurants and motels have higher annual water and wastewater use, while the retail stores and offices have lower annual flows. The historic average for all non-residential properties is 367 gpd and 433 gpd for all mixed use properties. The estimated current cost to maintain an on-site wastewater disposal system is approximately $2,800 to $4,300 per year, assuming that the non-residential establishment is required to pay approximately $200 to $800 for annual maintenance, $600 for each pump out (assumes an average of two to three times per year) and no financing costs.

All septic system owners face the inevitable need to replace their system at some point in time. The replacement cost of a conventional septic system (440 gallons) is estimated to be approximately $18,000, and $35,000 for an Innovative/Alternative Technology (I/A) system. The cost would be higher for larger systems that serve the various restaurants and motels in the Downtown Area.

It is important to note that if the Downtown Area is sewered in the future, there may be opportunities for both residences and businesses to change use or increase density of development on their properties, depending on revised zoning regulations approved by the Town that would be consistent with the Town's approved Comprehensive Plan. The changed uses and higher densities allowed under revised zoning may provide opportunities for greater revenue generation. The Planning Board is in the process of developing amendments to the zoning bylaw that would modify existing zoning, thereby allowing increased densities in certain parts of the downtown area.

Anticipated program costs and affordability considerations are presented in the Technical Memorandum Program Cost Impact and Affordability, dated June 30, 2016 and included in Appendix AB. Given the concerns about affordability of the program the Town is continuing to explore other types of financing and will look closely at the resulting costs to customers. As noted above, phasing the program would result in lower annual costs to customers although total program costs would increase due to the additional costs from inflation and/or the interest of interest financing above zero percent. The costs presented in Table 1 represent phasing program implementation over a 20 year time period. The Town is now looking at extending the program over an even longer period, potentially 40 years. The Town has continued to refine the financial model and is evaluating additional cost allocation scenarios. The possibilities include allocating some or all of the capital and/or Operation and Maintenance costs for the Non-Traditional technologies to all residents and businesses of the town. Additional sources of revenue are also being investigated. In addition, water usage and property assessment /tax data are being incorporated into the model to allow estimation of costs on a per parcel basis. The Town is also actively investigating the potential for public private partnerships to introduce private equity into the program and potentially reduce capital costs to the public. These efforts are ongoing and are briefly described in the following section.

7.5 Public-Private Partnerships

The Town is exploring the feasibility of private-public partnerships with private entities that would be served by the downtown system. Numerous sources define the term P3 as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance" (PPP Knowledge Lab, https://pppknowledgelab.org/ppp-cycle/what-ppp).

The primary use of P3 in water quality and wastewater planning is to introduce private equity and management structure into the construction and operation of the wastewater infrastructure, potentially reducing overall construction and operations costs, and thus the outlay of public dollars and associated financial burden to ratepayers. Private equity in water quality and wastewater programs has been demonstrated in many cases to reduce overall project costs due to lower labor costs (i.e. avoiding need to comply with Davis Bacon Act), aggressive, professional management techniques (e.g. equipment inventory sharing) and an expedited overall implementation schedule.

In addition to cost reduction, P3 has the potential benefit of reducing risk to the public entity by shifting some of the performance, construction, operation and compliance risks to the private entity. All risks must be evaluated closely when considering a P3 to confirm suitability for a particular application. P3s have the potential to be advantageous to the Town, but there are also potential disadvantages that the Town should be aware of. All the potential advantages and disadvantages need to be fully vetted with the Town and its technical, legal and financial representatives before any commitments are made. Specific advantages and disadvantages depend on the form the P3 would take and the specific terms and conditions of the contractual arrangement. The goal of the Town would be to minimize risk through negotiated contract terms and conditions. As part of the P3 assessment, the Town is evaluating potential options for alternative delivery such as Design-Build (DB) and Design-Build-Operate (DBO). These delivery methods can result in substantial savings as compared to a traditional design-bid-build project. Capital cost savings can average 21 percent and O&M savings can be an additional 5 to percent, based on data obtained from recent DB and DBO projects.

7.6 Conclusion

Efforts to further refine potential capital and O&M costs will be made over the next several months as preliminary design information becomes available. Additional sources of funding and alternative implementation schedules are also being investigated and will be incorporated into the model so that a more accurate assessment of affordability can be made.

8.0 Regulatory Review and Coordination

8.1 Regulatory Review and Coordination

No formal MassDEP or Massachusetts Environmental Policy Act review is required for the ACWMP, but coordination efforts with the CCC and informal coordination with MassDEP was conducted throughout the course of developing this ACWMP.

In 2010 the Town submitted the CWMP/SEIR to the Massachusetts Executive Office of Energy and Environmental Affairs to comply with Massachusetts Environmental Policy Act. The agency received several comment letters, which were considered during the evaluation process. AECOM has compiled all of the comment letters that were received by EOEEA on the Orleans CWMP/SEIR, and tabulated the summary points stated in each. This Technical Memorandum is written to summarize the comments that were submitted on the original CWMP, and to discuss the response/action that has been implemented to address the comment. The following table addresses all of the comments received and entered into the public record.

Agency	Summary of Comment	Response
EOEEA	Review Final Massachusetts Estuaries Project Report for Nauset Marsh to determine if any changes to the CWMP are needed to address nutrient loading and water quality issues affecting Nauset Marsh/Town Cove	Adaptive Management Plan, Section 8.4. SMAST will be conducting additional modelling.
	Conduct confirmatory modelling with Linked Model to identify estimated nitrogen reductions to be achieved	SMAST will be conducting additional modelling.
	Conduct additional modelling to confirm impacts of discharge to Little Namskaket Marsh	Up to six potential groundwater discharge locations have been identified. Further evaluation of these will occur to determine which is/are most appropriate and the Final CWMP will be updated with this information.
	Conduct additional monitoring and characterization of the existing Tri-Town plume	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
	Re-evaluate cluster systems for Cedar Pond	Cluster systems will be evaluated along with other options upon update of the CWMP plans Rock Harbor Creek Watershed, pending the determination by MEPA and DEP on the management of Cedar Pond.
	Conduct monitoring to assess future groundwater discharge at Tri-Town site	Up to six potential groundwater discharge locations have been identified. Further evaluation of these will occur to determine which is/are most appropriate and the Final Amended CWMP will be updated with this information.
	Prepare annual TMDL Compliance Report	Requires input from Town of Orleans
	Conduct monitoring for and address treatment of Contaminants of Emerging Concern (CEC)	Requires input from Town of Orleans

Agency	Summary of Comment	Response
	Moving forward perhaps with revisions, confirm that the core components of the proposed program do not require a MassDEP Chapter 91 License	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Work closely with MA NHESP to minimize impacts to rare species from all project components	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Submit final design plans to MHC for assessment of potential for impacts to historic and archaeological resources	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Consider DOER comments regarding greater CO2 reductions via alternative nitrogen demand technology and incorporate measures to increase energy efficiency	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase. Demonstration Projects for Non Traditional Technologies are intended to confirm nitrogen removal efficiencies, and therefore confirm potential to reduce emissions from traditional treatment
	Adopt by-laws, regulations and policies to limit new growth prior to installation of new sewers	Amended CWMP Section 6.3.2 - Downtown Future Growth Scenarios, Strategies to Limit Growth, Draft Regulations to Obtain Zero Interest Financing, and Implications for Wastewater Loading Impacts and Other Community Impacts in the Downtown. Nitrogen Bylaw has been adopted by Orleans.
	Work with Brewster, Eastham, MassDEP, Cape Cod Commission, Pleasant Bay Resource Management Alliance, and Cape Cod Water Protection Collaborative regarding regional solutions to water quality issues	CCC, PBA, DEP, Brewster, Eastham have all been part of OWQAP meeting monthly and engaged in plan development and agreement. CCC provided a Consistency Review and Letter in 2015 on the Consensus Plan.
	Use lower emission equipment and require contractors to retrofit diesel equipment and on-road Low Diesel Fuel	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase.
	Use Ultra Low Sulfur Diesl (ULSD) fuel to reduce emissions of fine particulate matter	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase.
	Use lower emission equipment in addition to requiring contractors to retrofit diesel-powered equipment with emissions controls, such as particulate filters or traps. Require contractors to use On-Road Low Sulfur Diesel in off-road construction equipment	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase.
	All refueling and maintenance should be on pavement and outside of sensitive areas	Construction requirements will be confirmed as the project moves from the planning phase into the design phase.

Agency	Summary of Comment	Response
	Develop a spill contingency plan	Construction requirements will be confirmed as the project moves from the planning phase into the design phase.
	Continue to work closely with MassDEP, CCC and PBA to design and implement a sustainable Comprehensive Wastewater Facilities Plan and mitigation plan to help offset the proposed municipal sewering impacts	Orleans and its' subcontractors continue to move forward in a collaborative approach.
	Characterize Tri-Town Plume	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
	Monitor cluster systems at Cedar Pond	Cluster systems are no longer planned in the Amended CWMP.
	Conduct confirmatory modelling regarding nitrogen reductions to be achieved	SMAST will be conducting additional modelling on Pleasant Bay, Nauset Estuary and Rock Harbor Creek.
	Conduct water quality monitoring at Namskaket Marsh	Up to six potential groundwater discharge locations have been identified. The discharge has been moved to Little Namskaket and other locations. Monitoring will be conducted at those locations as part of MassDEP GW Discharge Permit requirements Further evaluation of these will occur to determine which is/are most appropriate and the Final CWMP will be updated with this information.
	Minimize greenhouse gas emissions	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase. Demonstration Projects for Non Traditional Technologies are intended to confirm nitrogen removal efficiencies, and therefore confirm potential to reduce emissions from traditional treatment
	Evaluate need for sewering around Cedar Pond and address in Adaptive Management Plan	Requires input from Town of Orleans
	DRI Approval is effective through October 13, 2018	Noted
	Incorporate Massachusetts Estuaries Project Total Maximum Daily Loads for Nauset Marsh and Rock Harbor and revise approach to meet mandated load reductions	Adaptive Management Plan, SMAST will be conducting additional modelling. No TMDLs issues yet for these bodies. Nauset Estuary Plan is targeted at meeting draft TMDL.
	Evaluate need for cluster systems at Bakers Pond	Cluster systems are no longer planned in the Amended CWMP.

Agency	Summary of Comment	Response
MassDEP	Submit Preliminary Design Report for review	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Participate in regionalization discussions with towns and CCC and report status every two years in Adaptive Management Plan report	Include summary of the discussion and conclusions with Eastham and Brewster on regional facilities in ACWMP.
	Adjust Namskaket remaining assimilative capacity	Up to six potential groundwater discharge locations have been identified. Further evaluation of these will occur to determine which is/are most appropriate and the Final CWMP will be updated with this information.
	Update project schedule	Preliminary schedule in CWMP.
	Report on changes to geographical extent of sewering in Adaptive Management Plan	Collection System
Cape Cod Commission	Report on non-structural components	Adaptive Management Plan, Stormwater and Fertilizer of CWMP
	Provide for review final building , site and landscaping plans; coastal wetland impacts; stormwater management controls; impacts to wetland buffer; and planned turf management	Permitting requirements will be satisfied as part of ACWMP and subsequent project design features as the project moves from the planning phase into the design phase.
	Submit updated Adaptive Management Plan and detailed subtasks	Adaptive Management Plan Implementation of CWMP.
	Submit various reports and monitoring results	The Town continues to work with the CCC and shares documentation.
	Submit report on stormwater management/MS4 Phase II Program	Adaptive Management Plan, Stormwater and Fertilizer of CWMP.
	Submit results of enhanced natural attenuation determination	Non-Traditional treatment technologies under consideration for areas outside of Downtown Orleans. No natural attenuation from Downtown collection systems.
	Submit hydrogeological scope for plume analysis	Up to six potential groundwater discharge locations have been identified. Further evaluation of these will occur to determine which is/are most appropriate and the Final CWMP will be updated with this information
	Minimize impacts to NHESP resources	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Avoid impacts to wetland resource areas	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Submit Biological Monitoring Plan for coastal resources	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.

Agency	Summary of Comment	Response
	Coordinate with MHC regarding potential for impacts to historic/archaeological resources and report findings during construction	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Restore roadways disturbed for sewer installation	Construction requirements will be confirmed as the project moves from the planning phase into the design phase.
	Raised concerns regarding accuracy of Massachusetts Estuaries Project reports and the need to consider the National Academy of Scientists report	Adaptive Management Plan, Section 8.4. SMAST will be conducting additional modelling.
	Suggest evaluating alternative approaches to achieve water quality improvements, including cluster systems, PRBs, Green Infrastructure, Water Re-Use, oyster farming, and inlet widening	Non-Traditional Technologies and Water Re-Use in ACWMP. Continuing evaluation will occur as project design matures.
	After review, has no comments at the time.	No response needed
	Supportive of approach proposed in SEIR/CWMP	No response needed
	Supportive of approach proposed in SEIR/CWMP	No response needed
	Suggest evaluating decentralized and regional approaches to wastewater management. Concerns for Namskaket from the plume; no additional nitrogen into this system.	Non-Traditional treatment technologies under consideration – Section 8.0; USGS continued to monitor the plume, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
	Against approach proposed in SEIR/CWMP and suggest denying SEIR approval	Amended CWMP includes evaluation and implementation of Non-Traditional Technologies in most of Town in lieu of traditional collection and treatment systems.
	Apportioning of Namskaket Marsh assimilative capacity amongst three towns requires evaluation; in favor of monitoring/mapping Tri-Town plume; if regionalization occurs, issue of inter-basin transfer of water to the Tri-Town site must be evaluated	Up to six potential groundwater discharge locations have been identified. Further evaluation of these will occur to determine which is/are most appropriate and the Final Amended CWMP will be updated with this information. USGS continued to monitor the plume, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
David Farquar	Raised concerns regarding accuracy of Massachusetts Estuaries Project reports and the need to consider the National Academy of Scientists report	Adaptive Management Plan, Section 8.4. SMAST will be conducting additional modelling.

Agency	Summary of Comment	Response
Clean Water Action	Evaluate options for decreasing greenhouse gas emission; continue to utilize the Energy Star Portfolio Manager (ESPM) tool at significant design progress milestones with the goal to achieve a significantly higher rank.	Greenhouse gas emissions will be confirmed as the project moves from the planning phase into the design phase. Demonstration Projects for Non Traditional Technologies are intended to confirm nitrogen removal efficiencies, and therefore confirm potential to reduce emissions from traditional treatment
Division of Marine Fisheries (DMF)	Eastham areas (Rock Harbor and Town Cove/Nauset estuary watersheds) should be included in a joint sewer system and treatment at the Tri-Town facility	Eastham is updating their draft CWMP. Current plan is to use NT technologies in lieu of regional system with Orleans due to low density of development on Route 6 and long transmission conduit that would be required to sewer denser part of Eastham.
Orleans Pond Coalition	Little Namskaket Marsh Plume requires further evaluation	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen. This comment is about Little Namskaket. The next phase of planning with includes more detailed evaluation of discharge to the Little Namskaket aquifer.
Alan McClennen	Little Namskaket Marsh Plume requires further evaluation; limit use of fertilizers	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
Ben Buck	Little Namskaket Marsh plume requires further evaluation	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
Bev Carney	Submit final plans for evaluation of potential for impacts to historical and archaeological resources	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
Town of Brewster	Consult with NHESP regarding potential impacts to box turtle	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
	Supportive of approach proposed in SEIR/CWMP; Alliance agrees to implement fertilizer management; consideration should be given to monitoring and reporting on a regional basis	Adaptive Management Plan Section 9.6 - Stormwater and Fertilizer Monitoring in CWMP.
DOER	Contaminants of Emerging Concern (CECs) should be addressed in either sewage effluent or excess solid residuals from centralized treatment plants.	Include plan to address in design and monitoring requirements for new facility and discharge location.

Agency	Summary of Comment	Response
Jane Crowley, Eastham	Further evaluation of existing plume toward Little Namskaket Marsh is needed and the Weiskel report should be considered; SMAST results in Massachusetts Estuaries Project report and TMDL accuracy should be reevaluated.	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen. SMAST will be updating water quality modelling
Brian and Judy Embleton	Little Namskaket Marsh Plume requires further evaluation	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen. This comment is about Little Namskaket. The next phase of planning with includes more detailed evaluation of discharge to the Little Namskaket aquifer.
Kevin Cassidy	Little Namskaket Marsh Plume requires further evaluation; limit use of fertilizers	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
Mary Hartley	Little Namskaket Marsh plume requires further evaluation	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen.
Massachusetts Historical Commission (MHC)	Submit final plans for evaluation of potential for impacts to historical and archaeological resources	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
MA Natural Heritage and Endangered Species (NHESP)	Consult with NHESP regarding potential impacts to box turtle	Permitting requirements will be confirmed as the project moves from the planning phase into the design phase.
Pleasant Bay Alliance	Supportive of approach proposed in SEIR/CWMP; Alliance agrees to implement fertilizer management; consideration should be given to monitoring and reporting on a regional basis	Adaptive Management Plan Section 9.6 - Stormwater and Fertilizer Monitoring in CWMP.
David Dow	Contaminants of Emerging Concern (CECs) should be addressed in either sewage effluent or excess solid residuals from centralized treatment plants.	Include plan to address in design and monitoring requirements for new facility and discharge location.
Victoria Reis	Further evaluation of existing plume toward Little Namskaket Marsh is needed and the Weiskel report should be considered; SMAST results in Massachusetts Estuaries Project report and TMDL accuracy should be reevaluated.	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen. SMAST will be updating water quality modelling

Agency	Summary of Comment	Response
Brian and Judy Embleton	Little Namskaket Marsh Plume requires further evaluation	USGS continued to monitor, and filed final report to the Town in October, 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen. This comment is about Little Namskaket. The next phase of planning with includes more detailed evaluation of discharge to the Little Namskaket aquifer.

8.2 Cape Cod Commission

The DRI issued included several conditions. Many of these conditions require communication with the CCC on on-going efforts to design, plan and implement the CWMP. The CCC also wanted to be involved in the Adaptive Management Plan process. These conditions have been met, as the CCC has been informed of and involved in the current scope of work.

Monthly meetings have been held by the OWQAP over the last two years at which staff from the CCC as well as residents/representatives from Brewster and Eastham in attendance. The April 20th meeting included a discussion of the Consensus Agreement and proposed revisions. The May 15th meeting discussion centered on moving forward with P3s, including the plan as well as financial implications.

Additional meetings held in Orleans included April 1, 2016 and 11, 2016 which covered the Adaptive Management Plan.

Additional Development of Regional Impact conditions include actions that will take place in the future, as the plan is implemented. No other conditions were applicable to the current level of action within the process, but will be addressed in the future.

One condition included in the DRI (WRC16) called for Orleans to consult with the Town of Brewster as part of the Namskaket Creek Monitoring requirements for the Adaptive Management Plan and Ground Water Discharge Permit, and provide a draft and final GWDP application to the Town of Brewster. A hydrogeological site evaluation has been completed at one groundwater discharge site, and has been sent to MassDEP indicating discharge to the Atlantic Ocean at the proposed flow amount, or if increased flow a portion might discharge to Pochet Neck. However, if plans for the discharge location change and there is to be any discharge to Namskaket, a copy of the GWDP will be forwarded to the Town of Brewster.

8.3 MassDEP

MassDEP staff was also in attendance at the Adaptive Management Plan meetings help in Orleans on April 1, 2016 and April 11, 2016. Additional informal meetings with MassDEP staff were held on ##.

9.0 References

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