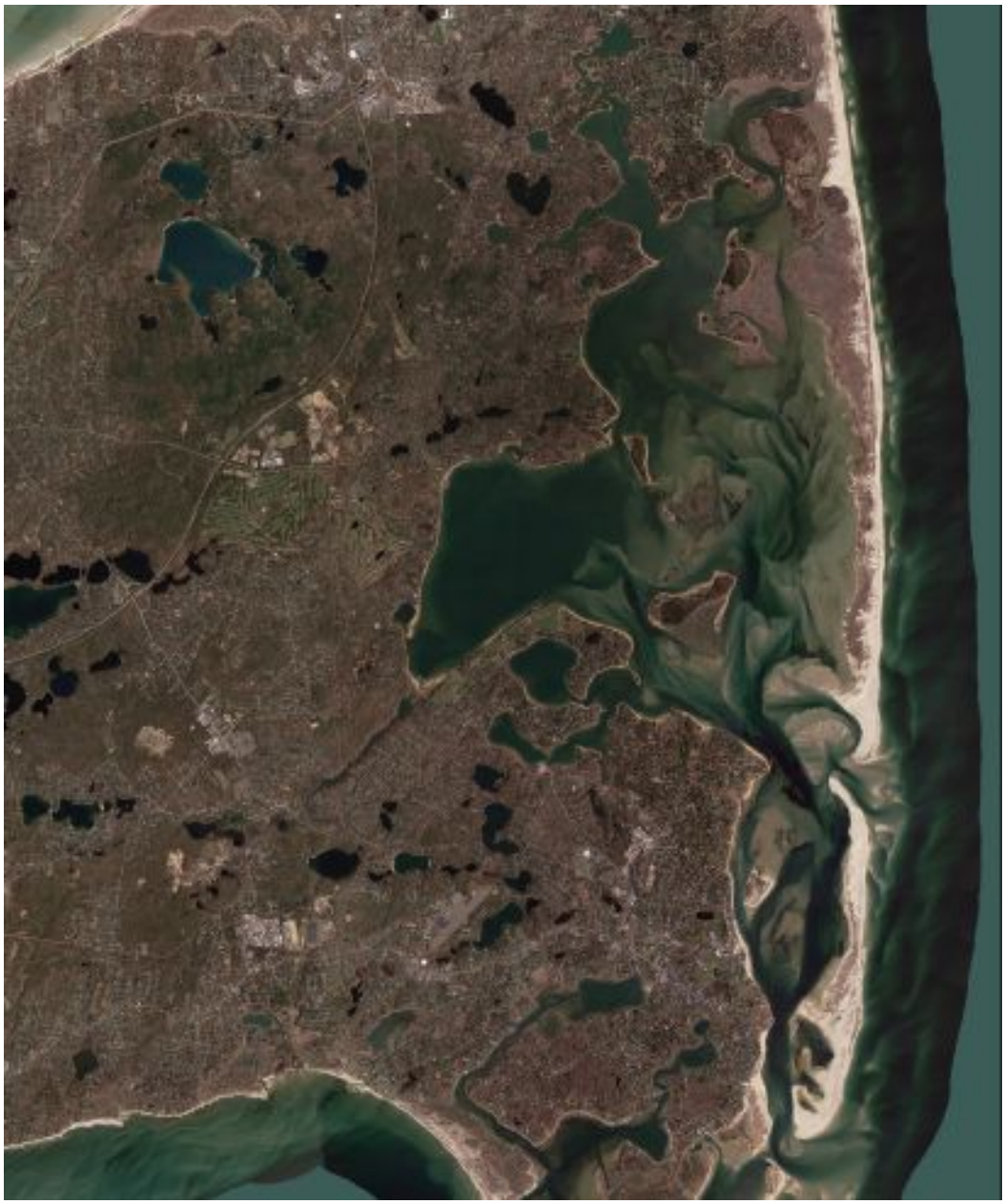
# Regional Watershed Permit Implementation for Pleasant Bay

SNEP WG18–PBA-12 Final Report



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Southeast New England Program

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PLEASANT BAY ALLIANCE

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# 1.0 Cover Information

February 24, 2022

Project Name Contract Number:
Regional Watershed Permit Implementation Project for Pleasant Bay
SNEPWG18-12-PBA

Grant Period:
August 1, 2018 – December 31, 2021
Grantee Organization:
Town of Chatham as fiscal agent for Pleasant Bay Alliance

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# 2.0 Project Report Narrative

## 2.A Project Overview

The Pleasant Bay Alliance (Alliance) is a governmental organization formed in 1998 by intermunicipal memorandum of agreement (MoA) among the Towns of Orleans, Chatham, Harwich, and Brewster, Massachusetts. Under the MoA, Chatham serves as fiscal agent for the Alliance. The Alliance is responsible for developing and implementing the multi-faceted Pleasant Bay Resource Management Plan encompassing the Pleasant Bay Area of Critical Environmental Concern (ACEC) and watershed (System). The plan addresses biodiversity, wetlands protection, fisheries, coastal resiliency, nutrient management, navigation, and public access.

Among its responsibilities, the Alliance is charged with overseeing the Pleasant Bay Watershed Permit issued by MassDEP to the Alliance towns. In this capacity the Alliance prepares the required annual compliance reports, coordinates joint activities under the Permit, undertakes engineering and economic studies to support permitted activities, and coordinates system-wide monitoring and modeling of water quality and other ecological parameters.

Pleasant Bay is among the largest estuarine systems in Southeast New England and a state-designated Area of Critical Environmental Concern (ACEC). Since 1998, the Pleasant Bay Alliance (Alliance) has coordinated a locally- and state-approved Resource Management Plan (RMP) for the ACEC and watershed aimed at preserving natural resources and extensive public benefits. The RMP identifies excessive nitrogen loading from watershed land uses as the primary impairment to water quality and habitat health. The Massachusetts Department of Environmental Protection (MassDEP), under the Federal Clean Water Act, established 19 Total Maximum Daily Loads (TMDLs) for Nitrogen in Pleasant Bay and its sub-embayments, requiring substantial reductions in nitrogen loading. Achieving the TMDLs is critical to the ecology, economy, and quality of life benefits derived from Pleasant Bay and shared by users from the surrounding towns, Cape Cod, and the state. Attaining water quality goals requires ongoing coordinated regional action

Each Alliance member town developed a plan to address its share of responsibility for reducing nitrogen from watershed sources. The Alliance analyzed the combined effect of the four town plans in the *Pleasant Bay Composite Nitrogen Management Analysis* (2017). The Towns endorsed the *Composite Analysis* as an accurate representation of each Town's share of current nitrogen load and load removal responsibility. The *Composite Analysis* provided the basis for subsequent development of a Targeted Watershed Management Plan (TWMP) by the Alliance and member towns. The Alliance and member towns participated in a Watershed Permit Pilot Project with MassDEP, US EPA, and Cape Cod Commission to pursue efficiencies and cost savings through coordinated implementation of nutrient management actions identified in the TWMP. Town Meetings in all four Alliance towns voted to authorize participation in a Watershed Permit.

As recipients of the first Watershed Permit in Southeast New England, the member towns face multiple issues related to Permit implementation, administration, monitoring and reporting for which there is no guidance or precedent. The lack of clear regulatory pathways, cost models, monitoring and reporting requirements, and management frameworks hinders swift implementation of promising non-traditional technologies for nitrogen mitigation. This proposed project, *Regional Watershed Permit Implementation Project for Nitrogen Management in Pleasant Bay,* will generate replicable guidance on key implementation issues. This guidance will benefit Alliance towns, and provide a resource for other communities participating in a Watershed Permit. As described below, the Project has four interrelated parts: Tasks 1 and 2 deal with optimizing non-traditional nitrogen reduction measures and exploring alternate funding mechanisms; Task 3 provides a means for modeling the effects of optimized nitrogen reduction scenarios based on updated model parameters; and Task 4 generates a comprehensive guidance document, videos and other tools for stakeholder engagement, and a public education program to convey guidance information to stakeholders in the Pleasant Bay watershed, and other Southeast New England communities.

## 2.B Task Reports

### 2.B.1 Task 1A. Municipal De-nitrifying Septic System Program

**Task Objective**

As part of the Southeast New England Program grant issued to the Pleasant Bay Alliance, the Town of Brewster evaluated the potential for using advanced septic systems (also called Innovative/Alternative or I/A systems) to reduce the nitrogen discharged into its portion of the Pleasant Bay watershed. The objectives were to evaluate the level of nitrogen reduction needed, understand the state's monitoring and oversight requirements, identify technologies that could provide the necessary reduction, assess program costs and recommend a regulatory structure that could be used to implement the program. Horsley Witten Group was lead technical consultant with contributions from the Barnstable County Health and Environment Department (I/A technology assessment) and Wright Pierce (cost model).

Below: Brewster has 341 homes in the watershed that could be included in a municipal I/A system program.


**Task Results**

<u>Assessment of Technologies able to meet required Nitrogen Reductions</u>

The Massachusetts Estuaries Program model used for the Pleasant Bay watershed estimates the nitrogen load from a traditional septic system using 90% of water consumption and a nitrogen concentration of 26.25 milligrams per liter (mg/L) for effluent discharged from traditional onsite septic systems. This concentration is lower than the typical nitrogen concentration for septic tank effluent entering a leaching facility as it takes into account nitrogen removed in the leaching facility as well as in the underlying soil. Using this estimated concentration, it was determined that each septic system in the unattenuated watersheds in Brewster would have to use an advanced nitrogen removal system to meet Brewster's nitrogen reduction goals. Furthermore, these systems would have to meet a treatment level of 12 mg/L to be able to fully meet Brewster's remaining portion of the Total Maximum Daily Load (TMDL) for nitrogen for Pleasant Bay. Currently there are no systems with "General Use" approval from the Massachusetts Department of Environmental Protection (DEP) that can provide this level of treatment. There are two technologies with pilot or provisional approval that might be able to meet a 12 mg/L threshold.

Cost Model

The cost for installing, operating and monitoring an advanced onsite system will depend on the technology that is selected and the level of oversight. The project estimated a capital cost for each system of approximately $33,900 and an annual operation and maintenance and monitoring cost of about $2,360. These costs are based on available information for the two systems identified as potentially capable of meeting the 12 mg/L nitrogen effluent standard, as well as information from DEP on monitoring and oversight requirements. Monitoring costs are higher for these systems because they are not yet approved for General Use.

Management Structure for a Municipal I/A Program

A management structure was proposed to establish the municipal I/A program and address ongoing operation, maintenance and monitoring requirements.

*Program Adoption*: Two regulatory mechanisms are proposed to establish the program: (1) a general bylaw adopted by Town Meeting vote to establish the program and (2) implementing regulations adopted by vote of the Board of Health to administer the program. The general bylaw would (a) require the use of the advanced onsite systems in the watershed with the appropriate number and treatment capability to meet Brewster's portion of the TMDL and (b) mandate that the Board of Health develop implementing regulations that provide the details of the design, maintenance and monitoring requirements for systems as they were installed. This approach provides a Town Meeting authorization to establish the program, and also allows flexibility for the Board of Health to update implementing regulations over time without the need for a Town Meeting vote.

*Operations and Monitoring*: The performance of the advanced onsite systems is directly tied to the way they are operated and maintained. Based on MassDEP policy, the Town must have oversight of the O&M program to ensure systems are working sufficiently to meet the nitrogen reduction goals of the TMDL. These requirements should be incorporated into the General Bylaw and the Board of Health regulation. DEP will also require regular monitoring for all advanced systems including quarterly sampling for the first year, and annual sampling thereafter. Systems that do not have General Use approval from DEP will have to be sampled quarterly for up to three years. Also, each system will need to be inspected monthly to ensure it is operating as intended.

**Lessons Learned**

- The use of Innovative/Alternative (I/A) systems as part of a comprehensive nitrogen management plan requires municipal oversight. Operation and management decisions cannot be left to the individual homeowner. Communities will need to maintain a management program staffed by appropriately certified wastewater treatment plant operators. Communities have the option of using municipal staff or contracting operators overseen by the municipal government.

- Program costs are driven by the availability of technologies capable of meeting the required level of nitrogen reduction and by the need for a robust system of inspection

and testing. In Brewster's case, the two technologies with potential to meet the require 12 mg/l are not approved for General Use, and this results in higher costs of monitoring and inspection.

- SRF funds may be available to cover costs in a municipal I/A program. Federal regulations governing the State Revolving Fund (SRF) program allow for loans to privately or publicly owned facilities, and Massachusetts dedicates $5 million a year for septic repair and replacement projects through the State Revolving Fund (SRF). MassDEP is in the process of providing guidance on how to access these loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install nitrogen reducing septic systems. Currently, the SRF program does fund a Community Betterment Septic Program that provides low interest loans to homeowners to upgrade or replace failed septic systems.

This description was summarized from the following reports:

*Pleasant Bay Alliance Task 1A: On-Site Denitrification Systems Summary Report*, July 2020, Horsley Witten Group

*Implementation of an Onsite Septic System Treatment Program for the Pleasant Bay Watershed*, December 2018, Horsley Witten Group

### 2.B.2 Task 1B. Lonnie's Pond Shellfish Feasibility Project

**Task Objective**

The Town of Orleans developed a nitrogen management strategy through their comprehensive wastewater management program (CWMP). This strategy included evaluation of non-traditional approaches, such as using oyster aquaculture to remove nitrogen within impaired estuaries. In 2016, the Town launched a three-year effort to evaluate the details associated with the implementation of an enhanced aquaculture program through the Lonnie's Pond Shellfish Feasibility Project. This evaluation included quantifying in detail the nitrogen removed by the oysters, evaluating strategies to maximize nitrogen removal, and the regulatory and financial issues associated with an on-going oyster program to address TMDL compliance.

In 2018, the Town worked with the Coastal Systems Program at the School for Marine Science and Technology, University of Massachusetts Dartmouth (CSP/SMAST) to develop a Lonnie's Pond Aquaculture and Nitrogen Management Plan. The Plan included details for a public/private partnership with a Town Request for Proposals (RFP) to select a private grower based on capabilities to implement the aquaculture portion of the Town Plan and a town-funded monitoring contractor to measure the nitrogen removal and associated water quality changes. The Town also worked with CSP/SMAST to develop a Quality Assurance Project Plan (QAPP) that detailed the nitrogen-removal monitoring steps. MassDEP approved the QAPP in 2019, ensuring that any documented nitrogen removed by the Lonnie's Pond aquaculture could be counted as part of the Town's compliance with the nitrogen thresholds of the Pleasant Bay nitrogen TMDL.

Above: Floating Oyster bags in Lonnie's Pond

As part of the Southeast New England Program (SNEP) grant issued to the Pleasant Bay Alliance, the Town of Orleans used SNEP funds to assist in the development of a) the Lonnie's Pond Aquaculture and Nitrogen Management Plan, b) the 2019 monitoring based on the Management Plan, c) a synthesis report of the 2016 to 2018 assessment of the enhanced aquaculture, and d) the Town RFP that selected the aquaculture contractor under the Management Plan.

## Task Results

Management Plan Development and Aquaculture Contractor RFPThe Lonnie's Pond Aquaculture and Nitrogen Management Plan was approved by the Town Select Board and Shellfish and Waterways Improvement Advisory Committee. The Plan detailed a strategy of having a private grower selected by the Town to grow oysters in Lonnie's Pond and an independent monitoring contractor to measure the nitrogen removed by the shellfish. This Plan included the lessons learned during the 2016 to 2018 demonstration project assessment phase and included input from MassDMF. The Town selected Ward Aquafarms as the private grower through a RFP process and selected CSP/SMAST as the monitoring contractor for the 2019 growing season.

2016 to 2018 Synthesis Report

CSP/SMAST prepared a three-year synthesis report on the 2016 to 2018 Lonnie's Pond Demonstration Project monitoring. Monitoring included water column measurements, both snapshot sampling and continuous recordings of oxygen and chlorophyll a, sediment interactions with biodeposits from the oysters, and stream flow and nitrogen inputs. The review of monitoring data included a number of important findings, including: a) oysters removed significant amounts of particulate organic nitrogen and chlorophyll-a (19 to 37%), b) moving oysters within Lonnie's Pond altered particulate removals, c) interannual differences in rain and stream inputs altered water column TN concentrations, d) oysters process 2X the nitrogen they incorporate and this directly impacts biodeposition of oyster feces and pseudofeces, e) water flow and oyster placement within the system impacts where biodeposition occurs and f) nitrogen removal from a single year's oyster deployment occurs over at least two years, as sediments and biodeposition in summer effect sediment nitrogen dynamics the following spring.

2019 Management Plan Implementation

In 2019, the Town began the public/private partnership implementation of the Lonnie's Pond Management Plan. Ward AquaFarms, the aquaculture contractor, deployed year one (seed) and year two oysters in mid-July. This constituted roughly 1.5 million oysters, weighing 1,359 kg live wet weight. Measurements by CSP/SMAST, the monitoring contractor, determined that these oysters had 4.2 kg N contained within their tissue and shell. Oysters remained in Lonnie's Pond until mid-December (average deployment of 144 days). Upon harvest in December 2019 there were 718,596 live year 1 and 69,427 live year 2 oysters containing a total N mass of 63.9 kg N in their tissue and shell. Accounting for the N content in the year 1 and year 2 oysters at the times of installation and harvest resulted in a net removal of 59.7 kg of nitrogen from Lonnie's Pond. This removal was 79% of the initial Management Plan goal (75 kg N) and 20% of the overall Lonnie's Pond TMDL nitrogen removal target. An additional 1.9 kg N was removed by year 3 and year 4 oysters retained in Lonnie's Pond from the 2018 demonstration project.

**Lessons Learned**

Working with the Town and Ward Aquafarms, CSP/SMAST recommended some changes that were implemented in 2020, including a) identifying the best 2 or 3 oyster strains to streamline oyster tracking, subsampling, and nitrogen removal efficiency, b) use the Orleans Transfer Station Scale "truck scale" for harvest weight determinations

(cross-checked comparisons showed it was appropriate), c) allow the aquaculture contractor to install small year 2 oysters in spring and then replace them with larger seed in July (larger oysters prevent seed loss encountered in 2019 and may achieve increased N removal).

Implementation of the recommended changes resulted in a 2020 harvest that exceeded the 75 kg N removal goal in the Lonnie's Pond Management Plan. Oyster deployment and water quality monitoring resulted in 93 kg N removal by shellfish growth and an estimated additional removal of 18 kg N through sediment denitrification if estimates were extended into spring 2021. A total of 111 kg/yr N removal would be equivalent to removing the N discharge from 21 houses.

This description was summarized from the following reports:

Town of Orleans Lonnie's Pond Aquaculture and Nitrogen Management Plan. 2018. CSP/SMAST. New Bedford, MA. 128 pp.

Lonnie's Pond Shellfish Demonstration Project Three Year Synthesis Report. May, 2019. CSP/SMAST. New Bedford, MA. 105 pp.

## 2.B.3 Task 2. Nitrogen Trading Pilot Project

**Task Objective**

Looking at the Pleasant Bay watershed in its entirety, one can identify the most cost-effective locations for nitrogen load removal. Nitrogen removed at those optimum locations will not necessarily match the towns' responsibilities for TMDL compliance. That is, without a watershed-wide approach, one or more of the towns in a shared subwatershed may implement projects that are not as cost-effective as projects in other towns. That problem can be overcome through nitrogen trading, in which the town with the low-cost options removes more nitrogen than it is responsible for, and another town removes less. The second town pays the first town for the "extra" nitrogen load that is removed on its behalf. With support from the Southeast New England Program Watershed Grant, the Pleasant Bay Alliance developed the nitrogen trading pilot project to: Survey existing nutrient trading programs; Select the most appropriate type of program for Pleasant Bay; Evaluate and compare the costs for building and operating nitrogen removal technologies to establish the "before-trading" costs; Identify 3 scenarios for Pleasant Bay; Evaluate the scenarios for cost and other factors and estimate potential savings; and Address funding and implementation issues needed to establish a nitrogen trading program

**Task Results**

Trading Appropriate for Pleasant Bay

In a two-party program, Town A strikes a deal directly with Town B wherein Town A removes more than its share of nitrogen on behalf of Town B who removes less than its share. In a three-party program, Town A sells credits to a "bank" or clearinghouse, from whom Town B buys credits. There are benefits to the three-party approach, but it is more cumbersome than the two-party program and would take significant time and effort to set up. The two-party approach can be accomplished by way of an Intermunicipal Agreement (IMA), and there is precedent in the region for successful use of this tool. Therefore, this project will assume a two-party approach implemented through a project-specific IMA between the buyer and the seller.

Comparison of Costs by Technology

The four watershed towns have formulated nitrogen removal plans using five technologies; public sewers, golf course fertilization management; on-site denitrification systems, permeable reactive barriers, and shellfish harvesting. This project evaluated the

reported costs for constructing and operating these technologies and compared those costs with their expected nitrogen removal capabilities. The result is a "unit cost" in dollars pre pound of nitrogen removed. The unit costs were found to vary widely and fall into three general categories:

- Low cost—golf course fertilizer management and shellfish harvesting
- Moderate cost—public sewers
- Higher cost—on-site denitrifying septic systems and permeable reactive barriers

The lowest cost technologies are constrained in the amount of nitrogen they can remove at the designated sites, so they cannot be readily expanded as part of a nitrogen trading program. The other selected technologies offer many opportunities to reduce cost.

Trading Scenarios

Three illustrative scenarios were formulated to study nitrogen trading issues within selected sub-watersheds:

- The River System (seller Orleans and buyer Brewster)—100 kg/yr
- Little Pleasant Bay (seller Brewster and buyer Orleans)—500 kg/yr
- Pleasant Bay Main (seller Harwich and buyer Brewster)—1,000 kg/yr

Based on a "strike price" halfway between the buyer's and seller's unit costs, it was determined that the transfers of nitrogen removal responsibility could result in an annual savings of about $670,000, which is equivalent to about $11 million in present worth. The savings represent about 14% of the buyers' expected costs for the more expensive technologies.

**Lessons Learned**

Implementation Considerations

To be successful, a nitrogen trading arrangement must address many factors:

- The transfer of nitrogen removal responsibility must be codified in the Watershed Permit.
- A detailed inter-municipal agreement should lay out all of the cost and nonfinancial issues, and would likely be preceded by a series of memoranda of understanding (the report includes an outline for a model IMA).
- There seem to be no major hurdles related to state funding of a project in which the seller removes nitrogen on behalf of the buyer.
- Nitrogen trades that involve more than one sub-watershed must consider the "equivalency factors" that normalize the nitrogen removal to its impact on the Bay.
- The most effective IMA should consider growth in the sub-watershed and the potential for future changes in Bay hydrodynamics.
- If a nitrogen trade involves a non-traditional technology, the DEP-required traditional back-up plan must be adjusted accordingly.
- There must be an effective public consolation program to support the trade, involving citizenry and interest groups in both the buying and selling towns.

Applicability Elsewhere

Nitrogen trading opportunities should exist in other watersheds across the region. Prime opportunities are where:

- A watershed spans multiple towns
- A range of nitrogen removal technologies has been selected, some of which have expansion capabilities
- The technologies have well-documented costs that cover a significant range of unit costs
- Watershed-embayment modeling is available to estimate equivalency factors when trading opportunities exist between sub-embayment.

This information was summarized from the following reports:

Report on Nitrogen Trading Opportunities Among Watershed Towns. 2021. Wright-Pierce

## 2.B.4 Task 3. Ecosystem Monitoring and Modeling for Implementation[1]

**Task Objective**

As part of the Massachusetts Estuaries Project (MEP), the MEP project team completed a 2006 ecological assessment of the Pleasant Bays system that included extensive data collection (*e.g.*, water column data, tidal elevations, bathymetry, sediment nutrient regeneration) and organization of the collected data into a series of linked models of the watershed nitrogen loading, tidal hydrodynamics, and measured water quality. These linked models were calibrated and validated using different sets of water quality parameters so they could be used to reliably predict the impacts of potential nitrogen management options and/or changes to the tidal regime. The MEP assessment concluded that large portions of the system, including all of the terminal ponds, were significantly impaired due to excessive nitrogen and that nitrogen had caused the system to lose more than 20% of its eelgrass since 1951.[2]

The Massachusetts Department of Environmental Protection (MassDEP) used the MEP assessment of Pleasant Bay to promulgate 16 nitrogen Total Maximum Daily Loads (TMDLs)[3] for various estuarine segments. TMDLs are required under the Clean Water Act for any state waters that are impaired. Following the 2007 adoption of the TMDLs, the watershed Towns began to work on developing and evaluating potential strategies to reduce nitrogen loads and concentrations to achieve acceptable water quality through Pleasant Bay.

As might be expected in such a highly dynamic system, the Pleasant Bay Estuary has changed since the completion of the MEP assessment. The most significant of these changes relates to the formation of new inlets with associated changes in hydrodynamics. A major shift occurred with the 2007 opening of a large new inlet opposite Allen Point in Chatham, which altered tides and water quality throughout most of the system. Various measurements have been collected to define how the initial post-breach conditions varied and how these conditions changed as the system continued to evolve. Towns in the watershed began to develop Comprehensive Wastewater Management Plans (CWMPs) and other strategies (*e.g.*, the new inlet to Muddy Creek) to address the observed water quality impairments while remaining flexible to accommodate further changes in the Pleasant Bay system. Under the auspices of the Pleasant Bay Alliance (PBA), the towns applied to MassDEP for a Watershed Permit to promote regional collaboration in the implementation of nutrient management plans. In 2018, MassDEP issued the Pleasant Bay Watershed Permit to the towns. Implementation activities under the Watershed

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[1] Summary includes excerpts from the following report: Howes, B., E. Eichner, and S. Kelley. 2021. *Ecosystem Monitoring and Modeling for Implementation (Task 3) of Regional Watershed Permit Implementation Project for Nitrogen Management in Pleasant Bay, Cape Cod, MA*. For the Pleasant Bay Alliance, Massachusetts. Technical Report by the Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 93 pp.

[2] Howes B., S.W. Kelley, J.S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner. 2006. Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA. 245 pp.

[3] MassDEP. 2007. FINAL Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Report # 96-TMDL-12, Control #244.0). 53 pp.

Permit sparked interest in updating the MEP assessment as a means for assessing progress under the permit.

In 2018, the PBA, Towns, and Coastal Systems Program at the School for Marine Science and Technology, University of Massachusetts Dartmouth (CSP/SMAST), technical lead of the MEP team, began discussing updating the MEP assessment of Pleasant Bay to better reflect current conditions in the Bay and using the updated linked models to review the water quality impacts of planned Town nitrogen management strategies. Using resources from the Southeast New England Coastal Watershed Restoration Program (SNEP) grant program and the Towns, CSP/SMAST and the rest of the MEP Technical Team updated key portions of the MEP linked models and provided updated tools for reliably predicting the impacts of potential nitrogen management options and/or changes to the tidal regime.

**Task Results**

Model Update Approach

In the SNEP update completed for this project, the MEP Technical Team collected updated Pleasant Bay data and incorporated it into a new version of the Pleasant Bay linked models. The Team also reviewed more recent eelgrass distribution in the system which showed that eelgrass loss has continued and this showed that the Bay now has 55% less eelgrass than 1951. Updated information included in the SNEP updated assessment of Pleasant Bay:

- Review of 2015 to 2019 monthly summer water quality data
- Collection and incubation of 67 sediment cores to measure nitrogen regeneration
- 2018 bathymetry based on LIDAR
- Tidal elevation data from 2017, 2018, and 2019
- Eelgrass areas in 2010 and 2019
- 2019 land use within the watershed with 2011 to 2015 water use for individual parcels, denitrifying septic systems, updated sewered parcels, building areas, agricultural uses, private treatment plant performance
- Natural N attenuation in Tar Kiln and Muddy Creek tributaries

Updated information was incorporated into updated linked models, including a watershed nitrogen loading model based on existing land use conditions, a hydrodynamic model of tidal changes, and a water quality model incorporating the results of the watershed nitrogen loading and the tidal hydrodynamics. Among the notable changes in the input data to the watershed nitrogen loading model were the following:

- 380 new parcels in the Pleasant Bay watershed (4% increase from the MEP)
- 550 parcels with new municipal water accounts (9% increase from the MEP) and 272 less private wells
- 119 innovative and alternative denitrifying septic systems with results from three or more monitoring events (84 of which are in Chatham)
- 158 acres of additional building footprint (61% increase from MEP due to better database records)
- 366 acres of road impervious surfaces (9% increase from MEP)

Among the notable changes in the input data to the tidal hydrodynamic model were the following:

- Meetinghouse Pond tide range has decreased about 17% since its post-breach maximum in 2007, and is now similar to the pre-breach range measured in 2004
- Chatham Fish Pier tide range is essentially the same as it was in 2007
- Muddy Creek residence time has decreased from 3.6 days in 2004 to 0.8 days in 2019
- Flood tide flow at the reconfigured breach inlet is divided among Pleasant Bay (85%) and Chatham Harbor (15%)
- Chatham Harbor is close to being functionally separate from the rest of Pleasant Bay with only 2% to 4% of the Bay tidal ebb flow exiting through Chatham Harbor
- Pleasant Bay system volume has decreased by 8% with increases in some subembayments (*e.g.*, Crows Pond, Ryders Cove) and decreases in others (*e.g.*, Muddy Creek, Lonnie's Pond)

Model Reliability

The water quality model incorporates the results from the hydrodynamic model and the watershed nitrogen loading model. The model is calibrated with one set of water quality parameters (salinity) and validated with a separate set (bioactive nitrogen). The water quality model check of measured water column concentrations was based on watershed nitrogen loads from existing development and land uses. The overall difference between the measured bioactive nitrogen at the 27 monitoring stations in Pleasant Bay and the modeled results was 4% or 0.018 mg/L. This exceptional fit between measured and modeled results is slightly better than the 2006 MEP modeling results and supports the reliability of predictions based on the model.

Model Scenarios

Once the reliability of the model was ensured, the MEP Technical Team created a watershed nitrogen management scenario based on current nitrogen management plans within each of the four watershed towns. Team staff incorporated details from Town staff and their consultants regarding nitrogen management plans including the following for each town:

- Chatham: connect all of its wastewater discharges within the Pleasant Bay watershed (including one private treatment plant) to a sewer system and discharge the treated wastewater outside of the watershed
- Harwich: phased installation of sewers to connect all wastewater discharges within the Pleasant Bay watershed and discharge the treated wastewater outside of the watershed
- Brewster: a) reductions in golf course fertilizers at the town-owned Captains Golf Course and b) installation of innovative/alternative denitrifying septic systems with 12 mg/L TN discharge in two subwatersheds that directly discharge to Pleasant Bay (Freemans Way Well and Tar Kiln Stream)
- Orleans: a) a sewer system to collect wastewater mostly within the Meetinghouse Pond watershed and discharging the treated effluent outside of the Pleasant Bay

watershed, b) installing 16 permeable reactive barriers (PRBs) to remove nitrogen from groundwater, and c) enhanced aquaculture in Lonnie's Pond to remove nitrogen within the pond (goal = 300 kg/yr removal)

The results of the nitrogen management scenario showed that the combined nitrogen management strategies within the four watershed towns generally result in bioactive nitrogen concentrations that meet or are less than the TMDL thresholds at both of the primary sentinel stations and 6 of the 8 secondary stations (Table E-1). The two secondary water monitoring stations where the TMDL thresholds were not attained were WMO-5, Pochet and WMO-6, Namequoit River.

The predicted sentinel station nitrogen concentrations (Table ES-1) reflect the net effect of four factors:

- A 3% increase in the watershed load due to development and redevelopment since the TMDLs were established.
- Revised estimates of nitrogen attenuation in Muddy Creek (decrease) and Tar Kiln Steam (increase).
- Changed hydrodynamics.
- An increase in nitrogen removal by the towns. The planned nitrogen removals are a 35% increase over the minimum required in the Watershed Permit. The bulk of the increases are due to town-wide sewering of all parcels in Chatham and extensive sewering in the Harwich portion of the watershed. Current planned removals meet the threshold targets (mostly) under the altered hydrodynamics. Just as was indicated in the MEP, there are likely other removal configurations that could meet the TMDLs and sentinel station concentrations.

Additional model runs are needed to separate these four factors as a way to determine if town requirements might be modified in the future. However, any potential reductions in one Town would need to be considered comprehensively with the other Towns since nitrogen additions in one part of the Bay watershed may cause nitrogen concentrations to rise in other sections of the Bay. In addition, the scenarios were run under current conditions and do not include future increases from build-out which should be considered before any reductions are planned. The updated MEP water quality model completed for this project can be used to predict water quality from modified nitrogen management scenarios and it is anticipated that additional scenarios based on alternative nitrogen management strategies being considered by the towns will be evaluated.

This summary information is based on the following report:

Howes, B., E. Eichner, and S. Kelley. 2021. *Ecosystem Monitoring and Modeling for Implementation (Task 3) of Regional Watershed Permit Implementation Project for Nitrogen Management in Pleasant Bay, Cape Cod, MA*. For the Pleasant Bay Alliance, Massachusetts. Technical Report by the Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 93 pp.

Table E-1.[4] Comparison of model average bioactive N (DIN+PON) concentrations in Pleasant Bay for 2020 present conditions and 2020 Composite loading. The primary sentinel threshold stations (0.16 mg/L target) are shaded orange, secondary threshold stations (0.21 mg/L target) are shaded blue. The Ryders Cove threshold is set as the average of the PBA-03 and CM-13. The Composite nitrogen management scenario attains the target concentration at both sentinel stations and at all but two of the secondary stations (*i.e.*, WMO-5, Pochet and WMO-6, Namequoit River; both shaded green).

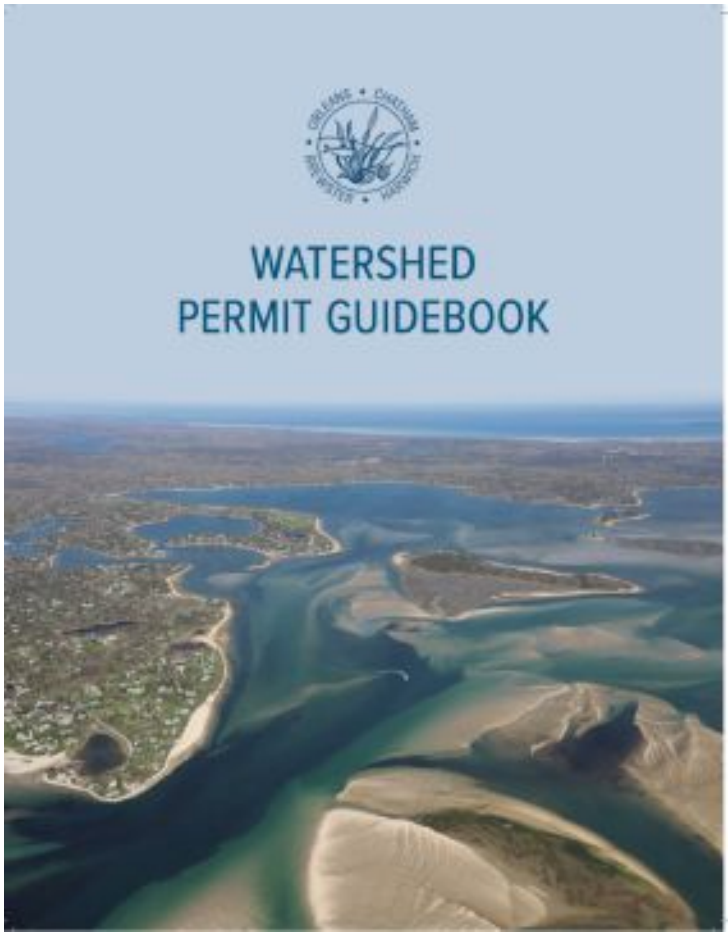
| Sub-Embayment | monitoring station | 2020 existing (mg/L) | 2020 composite (mg/L) | % change |
|---|---|---|---|---|
| Meetinghouse Pond | PBA-16 | 0.288 | 0.218 | -34.3% |
| Meetinghouse @Rattles Dock | WMO-10 | 0.238 | 0.196 | -27.3% |
| Meetinghouse @Off Lonnie's Inlet | WMO-08 | 0.192 | 0.171 | -19.4% |
| Lonnie's Pond | PBA-15 | 0.246 | 0.205 | -25.3% |
| Areys Pond | PBA-14 | 0.334 | 0.308 | -10.4% |
| Namequoit River Upper | WMO-6 | 0.239 | 0.220 | -12.3% |
| The River-Mouth | PBA-13 | 0.148 | 0.140 | -12.5% |
| Pochet - Upper off Town Landing | WMO-05 | 0.279 | 0.256 | -11.8% |
| Pochet - Basin@ Mouth | WMO-03 | 0.146 | 0.138 | -12.9% |
| Little Pleasant Bay – Head | PBA-12 | 0.139 | 0.132 | -12.7% |
| Little Pleasant Bay - Main Basin | PBA-21 | 0.132 | 0.126 | -12.5% |
| Paw Wah Pond | PBA-11 | 0.207 | 0.187 | -16.3% |
| Little Quanset Pond | WMO-12 | 0.185 | 0.173 | -11.9% |
| Quanset Pond | WMO-01 | 0.153 | 0.143 | -14.5% |
| Round Cove | PBA-09 | 0.254 | 0.150 | -61.2% |
| Muddy Creek – Upper | PBA-05A | 0.503 | 0.220 | -67.5% |
| Muddy Creek – Lower | PBA-05 | 0.224 | 0.152 | -51.4% |
| Pleasant Bay-Head | PBA-08 | 0.121 | 0.115 | -16.2% |
| Pleasant Bay- Upper Strong Island | PBA-19 | 0.104 | 0.101 | -15.0% |
| Pleasant Bay off Muddy Creek | PBA-06 | 0.140 | 0.123 | -30.4% |
| Pleasant Bay lower Strong Island | PBA-20 | 0.103 | 0.100 | -15.8% |
| Ryders Cove Upper | PBA-03 | 0.218 | 0.140 | -58.2% |
| Ryders Cove Lower | CM-13 | 0.113 | 0.103 | -34.5% |
| Crows Pond | PBA-04 | 0.116 | 0.106 | -31.3% |
| Chatham Harbor – Upper | PBA-01 | 0.099 | 0.098 | -6.7% |

[4] Howes, B., E. Eichner, and S. Kelley. 2021. *Ecosystem Monitoring and Modeling for Implementation (Task 3) of Regional Watershed Permit Implementation Project for Nitrogen Management in Pleasant Bay, Cape Cod, MA.* For the Pleasant Bay Alliance, Massachusetts. Technical Report by the Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 93 pp.

### 2.B.5 Task 4. Public Outreach

**Task Objective**

The four Alliance communities that are participating in the Pleasant Bay Watershed Permit are undertaking substantial investments to achieve the nitrogen reduction required for regulatory compliance. Substantial benefits to the health of Pleasant Bay are anticipated from implementation activities called for under the Watershed Permit. The programmatic guidance, costs analyses, and protocols for monitoring and assessing the efficacy of non-traditional technologies developed under the SNEP WG18 was intended to inform local decision-making. The deliverables and lessons learned under this Project have potential for broader application in other Southeast New England coastal communities.




Accordingly, a primary objective of the public outreach task is to make the information and analysis generated by SNEP-funded work available to Select Boards and other town committees and voters in each Alliance community on a timely basis, to assist them in refining nitrogen management plans and making critical investment decisions.

A secondary objective is to provide tools and analysis that member towns and other coastal communities could consult to evaluate and select among alternative nitrogen management strategies.

**Task Results**

Public outreach activities encompassed the following:

- Study and model update findings were presented to Select Boards in each of the four Alliance towns. Written updates on project tasks were provided in late 2020, and meetings and presentations with Select Boards were held in August – September 2021.

- Project team members and Alliance represenatives shared relevant information about SNEP-funded work at Town Meetings during discussion of wastewater funding articles.

- Publication of Pleasant Bay Watershed Permit Guide Book is intended to serve as a case study of the first Watershed Permit in the Commonwealth; to provide information about the process of developing a watershed permit, and insights on issues that multiple towns need to be ready to address if participating in a watershed permit. The guidebook also summarizes the implementation studies funded by the SNEP WG18 grant. The intended audience of the guidebook includes local and regional officials interested in entering into a watershed permit, as well as state and federal agencies who may use the guidebook as a reference and as a compendium of relevant model documents.

- Pleasant Bay Alliance website provides access to all SNEP WG18 funded reports with fact sheets and recorded presentations The Alliance has created a webpage for posting all studies, including SNEP-funded deliverables, and other public outreach tools. The webpage is http://pleasantbay.org/programs-and-projects/watershed-planning/pleasant-bay-watershed-permit. The following materials have been posted:

  Task 1A: Municipal Denitrification Septic System Program
  Fact Sheet
  Zoom-recorded video presentation of key findings
  Task 1A final report

  Task 1B: Lonnie's Pond Shellfish Program
  Fact Sheet
  Zoom-recorded video presentation of key findings
  Task 1B final reports

  Task 2: Nitrogen Trading Study
  Fact Sheet TBD
  Task 2 final report

  Task 3: MEP Model Update
  Executive Summary posted (see deliverables)
  Task 3 final report

  Task 4: Outreach and Guidebook
  Watershed Permit Guidebook

- Presentations of key findings of work funded by SNEP WG18 were made at the following regional events:

- Cape Coastal Conference sponsored by the Waquoit Bay Estuarine Research Reserve (2018)
- One Cape Conference sponsored by the Cape Cod Commission (2019)
- New England Water Environment Association (NEWEA) Presentations (2019, 2022)
- Restore America's Estuaries National Coastal and Estuarine Summit (2020)

**Lessons Learned**

A number of factors created limitations on the scope of outreach activities. Of greatest relevance was the outbreak of the pandemic beginning in 2020, which curtailed the ability to hold in person meetings and public presentations.

A secondary issue was the timing of deliverables. The completion of the model update, was delayed due to the pandemic, and this set back the timeline for delivery of the model update final report and completion of the nitrogen trading study.

The extremely technical nature of the reports and findings made it a challenge to isolate and communicate the issues of greatest import for each community in a concise manner. Care was taken to adapt and tailor standard update presentations to the specific issues or constraints facing each town.

As a result of these outreach efforts, the findings of SNEP WG18 work had the following impact on community deliberations and decision making:

Harwich – the Task 3 MEP model update report, including revised attenuation for two Muddy Creek sub-basins, was influential in the Town's decision to re-evaluate the amount of sewering planned in the upper and lower Muddy Creek subwatersheds and to prioritize near-term efforts on the two other Pleasant Bay subwatersheds in Harwich.

Brewster – the findings of the Task 1A report on the implementation of a municipal denitrifying septic system program have contributed to the Town's decision to continue evaluation of multiple other nitrogen removal alternatives. The implications of the Task 3 MEP model update report, including revised attenuation for Tar Kiln marsh sub-embayment, are also being evaluated, including nitrogen trading (Task 2).

Orleans – the Task 1B Shellfish monitoring reports contributed to the Town's understanding that shellfish aquaculture cannot be relied on to provide removals sufficient to achieve nitrogen reductions scheduled under the Watershed Permit. Alternative removal strategies are under evaluation.

Chatham – The Task 3 model update helped to confirm the extent of unplanned removals in the Muddy Creek subwatersheds shared with Harwich.

## 2.C Compliance

The *Secondary Data Quality Assurance Project Plan for Pleasant Bay Alliance Regional Watershed Permit Implementation Project* was approved by US EPA in October 2019. This secondary QAPP covers tasks 1A, part of 1B, and task 2. In addition, task 3 data quality objectives are outlined in Standard Operating Procedures (SOPs) included in the QAPP titled Massachusetts Estuaries Project Quality Assurance Project Plan (QAPP) Year 1 Final (SMAST QAPP) and approved by the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (DEP). Those SOPs are provided in Appendix A to this QAPP.

A separate QAPP has been developed for the Lonnie's Pond water quality monitoring outlined in task 1B:

> *Town of Orleans Lonnie's Pond Aquaculture and Nitrogen Management Plan Quality Assurance Project Plan: 2019-2021.* Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. 690 pp.

## 2.D Project Partners

Town of Brewster (and consultant Horsley Witten) – The Town of Brewster is participating as a project partner. Brewster, along with its consultant, Horsley Witten, is performing work under Task 1.A as described above. Horsley Witten also entered into a sub-contract with Wright Pierce to assist in the development of QAPP and finalize review through VHB and EPA. Chris Miller, Director of Natural Resources, Town Planner Ryan Bennett and new Health Director Amy Van Hone participate in project team meetings and provide critical input for all tasks.

Town of Chatham – The Town is participating as a project partner and is playing a significant to role in the development of Task 2, nitrogen trading demonstration project. Dr. Robert Duncanson, Director of Health and Natural Resources, provides critical input for all tasks.

Town of Harwich - The Town is participating as a project partner and is playing a significant to role in the development of Task 2, nitrogen trading demonstration project. Heinz Proft, Director of Natural Resources, and Dan Pelletier, Water Department Superintendent, provide critical input for all tasks.

Town of Orleans (and consultant AECOM and UMASS/SMAST) - The Town of Orleans is participating as a project partner. Orleans, along with its consultant, AECOM and SMAST/UMASS-Dartmouth, is performing work under Task 1.B as described

above. Mr. George Meservey, Director of Community Development, provides critical input for all tasks.

Barnstable County Health and Environment Department (BCHED) – BCHED is participating as a co-task leader, along with Town of Brewster/Horsley Witten, in the development of a science based implementation plan for Task 1.A Onsite De-nitrification Septic Systems.

School for Marine Science and Technology/UMASS-Dartmouth – SMAST is performing work described under Task 3 above. SMAST also developed the Part 1 monitoring report for the Lonnie's Pond Shellfish Demonstration project (Task 1.B) described above.

Pleasant Bay Alliance (and consultant Wright Pierce) – The Alliance is serving as Project Manager for the Regional Watershed Permit Implementation Project for Pleasant Bay. Wright Pierce, consultant to the Alliance, is leading work under Task 2, Nitrogen Trading Pilot Project, and is providing technical support for all tasks.

Staff from the Cape Cod Commission (Tim Pasakarnis, Erin Perry) and Massachusetts Department of Environmental Protection (Brian Dudley and Drew Osei) regularly attend monthly work group meetings.

## 2.E Volunteer and Community Involvement

Members of the Pleasant Bay Alliance Steering Committee are volunteers appointed by their respective Select Boards. These members participate in regular SNEP team meetings and bring to these discussions an awareness of local priorities and concerns. Volunteer Steering Committee members include: Allin Thompson (Harwich), Dolly Howell (Harwich), Chuck Bartlett (Chatham), DeeDee Holt (Chatham), Fran McClennen (Orleans) and Walter North (Orleans). Brewster Steering Committee members are Brewster town staff and are not technically volunteers.

## 2.F Outreach & Communications

These activities are described in Section 2.2.4.

# 3.0 Project Budget Report

The budget report must provide sufficient information and detail to explain Project expenses for the entire Project, in the context of the objectives, tasks, and categories provided in the Project narrative and budget under Attachment 3. The budget report should be organized so that a reviewer can easily judge whether expenditures tracked the original Project budget and, if not, to understand why.

## 3.A. Summary Budget Table

**Summary Budget Table**

| | Budget Category | Total Budgeted Funds | Total Budgeted Match | Total Budgeted Grant + Match | Actual Grant Funds Expended | Actual Match Funds Expended | Actual Expended Grant + Match | Match Source |
|---|---|---|---|---|---|---|---|---|
| a | Personnel | 0 | 67,900 | 67,900 | 0 | 82,729 | 82,729 | Alliance & Town budgets |
| b | Fringe | 0 | 0 | 0 | 0 | 0 | 0 | |
| c | Travel | 0 | 0 | 0 | 0 | 0 | 0 | |
| d | Equipment | 0 | 0 | 0 | 0 | 0 | 0 | |
| e | Supplies | 0 | 0 | 0 | 0 | 0 | 0 | |
| f | Contractual | 250,000 | 200,890 | 450,890 | 249,998 | 265,550 | 515,548 | Town budgets |
| g | Other-Travel | 0 | 2,178 | 2,178 | 0 | 0 | 0 | |
| h | Total Direct | 250,000 | 270,968 | 520,968 | 249,998 | 348,279 | 598,277 | |
| i | Indirect | 0 | 0 | 0 | 0 | 0 | 0 | |
| j | Total | 250,000 | 270,968 | 520,968 | 249,998 | 348,379 | 598,277 | |

## 3.B Detailed Budget Table

Shown on following pages 25A-25D

**Regional Watershed Permit Implementation for Pleasant Bay - Pleasant Bay Alliance, Budget Table for Invoice 07, June 30-October 31, 2021**

| 3.A. Budget Table with Cost Categories | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cost Item** | **Cost Basis** | **RAE SNEP Request** | **Non-Fed Match** | **Match Source** | **Total Cost** | **Current Match** | **Previous Match** | **Balance** | **Current Invoice** | **Previous Invoice** | **Balance** |
| | | | | | | | | | | | |
| **Personnel** | | | | | | | | | | | |
| Alliance Coordinator Ridley | 300 hours at $65/hr to develop/review deliverables | 0 | $19,500 | Alliance budget in kind | $19,500 | $0 | $29,640 | ($10,140) | $0 | $0 | $0 |
| Duncanson | 200 hours at $71/hr to develop/review deliverables | 0 | $14,200 | Chatham budget in kind | $14,200 | $0 | $9,940 | $4,260 | $0 | $0 | $0 |
| Meservey | 200 hours at $57/hr to develop/review deliverables | 0 | $11,400 | Orleans budget in kind | $11,400 | $0 | $22,287 | ($10,887) | $0 | $0 | $0 |
| Proft | 200 hours at $57/hr to develop/review deliverables | 0 | $11,400 | Harwich budget in kind | $11,400 | $0 | $7,638 | $3,762 | $0 | $0 | $0 |
| Miller | 200 hours at $57/hr to develop/review deliverables | 0 | $11,400 | Brewster budget in kind | $11,400 | $0 | $13,224 | ($1,824) | $0 | $0 | $0 |
| **Total Personnel** | | 0 | $67,900 | | $67,900 | $0 | $82,729 | ($14,829) | $0 | $0 | $0 |
| | | | | | | | | | | | |
| **Total Fringe** | NA | NA | NA | NA | NA | | | | | | |
| | | | | | | | | | | | |
| **Contractual** | | | | | | | | | | | |
| **Project QAPP** | | | | | | | | | | | |
| QAPP Development Horsley Witten Group (HWG) | Contractual | $0 | $3,000 | Alliance budget | $3,000 | $0 | $3,000 | $0 | $0 | $0 | $0 |
| **QAPP Subtotal** | | $0 | $3,000 | | $3,000 | $0 | $3,000 | $0 | $0 | $0 | $0 |
| **Task 1A Onsite** | | | | | | | | | | | |
| Barnstable County- Admin, Analysis, reporting: Heufelder Lead Subtasks 1,2,3, assist subtask 4,5 | 20 days at 462.50/day | $0 | $9,250 | na | $9,250 | $0 | $9,250 | $0 | $0 | $0 | $0 |

| Cost Item | Cost Basis | RAE SNEP Request | Non-Fed Match | Match Source | Total Cost | Current Match | Previous Match | Balance | Current Invoice | Previous Invoice | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lead: Barnstable County- Admin, Analysis, Reporting: Baumgaertel Lead Subtasks 1,2,3, assist subtask 4,5 | 30 days at 312/day | $0 | $9,360 | na | $9,360 | $0 | $9,360 | $0 | $0 | $0 | $0 |
| Horsley Witten- Develop Regulatory approach, Municipal Monitoring and Maintenance Lead subtask 5; assist subtask 4 | Contractual | $5,000 | $25,000 | Brewster contribution of 25,000 DLTA grant | $30,000 | $0 | $25,000 | $0 | $0 | $5,000 | $0 |
| Coordination - Wright - Pierce lead subtask 4, assist subtask 3 | Contractual | $10,250 | $0 | | $10,250 | $0 | $0 | $0 | $0 | $10,300 | -$50 |
| **Task 1A Subtotal** | | $15,250 | $43,610 | | $58,860 | $0 | $43,610 | $0 | $0 | $15,300 | -$50 |
| **Shelllfish Aquaculture – Task 1B** | | | | | | | | | | | |
| Lonnie's Pond Monitoring Program & Report | Contractual | $40,000 | $0 | | $40,000 | $0 | $0 | $0 | $0 | $40,000 | $0 |
| Municipal Managemen Plan AECOM | Contractual | $0 | $19,500 | Town of Orleans cash | $19,500 | $0 | $19,500 | $0 | $0 | $0 | $0 |
| Technical input: Wright-Pierce | Contractual | $0 | $1,000 | Alliance budget - cash | $1,000 | $0 | $1,050 | -$50 | $0 | $0 | $0 |
| **Task 1C Subtotal** | | $40,000 | $20,500 | | $60,500 | $0 | $20,550 | -$50 | $0 | $40,000 | $0 |
| **Nitrogen Trading Pilot – Task 2** | | | | | | | | | | | |
| Analysis and reporting: Wright-Pierce- | Contractual | $64,000 | $0 | | $64,000 | $0 | $0 | $0 | $0 | $63,360 | $640 |
| Legal assistance for model agreement | Contractual | $5,000 | $0 | | $5,000 | $0 | $0 | $0 | $0 | $2,000 | $3,000 |
| 3 Scenario Model Runs | Contractual | $9,780 | $5,000 | Alliance budget | $14,780 | $0 | $0 | $5,000 | $0 | $0 | $9,780 |
| **Task 2 Subtotal** | | $78,780 | $5,000 | | $83,780 | $0 | $0 | $5,000 | $0 | $65,360 | $13,420 |
| **Ecosystem monitoring and modeling– Task 3** | | | | | tot cost | curr match | prev match | bal match | curren inv | prev inv | bal |
| Assess composite strategies using existing MEP model | Contractual | $12,274 | $8,040 | Town appropriation - cash | $20,314 | $0 | $8,040 | $0 | $0 | $12,274 | $0 |
| Install tide gages and ADCP profilers, collect data | Contractual | $11,220 | $22,780 | Town appropriation - cash | $34,000 | $0 | $22,780 | $0 | $0 | $11,220 | $0 |
| Water Quality database update | Contractual | $3,300 | $6,700 | Town appropriation - cash | $10,000 | $0 | $6,700 | $0 | $0 | $3,300 | $0 |
| Update town land use and water use in nitrogen loading model | Contractual | $8,250 | $16,750 | Town appropriation - cash | $25,000 | $0 | $16,750 | $0 | $0 | $8,250 | $0 |
| Integrate watershed N loading and water quality model | Contractual | $21,450 | $43,550 | Town appropriation - cash | $65,000 | $0 | $43,550 | $0 | $0 | $21,450 | $0 |

| Cost Item | Cost Basis | RAE SNEP Request | Non-Fed Match | Match Source | Total Cost | Current Match | Previous Match | Balance | Current Invoice | Previous Invoice | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Calibrate/validate model with water quality data | Contractual | $9,900 | $20,100 | Town appropriation - cash | $30,000 | $0 | $20,100 | $0 | $0 | $9,900 | $0 |
| Incorporate town strategies - composite scenario | Contractual | $3,630 | $7,370 | Town appropriation - cash | $11,000 | $0 | $7,370 | $0 | $0 | $3,630 | $0 |
| Provide N loads and load reductions by town and subwatersheds | Contractual | $2,475 | $5,025 | Town appropriation - cash | $7,500 | $0 | $5,025 | $0 | $0 | $2,475 | $0 |
| Reporting and Presentation | Contractual | $7,425 | $15,075 | Town appropriation - cash | $22,500 | $0 | $15,075 | $0 | $0 | $7,425 | $0 |
| Sediment regeneration analysis | Contractual | $0 | $53,000 | Town appropriation - cash | $53,000 | $0 | $53,000 | $0 | $0 | $0 | $0 |
| Technical input: Wright-Pierce | Contractual | $7,046 | $0 | Alliance budget - cash | $7,046 | $0 | $0 | $0 | $2,000 | $7,000 | -$1,954 |
| Additional Modeling Scenarios | Contractual | | | | | | | | $8,314 | $0 | -$8,314 |
| Attenuation Evaluation | Contractual | | | | | $0 | | | $8,400 | | -$8,400 |
| **Task 3 Subtotal** | | $86,970 | $198,390 | Town appropriation - cash | $285,360 | $0 | $198,390 | $0 | $18,714 | $86,924 | -$18,668 |
| **Guidance Document/Deliverables – Task 4** | | | | | | | | | | | |
| Writing, editing reviewing guidance book, including graphic design | Contractual | $19,500 | $0 | na | $19,500 | $0 | $0 | $0 | $0 | $19,500 | $0 |
| Graphic design | Contractual | $0 | $0 | na | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Technical Input, presentations - Wright-Pierce | Contractual | $3,000 | $0 | na | $3,000 | $0 | $0 | $0 | $0 | $3,000 | $0 |
| Printing expenses | 100 copies @ 30 | $0 | $3,000 | Friends of Pleasant Bay - cash | $3,000 | $0 | $0 | $3,000 | $0 | $0 | $0 |
| Graphic design | Contractual | $2,500 | $0 | na | $2,500 | $0 | $0 | $0 | $0 | $1,200 | $1,300 |
| Video series | 5 videos @2,000 | $0 | $0 | na | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Meeting expenses | 8 public meetings/worksh ops @$500 | $4,000 | $0 | na | $4,000 | $0 | $0 | $0 | $0 | $0 | $4,000 |
| **Task 4 Subtotal** | | $29,000 | $3,000 | | $32,000 | $0 | $0 | $3,000 | $0 | $23,700 | $5,300 |
| **Total Contractual** | | $250,000 | $273,500 | | $523,500 | $0 | $265,550 | $7,950 | $18,714 | $231,284 | $2 |
| | | | | | | | | | | | |
| **Travel** | | | | | | | | | | | |
| Airfare | RT @ $400 | 0 | $400 | Alliance budget | $400 | $0 | $0 | $400 | $0 | $0 | $0 |
| Hotel | 7 @ $179 | 0 | $1,253 | Alliance budget | $1,253 | $0 | $0 | $1,253 | $0 | $0 | $0 |

| Cost Item | Cost Basis | RAE SNEP Request | Non-Fed Match | Match Source | Total Cost | Current Match | Previous Match | Balance | Current Invoice | Previous Invoice | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Per Diem | 7 @ $75 | 0 | $525 | Alliance budget | $525 | $0 | $0 | $525 | $0 | $0 | $0 |
| **Travel Subtotal** | | 0 | $2,178 | | $2,178 | $0 | $0 | $2,178 | $0 | $0 | $0 |
| **Total Travel** | | 0 | $2,178 | | $2,178 | $0 | $0 | $2,178 | $0 | $0 | $0 |
| | | | | | | | | | | | |
| **Total Supplies** | NA | NA | NA | | NA | | | | | | |
| | | | | | | | | | | | |
| **Total Direct Cost** | | **$250,000** | **$343,578** | | **$593,578** | | | | $18,714 | | |
| Total Mod Direct Cost | | NA | NA | | NA | | | | | | |
| Total Indirect Cost (10% of TMDC) | | $0 | NA | | $0 | | | | | | |
| **Totals** | | **$250,000** | **$343,578** | | **$593,578** | **$0** | **$348,279** | **-$4,701** | $18,714 | $231,284 | $2 |

## 3.C. Budget Narrative

The Alliance accomplished all proposed tasks within the project budget, including additional related work not initially itemized in the original grant agreement. The final match contribution of $348,379 exceeds the budgeted match of $270,968 and represents 139% of the grant amount and 58% of total project cost.

### Changes to Match

The following changes account for most of the increase in match:

- Sediment core samples and benthic regeneration analysis was added to Task 3, to augment new ecological data for the model update. This work was funded by the Town of Orleans and Town of Chatham ($53,000).
- Grant funds budgeted for work to be completed by the Barnstable County Health and Environment Department ($18,610) was not invoiced to the project. Since the work was undertaken in support of Task 1A, the value was attributed to match.
- Staff time contributed from the Alliance Coordinator and town representatives exceeded the budgeted amount by more than the $19,829 reported.

### Changes to Scope

The following $18,720 in budgeted amounts were not utilized as initially proposed:

- $13,420 from Task 2 for legal work and additional modeling and analysis of nitrogen trading scenarios was not undertaken on advice of Alliance member towns.
- $5,300 from Task 4, largely for meeting expenses, was not utilized due to Covid-19 restrictions.

Following consultation with Restore America's Estuaries, $18,714 in funds were re-purposed as follows:

- Two additional modeling scenarios were incorporated in the Task 3 model update report ($8,314).
- The majority of a $12,000 cost associated with an attenuation evaluation stemming from new data generated by the Task 3 model update report was charged to Task 3 ($8,400). The balance of $3,600 was charged to the SNEP WG20-12-PBA2
- $2,000 in additional technical assistance was provided by Wright-Pierce for support of tasks 1A, Task 3, and the attenuation evaluation.

## 4.0 Supporting Materials

Include high-resolution digital copies, using PDF format for documents and JPG or TIFF format for images, of supporting materials related to the Project, including:

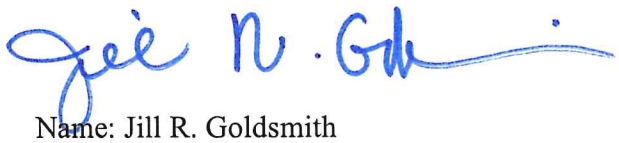
- Project maps and drawings;
- Maps of Project results or outcomes if applicable;
- Technical memoranda, data analyses and modeling reports;
- Project photographs, including photos depicting implementation sites before, during, and after implementation; photos of Project signs, etc.;
- Press releases, news articles, brochures, educational curricula, etc.

In the event that file sizes for supporting materials are too large to attach, contact RAE to set up a shared cloud file.

## 5.0 Certification

The undersigned verifies that the descriptions of activities and expenditures in this final report are accurate to the best of my knowledge; and that the activities were conducted in agreement with the grant contract. I also understand that matching fund levels established in the grant contract must be met.

Grantee Signature:



Name: Jill R. Goldsmith

Job Title: Town Manager

Date: February 24, 2022

Organization: Town of Chatham for Pleasant Bay Alliance