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WELLFLEET HARBOR
TARGETED WATERSHED MANAGEMENT PLAN

FINAL REPORT

28 JUNE 2022

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EXECUTIVE SUMMARY

WELLFLEET HARBOR
TARGETED WATERSHED MANAGEMENT PLAN

The goal of this plan is to mitigate water quality impairments, restore marine habitats, and bring the coastal waters associated with Wellfleet Harbor into compliance with the Clean Water Act. The plan is the product of over twenty years of planning and engineering studies and integrates the approaches developed by the Cape Cod 208 Water Quality Plan Update. It is based upon a hybrid approach that integrates both traditional and non-traditional technologies to reduce excessive nitrogen loads. The plan prioritizes those technologies that have lower costs, quicker results, provide local co-benefits (including jobs), and minimize climate impacts. It includes an adaptive management plan that provides for a full evaluation of emerging nature-based technologies backed up with conventional wastewater treatment systems.

The plan includes four phases (five years each) over a 20-year period. The first phase includes a downtown sewer, installation of a new generation of innovative & alternative (I&A) septic systems, the development of a permeable reactive barrier (PRB) pilot project, salt marsh restoration, the development of a sustainable shellfish habitat program, stormwater retrofits, and the construction of a neighborhood-scale wastewater treatment plant to facilitate an affordable housing project at 95 Lawrence Road that will connect to neighboring municipal facilities.

The second and subsequent phases call for expansion of these strategies based upon performance during the first pilot phase. The plan recommends that enhanced I&A septic systems be installed at property-owner initiatives linked to new construction, upgrades, expansions, and real estate transfers. The hybrid plan includes contingencies for the construction of traditional sewers and a wastewater treatment plant to supplement the earlier phases of the plan to meet water quality goals.

1.0 PURPOSE

Water quality in Wellfleet Harbor is impacted by excessive nitrogen inputs from sewage, fertilizers, and stormwater runoff as well as ecosystem losses. This has caused eutrophication of coastal waters and the loss of native eelgrass habitat and an increase in what has been locally termed “black custard” which represents a threat to the shellfish industry. Precipitation and natural sources also contribute nitrogen to the ecosystem. The purpose of this report is to identify and evaluate options to manage the nitrogen inputs and to develop a plan to restore water quality in the Wellfleet coastal waters.

The Targeted Watershed Management Plan is intended as a planning document to assist the town on prioritizing nutrient management strategies and to provide a framework for an adaptive management plan as a guide to developing more site-specific options for the implementation of individual projects. This Plan incorporates both traditional wastewater collection and treatment and non-traditional strategies. It relies upon existing documents and past studies and does not include any new field investigations. The document is intended to guide the need for additional site investigations and engineering designs.

The overall goals of the plan are as follows:

- Restoration of Ecosystems & Water Quality Compliance with Clean Water Act
- Quicker Results Reduced Costs
- Promote Affordable Housing
- Maximize Local Co-Benefits Minimize Climate Impacts

The specific objectives of this Targeted Watershed Management Plan are to:

- Compile prior plans and to update them in accordance with the findings of the recent Massachusetts Estuary Project (MEP) report,
- Compare the proposed nitrogen removals against the required threshold levels for Wellfleet Harbor established by the MEP report,
- Identify gaps and overlaps in the collective plans for nitrogen removal,
- Identify actions that may be helpful in improving the cost-effectiveness of the combined plans, Document consistency with the Cape Cod Commission’s 208 Plan Update, and
- Provide the foundation for a Watershed Permit to be issued by the Massachusetts Department of Environmental Protection (DEP).

2.0 DATA SOURCES AND METHODS

This plan is modeled after the approaches and strategies outlined in the Cape Cod Commission's 2015 Cape Cod Area-Wide Water Quality Plan Update (referred to in this report as the 208 Plan). The 208 Plan was certified by the Governor of Massachusetts and approved by the U.S. Environmental Protection Agency.

It is vital to acknowledge that this plan is the result of over 10 years of prior work, novel demonstration projects and local data collection, without which, many alternative options would not have been possible. The plan was developed in coordination with the Wellfleet Clean Water Advisory Committee (including members Curt Felix, Richard Wulsin, Fred Vanderschmidt, and John Cumbler), and with valuable input from Nancy Civetta (Shellfish Constable), Hillary Greenberg-Lemos (Health and Conservation Agent), and Ryan Curley (Selectboard Chair) and in consultation with the boards and committees in Town. It is also important to acknowledge the past efforts of prior Comprehensive Wastewater Management Committee members and town staff, the pioneering work of George Heufelder and Brian Baumgaertel of the Barnstable County Department of Health and Environment and the Massachusetts Alternative Septic System Test Center, and the cooperative assistance provided by Erin Perry, Tim Pasakarnis, and Jay Detjens of the Cape Cod Commission, Brian Dudley, Millie Garcia-Serrano and Andrew Osei of the Massachusetts Department of Environmental Protection, Amy Costa of the Provincetown Center for Coastal Studies, MaryJo Feuerbach of the U.S. Environmental Protection Agency, UMass Boston, USDA and NOAA.

Valuable technical assistance including GIS analyses, Watershed Decision Support Tool (MVP) modeling, and advising was provided by the Cape Cod Commission and the Massachusetts Alternative Septic System Test Center (MASSTC). The nitrogen loading analyses and estimated reductions are based upon the Cape Cod Commission's Technology Matrix that was developed and peer reviewed by representatives of USEPA, MADEP, Cape Cod Water Protection Collaborative, The Nature Conservancy, Woods Hole Oceanographic Institution, Marine Biological Laboratory, Massachusetts Alternative Septic System Test Center, Barnstable County Department of Health and Environment, Buzzards Bay Coalition, Cape Cod Commission, and others.

The Town of Wellfleet prepared a Comprehensive Wastewater Management Plan – Interim Needs Assessment and Alternatives Analysis Report (2001) and a Draft Comprehensive Wastewater Management Plan; Phase II – Alternatives Analysis (2014). The Town of Eastham has completed a Needs Assessment (2012). The Town of Truro undertook an Integrated Water Resources Management Plan (2012). The Massachusetts Estuary Project (MEP) completed a linked model for Wellfleet Harbor including an assessment of existing and threshold nitrogen loading rates (2017). Additionally, the Cape Cod Commission formulated a Watershed Report for Wellfleet Harbor and the three towns that incorporates the findings of the MEP report. Both the Draft Comprehensive Plan and Cape Cod Commission Report contain potential traditional and non-traditional strategies for reducing the nitrogen loads that are the primary cause for water quality problems. Most recently the Town of Wellfleet commissioned GHD to conduct a hydrogeologic evaluation of the town's transfer site as a potential wastewater treatment and disposal site (2020).

This analysis incorporates information from the Wellfleet Harbor portion of each town's wastewater management and planning reports and more recent watershed plans prepared by the Cape Cod Commission. The nutrient loading and load reduction information is based on the analyses generated by the Massachusetts Estuaries Project (MEP) and analyzed by the Cape Cod Commission as part of the 208 Plan Update efforts. The MEP report is based upon water quality data collected during the period 2003 – 2011 and land use analysis as of 2010.

This report also incorporates the results and findings of several recent and on-going studies on Cape Cod and Long Island, New York. These include evaluations of various shellfish propagation and permeable reactive barriers (PRBs) by the towns of Wellfleet, Orleans, Eastham, Mashpee, and Falmouth and performance data on a new generation of enhanced innovative & alternative (I&A) septic systems by the Barnstable County Department of Health and Environment, the Massachusetts Alternative Septic System Test Center (MASSTC) and the Center for Clean Water Technology at Stony Brook University, New York.

Recent performance data and costs associated with the traditional and non-traditional technologies were derived from pilot projects in the towns of Wellfleet, Orleans, Eastham, Barnstable, and Falmouth as well as Long Island, New York.

3.0 BACKGROUND

Wellfleet Harbor is the largest coastal embayment on Cape Cod. It is a state-designated Outstanding Resource Water (ORW) associated with the Cape Cod National Seashore. It has also been designated as an Area of Critical Environmental Concern (ACEC) by the Commonwealth of Massachusetts. According to the Cape Cod Commission, the water surface of the Bay covers nearly 11,647 acres and approximately 12,322 acres of land surface are within the watershed.

According to the 2018 Watershed Report prepared by the Cape Cod Commission the watershed is comprised of 5009 parcels, 75% of which are residential. The average density is 2.5 acres/parcel. For modeling purposes, the system has been delineated into seven separate subembayments. The land area contributing groundwater and, thus, nitrogen load to each subembayment is identified as a separate subwatershed.

The MEP study determined that the water quality in most Wellfleet Harbor subembayments is moderately or significantly impaired. So called "controllable" or anthropogenic nitrogen has been identified as the principal contaminant from the following sources: septic systems (78%) stormwater runoff (9%) lawn and golf fertilization (9%) landfill (2%), and farm animals (2%).

It is also interesting to note that when considering all sources of nitrogen (controllable and non-controllable) to the estuary, wastewater comprises 42% and direct precipitation 40% of the total nitrogen loads to the system. Recent research suggests that nitrogen concentrations (and loads) from precipitation have been declining (see Figure 1). If these reductions in nitrogen loads from precipitation can be maintained via continued enforcement of the Clean Air Act (restricting nitrous oxide emissions) this may assist in the restoration efforts.

In another study by Agnes Mittameyer from the Provincetown Center for Coastal Studies, the nitrogen content of "black custard" sediments, a eutrophic by-product, contained 85% nitrogen from phytoplankton and 15% nitrogen from marine vegetation. Therefore, it is clear the Plan must include and does include options for in-estuary nutrient reduction strategies to achieve compliance. This further supports the Plan's balanced approach using a variety of options so that the monitoring results drive the process, ensuring protection of taxpayer resources and ensuring that Plan options ultimately resolve the problem in the most cost-effective manner.

Overall, the MEP determined that 31.2% of the nitrogen loads in 2010 (when the MEP analysis was conducted) must be removed to restore water quality. When considering future buildout conditions as much as 50% of the future nitrogen load must be removed. Individual sub-embayments have variable nitrogen removal needs.

Each of the three towns in the Wellfleet watershed actively participated in the Cape Cod Commission's 208 planning process and contributed to the development of various watershed plans for nitrogen removal for Wellfleet Harbor. These plans were incorporated into the Cape Cod Commission's Watershed Report (2017).

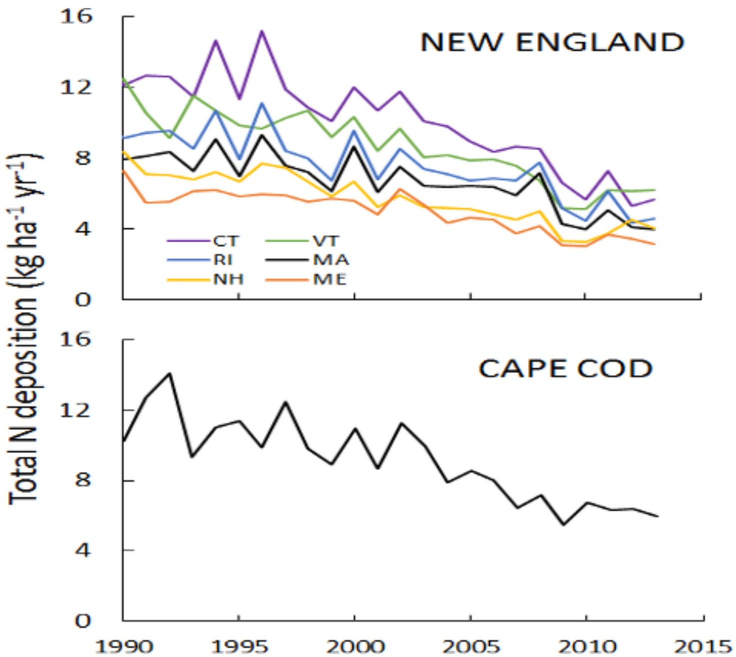


Figure 1 - Declining nitrogen concentrations in precipitation (Lloret and Valiela, 2014)

4.0 NITROGEN LOADS, THRESHOLDS, AND REMOVAL REQUIREMENTS

The existing, buildout, and threshold (target) nitrogen loads are identified in the Massachusetts Estuaries Project (MEP) report (2017). Table VIII-3 of the MEP report identifies "present" daily loads as of 2008-2010 when the land use and water quality analyses were conducted. Converting these values to annual loads indicates that controllable loads for the entire Wellfleet Bay system total 29,105 kg/year.

To update these figures to current (2022) we compiled building permit data from the 2011 – 2020 period and applied the MEP nitrogen loading coefficients. This analysis indicates that 247 additional **or expansions** septic systems (and associated lawns and impervious surfaces) were added during this period resulting in an estimated current nitrogen load of 30,180 kg/year (see Table 1 and Figures 3 and 4).

Table 1 - Nitrogen Thresholds and Required Reductions (kg/year)

	Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Current Watershed Loads (2022)	10421	2047	3736	2798	3605	6636	937	30180
Projected Loads 2042 (20 years)	10901	2166	3976	2975	3845	7010	1005	31878
Buildout Loads	13184	2683	5406	3989	5409	8439	1529	40639
MEP thresholds/Targets	9902	657	1110	1675	3453	3154	434	20385
Reduction Required from Current (2022)	519	1390	2626	1123	152	3482	503	9795
Reduction Required (2042)	999	1509	2866	1300	392	3856	571	11493
Reduction Required from Buildout	3282	2026	4296	2314	1956	5285	1095	20254

An additional nitrogen loading analysis was prepared for the twenty-year planning period (2022 – 2042) as part of this project. This analysis is based upon a projection of building permits and presented in Section 9 of this report. It indicates that the projected future nitrogen load in 2042 is estimated at 31,878 kg/year requiring a reduction of 11,493 kg/year or 39%.

The buildout analysis conducted by MEP indicates the potential addition of 1517 new residential homes within the watershed and a total controllable load of 40,639 kg/year. Controllable loads include wastewater (septic systems), stormwater, and fertilizers. The annual total threshold (target) load is 20385 kg/year. Thus, the required reduction from future potential buildout conditions is 20,254 kg/year or 50%. This underscores the fact that the watershed plan should focus on managing growth to prevent some of the increased loads associated with future development.

It is important to remember that in addition to meeting the overall (total) nitrogen reduction requirements that individual reductions for each subembayment must also be met to restore the whole ecosystem. The individual "threshold changes" indicate the degree of reduction for each subembayment. Table 1 and Figures 2 and 3 provide summaries of loading reductions required to meet MEP thresholds for each subembayment under current, 2042, and buildout conditions.

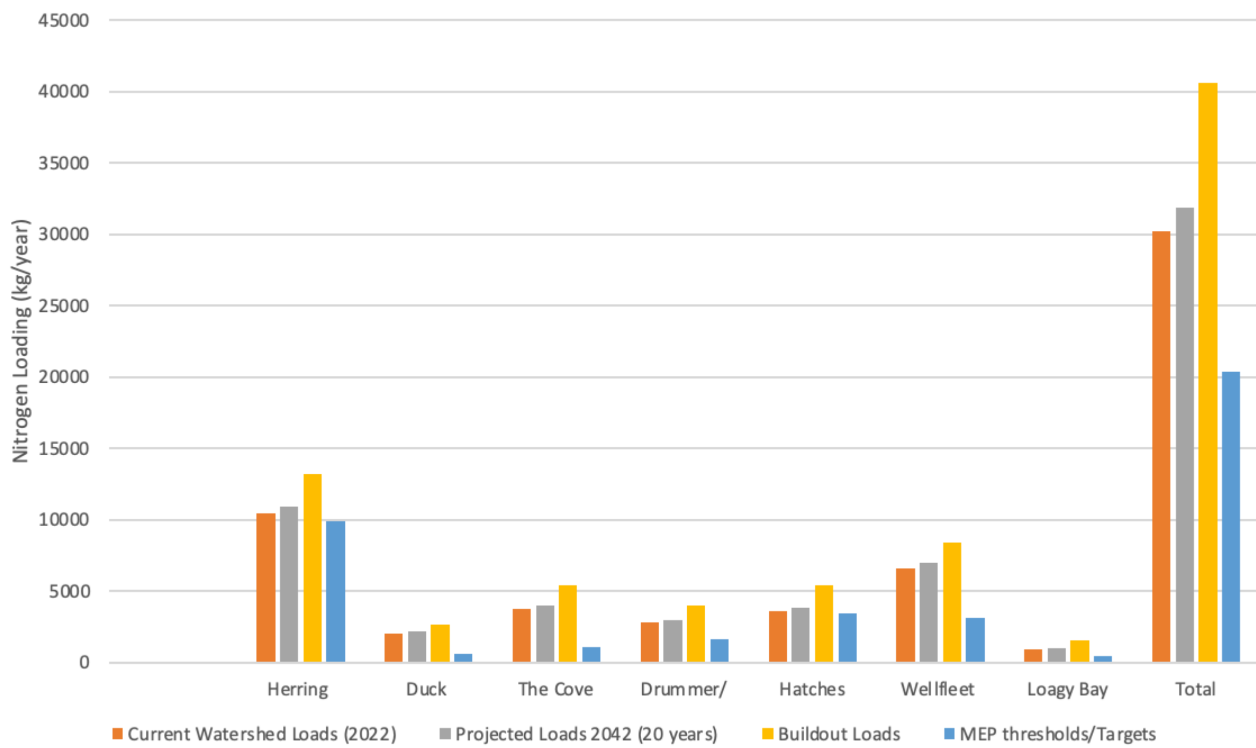


Figure 2 - Required Nitrogen Loads and MEP Thresholds

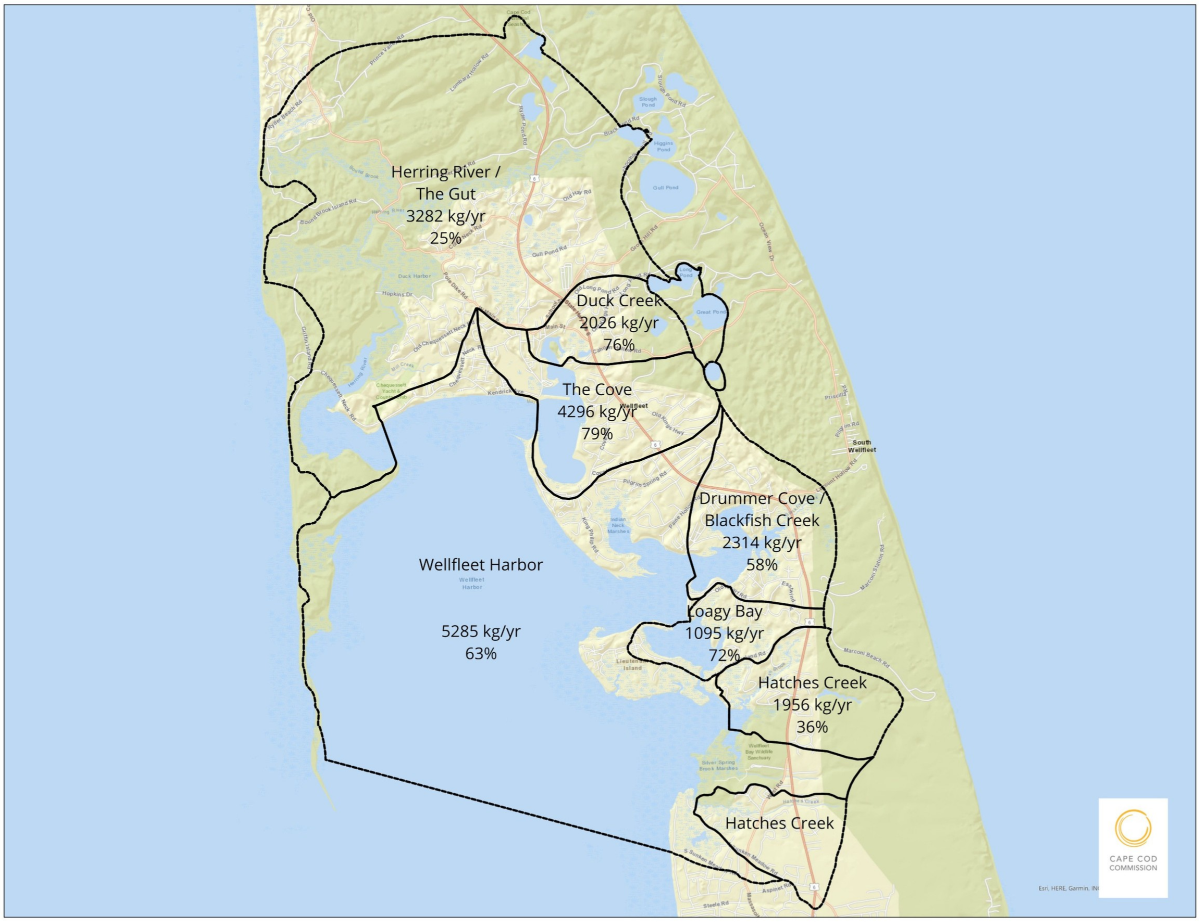


Figure 3 - MEP subwatersheds and required nitrogen loading reductions (at buildout)

5.0 ALLOCATION OF RESPONSIBILITY FOR NITROGEN LOAD REMOVALS

Nitrogen load allocations were calculated as part of the 208-planning process. The approach for calculating allocation of responsibility is documented in chapter 8 of the 208 Plan and a complete breakdown of nitrogen load responsibility by town is provided in appendix 8C of the 208 Plan. According to the 2018 Cape Cod Commission's Watershed Report for Wellfleet Harbor the allocated loads are as follows: Wellfleet 87%, Eastham 11% and Truro 2%. Memoranda of Understanding currently exist between the three towns. Every indication is that they have an excellent working relationship and that we can be optimistic that there will be a cooperative effort and agreement in participating in the implementation of this plan.

6.0 DESCRIPTION OF TOWN PLANS FOR WELLFLEET HARBOR

The Town of Wellfleet has undertaken or participated in three prior projects in the last twenty years to study wastewater needs and potential solutions including downtown wastewater collection options (see figures 4 and 5).

In 2001 Woodard and Curran conducted a comprehensive analysis of water supply and wastewater needs throughout the town. This project analyzed water quality in private wells, evaluated Title 5 compliance, provided a detailed analysis of four study areas. This analysis provided a lot-by-lot analysis within these study areas and identified locations of high nitrates in wells and limitations for compliance with minimum setbacks from wetlands and/or wells. A public water supply system was recommended (and ultimately constructed) to service the downtown area and resolve drinking water quality issues in private wells (see figure 6). The project also identified potential wastewater sewer collection areas in the downtown area and evaluated treatment and disposal sites. As a result a public water system was recommended to alleviate private well water quality issues in the downtown area of Wellfleet. This system was constructed and currently serves the downtown area (see figure 6).

In 2014 Environmental Partners (EP) conducted an updated analysis of potential methods to reduce nitrogen loading. It evaluated a range of technologies including aquaculture, shellfish, I&A septic systems, and central wastewater collection and treatment options. The EP report provided comparative cost estimates for these various technologies on a cost per nitrogen reduction basis ($/kilogram). This analysis suggested that several non-traditional technologies were likely to be most cost effective at reducing nitrogen loads.

In 2014-2015, Cape Cod Commission staff undertook a two-year study of potential nutrient management solutions and identified a broader range of potential solutions including both traditional and non-traditional technologies. More recently the Massachusetts Estuaries Project (MEP) published a detailed assessment of Wellfleet Harbor and has identified specific nutrient reduction targets throughout the town.

7.0 COMPARISON OF PRIOR TOWN PLANS WITH REMOVAL REQUIREMENTS

The prior wastewater engineering studies by Woodard and Curran and Environmental Partners were conducted before the completion of the Massachusetts Estuaries Project (MEP) published in 2017. Thesestudies were undertaken without specific nitrogen load reductions as goals. Instead, they focused on lotsizes, private well water quality data, and Title 5 siting requirements as criteria for identifying potential sewer collection areas.

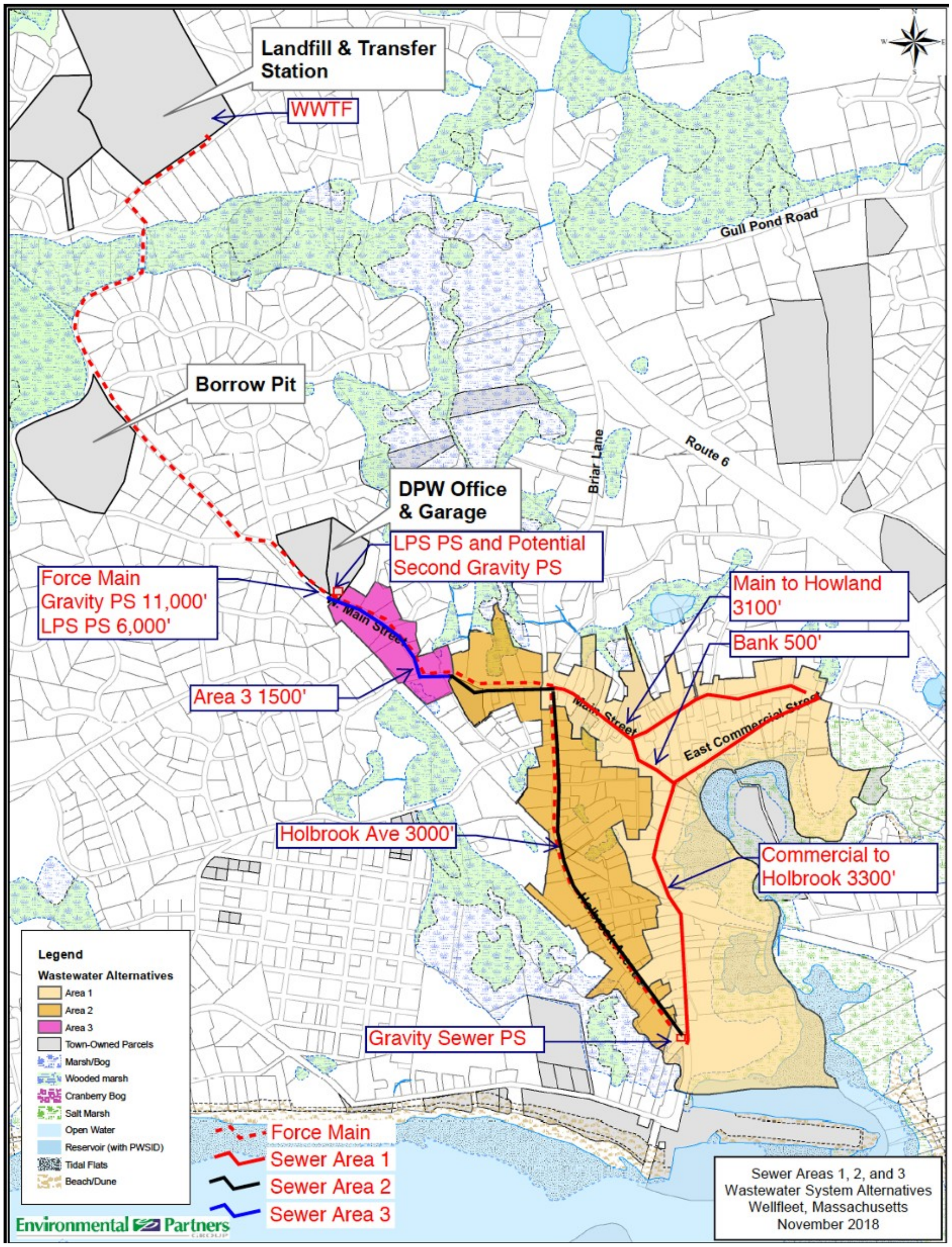


Figure 4 - Potential Sewer Collection Areas (Environmental Partners, 2018)

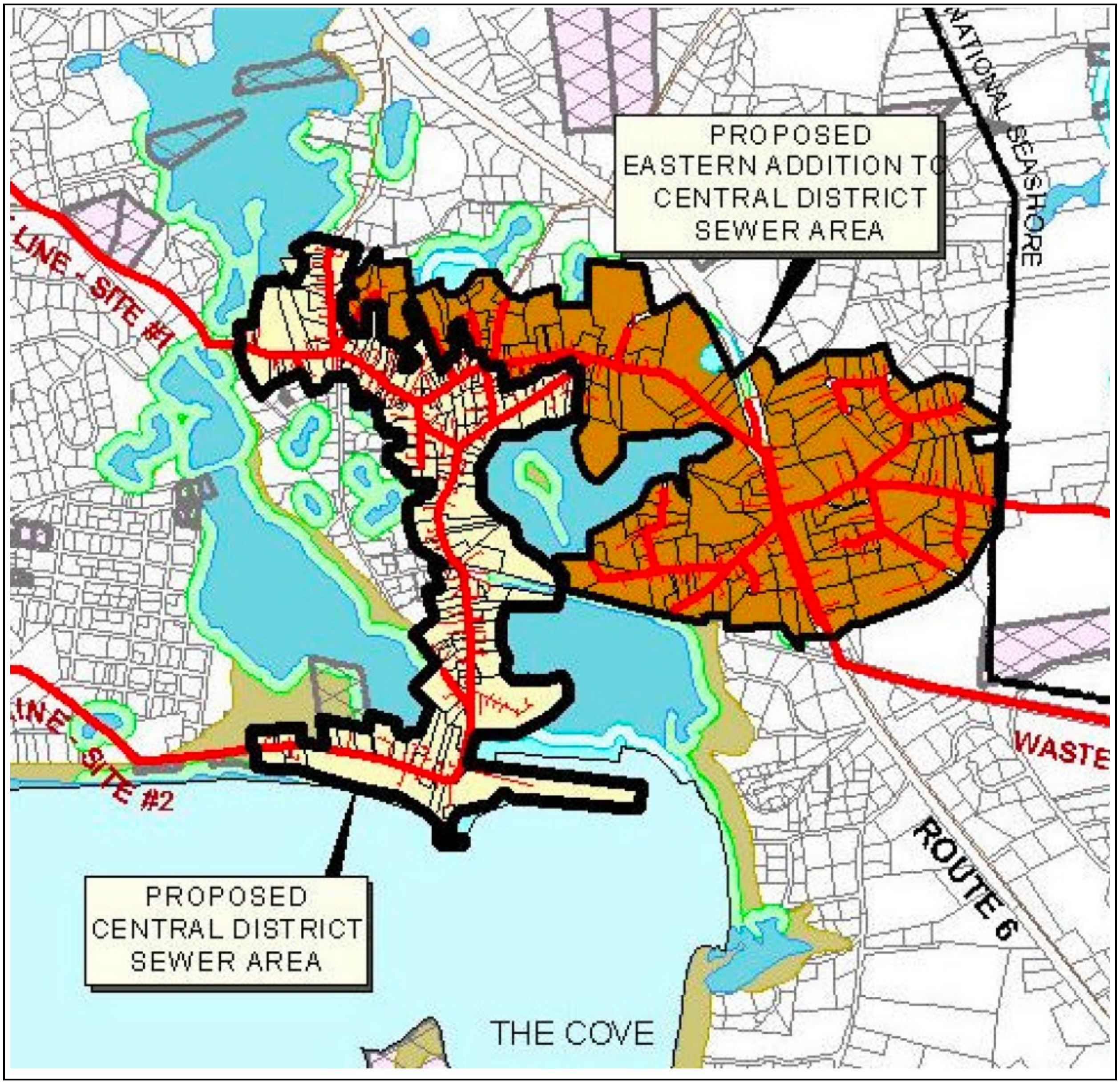


Figure 5 - Potential Sewer Collection Areas (Woodard and Curran, 2001

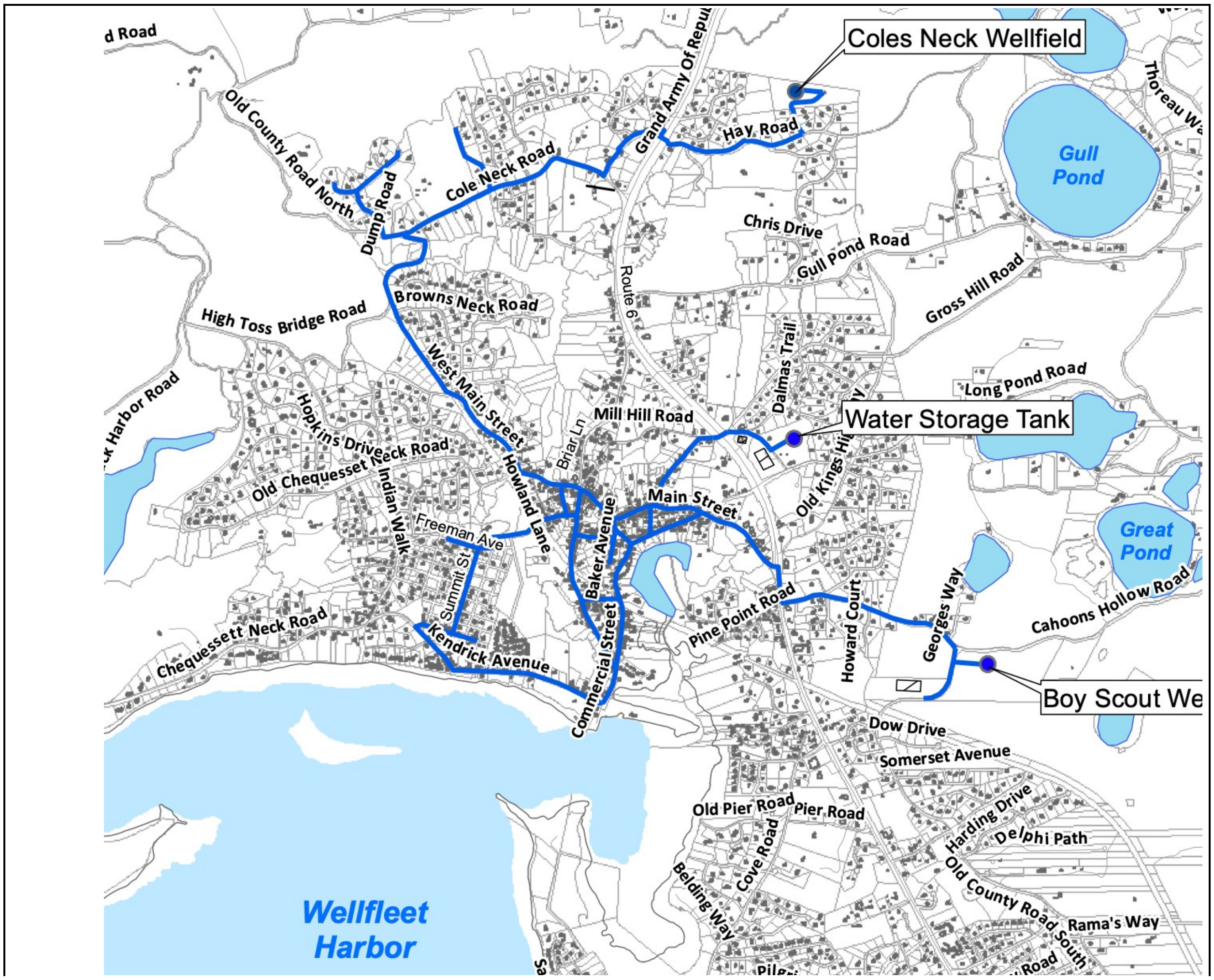


Figure 6 - Public Water Supply Distribution System

8.0 CHOICE OF TECHNOLOGIES

Preliminary traditional and non-traditional plans to reduce nitrogen loads to Wellfleet Harbor were developed as part of the Cape Cod 208 Water Quality Plan Update using the Cape Cod Commission's (CCC) MVP tool, CCC Technologies Matrix and incorporating prior work completed by the Town of Wellfleet. Several public meetings were held during 2014 – 2015 as part of the 208 process to discuss a broad range of 43 nitrogen reduction strategies and to incorporate input from residents and local officials. Additional public meetings were conducted as part of this study to evaluate technology options.

This report incorporates findings from recent in-field studies and reports regarding a new generation of innovative and alternative (I&A) septic systems, permeable reactive barriers and shellfish restoration pilot projects conducted by the towns of Barnstable, Eastham, Falmouth, and Orleans and on-going studies of enhanced I&A septic technologies by the Coalition for Buzzards Bay, Barnstable County Department of Health and Environment, Town of Barnstable, the Barnstable Clean Water Coalition, U.S. Environmental Protection Agency Office of Research & Development, The Nature Conservancy and the Massachusetts Septic System Technology Center.

As part of this study three possible approaches to compliance with the MEP thresholds were considered: 1) a traditional approach relying on conventional wastewater collection systems and treatment plants, and 2) a non-traditional approach relying on a range of nature-based solutions including a new generation of enhanced innovative and alternative (I&A) septic systems, permeable reactive barriers, shellfish, ecosystem restoration, stormwater management, and fertilizer reductions and, 3) a hybrid plan incorporating both traditional and non-traditional technologies.

8.1. TRADITIONAL TECHNOLOGIES

Centralized Wastewater Collection and Treatment: The traditional technologies include sewer collection areas, treatment plants and disposal sitse. The town's prior reports prepared by Woodard and Curran and Environmental Partners. identified potential sewer service areas and treatment plant/wastewater disposal locations. The current Transfer Station was identified as the recommended wastewater disposal area by Environmental Partners in their March 2014 Comprehensive Wastewater Management Plan, Phase II, Alternatives Analysis (see figure 1). The Town of Wellfleet Transfer station is a 28.1- acre parcel located at 266 Coles Neck Road. The parcel is currently used as a landfill and transfer station.

To determine the required capacity of the disposal site to accept treated wastewater, an analysis was performed by the Cape Cod Commission staff. This analysis translated the required nitrogen reductions to wastewater flows to meet the MEP thresholds. It also incorporated collection and treatment of a portion of the Herring River watershed as an offset for the potential addition of nitrogen from the wastewater treatment plant effluent. This analysis suggests that the design flow capacity for the wastewater treatment plant at this location would be approximately 340,000 gallons per day (based upon nitrogen loads existing at the time of the MEP report) and 780,000 gallons per day according to the MEP buildout.

In 2020 GHD was retained by the Town of Wellfleet to conduct a hydrologic evaluation of the Transfer Station as a potential wastewater treatment and disposal location. The evaluation included the installation of a monitoring well, determination of depth to water table, percolation tests and a hydraulic loading test. The results of this evaluation indicate that the site can assimilate 780,000 gallons per day. A leaching area of 133,000 square feet was identified at a hydraulic loading rate of 7 gallons/square foot-day.

Neighborhood/Cluster Wastewater Systems: Another traditional treatment option is multiple smaller-scale wastewater treatment systems that can be targeted to specific neighborhoods. These can include smaller shared Title 5 systems that service multiple properties using enhanced innovative & alternative (EIA) technologies (up to 10,000 gallons/day) or small-scale wastewater treatment plants (10,000 gallons/day and greater).

An affordable housing project located at 95 Lawrence Road has been identified as a location for a neighborhood-scale wastewater treatment plant. The site is located within the Duck Creek watershed where a significant nitrogen reduction is required. Utilizing funding provided by the Commonwealth of Massachusetts Department of Housing and Community Development's District Local Technical Assistance program through the Cape Cod Commission, On-Site Engineering evaluated wastewater options for the site. This evaluation considered three options: 1) an innovative and alternative septic system for the housing project alone, 2) a wastewater treatment plant to service the housing development and the three adjacent municipal buildings, and 3) a larger wastewater treatment plant to service the housing development, the municipal buildings and a number of residential homes in the neighborhood. The results of the evaluation indicated that option 3 would provide the most significant nitrogen reduction benefit to Duck Creek and would provide a cost-effective solution (see Figure 7A). This approach was supported at Wellfleet Town Meeting 2021 at which funding was appropriated for the design and permitting of the wastewater treatment facility. A second alternative approach would include only the housing project and the municipal buildings (see Figure 7B). Ultimately this second option was selected for the plan as it was deemed that a downtown collection system would be more cost effective.

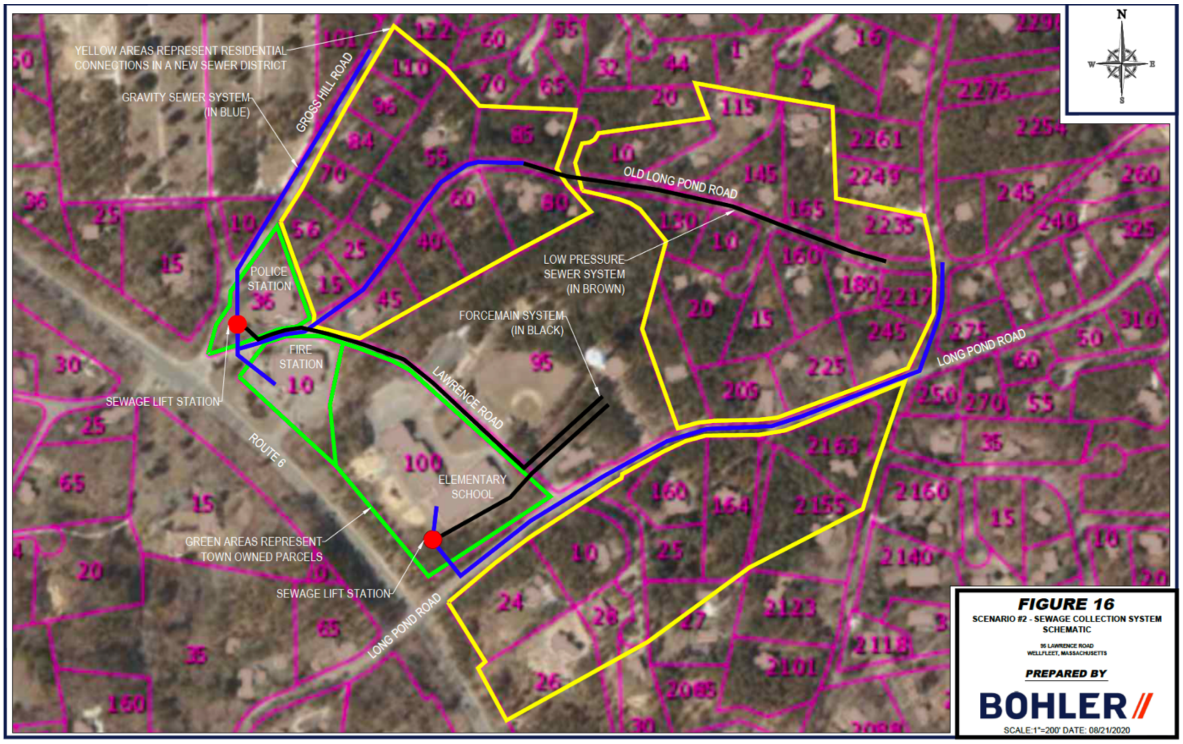


Figure 7A - 95 Lawrence Road project - Neighborhood Wastewater Sewershed A

Figure 7B - 95 Lawrence Road project – Municipal Buildings Wastewater Sewershed B

Additional neighborhood/cluster systems could be utilized in other higher-density areas throughout the town. The 2001 Woodard and Curran report identified several study areas where limitations for on-site septic systems were analyzed. These include the Wellfleet Center downtown, South Wellfleet, and South of Wellfleet Center areas (see figure 8). These areas included elevated nitrate concentrations in private wells and small lot areas where Title 5 setback variances were required.

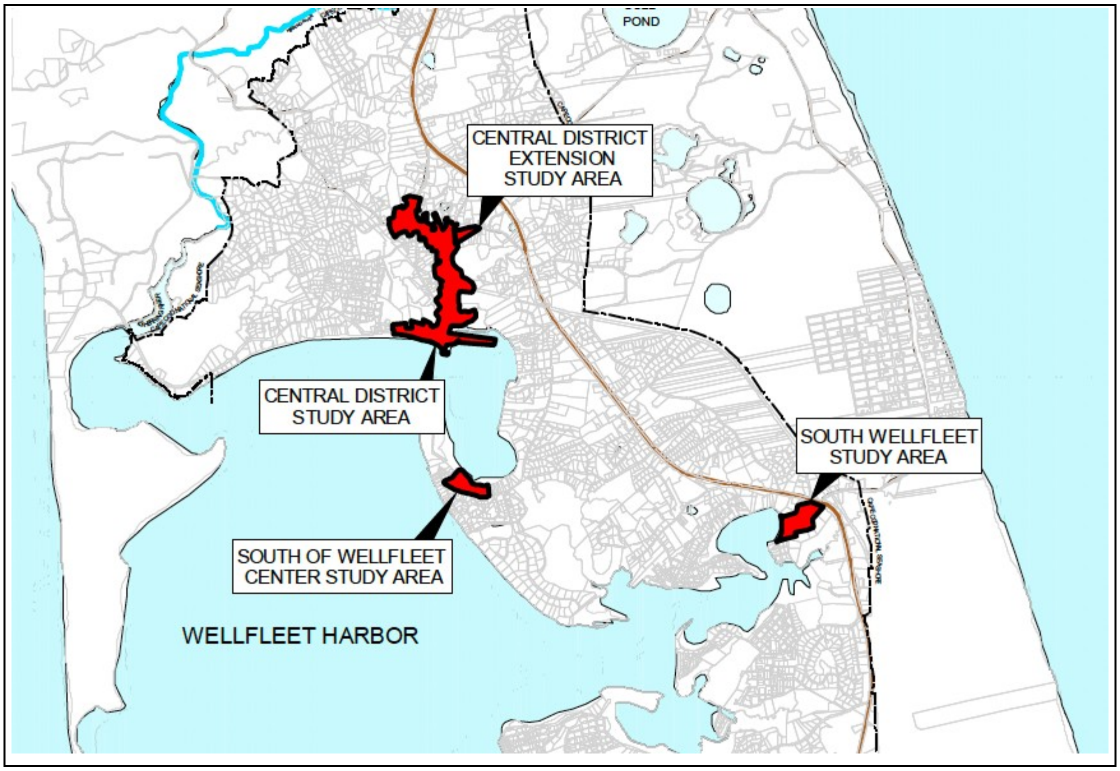


Figure 8- Wastewater Study Areas (Woodard & Curran, 2001)

8.2 Non-Traditional Technologies

A broad range of non-traditional technologies were identified and evaluated as viable nitrogen reduction tools as part of the Cape Cod Commission's Cape Cod 208 Water Quality Update (2015). These technologies were presented to Wellfleet stakeholders and residents as part of the 208-planning process at a series of public meetings.

The non-traditional strategies discussed at the public meeting included shellfish restoration, aquaculture, permeable reactive barriers, innovative and alternative (I&A) septic systems, stormwater management, fertilizer management, inlet widening, and coastal ecosystem restoration. These technologies have been vetted by two independent technical review panels as part of the 208 Plan development and more recently by The Nature Conservancy and a panel of experts convened by the Cape Cod Commission (CCC). Performance data on each technology is documented and referenced in the CCC Technology Matrix (2020), Barnstable County Department of Health and Environment (2019), and an on-going research project conducted by the U.S. Environmental Protection Agency, Office of Research and Development (USEPA ORD), The United States Geological Survey (USGS), Barnstable Clean Water Coalition, and The Nature Conservancy (TNC) in the Town of Barnstable. The Town of Orleans has provided performance results from several pilot projects including an aquaculture project in Lonnie's Pond and a permeable reactive barrier. The Town of Eastham has also installed a permeable reactive barrier and is currently evaluating the performance of that system.

Enhanced Innovative & Alternative (I&A) Septic Systems: Like most Cape Cod towns, Wellfleet has relied upon on-site wastewater disposal systems throughout its history. Over the last twenty years 158 innovative and alternative (I&A) septic systems have been installed to reduce nitrogen impacts. However, these I&A systems have provided only marginal benefits. According to research conducted by the Barnstable County Department of Health and Environment (BCDHE) these I&A systems reduce the nitrogen load on average by approximately 27% - not enough to address the required nitrogen loading reductions to the embayments.

However, a new generation of I&A technologies have been developed and are providing significantly better results (see figures 9, 10, and 11). These systems were identified as "enhanced" I&A (EIA) systems in the Cape Cod Commission's Cape Cod 208 Water Quality Plan Update. They include both proprietary and non-proprietary systems. Recent test data provided by third-party organizations (including MASSTC and NYS Stony Brook) indicate the current performance of the wood chip-based septic technologies is in the range of 5 - 8 mg/liter (75 – 90% removal).

According to a recent report by BCDHE (2019) a series of non-proprietary woodchip-based systems have been producing average removal rates of 75% or more with effluent concentrations at less than 8 mg/liter. Additional advantages of these new designs are that they are more passive, requiring less pumps and mechanical systems and they are easily maintained with accessible ports to replace the reactive media on a periodic basis (once every ten years is estimated).

The woodchips provide a carbon source for naturally-occurring bacteria to break down the nitrogen to harmless nitrogen gas (a process called denitrification). At least two proprietary technologies (Nitrex and NitROE) also utilize a woodchip-based system and have gained both pilot and provisional approvals from MADEP as part of their I&A permitting program. Both of these systems have tested at the Massachusetts Alternative Septic System Test Center (MASSTC) and been installed at multiple locations on Cape Cod and are currently available for installation in Wellfleet.

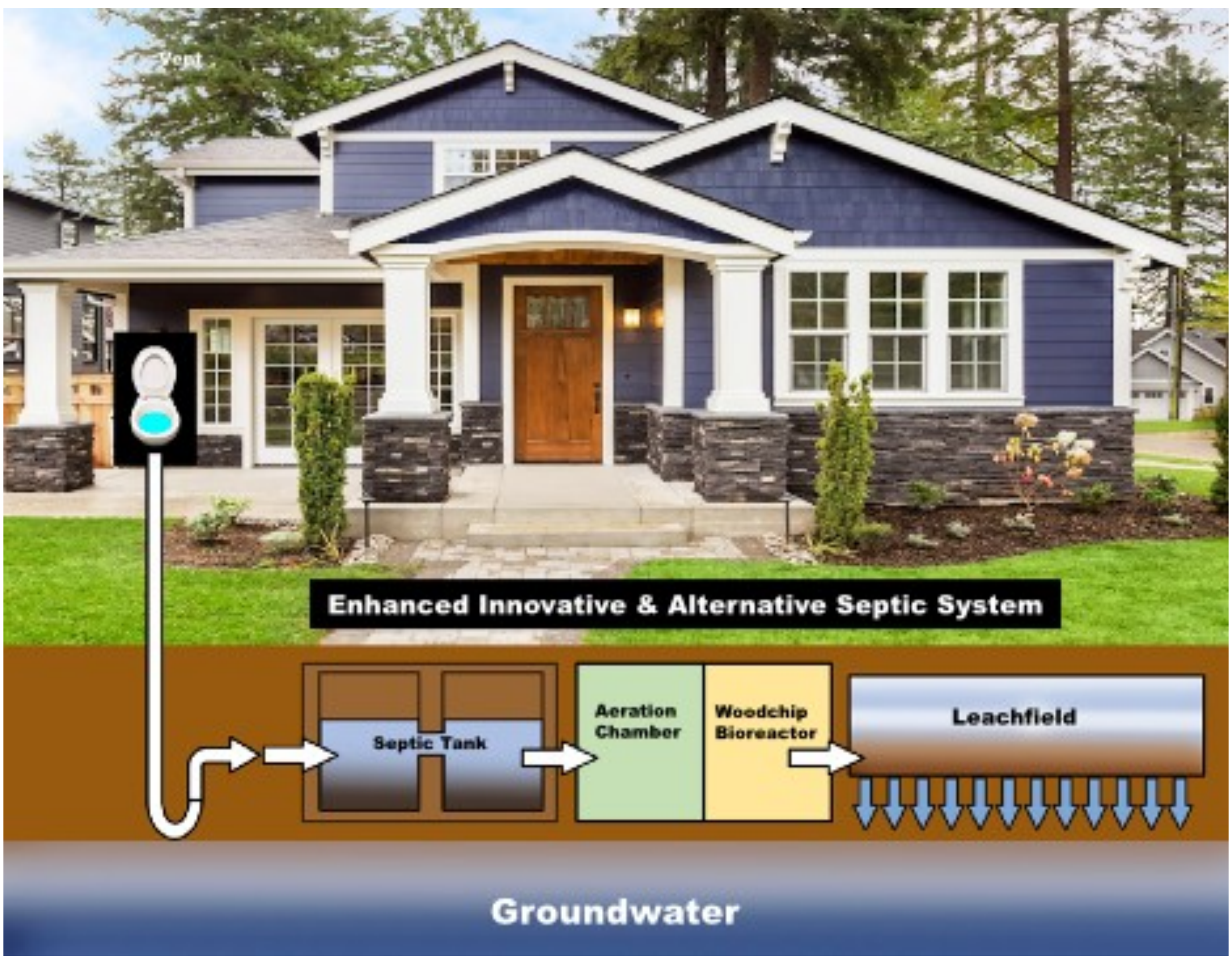


Figure 9 - Enhanced I&A Septic System

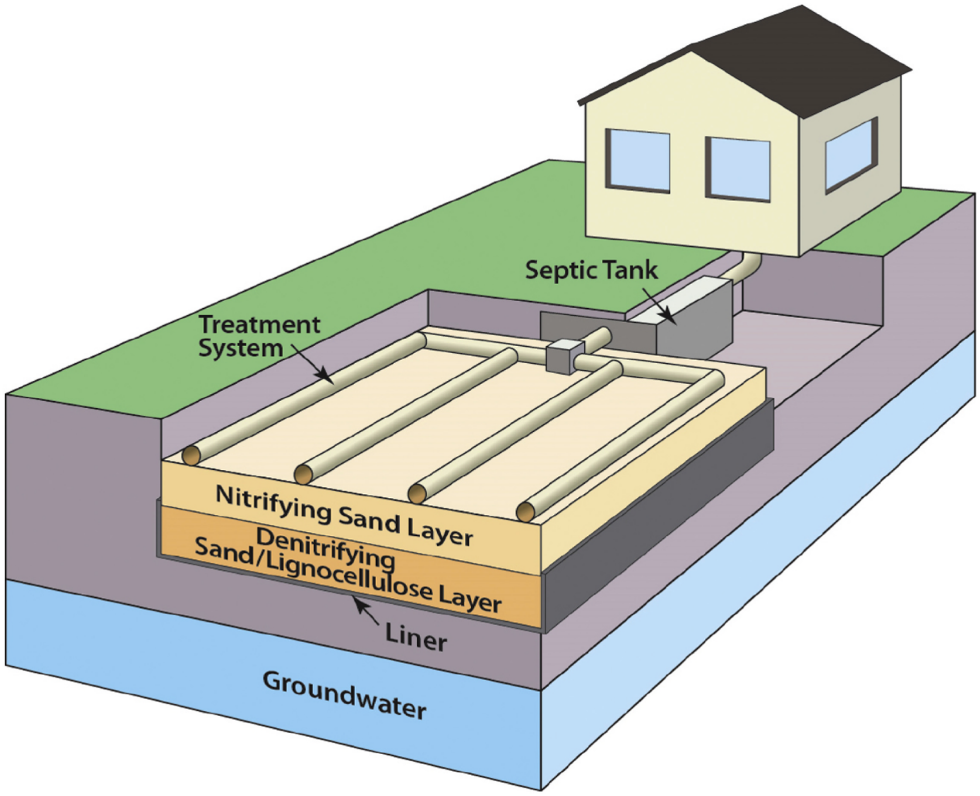


Figure 10 – Non-proprietary woodchip "layer cake" septic system design (MASSTC)

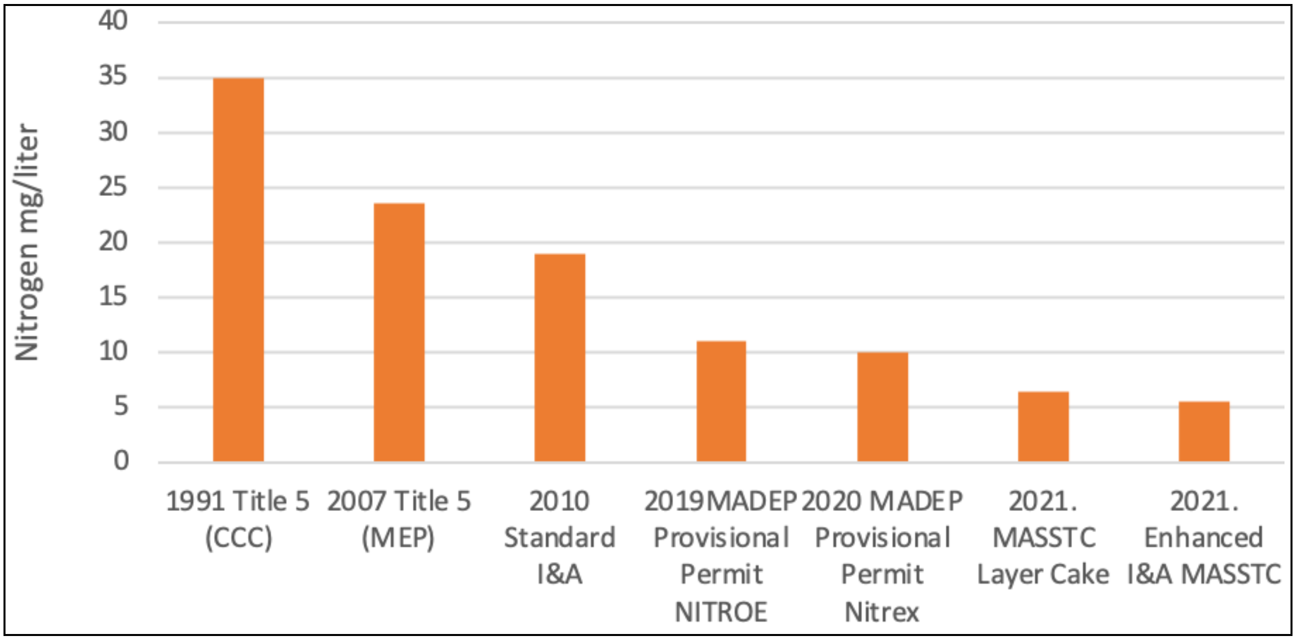


Figure 11 - On-Site Septic System Nitrogen Removal Performance Trend

Additionally, several non-proprietary I&A septic systems using the woodchip bioreactor technology have been developed by the Massachusetts Septic System Test Center (MASSTC) on Cape Cod and the Center for Clean Water at Stony Brook University on Long Island, NY. These include a system referred to as the "layer cake" technology that introduces a layer of woodchips beneath the septic leaching field. Several modifications of this system have been developed by MASSTC and are producing excellent results (Heufelder, 2019).

These technologies are also being researched in Long Island, New York. Stony Brook University has published a study that demonstrates 80 – 90% removal of nitrogen using three non-proprietary designs similar to those developed at the Massachusetts Septic System Test Center (MASSTC).

This study also demonstrated greater than 90% removal efficiencies for organic chemicals including pharmaceuticals, personal care products, DEET, and other compounds that are being identified in wastewater (Gobler, et al., 2021). Gobler suggests that these woodchip-based systems have higher removal rates than traditional wastewater treatment plants for some of these organic compounds due to their higher hydraulic retention time with the reactive media. He indicates that the retention time in these septic systems several days compared to much shorter retention times of hours at conventional wastewater treatment plants.

Another study of these enhanced I&A septic systems is underway in the Town of Barnstable and has completed a detailed review of available performance data. Project partners include U.S. Environmental Protection Agency, Office of Research & Development, The Massachusetts

Septic System Technology Center, The Nature Conservancy, and the Barnstable Clean Water Coalition. Approximately twenty of these systems are being installed in a high-density neighborhood near Shubaels Pond. Extensive monitoring of influent, effluent, and groundwater quality is being conducted by USEPA. These systems will also be testing the use of remote sensors to monitor both their operation (pumps) and performance (nitrogen tests). The success of these remote monitoring devices may lead to further reduce operation, maintenance, and monitoring costs associated with these systems in the future.

This new generation of I&A systems may reduce the required footprint (area) required for installation. Test data on these systems indicate that in addition to nitrogen reductions the total suspended solids (TSS) is substantially less. MADEP allows for smaller leaching facilities associated with wastewater treatment systems that have lower solids loading. Therefore, it may be possible for some of these new I&A systems to qualify for reduced size leaching facilities. This would further reduce their cost and would ease siting requirements on smaller parcels.

Another important component of an enhanced I&A septic system program is the development of a Responsible Management Entity (RME). The RME will be responsible for compiling and reporting the monitoring data to determine the overall effectiveness of these systems in removing nitrogen. They may also be responsible for oversight of operation and maintenance to ensure that they systems are property functioning. Currently the Barnstable County Health and Environment Department is evaluating the possibility of providing some of these RME services. The Cape Cod Commission has organized an RME working group and is in the process of developing options for communities looking to establish an RME. It is likely that an RME can reduce annual operation and maintenance costs by integrating remote sensing of air pump operations and economies of scale in providing coordinating sampling services.

Permeable Reactive Barriers: Permeable Reactive Barriers (PRBs) are subsurface filters that intercept and treat nitrogen-enriched groundwater before it discharges to coastal waters. PRBs may provide a cost-effective solution for Wellfleet Harbor. Recent pilot project results in the towns of Orleans and Eastham suggest that high attenuation rates (90%) are achievable. A PRB installed adjacent to Waquoit Bay has also demonstrated high removal rates. This project is also providing some indication of the probable lifespan of the woodchip bioreactor. The project has been in place for over 15 years with little appreciable decay of the bioreactor materials (Ken Foreman, Woods Hole Marine Biological Laboratory).

According to the Cape Cod 208 Plan there are two types of PRBs available to communities. These include the trench method where woodchips are backfilled into an excavation to intercept groundwater and the use of injection wells to introduce a carbon-based fluid to provide the carbon source for the native soil bacteria (see figures 12 and 13).

A third option bulkhead PRB that incorporates the woodchip bioreactor into a coastal engineering structure such as a bulkhead. A bulkhead PRB was installed on Long Island and was studied by the Center for Clean Water at Stony Brook University (see figures 12-16).

Preliminary monitoring of this system has shown a nitrogen attenuation rate of greater than 80%. This approach has the potential benefit of cost sharing the installations for multiple purposes including shoreline stabilization restoration and nitrogen attenuation. Installations could be coordinated and timed with on-going shoreline stabilization projects, significantly reducing costs.

To evaluate the potential nitrogen reduction associated with the installation of PRBs the Cape Cod Commission's MVP model was utilized to delineate contributing areas and associated nitrogen loads for a PRB project along Commercial Street within the Duck Creek and Cove sub watersheds. An estimated nitrogen removal rate of 75% was applied to these loads.

A town-owned parcel (111 East Commercial Street) at the corner of Bank Street and Commercial Street provides a possible pilot location for a PRB (see figure 17). Commercial Street is oriented perpendicular to groundwater flow directions and could intercept groundwater and attenuate nitrogen loads from the high-density downtown center. Its location near the shoreline discharge area provides an optimal location to capture upgradient nitrogen loads and a relatively thin groundwater lens that may enable a trench-method PRB at reduced costs. Funding of $50,000 was appropriated at the 2021 Wellfleet Town Meeting to conduct a preliminary hydrological and engineering evaluation of a pilot project. However, because the town is currently considering a downtown collection system that would treat this same area the pilot PRB project is on hold. Alternative locations are being considered.

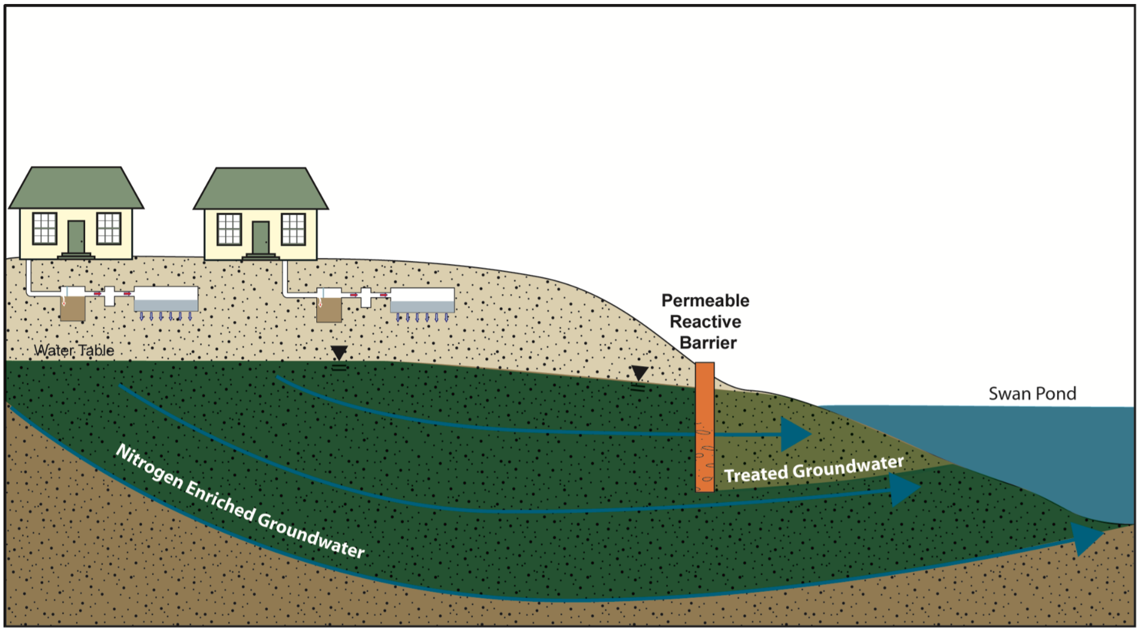


Figure 12 - Permeable Reactive Barrier (Trench Method)

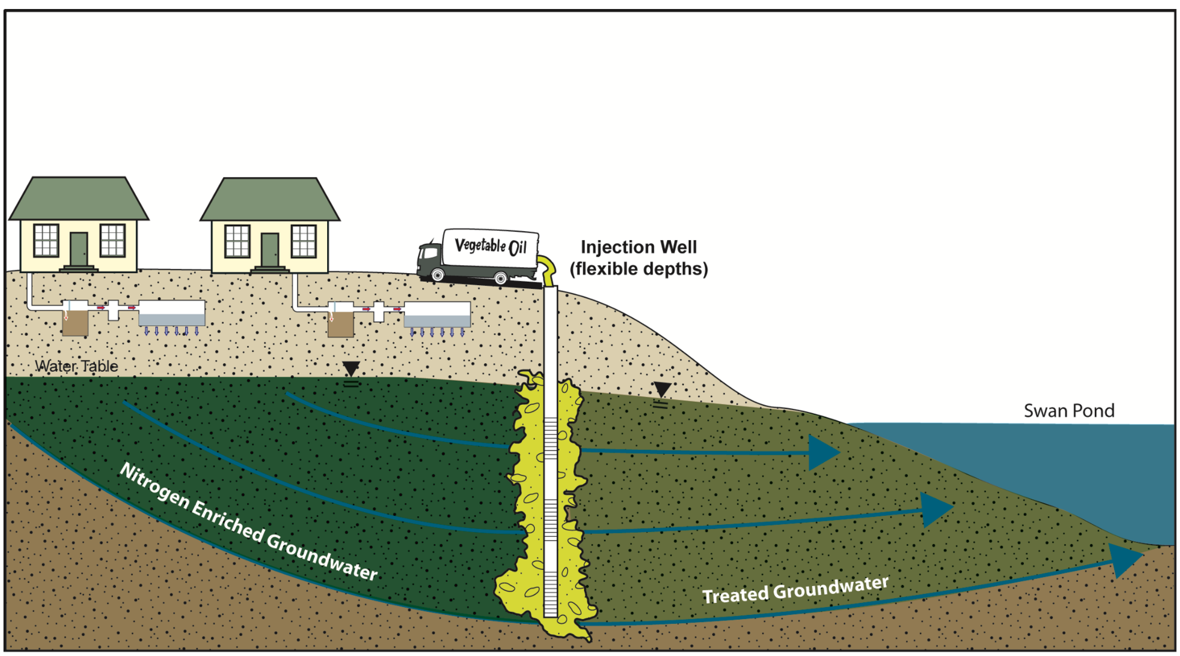


Figure 13 - Permeable Reactive Barrier (Injection Well Method)

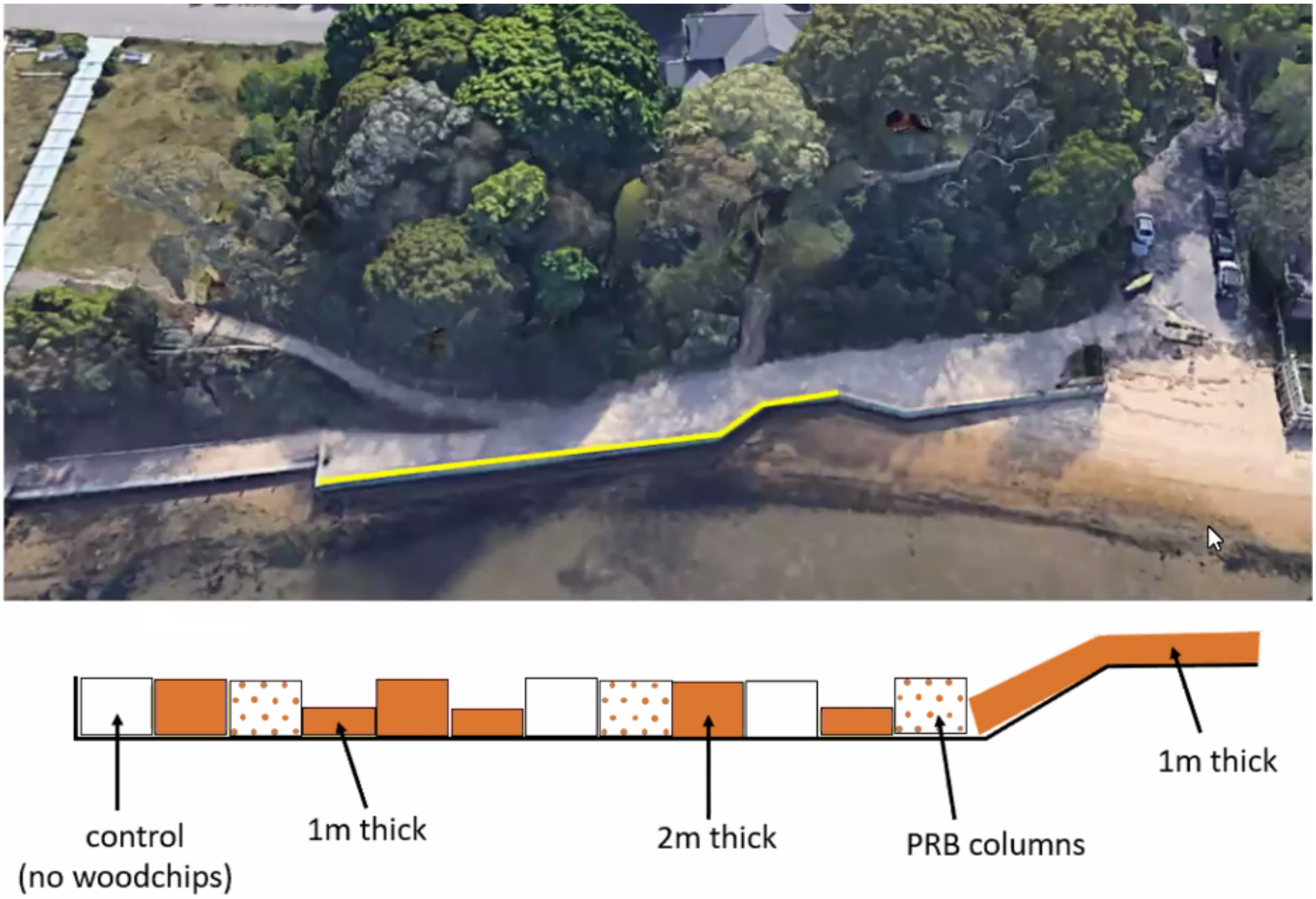


Figure 14 - Permeable Reactive Barrier (Bulkhead Method)

Figure 15 - Permeable Reactive Barrier (bulkhead under construction)

Figure 16 - Completed Bulkhead PRB

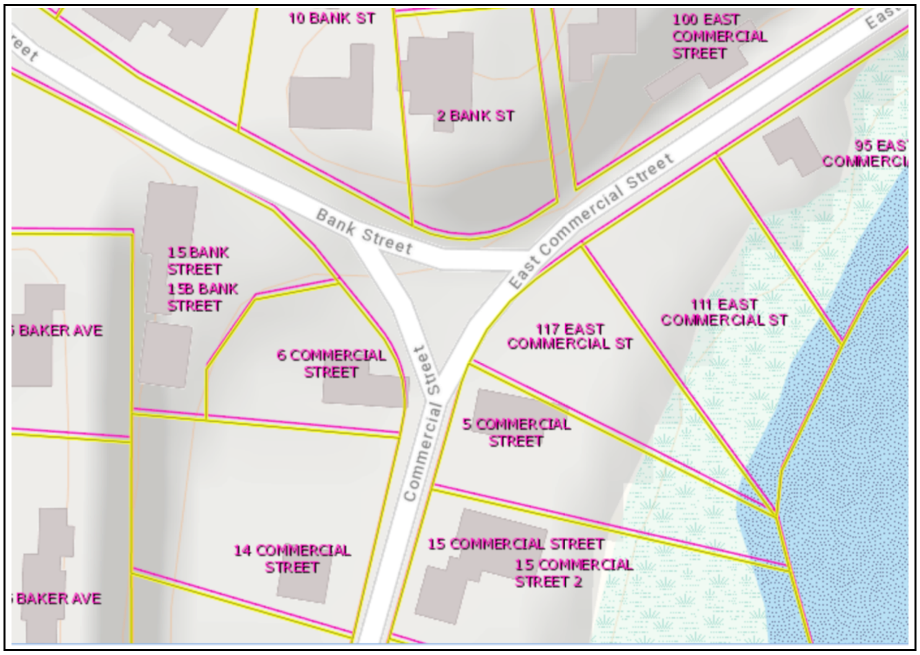


Figure 17 – Potential PRB Pilot Project Location (117 East Commercial Street)

Shellfish/Aquaculture: Shellfish are filter feeders and naturally assimilate nitrogen in the water column as a food source. Shellfish productivity is an effective means of mitigating excess nitrogen loading. It provides quick/immediate results, provides local jobs, and local food.

The Town of Wellfleet has focused on shellfish restoration and aquaculture research over the past several decades. Inherent in this approach is a belief that the marine ecosystem must be restored to enable it to metabolize and assimilate both natural and anthropogenic nutrient loads. The Cape Cod Commission's 208 Plan Update identified shellfish productivity as one of the most cost-effective methods to attenuate nitrogen loading. It also provides significant local jobs. A pilot project conducted by the town in conjunction with University of Massachusetts and the Center for Coastal Studies reported significant water quality improvement in the inner harbor area.

Recent updates to the Cape Cod Commission's Technology Matrix (2017) indicate a range of potential nitrogen mitigation associated with shellfish and aquaculture ranging from 52 – 300 kg/acre-year for these projects (see Table 2). These analyses are based upon harvesting of shellfish and removal of the nitrogen-laden tissue. They are also based upon assumed shellfish densities.

Table 2 - Nitrogen Uptake Rates – Shellfish (Source: Cape Cod Commission, Technology Matrix, 2017)

Cape Cod Commission, Technology Matrix Update (2017)
Shellfish/Aquaculture

Type of Shellfish Grown and Method	Shellfish Initial Weight[1]	Shellfish Final Harvest Weight (HW)[1]	Increase in Weight[2]	Nitrogen Content[1]	Grow-Out Time[1]	Shellfish Nitrogen Uptake[3]	Deployment Density[4]	Shellfish Deployed[5]	Mortality Estimate	Harvest Density	Harvest Target[5]	Annual Nitrogen Uptake[6]
	grams	grams	grams	% of HW	years	grams/year	shellfish/sq.ft.	#/acre	%	shellfish/sq.ft.	#/acre	kilograms/acre/year
Year 1 Oysters Nursery Culture[7] (low density)	0.20	30	30	0.43%	1	0.13	19	820,000	15%	16	700,000	90
Year 1 Oysters Nursery Culture[7] (high density)	0.20	30	30	0.43%	1	0.13	73	3,180,000	15%	62	2,700,000	350
Year 2 Oysters Cultured to Harvest (low density)	30	60	30	0.43%	1	0.13	11	470,000	15%	9.2	400,000	52
Year 2 Oysters Cultured to Harvest (high density)	30	60	30	0.43%	1	0.13	22	940,000	15%	18	800,000	100
Wild Oyster Bed Maintenance	0	71	71	0.50%	3	0.118				10	440,000	52
Quahogs Under Net (Year 1, Year 2)	1.0	40	39	0.43%	2	0.084	50	2,180,000	40%	30	1,310,000	70
Quahogs Broadcast for Harvest	40	57	17	0.43%	1	0.073	6.0	260,000	20%	4.8	210,000	15

According to data reported by the Massachusetts Department of Marine Fisheries (DMF) shellfish harvests (landings) have increased over the past decade since the MEP study was conducted (see figures 18 and 19). The growth in shellfish landings over the 2010 – 2019 period increased from 1.5 million pounds to 2.5 pounds. Converting this to nitrogen attenuation this represents an increase from 3050 kg/year (2010) to 5000 kg/year (2019) for a net increase of 1950 kg/year over the ten-year period.

The DMF data is reported by shellfish classification areas. There are four designated classification areas in Wellfleet (see figure 20. According to these data most of the growth in landings over the last ten years has occurred in CB14. This growing area includes Loagy Bay, Blackfish Creek/Drummer Cove, and a portion of Wellfleet Harbor. The increased landings in CB14 translate to a net reduction in nitrogen load of 1350 kg/year over the ten-year period. Growing area CB11 has also demonstrated significant growth in landings with an associated load reduction of 600 kg/year.

These data are conservative representations for several reasons. First, they do not include recreational shellfish landings that are estimated at approximately 10 - 25% of the commercial landings (personal communications Ryan Curley, Nancy Civetta and John Mankevetch). Secondly, they represent only two species (oyster and hard clam) for which DMF data is available in the growing areas. It is known that additional harvests for blue mussels, scallops, and blood arc clams exist but these are not accounted for in these data. Thirdly, there are additional harvest areas beyond the four DMF-designated classification areas within Wellfleet.

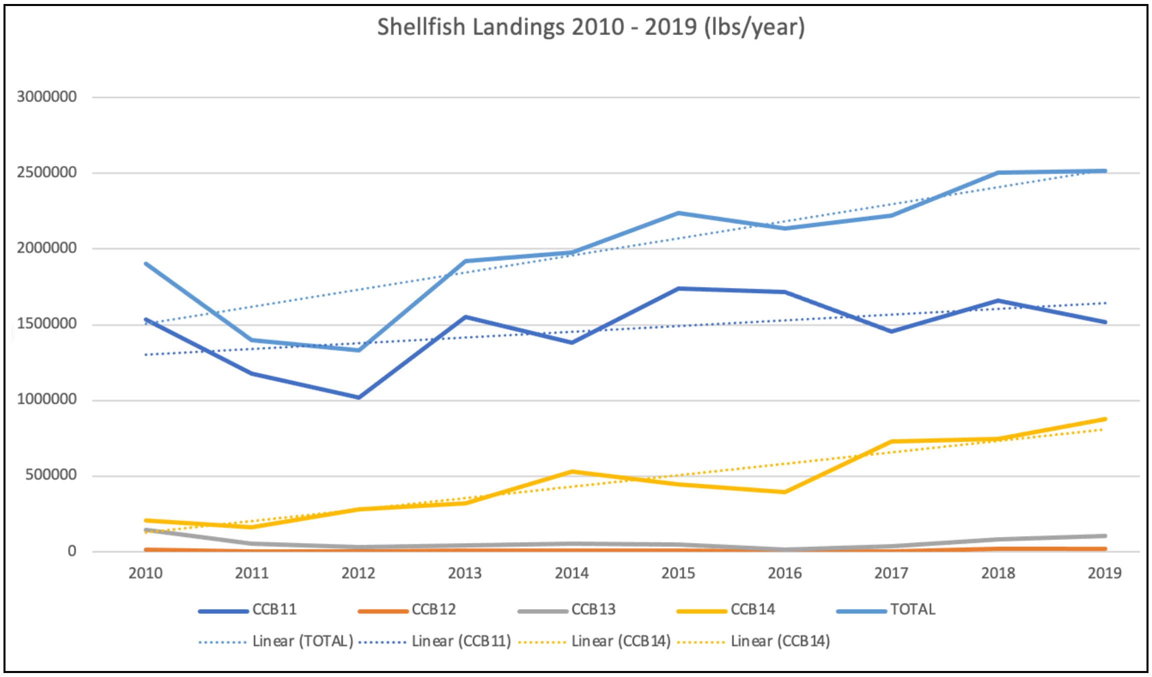


Figure 18 – Shellfish Landings 2010 – 2019

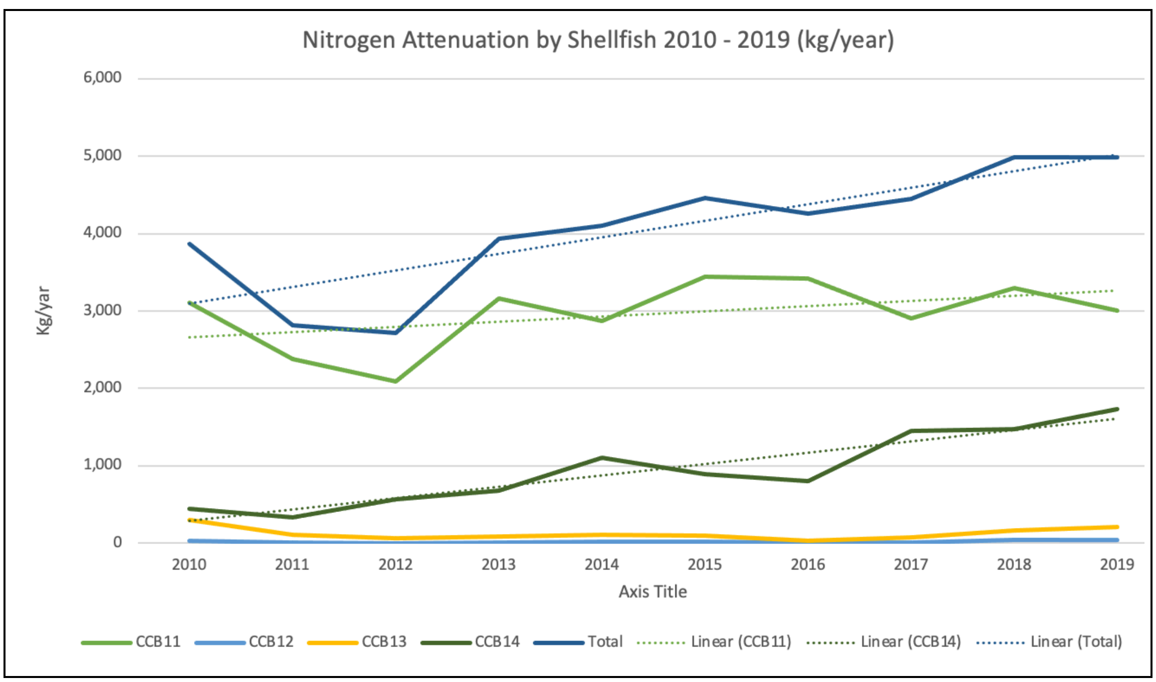
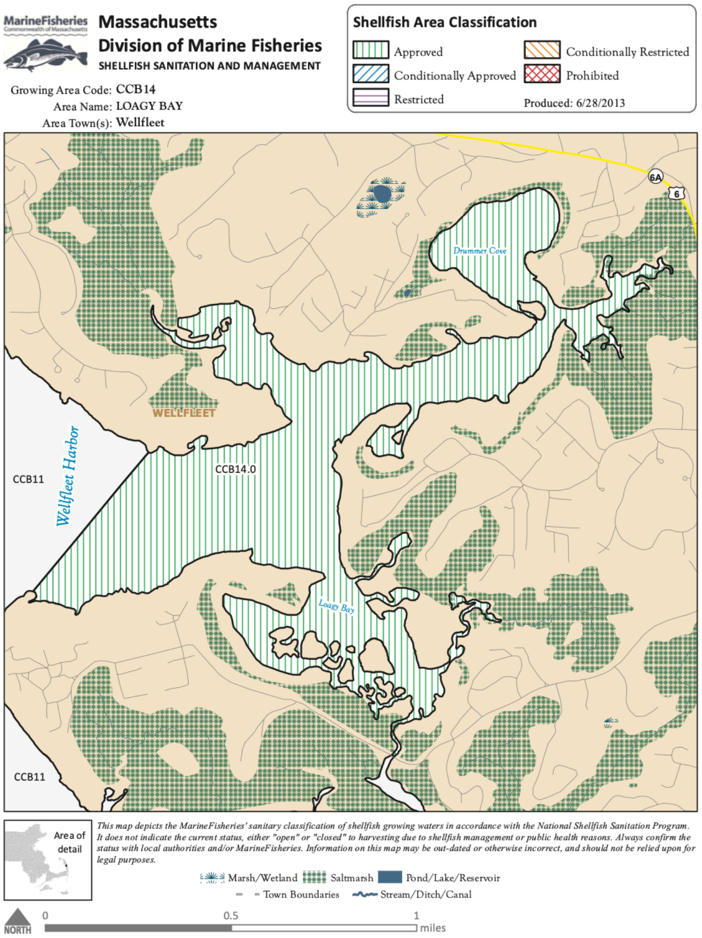


Figure 19 – Nitrogen Attenuation by Shellfish 2010 - 2019



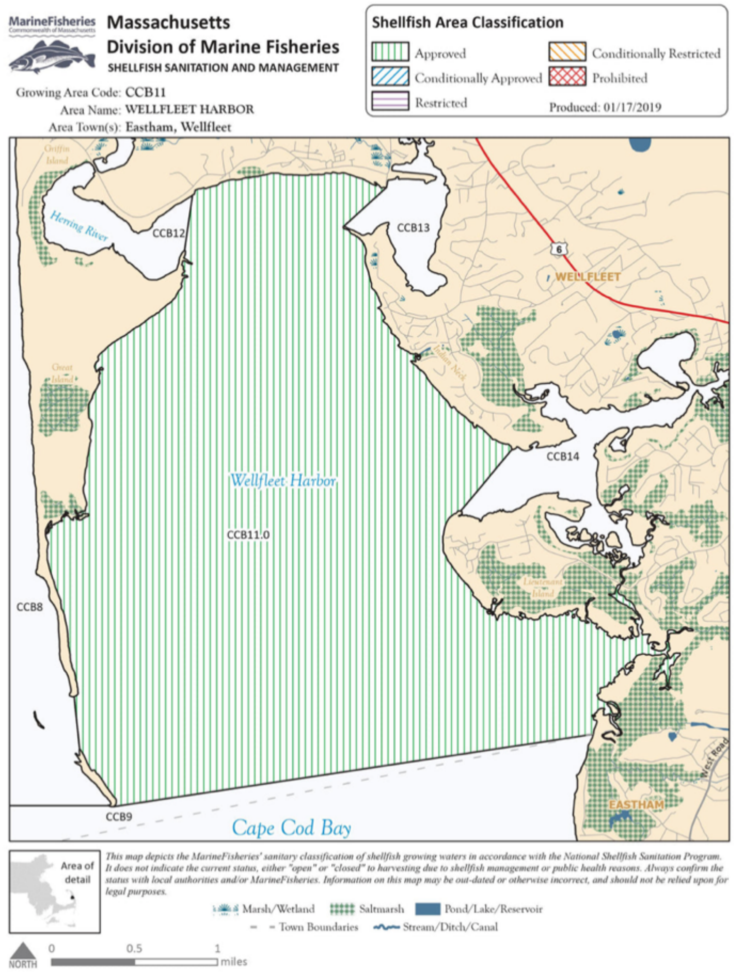
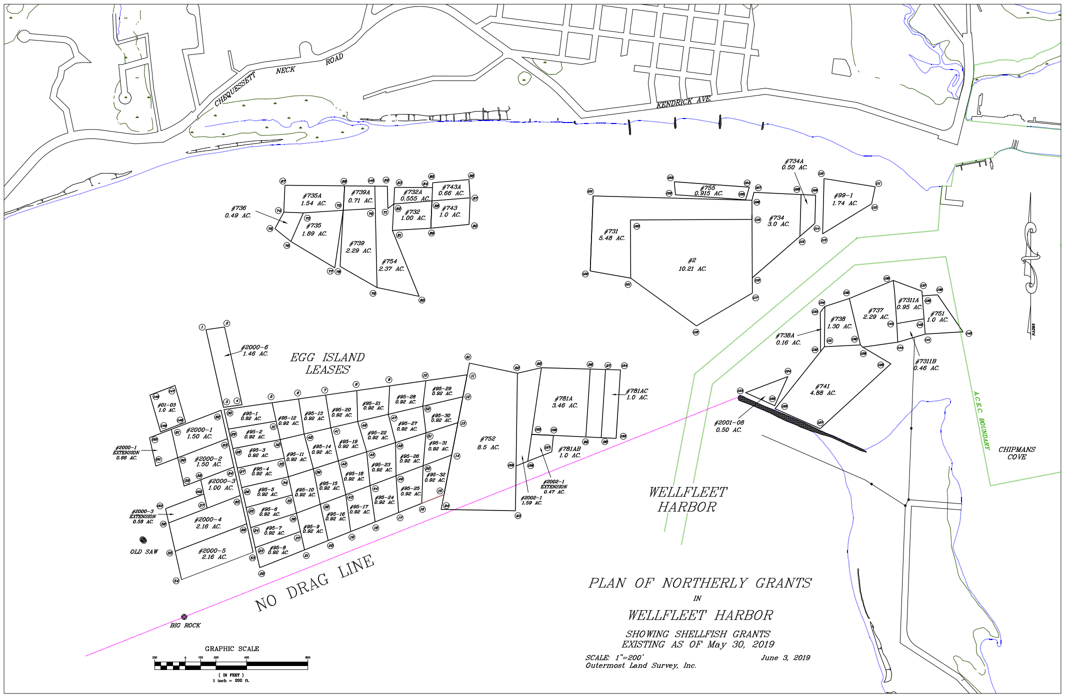


Figure 20 –Shellfish Classification Areas (MADMF)



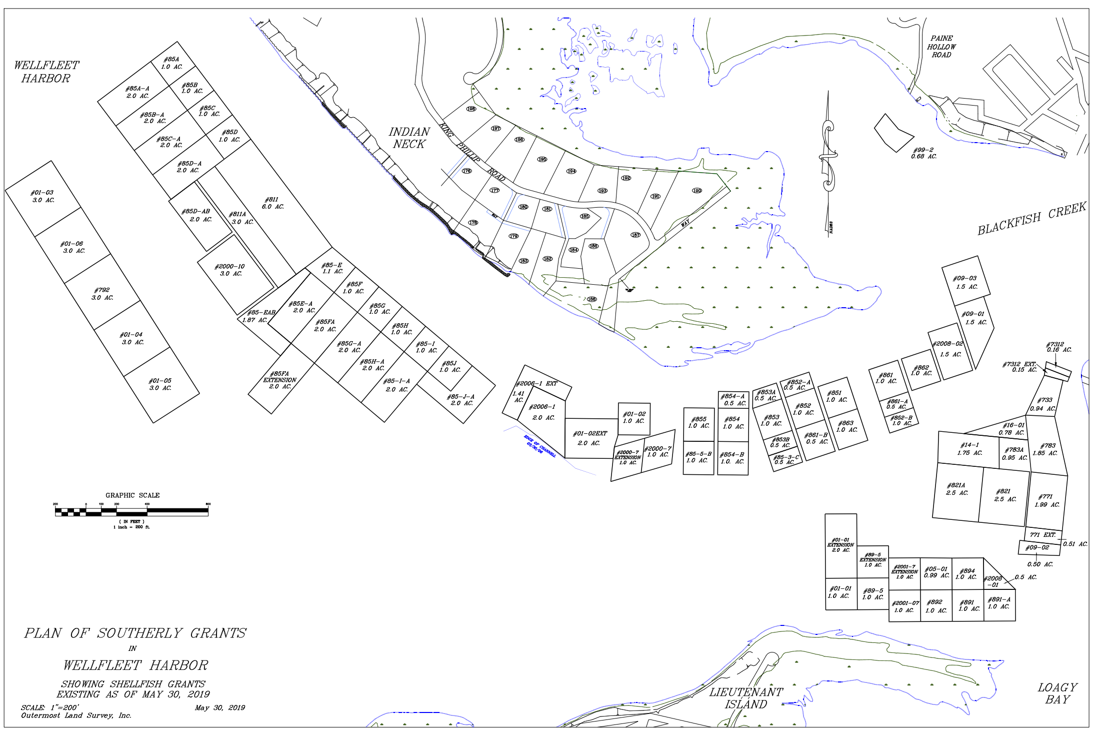


Figure 21 A and B – Shellfish Grant Areas

There is evidence that additional nitrogen attenuation (beyond removal rates associated with uptake and harvest) occur in the benthic zone associated with shellfish ecosystems. This includes research in the Chesapeake Bay region and more recently on Cape Cod in the towns of Wellfleet, Falmouth and Orleans. A study conducted in Wellfleet by the University of Massachusetts identified significant water quality improvements in the Duck Creek embayment

(Frankic, 2015). A recent publication prepared by University of Massachusetts SMAST (2019) reports denitrification rates referred to as "oyster effect" of 24 – 36% (as additional attenuation to the harvest removal rates) during the first two years of a study in Lonnies Pond in Orleans associated with the biodeposits. While these additional nitrogen attenuation benefits are not directly accounted for by tracking the harvest data they may contribute to improved water quality conditions at the sentinel monitoring station.

To support sustainable management and the potential for continued growth of the shellfishery several meetings were conducted with the Shellfish Constable and the Shellfish Advisory Committee. As a result, a five-year plan was developed that includes several "no take" propagation areas and moderate increases in seed purchase and distribution (see Appendix).

Coastal Ecological Restoration: Coastal ecological restoration includes restoring natural flow (including tidal flushing) conditions and ecological functions that support nutrient recycling. The Town of Wellfleet has identified numerous potential restoration projects that will restore lost large areas of salt marsh. These include Herring River, Mayo Creek and others. Most of these projects are intended to restore tidal flow into areas that have been historically blocked by water control structures such as dams, dikes, clapper valves, culverts, etc. Salt marshes have been well documented to provide nitrogen attenuation processes.

The two habitat restoration projects that are underway in Wellfleet (Mayo Creek and Herring River) will likely result in significant water quality and habitat improvements. However, these projects are very site-specific and the resulting nitrogen reductions are difficult to estimate. We recommend that they are included in the overall strategy and that their corresponding nitrogen reduction credits be established through monitoring as part of the adaptive management program.

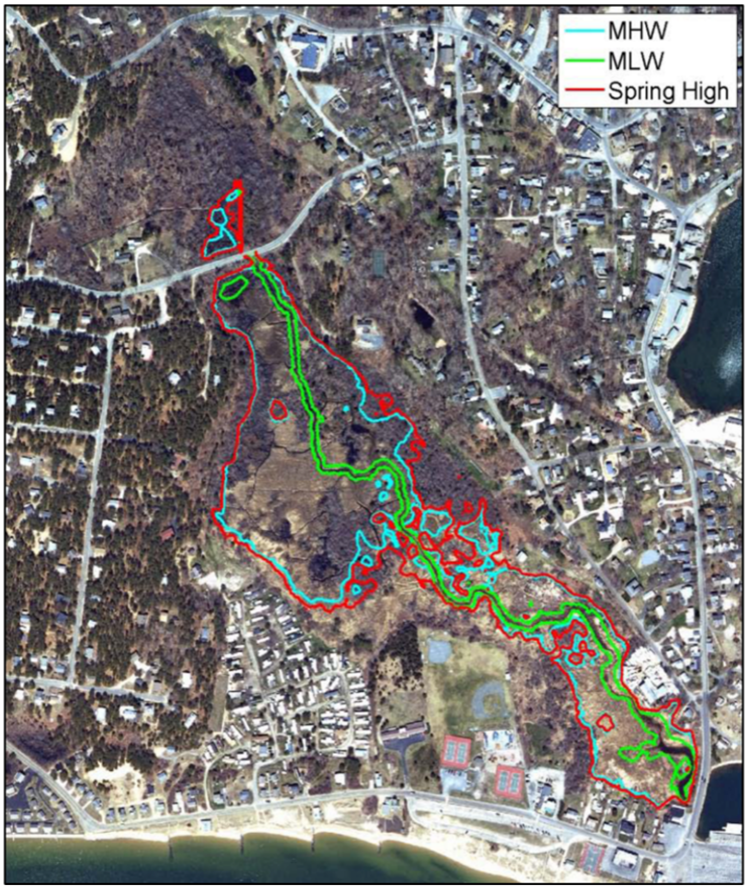


Figure 22 - Mayo Creek Restoration Project (Woods Hole Group, 2016)

To estimate the nitrogen attenuation benefits of the Mayo Creek project flow data was obtained from a Woods Hole Group report (2011) and water quality data (2017 – 2018) was provided by the Center for Coastal Studies (see Figure 22). Existing nitrogen loading data for the Mayo Creek watershed was obtained from the Cape Cod Commission's MVP model. Based upon this data and applying the MEP default value of 40% nitrogen removal associated with salt marsh an estimated nitrogen attenuation of 317 kg/year was derived.

Several other potential restoration projects have been identified and can provide additional nitrogen mitigation (Curley, 2019). The Herring River restoration project is the largest example. These supplemental projects can be monitored and credits can be provided as part of the adaptive management approach.

Stormwater Management: Nitrogen reductions can also be achieved through the implementation of stormwater retrofit projects (including mitigation of the Route 6 drainage) and fertilizer reductions. Credits of 25% reductions are allowed on an interim basis as part of the 208 Plan. These reductions will be required to be documented as part of the monitoring and adaptive management program.

The Town of Wellfleet constructed a stormwater infiltration project along Commercial Street in 2012 (see figure 23). The project was funded with a grant provided by the USDA Natural Resources Conservation Service and included a series of infiltration structures beneath the roadway. This project provides significant water quality benefits with expected reductions in both pathogens and nutrients.

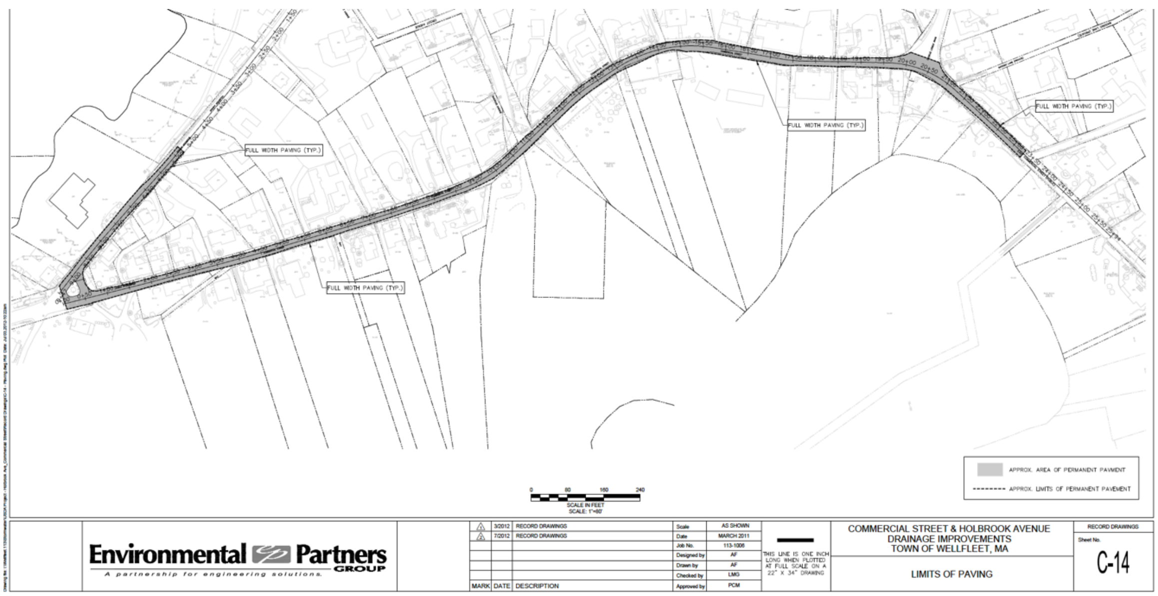


Figure 23 – Stormwater Infiltration Project – Commercial Street

A current stormwater project is under study by the MADOT at the intersection of Route 6 and Main Street (Figure 24). Two meetings were conducted with town officials and MADOT staff. We provided recommendations to eliminate direct discharges and to integrate green infrastructure practices into the project and are awaiting a response from MADOT to discuss these in more detail. During discussions with MADOT about the project the the use of stormater infiltration systems was favored. We also discussed the possibility of modifying infiltration structures by adding woodchip media to encourage enhanced denitrification. According to a report prepared by Offshoots and Horsley Witten Group, Inc. infiltration practices may provide total nitrogen (TN) attenuation in the range of 40 – 65% (see Table 3). Figure 24 shows subsurface infiltration chambers that are widely used in stormwater projects throughout Massachusetts.

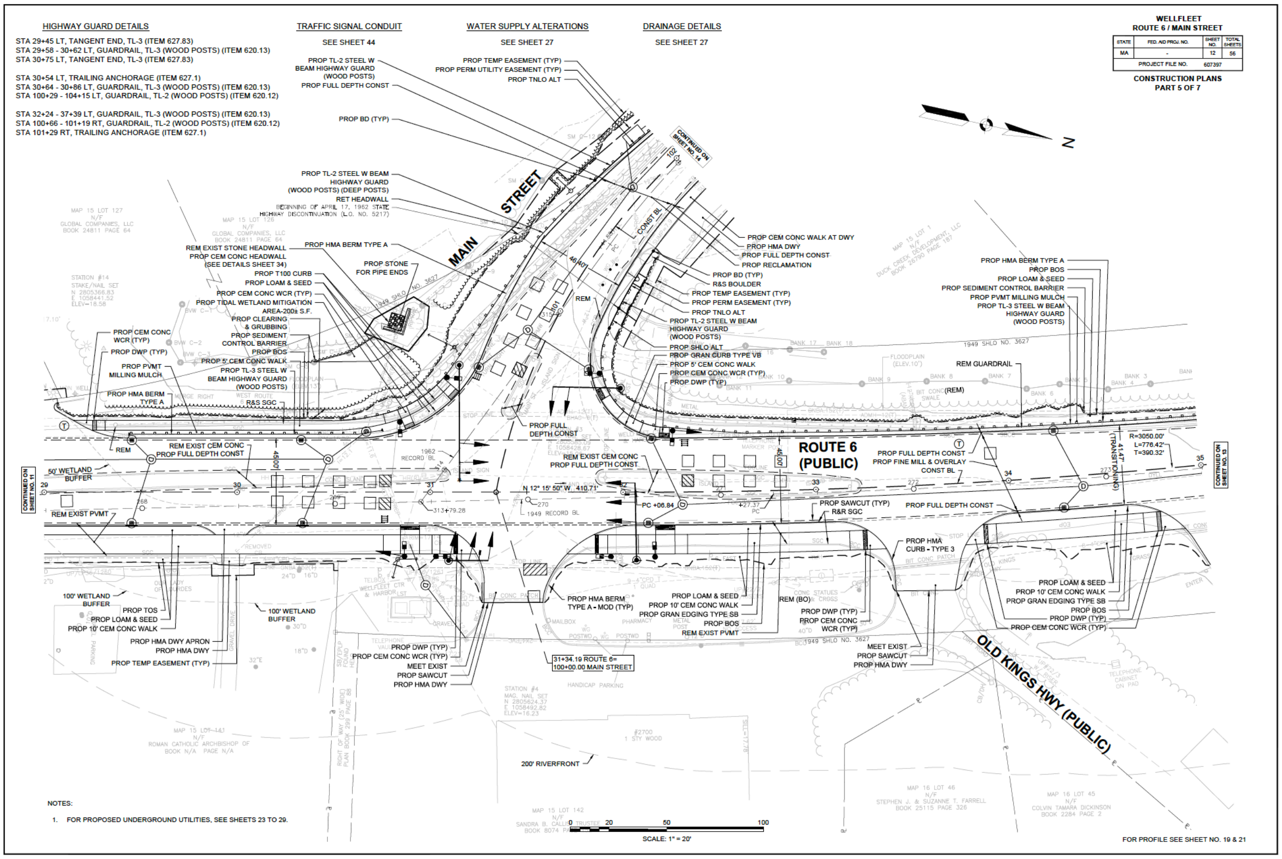


Figure 24 – Stormwater Retrofits – Route 6 / Main Street (MADOT)

Another stormwater improvement is planned at the bridge crossing the Herring River project. This will include infiltration chambers and biotention planters. Nitrogen attenuation rates are estimated at approximately 30 – 55% according to the designer (Fuss & O'Neill).

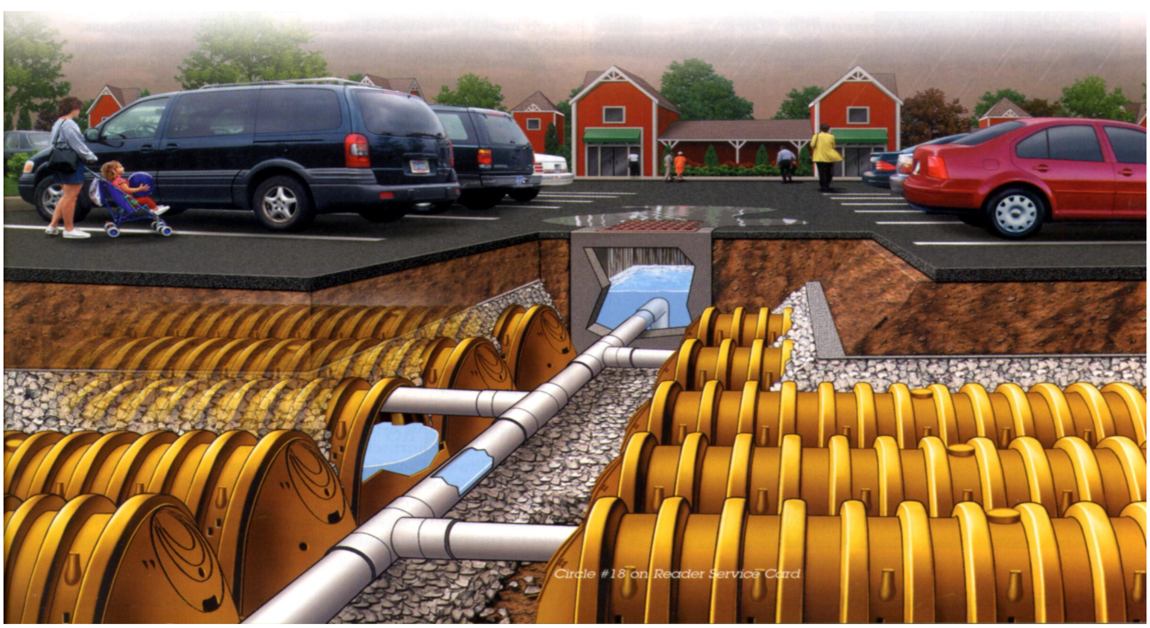


Figure 25 – Stormwater Infiltration with Subsurface Chambers

Table 3 – Pollutant Attenuation – Stormwater Management Practices

GROUP	PRACTICE	MEDIAN POLLUTANT REMOVAL EFFICIENCY (%)			
		TSS	TP	TN	Bacteria
EXISTING LANDFORMS	Depression	See Infiltration Basin			
WET PRACTICE	Shallow Wetland	85%[2]	48%[3]	30%[2]	60%[2]
	Gravel Wetland	86%[3]	53%[1]	55%[3]	85%[2]
	Wet Swale	85%[3]	48%[3]	30%[2]	60%[2]
DRY PRACTICE	Infiltration Basin	90%[2]	65%[3]	65%[2]	95%[2]
	Infiltration Trench	90%[2]	65%[3]	65%[2]	95%[2]
	Subsurface Chambers	90%[2]	55%[2]	40%[2]	90%[2]
	Recharge Basin	90%[2]	55%[2]	40%[2]	90%[2]
FILTRATION PRACTICE	Sand Filter	86%[3]	59%[3]	32%[3]	70%[2]
	Bioretention	90%[1]	30%[2]	55%[2]	70%[2]
	Bioswale	90%[1]	30%[2]	55%[2]	70%[2,6]

Source: Offshoots and Horsley Witten Group (2016)

Fertilizer Reduction/Fertigation Wells: The MEP model assumes that approximately half of the lawns are fertilized with a weighted loading rate of 1.08 pounds (0.5 kg) N/year-lawn. MEP also assumes that 20% of the applied fertilizer load leaches to groundwater and ultimately contributes to coastal waters. Overall, the report indicates that fertilizers represent approximately 9% of the controllable nitrogen load to the embayments.

As part of the 208 Plan Update towns are allowed to propose a 25% nitrogen load reduction for fertilizer management as part of a watershed plan. Management measures can include a local bylaw restricting use and/or public education programs designed to reduce fertilization.

Whereas the majority of Wellfleet residents have on-lot private wells for water supply this represents an opportunity to recycle nitrogen entrained in groundwater as a fertilizer source for lawns along with irrigaiton. This process was identified in the Cape Cod Commission's 208 Plan and is referred to as "fertigation wells" (see Figure 26). The MEP model assumes that eighty percent of the applied fertilizers are assimilated by the lawn.

The Woodard & Curran report identified areas throughout the town with elevated nitrogen concentrations in the range of 2 – 4 mg/liter. Assuming a 12-week irrigation period, an application rate of one inch/week, and nitrate-nitrogen concentrations in the range of 2 - 4 mg/liter a fertigation well could achieve 0.25 - 0.5 kg/year reduction per home. This would require a public education program to utilize existing wells as a source of both irrigation and fertilization (fertigation) and reduce the amount of supplemental commercial fertilizers. The public education plan could be coupled with on-site water quality measurements of the nitrate concentrations of the fertigation water applied.

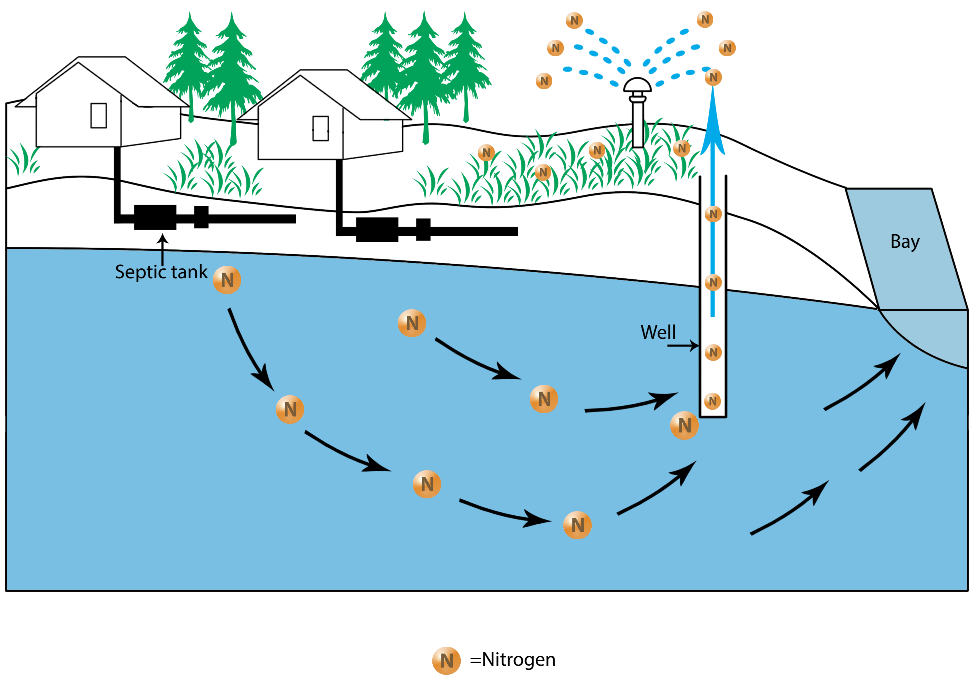


Figure 26 - Irrigation (Fertigation) Well Recycling Nitrates in Groundwater

8.3. HYBRID PLAN

To integrate both traditional and non-traditional approaches to nitrogen reductions we have prepared a hybrid plan and a conventional contingency plan (see Tables 4 and 5). The hybrid plan prioritizes those technologies that have lower costs, quicker results, provide local co-benefits (including jobs), and minimize climate impacts. The hybrid plan provides flexibility and choices for the town. It includes an adaptive management plan to provide for a full evaluation and pilot testing of emerging technologies that were identified in the Cape Cod Commission's 208 Plan with traditional technologies provided as a contingency/backup plan.

As discussed earlier in this report the continued use of conventional Title 5 systems for on-going, future development and redevelopment poses significant challenges to meeting the MEP thresholds. The proposed plan recommends the use of currently available enhanced I&A septic systems to minimize and mitigate these increasing impacts. This recommendation is consistent with the recent lawsuit filed by the Conservation Law Foundation against other Cape Cod towns asserting that the continued reliance on Title 5 systems in impaired watersheds is inconsistent with the Clean Water Act.

The plan includes four phases (five years each) over a 20-year period. The first phase includes both traditional and non-traditional technologies. It includes the construction of a downtown wastewater collection and treatment system that would service approximately 200 properties. It also contains the installation of enhanced I&A septic systems, the development of a permeable reactive barrier pilot project, stormwater retrofits, fertilizer management, and a shellfish propagation management program.

The second and subsequent phases call for expansion of these strategies based upon performance during the first phase and choices made by the town. Depending upon the test results, subsequent phases could include the construction of a full-scale permeable reactive barrier. The PRB's proximity to the shoreline will result in immediate improvements in coastal water quality.

The installation of enhanced I&A septic systems would be required for all new construction, upgrades, expansions, and real estate transfers within the impacted subwatersheds. By timing the implementation of these systems with individual property owner decisions this approach is less disruptive and minimizes construction costs. System upgrades can be made based upon the property owners' proposed construction schedules and/or property transfers. Costs are minimized by timing the installation of the treatment unit coincident with the construction of a new or larger septic system.

Recent data provided by the Wellfleet Board of Health (2017-2019) shows the number of new and upgraded (expanded) septic systems has averaged 52 per year. According to a recent housing analysis by the town approximately half of these systems are associated with "tear downs" and expansions of existing homes (Town of Wellfleet, 2017).

The Board of Health is currently considering a regulation that would require additional upgrades where cesspools are still in use. Upgrades could also be triggered by real estate transactions. It is anticipated that these drivers would result in a sufficient number of upgraded (enhanced) I&A systems to meet the MEP target reductions over the twenty-year planning period.

Figure 27 illustrates the components of the hybrid plan. It shows the locations for downtown sewers, the 95 Lawrence Road wastewater treatment system, a permeable reactive barrier, ecological restoration projects at Mayo Creek and Herring River, and the Route 6 stormwater restoration project. The plan also shows enhanced I&A septic systems and shellfish throughout the town.

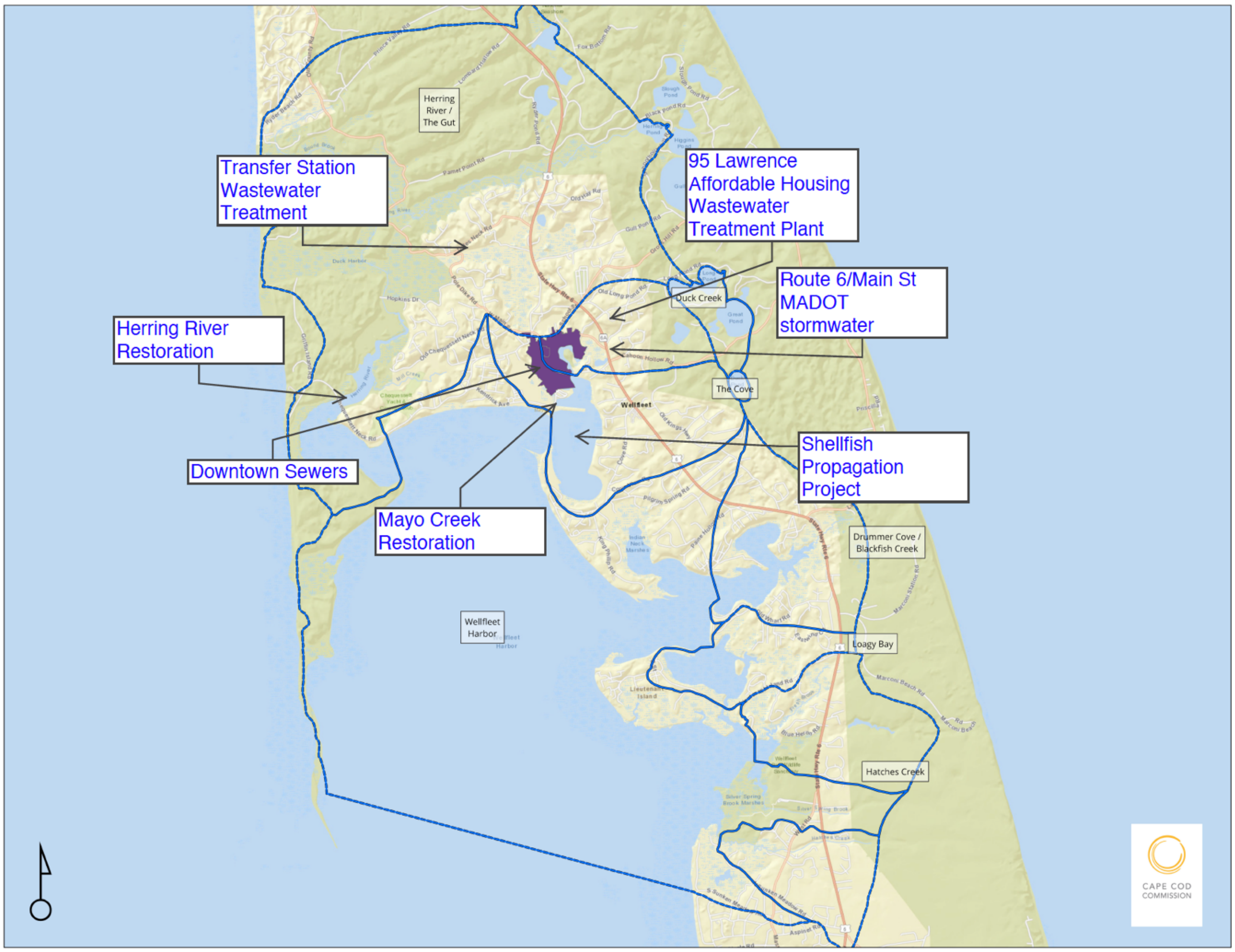


Figure 27 -Watershed Strategy Overview

GHD has prepared alternative sewer collection areas based upon the MEP nitrogen thresholds and required reductions. Two "bookend" plans were prepared (see Figures 28 and 29).

Scenario A includes a targeted downtown sewer collection area within the Duck Creek and Cove watersheds. This plan was designed as part of a hybrid approach that utilizes both traditional and non-traditional technologies to achieve the MEP targets. It also includes a potential alternative location for a smaller scale treatment plant at the town hall parcel.

According to available site data provided by the Wellfleet Health Department this site may have adequate capacity for the smaller downtown sewer service area. Additional test pits and groundwater mounding analysis is required to verify the capacity of this site.

Scenario B identifies a contingency plan with a more extensive sewer collection area that would meet these same MEP targets without the non-traditional technologies. It is supplemented only with those innovative & alternative (I&A) septic systems that currently have General Approval and have a nitrogen effluent concentration of 19 mg/liter. Scenario B would utilize the town transfer station as the wastewater treatment and disposal location.

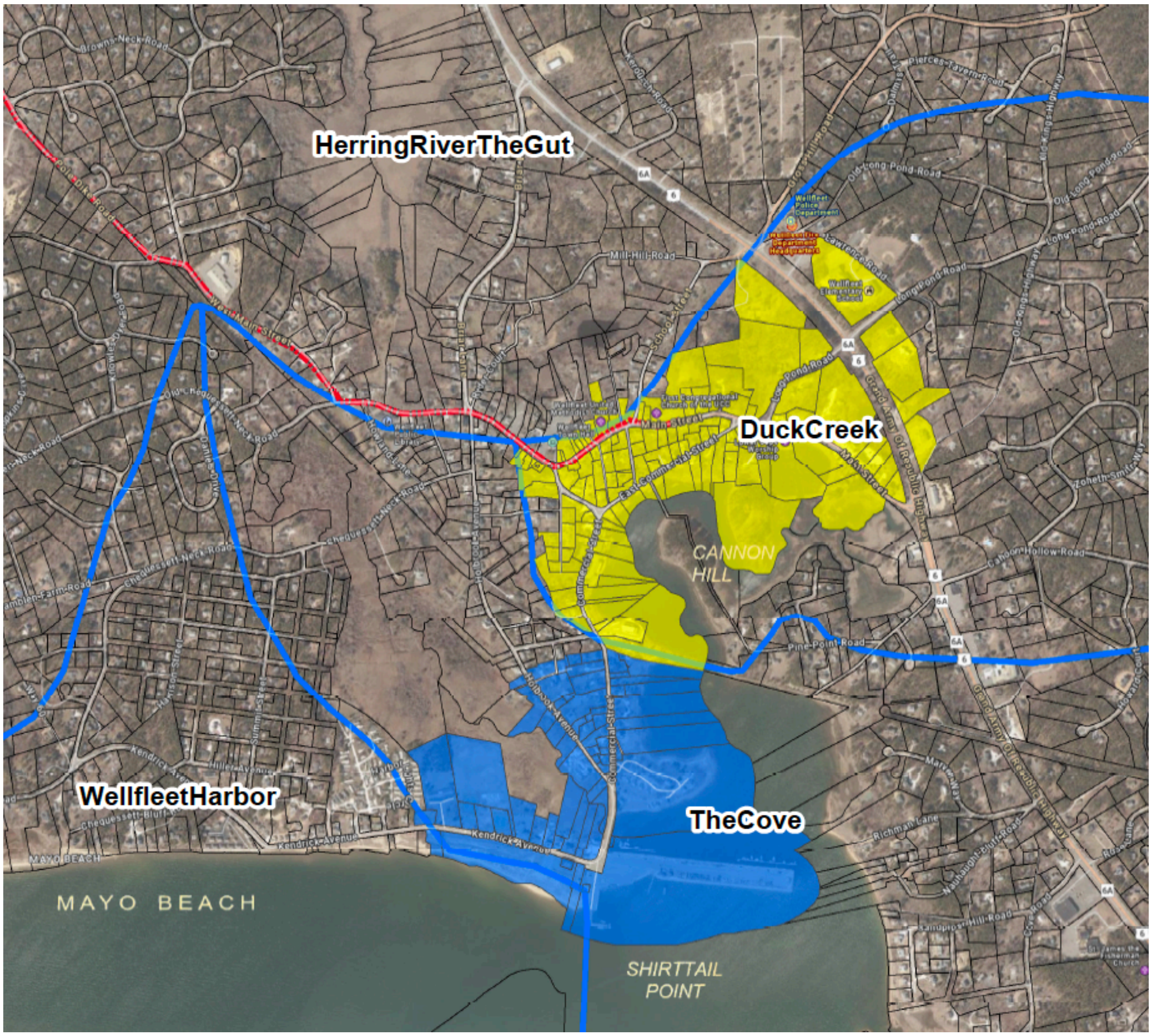


Figure 28 – Downtown Sewer Areas for Hybrid Plan (Scenario A)

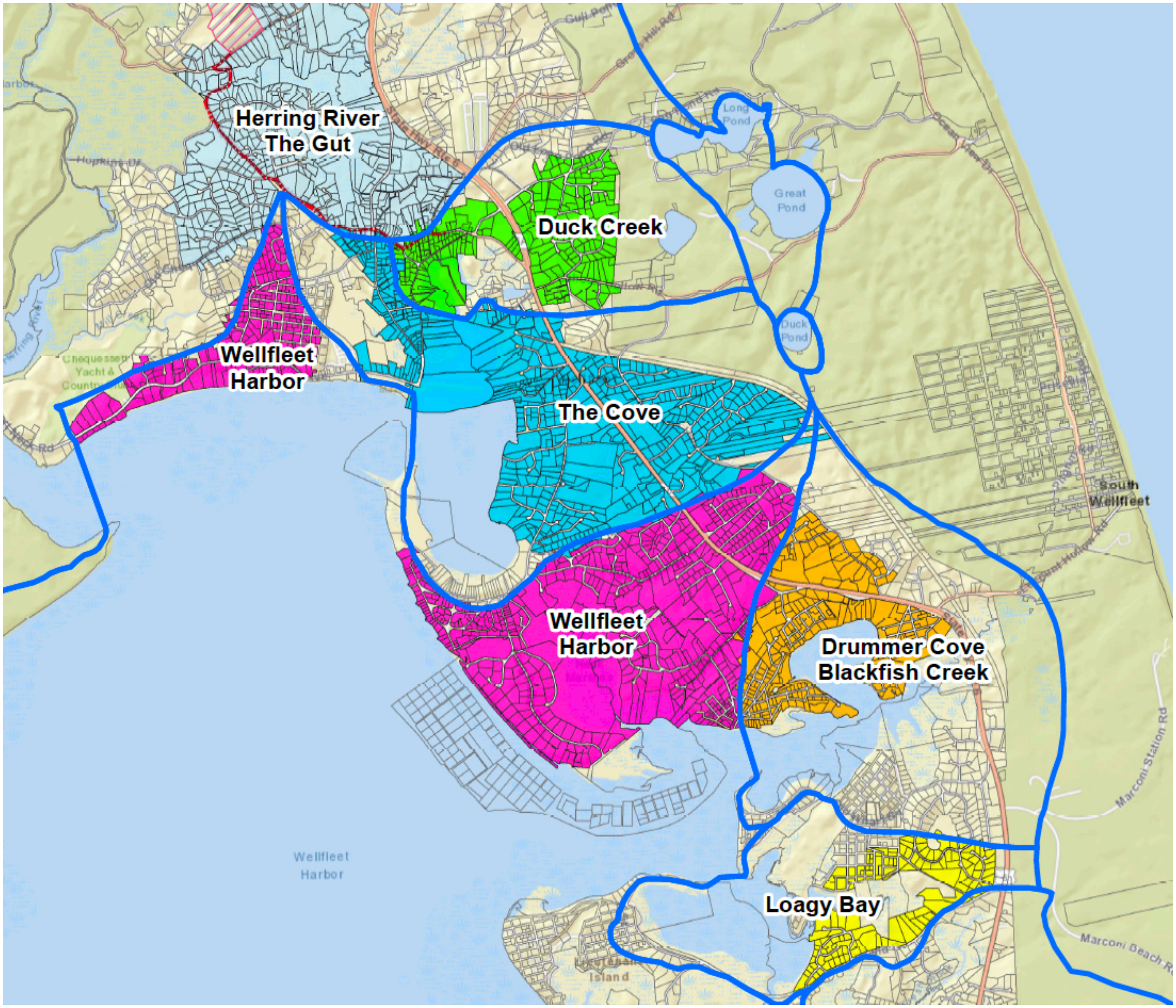


Figure 29 – Town-Wide Sewer Areas for Conventional Contingency Plan (Scenario B)

Scenario A - Hybrid Plan (I&A @ 8 mg/liter)		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay		Total
Health Regulation Require Enhanced I&A Future Development		307	65	147	113	153	239	43		1069
Existing Systems Upgraded Enhanced I&A Upgrades		632	397	1729	0	147	2634	221		5760
Fertilizer Mitigation 25%		151	37	107	54	47	133	20		549
Stormwater Reductions 25%		164	42	108	55	45	104	16		534
Aquaculture/Shellfish/Harvest (2010 - 2019)					1080		600	270		1950
Ecological Restoration				317						317
Permeable Reactive Barrier										0
Collection & Treatment		0	967	458	0	0	146	0		1571
	95 Lawrence	0	88	0	0	0	0	0		
	Harborside Trailer Park (Upgrade 2012)			0	0		146	0		
	Downtown Sewers - Existing Load		864	449						
	Downtown Sewers - Future Load	0	15	9	0	0	0	0		
Treated Effluent Nitrogen Load to Herring River		-255								-255
Total Load Reduced		999	1509	2866	1302	392	3856	571		11495
Remaining Load (Kg/Year)		0	0	0	-2	0	0	0		11495

Scenario B - Conventional Contingency Plan (I&A @ 19 mg/liter and No Non-Traditional Technologies)		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay		Total
Health Regulation Require I&A Future Development		106	24	47	40	61	80	14		371
Existing Systems Upgraded I&A Upgrades		625	0	1	241	331	374	1		1573
Fertilizer Mitigation 25%										
Stormwater Reductions 25%										
Aquaculture/Shellfish/Harvest										
Ecological Restoration										
Permeable Reactive Barrier										
Collection & Treatment		2460	1485	2819	1019	0	3402	556		11741
	95 Lawrence	0	88	0	0	0	0	0		
	Harborside Trailer Park (Upgrade 2012)			0	0		146	0		
	Municipal Sewers - Existing Load	2400	1372	2766	1000		3200	544		
	Municipal Sewers - Future Load	60	25	53	19	0	56	12		
Treated Effluent Nitrogen Load to Herring River		-2192								-2192
Total Load Reduced		999	1509	2866	1300	392	3856	571		11493
Remaining Load (Kg/Year)		0	0	0	0	0	0	0		11493

Tables 4 and 5 – Hybrid and Conventional Contingency Plans (Kg/Year)

Sensitivity Analysis: To evaluate the potential outcomes of this hybrid approach we have conducted sensitivity analyses for several possible scenarios. These analyses included a range of potential performance for enhanced I&A septics and a range of sustainable growth of the shellfish industry.

The first sensitivity analysis included a range of three possible performance scenarios associated with the treatment performance of the enhanced innovative and alternative (I&A) septic system. The effectiveness of the enhanced I&A systems to meet the identified MEP thresholds were evaluated at 5 mg/liter, 8 mg/liter, and 11 mg/liter performance levels (see Figure 30). These scenarios also include conservative estimates of nitrogen attenuation performance of the other associated technologies including the 95 Lawrence Road wastewater treatment facility, limited downtown sewers, stormwater management, and ecological salt marsh restoration). No future nitrogen reduction credits were assumed for shellfish/aquaculture or permeable reactive barriers.

Actual performance data for these systems is provided by the Massachusetts Alternative Septic System Test Center (MASSTC). According to their recent report the non-proprietary I&A systems are achieving an average effluent concentration of 6.5 mg/liter (Heufelder, 2019). MASSTC also provides performance data on proprietary I&A septic systems. Two of these systems (NITROE and NITREX) have reported median effluent concentrations of 5.1 and 6.2 mg/liter respectively.

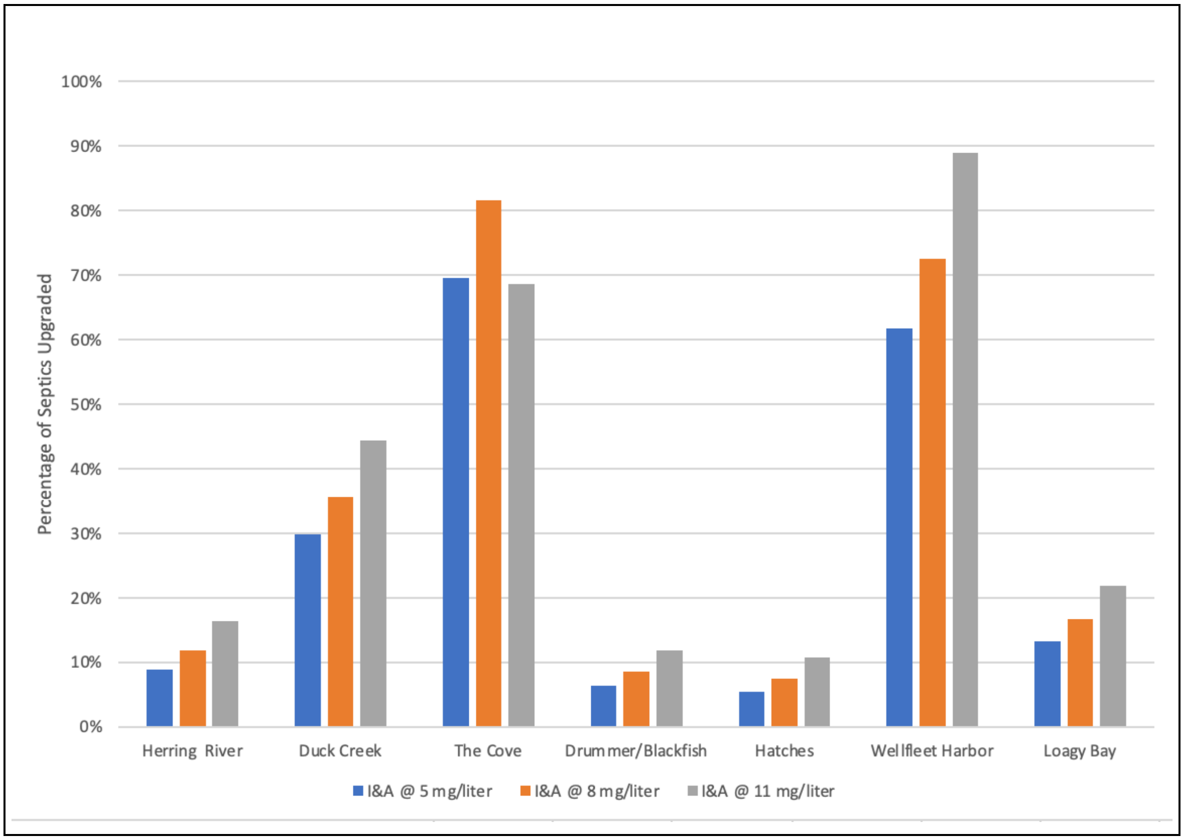


Figure 30 – Sensitivity Analysis for Enhanced I&A Septic Systems

The results of the sensitivity analysis are summarized in Figure 29 and indicate that the MEP thresholds can be achieved in all of the subwatersheds using the enhanced I&A septic systems for the 20-year (2042) planning period with performance at 5 mg/liter, 8 mg/liter levels, and 11 mg/liter.

A second sensitivity analysis was conducted to evaluate a range of potential future scenarios regarding the town's shellfish resources. Recognizing it is difficult to predict future conditions with this resource area and its inherent variability three scenarios were evaluated. These include a continued growth of the resource and industry based upon the last ten-year landings records which demonstrated increased nitrogen reductions of 1950 kg/year. If the shellfish industry continues to grow at this rate the nitrogen reductions would increase by approximately 3900 kg/year over the next twenty years. A second scenario assumes that this growth rate is reduced by half of the current rate and would increase by 1950 kg/year over the twenty-year planning period. The third scenario is the most conservative and assumes no growth of the industry over the next thirty years.

To provide an estimate of the potential costs savings associated with these growth scenarios I have calculated the equivalent reduction of innovative enhanced I&A septic systems that would be required to achieve the MEP thresholds at an estimated cost of $35,000 per system. The results of this analysis suggests that if the shellfish industry continues to grow at the existing rate (scenario 1) until 2042 it may reduce the costs associated with I&A septic conversions by approximately $41 million/year over the twenty-year planning period). If the industry grows at a rate of half of the existing rate (scenario 2) the costs savings are estimated at approximately $21 million over twenty years.

The proposed hybrid plan assumes no growth of the shellfish industry. However, some continued expansion that may take place over the twenty-year plan period can be accounted for and applied as nitrogen reduction credits through adaptive management as part of the proposed Watershed Permit.

Table 6 – Sensitivity Analysis – Shellfish Projections and Cost Benefits

	senario 1	scenario 2	senario 3
growth rate	existing rate	50% growth	0% growth
nitrogen attenuation (Kg/Yr)	3900	1950	0
potential cost savings ($M)	41.5	20.7	0

9.0 MANAGING GROWTH

Like other Cape Cod communities Wellfleet faces continued growth pressures which will exacerbate existing water quality problems if unchecked. The potential growth also presents potential significant cost increases associated with required treatment costs to the town. This report provides options to manage growth under two scenarios: 1) a twenty-year planning period (2022 - 2042) and 2) buildout conditions.

Twenty-Year Growth Projection (2022 – 2042): To provide a projection for future growth during the 30-year planning period building and septic system permits during the last 20 years (2000 – 2019) were reviewed. This data suggests a average annual growth rate of 29.4 new and upgraded septic systems per year (590 new and upgraded septic systems) over the 20-year planning period. The Wellfleet Housing Needs Assessment and Action Plan (2017) provides construction data during the 2000-2016 period (see figure 31) and indicates that approximately half of these permits represented new homes, the other half were expansions of existing homes.

To estimate future increases in nitrogen loading associated with this growth during the 20-year period 295 new homes were added at nitrogen loading rates of 4.73 kg/year-home. Nitrogen load increases associated with the 295 housing expansions was estimated at one-third of this rate at 1.58 kg/year-home. This assumes an increase of one person per household in addition to the existing occupancy rate of 1.98 persons/household (Wellfleet Housing Study).

Housing Growth

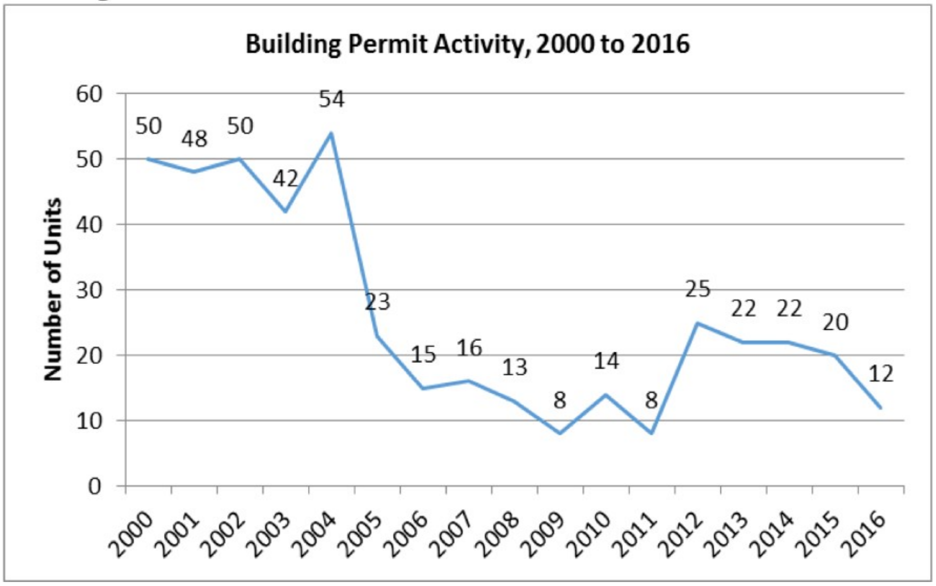


Figure 31 - Housing Growth 2000 - 2016 (Wellfleet Affordable Housing Plan, 2017)

Several other recommendations were made in the Housing Plan that can be integrated into this plan. These include the following:

• Integrate affordable housing into the Cluster Residential Development Bylaw. The Town will investigate amending its zoning to provide mandates and incentives for including affordable housing in its Cluster Residential Development by-law that promotes a smarter way of developing land besides the traditional subdivision and suburban sprawl.

• Allow more diverse housing types in more areas

• The Town should consider where somewhat denser housing development might be added, scrutinizing its zoning districts for opportunities to weave more diverse housing types, including multi-family housing, into neighborhoods.

These affordable housing recommendations could also provide additional benefits regarding cost-effective wastewater treatment options. Clustering and integrating future housing with existing development enable the application of shared or neighborhood wastewater systems including both enhanced I&A septic technologies and neighborhood wastewater treatment plants (such as the 95 Lawrence Road project).

Buildout: A buildout analysis provides a theoretical maximum level of development that could occur based upon the number of existing developable parcels and zoning restrictions. The 2017 MEP report provided an estimated buildout condition assuming that every developable lot was built to its full capacity in accordance with zoning laws. The MEP buildout is relatively straightforward and is generally completed in four steps: 1) each residential parcel classified by the town assessor as developable is identified and divided by minimum lot sizes specified in town zoning and the resulting number of new residential units is rounded down, 2) parcels classified as developable commercial and industrial parcels by the town assessor are identified, 3) residential, commercial and industrial parcels with existing development and areas greater than twice zoning's minimum lot size are identified, divided by the minimum lot size and the resulting number of new units is rounded down, and 4) results are discussed with town staff and/or planning board members and the analysis results are modified based on local knowledge. The MEP report also states that, "it should be noted that the initial MEP buildout approach is relatively simple and does not include any modifications/refinements for lot line setbacks, wetlands, road construction, frontage requirements, parcel shape requirements, or other more detailed zoning provisions". This buildout analysis suggests that anthropogenic nitrogen loads could increase by 40% with individual subwatershed increases of 30% - 71%

Growth Management Options: In general, there are three potential options to manage this future growth from a water quality perspective. They include:

1. Best available technology to accommodate growth
2. Transfer of Development Rights to re-focus growth to less-sensitive areas
3. Open space land acquisition to reduce buildout

Best Available Technology at Full Buildout: The first option is to provide adequate wastewater treatment technology to accommodate growth by providing the necessary wastewater infrastructure. This could be achieved by providing state-of-the-art, on-site septic technology (enhanced innovative and alternative systems) and/or connection to the downtown sewer collection and treatment systems.

Transfer of Development Rights (TDR): Another approach to address the water quality implications of the full buildout impact would be to re-direct future growth to those watersheds that have higher assimilative capacity for additional nitrogen. This could be accomplished using a transfer-of-development rights (TDR) regulatory mechanism. TDR is a growth control option that can be adopted as part of the town's zoning bylaw. TDR provides the option (and incentive) to trade or transfer development rights from those watersheds that are most threatened by excessive nitrogen from future development to those areas of town that have more capacity.

Density bonuses can be provided to property owner as incentives. According to the sensiviity analyses TDR could be applied to meet MEP thresholds using enhanced I&A septic systems under buildout conditions by redirecting growth from three sub watersheds (The Cove, Drummer Cove and Blackfish Creek, and Loagy Bay) to the Herring River sub watershed. It is also possible that the Herring River restoration project would provide additional assimilative capacity within that subwatershed.

Open Space & Land Acquisition: A third option is to moderate growth is to reduce the buildout by acquiring developable land as part of an open space/land conservation program. The Wellfleet Conservation Trust has been active in acquiring open space and developing conservation restrictions. The town's 2005 Open Space Plan identified 524 vacant acres which could be protected for conservation/recreation. The Plan identifies Wellfleet Harbor water quality as a key goal. Current and near future land acquisition funding will come largely through Community Preservation Act (CPA) funds. The Plan recommended that, "the town should continue to work in conjunction with land trusts (i.e. the Wellfleet Conservation Trust, The Compact of Cape Cod Conservation Trusts, Inc. etc.) to acquire conservation restrictions on all unprotected municipal lands even if they are currently designated as conservation and recreation land and on any privately owned land that exhibits conservation values including wetland resource areas".

Ideally, a combination of these three approaches may reduce the burden associated with future potential growth and the associated increases in nitrogen loading.

10.0 COSTS

Preliminary cost estimates for sewer collection and treatment systems have been provided by GHD (see Appendix). To estimate costs associated with innovative and alternative (I&A) septic systems. I have compiled actual cost data from two projects on Cape Cod in the towns of Barnstable and Falmouth. These studies were conducted by two third-party organizations – Barnstable Clean Water Coalition and Buzzards Bay Coalition. Assistance was also provided by the Massachusetts Alternative Septic System Test Center (MASSTC) in both projects.

A total of sixteen I&A septic systems (eight in each study) were installed and are being monitored for performance. Reported costs include engineering design and construction (including nitrogen attenuation technologies and installation). Half of the systems (6) required full upgrades including new septic tanks and leaching facilities. The other half (6) were retrofitted by adding the nitrogen attenuation technology and in some cases with partial upgrades including either a new septic tank or leaching facility.

The average costs for construction were reported at $22,372 for retrofits, $27,981 for partial upgrades, and $34,172 for full replacement upgrades. The overall average construction cost was $27,668. To account for recent inflation costs in my analysis I have increased this to $35,000 per system.

To estimate the overall costs of the hybrid and conventional plans I have applied the cost estimates provided by GHD for the centralized sewering, the costs associated with the 95 Lawrence project provided by Bohler Engineering, and the I&A septics at cost of $35,000 (including engineering design of $5000 per system). Table 7 provides a summary of these costs.

Table 7 – Costs ($ Millions)

	Scenario A Hybrid	Scenario B Traditional
Collection System	$9.4	$80.4
Wastewater Treatment	$10.9	$32.7
Sewer Laterals	$3.2	$27.5
Design	$2.0	$11.3
Construction Services	$5.0	$30.7
Total Municipal Centralized Infrastructure	$30.5	$182.6
Collection System	$0.8	$0.8
Wastewater Treatment	$0.9	$0.9
Leaching System	$0.2	$0.2
Design & Contingencies	$0.6	$0.6
Total 95 Lawrence Capital Costs	$2.5	$2.5
I&A Septics	$63.0	$44.9
Design	$10.6	$7.5
Total I&A Septics	$73.6	$52.4
TOTAL COSTS (millions)	$106.6	$237.5

Cost estimates for other portions of the plan and for operation, maintenance, and monitoring are under preparation. The costs associated with the permeable reactive barrier (PRB) will be estimated associated with the pilot project investigation and design study that has been approved by the recent town meeting. It is interesting to note that these costs could be reduced by as much as $41 million with continued growth of the shellfish industry (see Sensitivity Analysis of this report).

To estimate the cost efficiency of the enhanced I&A septic systems and the centralized sewering options a lifecycle analysis was performed using a project period of twenty years (Table 8). The analysis includes a range of performance (nitrogen removal) for the enhanced I&A septic systems (5 – 11 mg/liter) and the centralized wastewater treatment plant (3 – 5 mg/liter).

Table 8 – Comparative Costs – Wastewater Alternatives

	Concentration	N load	N reduction		Cost	
	mg/liter	kg/year	kg/year	percentage	capital	$/kg
Title 5 system	23.6	4.73				
I&A @ 5 mg/liter	5	0.90	3.83	81%	$ 35,000	$ 457
I&A @ 8 mg/liter	8	1.44	3.29	69%	$ 35,000	$ 533
I&A @ 11 mg/liter	11	1.98	2.74	58%	$ 35,000	$ 638
I&A @ 19 mg/liter	19	3.43	1.30	28%	$ 35,000	$ 1,344
Town-wide WW @ 3 mg/l	3	0.54	4.19	89%	$ 76,400	$ 912
Town-wide WW @ 5 mg/l	5	0.90	3.83	81%	$ 76,400	$ 998
Downtown WW @ 3 mg/l	3	0.54	4.19	89%	$ 109,800	$ 1,311
Downtown WW @ 5 mg/l	5	0.90	3.83	81%	$ 109,800	$ 1,435
Cluster Treatment A @ 6 mg/l	6	174	511	75%	$ 4,703,300	$ 460
Cluster Treatment A @ 10 mg/l	10	290	395	58%	$ 4,703,300	$ 595
Cluster Treatment B @ 6 mg/l	6	124	365	75%	$ 2,546,210	$ 349
Cluster Treatment B @ 10 mg/l	10	207	282	58%	$ 2,546,210	$ 451

Note: Cluster Treatment is for 95 Lawrence Road project. Option A includes the municipal buildings and the neighborhood. Option B includes the municipal buildings.

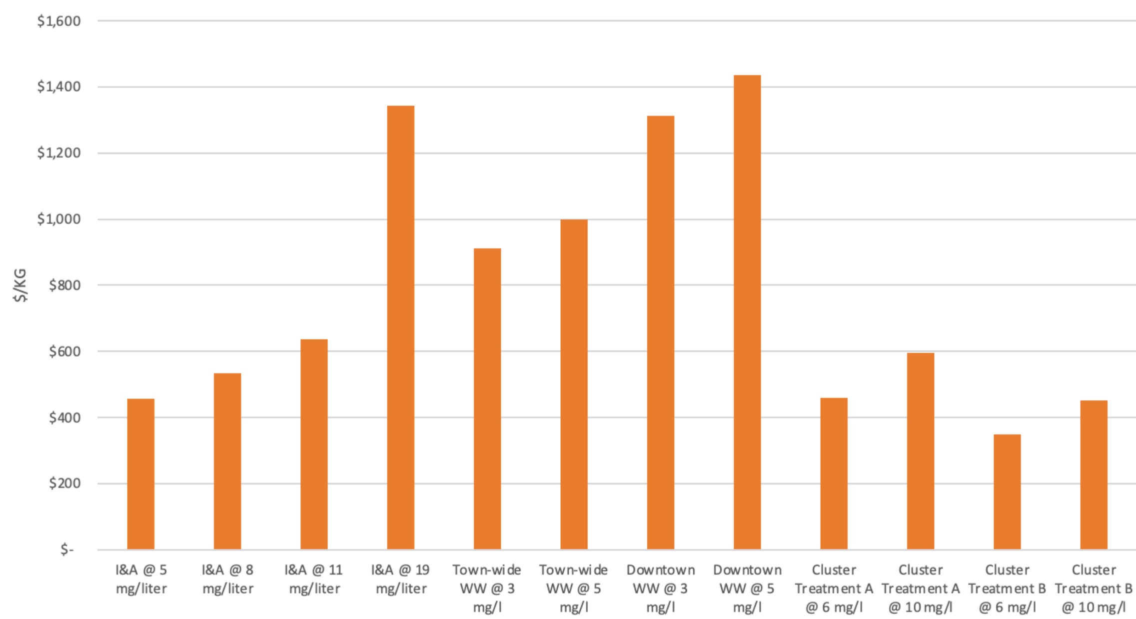


Figure 32 – Cost Effectiveness – Wastewater Treatment Alternatives

11.0 Implementation Schedule

The proposed plan is organized into a 20-year implementation framework, consisting of four, five-year periods (see Table 9). Each phase identifies specific project implementation elements for each subwatershed. As stated earlier in this report Phase 1 includes a downtown sewer collection and treatment system, a neighborhood cluster wastewater treatment system, development of an RME, implementation of enhanced I&A septic systems, and a pilot permeable reactive barrier. Phase 1 also includes the Mayo Creek restoration project, continued growth of the shellfish industry, fertilizer management, and stormwater remediation projects.

Subsequent phases include the continued deployment of enhanced I&A septic systems, implementation of stormwater retrofits and fertilizer management. An adaptive management process will be used to guide detailed decision-making in each subsequent phase. Ultimately. the plan is designed to achieve the MEP thresholds and the required nitrogen loading reductions. The plan includes nitrogen loading reductions that have occurred since the MEP analysis in 2010 (including the upgrade of the Harborside Village wastewater treatment plant and increases in shellfish harvest).

The proposed implementation of enhanced I&A systems is linked to property-owner initiatives including new construction, expansions of buildings, repairs to failing systems, and real estate transactions. A proposed Health Regulation (and possibly a Wetlands Regulation) could provide these triggers that would direct conversion to the more effective septic system technologies over the twenty-year planning timeframe.

Table 9 – Targeted Watershed Plan Implementation Schedule

Phase		Nitrogen Reduction Strategies														TOTAL
		Wastewater Collection/Treatment		Enhanced I&A Septics		Stormwater		Fertilizer		Permeable Reactive Barrier (PRB)		Shellfish		Ecological Restoration		
			kg /yr		kg/yr		kg/yr		kg/yr		kg/yr		kg/yr		kg/yr	kg/yr
0	2010 - 2022	Upgrade Harborside VillageWastewater Treatment Plant	146									Increased Shellfish Landings	1950			2096
	2023 - 2024	Engineering Design of 95 Lawrence - Design & Permit Phase 1 (Housing & Municipal Properties), Evalute Town Hall parce, and Design of Downtown Sewers		Establish Responsible Management Entity (RME) and Install 100 EIA systems (50/year)	329	Design & Permitting Rte 6 MADOT project		Develop Fertilzer Controls and Outreach		Pilot Project		Pilot Propagation Project - Cove		Mayo Creek Design & Permitting		329
1	2025 - 2027	Construct Phase 1 95 Lawrence project, Downtown Sewer & Treatment Plant	1425	Establish Responsible Management Entity (RME) and Install 300 EIA systems (100/year)	987	Construct Route 6 MADOT project	134	Implement Fertilizer Controls	137	Construct PRB		Harvest Cove Pilot Project		Mayo Creek Construction & Monitoring	317	3000
2	2028 - 2032	Identify & Construct Additional Neighborhood Systems		Install 576 EIAs (115/year)	1895	Identify and Construct additional stormwater mitigation	134	Implement Fertilizer Controls	137			Potential growth		Herring River		2166
3	2033 - 2037	Identify & Construct Additional Neighborhood Systems		Install 576 EIAs (115/year)	1895	Identify and Construct additional stormwater mitigation	134	Implement Fertilizer Controls	137			Potential growth		Sunken Meadow (Hatches Creek)		2166
4	2038 - 2042	Identify & Construct Additional Neighborhood Systems		Install 576 EIAs (115/year)	1895	Identify and Construct additional stormwater mitigation	134	Implement Fertilizer Controls	137			Potential growth		Trout Brook (Upper Basin)		2166
Totals			1571		7001		534		549		0		1950		317	11922

12.0 Opportunities for Nitrogen Trading

The towns of Truro and Eastham share smaller portions of the Wellfleet Harbor watershed. Their options to participate in the reduction of nitrogen loads include both source controls and nitrogen trading. Source controls include the conversion of existing septic systems to enhanced I&A systems. Nitrogen trading could include financial contributions towards the implementation of strategies within the Town of Wellfleet at locations closer to receiving waters where the benefits might be realized in a shorter timeframe and for less cost.

Nitrogen trading could also be applied to support potential growth management strategies such as a transfer-of- development-rights (TDR) zoning initiative. Nitrogen credits could be linked to development rights and could be used to calculate incentives to redirect potential growth to areas of the town that are either served by sewers or have the assimilative capacity to accept additional nitrogen loading.

13.0 Public Participation

The Town of Wellfleet has conducted dozens of public meetings regarding wastewater and nutrient management over the last twenty years. These have included meetings during the prior engineering studies (Woodard & Curran and Environmental Partners). The Cape Cod Commission conducted eight public meetings during the Cape Cod 208 Water Quality planning process.

During the last two years the Wellfleet Comprehensive Wastewater Committee has conducted dozens of public meetings, several in conjunction with other local boards including Select Board, Planning Board, Natural Resources Board, Shellfish Advisory Committee, and the Finance Committee. Based upon input from the Shellfish Advisory Committee the name of the Comprehensive Wastewater Committee was changed to the Clean Water Advisory Committee reflecting a broader focus on nutrient management recognizing that nitrogen is a critical food source for coastal ecosystems.

Most recently, three articles were prepared to begin work on the primary elements of the recommended hybrid plan, were presented and discussed at the June 26, 2021 town meeting. These articles included funding for three pilot projects: 1) enhanced I&A septic systems, 2) permeable reactive barrier, and 3) neighborhood wastewater treatment system for the 95 Lawrence affordable housing project. All three of these articles were passed with unanimous or super majority votes and were subsequently endorsed at the town referendum vote on June 30, 2021.

A series of webpages have been developed and are posted on the town's website at https://www.wellfleet-ma.gov/clean-water-advisory-committee. This website provides descriptions of the plan and the recommended technologies. Background reports and other relevant documents are also provided at this location

14.0 MONITORING

Water quality monitoring will be conducted in the receiving waters (at the MEP sentinel station) and within each subwatershed at the locations of the nitrogen reduction strategies. Monitoring protocols will be developed based upon Cape Cod Commission's "Preliminary Guidance for Piloting, Monitoring, and Evaluating Non-Traditional Water Quality Improvement Technologies on Cape Cod" (2016) and MADEP protocols.

Effluent water quality and flow will be measured at the wastewater treatment facilities (including the 95 Lawrence Road project). Enhanced I&A septic systems will be monitored in accordance with MADEP requirements. Permeable reactive barriers will be evaluated using upgradient and downgradient wells. Shellfish landings will be tracked in accordance with MA Division of Marine Fisheries protocols. Ecological restoration projects (including Mayo Creek) will be evaluated using pre- and post-project water quality monitoring data. Stormwater retrofit projects (including Route 6) will be documented.

Water quality monitoring will also be conducted at the Sentinel Station in Wellfleet Harbor and other in-water stations to assess ecosystem health improvements over time.

15.0 ADAPTIVE MANAGEMENT

The hybrid plan is designed based upon the Cape Cod Commission's 208 approach to be implemented using an adaptive management approach (see figure 33). At the end of each five-year phase the effectiveness of the plan at achieving nitrogen loading reductions will be evaluated. Accordingly, adjustments will be made to the plan as needed.

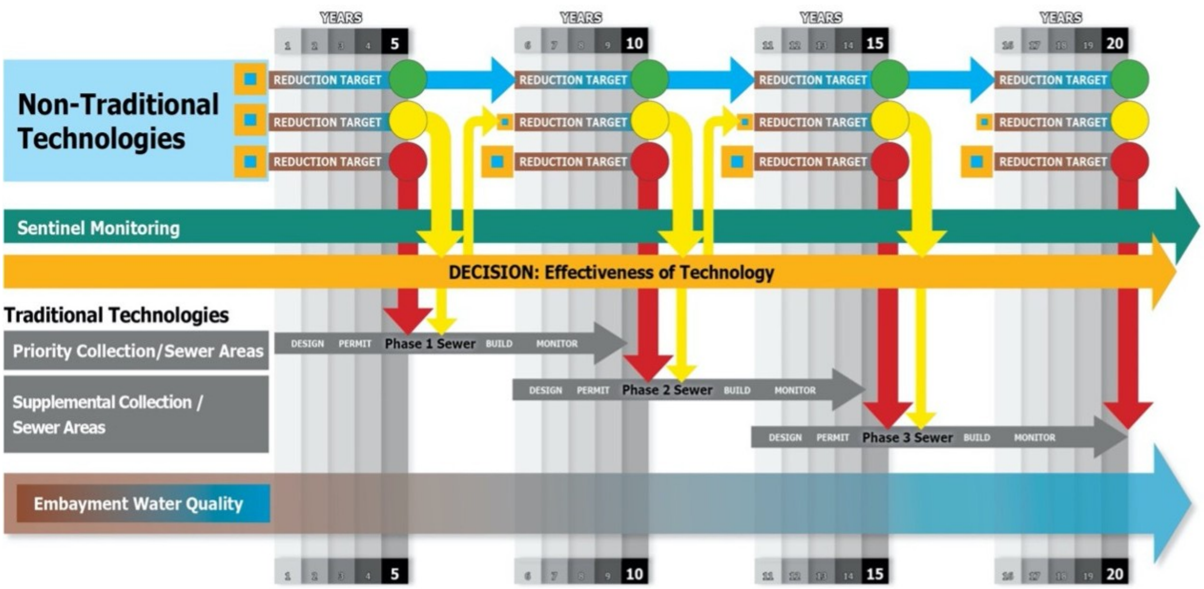


Figure 33: Adaptive Management

16.0 CONSISTENCY WITH 208 PLAN UPDATE (CAPE COD COMMISSION)

Wellfleet Harbor has been identified by the Cape Cod Commission as a priority watershed for the development of a Targeted Watershed Nutrient Management Plan (TWMP). Among the purposes of the TWMP is to demonstrate consistency with the 208 Plan Update and provide a basis for watershed permitting that includes both traditional and non-traditional technologies. Specific guidance on the requirements for 208 Plan Update consistency has been provided by the Cape Cod Commission in Appendix G of the 2017 Addendum to the Water Quality Management Plan.

17.0. FINANCING

17.1 SHORT-TERM RENTAL TAX

Legislation was signed into law in December, 2018 which expands the room occupancy excise, G.L. c. 64G, to short-term rentals of property for more than 14 days in a calendar year, starting July 1, 2019 for which a rental contract was entered into on or after January 1, 2019. The town of Wellfleet recently raised this tax rate from 4% to 6% at 2021 town meeting. It is estimated that the additional rooms tax generated from this category of rental property will provide an additional $1 million per year. Over the next 20 years it is estimated this fund could generate in excess of $20 million.

17.2 CAPE COD & ISLANDS WATER PROTECTION FUND

Preliminary projections for revenue to be generated by the Cape Cod & Islands Water Protection Fund (CCIWPF) amount to $18 million annually. A tax rate of 2.75% is applied to stays in hotels, motels, B&B's, other lodging establishments as well as short-term rental properties rented in excess of 14 days in a calendar year. The revenue will be awarded to communities in the form of principal subsidies on loans issued through the State Revolving Loan Program. During the September 2020 – August 2021 period approximately $800,000 was collected in Wellfleet. Over the next 20 years it is estimated this fund could generate in excess of $16 million.

17.3. AMERICAN RESCUE PLAN ACT

In 2022 the United States Congress passed legislation authorizing funding to assist states and local goverments with inftrastructure funding. Current discussions at the Barnstable County Commissioners suggest that these funds will be available to subsidize the Cape & Islands Water Protection Fund and the Barnstable County Septic Loan Program.

17.4 Barnstable County Septic Loan Program

Historically this loan program has been administered by the Barnstable County Department of Health & Environment and assists homeowners to upgrade hydraulically failed septic systems. Recent discussions with the Barnstable County Commissioners indicate that this program is likely to be expanded to include upgrades to enhanced I&A septic systems with lower interest rates and potentially loan forgiveness.

17.5 Stabilization Fund

A new Stabilization Fund could be established to dedicate a portion of this new revenue stream to the comprehensive management of the town's water and wastewater needs and none of the revenue will be credited to the General Fund.

17.6 Sewer Assessments

Chapter 83 of the General Laws allows for the issuance of assessments to property abutters for a proportional share of the cost for a common sewer. The town will make every effort to maximize the number of property abutters on a specific sewer project to keep the proportional share of the costs to the least amount possible. The town could set an upper limit on the sewer assessments and subsidize them depending upon the amount of principal subsidies received from the CCIWPF and tax revenue generated from meals and rooms taxes. A reasonable upper limit may be defined as the average cost to replace a septic system.

Property owners have the option to pay the sewer assessment in full or apportion the cost to future tax bills for up to 30 years under Chapter 83 of the General Laws. The interest rate applied to the apportioned assessments is either 5%, or by vote of the Selectboard, can be at a rate up to 2% above the net rate of interest chargeable to the town for the project to which the assessment relates.

17.7 System Development Charges

This is a fee in the utility industry that is charged to new customers of a utility system to pay for the investments made into the "backbone" of a system. There are three (3) methods that could be used to calculate the charge:

- Historical buy-in method – typically used when the existing system has sufficient capacity to serve new development now and into the future
- Incremental cost method – typically used when the existing system has limited or no capacity to serve new development and new facilities are needed to serve the next increment of new development

- Combined approach – typically used where some capacity is available in parts of the existing system, but new or incremental capacity will need to be built in other parts to serve new development in the near future

The financing plan includes a system development charge that would be paid at the time of connection to the sewer system

17.8 Debt Issuance

When debt is necessary to finance capital improvements, the town either issues General Obligation Bonds through the capital markets or obtains loans through state agencies such as the Department of Environmental Protection's Massachusetts Clean Water Trust (MCWT) that offers municipal infrastructure financing programs at low interest rates, occasional principal subsidies, and with attractive repayment terms.

The MCWT offers 0% loans for projects that contribute to nutrient enrichment reduction; 1.5% loans for Housing Choice Communities and 2% loans as a standard option. The loans can be amortized for up to 30 years provided the asset has a useful life exceeding that time period.

Project costs that are not financed through the MCWT will be financed with a General Obligation Bond issue in the capital market. The town's current bond rating is AAA and should result in 20 year loan rates of approximately in the 4% to 6% range under current market conditions.

17.9 Federal & State Grants

Most grants available from state and federal agencies for sewer infrastructure require target pilot projects and innovative or "green" projects. Grants are typically not available for standard utility infrastructure needs such as replacing sewer mains or building of pump stations to meet on-going demand. Federal and State assistance has been directed to the MCWT to date which has allowed for the favorable borrowing conditions mentioned previously. This financing plan assumes this method of assistance will continue.

17.10 Property Taxes

The financial plan can include property taxes as a funding source for the program. They may be in the form of an operating override dedicated for a capital or debt exclusion to cover some or all of a project's cost, or a reprioritization of the existing tax levy for this purpose.

17.11 Responsible Management Entity (RME)

A significant portion of the proposed watershed plan includes numerous enhanced septic systems throughout the town. These systems will be best managed through a coordinated responsible management entity (RME) that can coordinate operational visits, inspections, and monitoring requirements. The RME can be the organization that calculates the resulting nitrogen reductions and reports to MADEP. It can be supported through a fee structure paid for by property owners and/or the Town of Wellfleet.

The U.S. Environmental Protection Agency (USEPA) has developed guidance on various RME structures and approaches. They include an alternative models that include both private and public (municipal) ownership of septic systems and a range of services (USEPA, 2003). At this point, this plan recommends EPA model 4 in which private ownership of septic systems and on-site treatment technologies supported by a town-wide RME that would provide the operation, maintenance, and monitoring services. These services would be paid for by a fee to property owners.

18.0 REFERENCES

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Technical Memorandum

June 27, 2022

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Copy to		Email	anastasia.rudenko@ghd.com
From	Anastasia Rudenko, PE, BCEE, ENV SP	Project No.	11216492
Project Name	Town of Wellfleet TWMP – Preliminary Sewer Analysis		
Subject	Preliminary Sewer Analysis – Final		

1. Introduction

The Town of Wellfleet, Massachusetts (Town) is undertaking a Targeted Wastewater Management Planning (TWMP) process to develop strategies for addressing wastewater needs and nutrient impacts to the Town's coastal estuaries.

This memorandum summarizes the evaluation that was completed to assess the approximate extent of centralized sewer infrastructure required to meet the Town's nitrogen reduction strategies under two scenarios—the Massachusetts Estuaries Project (MEP) Hybrid Threshold Compliance Plan and MEP Traditional Threshold Compliance Plan.

2. References, Datasets, and Design Guidelines

The references, datasets, and guidelines listed below were used to develop this memorandum. Documents are referred to by the abbreviation indicated in parenthesis for the remainder of the memorandum.

References:

– 'Wellfleet Harbor Targeted Watershed Management Plan – Draft Final Report', prepared by Scott Horsley, Water Resources Consultant and dated June 15, 2022 (2022 Draft Wellfleet TWMP)

– 'Groundwater Modeling Evaluation of Treated Effluent Recharge to Groundwater Wellfleet Transfer Station – Final Technical Memorandum', prepared by GHD and dated April 27, 2021. (2021 GHD Wellfleet Transfer Station Evaluation)

– 'Massachusetts Estuaries Project – Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Wellfleet Harbor Embayment System Town of Wellfleet, Massachusetts Final Report – March 2017', prepared by the University of Massachusetts Dartmouth School of Marin Science and Technology and Massachusetts Department of Environmental Protection. (Wellfleet Harbor MEP Report)

– 'Comprehensive Wastewater Management Plan: Phase II – Alternatives Analysis Draft Report' prepared by Environmental Partners, dated March 2014. (2014 Environmental Partners Alternatives Analysis Draft Report)

– 'Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod – Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning,' prepared by the Barnstable County Wastewater Cost Task Force, updated by AECOM – April 2010 (Updated April 2014 v2) (2010 CCC Cost Comparison Report)

– ‘Zoning Map Wellfleet, MA – April 2004’
– ‘Water Supply & Wastewater Disposal Study, Wellfleet MA’ prepared by Woodard & Curran & Lombardo Associates, Inc., dated October 2001. (2001 Woodard & Curran & Lombardo Associates Wastewater Study)

Datasets:

– 2018 – 2020 public water system usage data, provide by the Town of Wellfleet.
– Town of Wellfleet standardized assessor’s parcel mapping data set, last edited May 13, 2013.

Guidelines:

– ‘Guidelines for the Design, Construction, Operation and Maintenance of Small Wastewater Treatment Facilities with Land Disposal’, prepared by MassDEP and revised in July 2018 (2018 MassDEP Small WWTF Guidelines).

3. Preliminary Sewer Analysis

3.1 Centralized Sewer Areas

An analysis was conducted to identify potential areas for centralized sewer infrastructure as part of the Town’s MEP Threshold Compliance Approaches development. Areas targeted for sewering were developed based on a review of previous evaluations that have been completed as part of the Town’s nitrogen management planning process (2001 Woodard & Curran & Lombardo Associates Wastewater Study and 2014 Environmental Partners Alternatives Analysis Draft Report).

Previous evaluations identified Wellfleet’s “Central District” for potential sewering due to the density of parcels in this area. The Central District is shown on Wellfleet’s Zoning Map as portions of Kendrick Avenue, Commercial Street, Main Street, Bank Street, and Briar Lane. The Central District is located primarily in the Duck Creek and The Cove sub-watersheds of Wellfleet Harbor.

Centralized wastewater treatment nitrogen reduction targets were established for two MEP Threshold Compliance Approaches by Water Resources Consultant Scott Horsley as part of the 2022 Draft Wellfleet TWMP. Both approaches are outlined in Section 3.4. Centralized sewers areas were identified to meet the established nitrogen reduction targets in each sub-watershed based on a wastewater flow estimate analysis, described in Section 3.3.

3.2 Centralized Wastewater Treatment and Treated Effluent Recharge

During the TWMP process the Wellfleet Transfer Station Parcel (266 Coles Neck Road) was identified as a potential site for the infiltration of treated wastewater effluent from a potential future wastewater treatment facility. This evaluation presumes that centralized wastewater treatment and treated effluent recharge are located on the Wellfleet Transfer Station Parcel.

Field investigations (groundwater monitoring well installation, soil boring and hydraulic load testing) conducted by GHD in 2020 indicate a high infiltration rate at the site for treated effluent recharge. Conceptual layouts, developed during this evaluation, indicate adequate available area for treated effluent recharge up to 0.79 mgd average annual flow (based on a design hydraulic loading rate of 7 gpd/sf during maximum month conditions).

As part of the Transfer Station parcel evaluation, a local-scale groundwater flow model based on the USGS regional groundwater flow model (Masterson, 2004) was developed by GHD for the lower Cape Cod aquifer system. Effluent recharge simulation results provided by the local-scale model indicate that treated effluent discharge migration in groundwater to surface water is within the Herring River sub-watershed of the Wellfleet watershed.

Due to its location in a sub-watershed with a MEP nitrogen threshold target, this evaluation assumes that centralized treatment at the site will achieve an effluent Total Nitrogen concentration of 5 mg/L in order to minimize the re-introduction of nitrogen to the sub-watershed through treated effluent recharge. Each MEP

Threshold Compliance Approach outline in Section 3.4 includes an increased septic nitrogen reduction goal in the Herring River sub-watershed to offset nitrogen re-introduced to this sub-watershed through treated effluent recharge.

3.3 Wastewater Flow Estimate Development

3.3.1 Parcel with Available Water Use Data

Water usage data for 261 parcels for the years 2018 through 2020 within the Town of Wellfleet was provided by the Wellfleet Water District. This data was used to develop estimated wastewater flows for parcels within the Town connected to the Public Water Supply system. Two hundred and twenty (220) of the 261 parcels in the dataset had water usage (values greater than zero). The 41 parcels listed on public water supply with no apparent water usage during the study period were taken out of the dataset and assigned average water usage data based on MEP assumptions, as outlined in Section 3.3.2.

The water use information was joined to the most recent Assessor's data (May 13, 2013) by account numbers using GIS. A 90% conversion factor (which is consistent with the conversion factor used in the MEP reports) was used as an estimate to convert water usage to wastewater flow.

Table 1 summarizes average daily wastewater flows for properties with water use data. The relatively low per property single family residential wastewater flows are indicative of the seasonal nature of these properties, typically trending with higher water usage in the summer and lower water usage in the winter. Three-year average daily wastewater flows were used to calculate average per parcel nitrogen loads for this analysis. Peaking factors from regional wastewater treatment facilities of similar sizes were used to accommodate for the seasonality of the water usage in conceptual wastewater treatment facility sizing.

Table 1 Average Wastewater Flows for Parcels Connected to the Public Water Supply

Type of Parcel	Wastewater Flow[1]
Single Family Residential	82 gpd
Commercial	375 gpd

1. Wastewater flow was calculated using water usage data, provided by the Wellfleet Water District, for the years 2018 through 2020, and a 90% conversion factor from water usage to wastewater flow.

3.3.2 Parcels with No Available Water Use Data

MEP assumptions were used to estimate water usage for parcels not connected to the Public Water Supply. A 90% conversion factor was used to convert water usage to wastewater flow (allowing for an estimated outdoor water usage of 10%). MEP assumptions used in this analysis are summarized in Table 2. Wastewater flow assumptions were joined by land use code to the Town's most current available parcel data (May 13, 2013) through GIS.

Table 2 Wastewater Flow Assumptions for Parcels with No Available Water Use Data

Type of Parcel	Wastewater Flow
Single Family Residential[1]	145 gpd x 0.9 = 131 gpd/property
Multi-Family Residential[2]	290 gpd x 0.9 = 261 gpd/property
Commercial[1]	180 gpd / 1,000 SF of building
Industrial[1]	44 gpd / 1,000 SF of building

References:

1. "Massachusetts Estuaries Project – Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Wellfleet Harbor Embayment System Town of Wellfleet, Massachusetts Final Report – March 2017", prepared by the University of Massachusetts Dartmouth School of Marin Scient and Technology and Massachusetts Department of Environmental Protection – Table IV.2
2. "Massachusetts Estuaries Project – Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Wellfleet Harbor Embayment System Town of Wellfleet, Massachusetts Final Report – March 2017", prepared by the University of Massachusetts Dartmouth School of Marin Scient and Technology and

Type of Parcel	Wastewater Flow
Massachusetts Department of Environmental Protection – Section IV.1.2. Multi-family dwellings are classified as land use codes 109 or 111.	

3.4 MEP Threshold Compliance Approaches

Two alternate MEP Threshold Compliance Approaches were developed by Water Resources Consultant Scott Horsley as part of the Wellfleet Targeted Watershed Management Plan project to meet the Town's anticipated MEP Nitrogen Thresholds. Both compliance approaches are outlined in this section. Each compliance approach includes growth assumptions, developed by Scott Horsley, for a 20-year planning horizon through 2042.

3.4.1 Wellfleet MEP Hybrid Threshold Compliance Approach

The Wellfleet MEP Hybrid Threshold Compliance Approach (Table 3) incorporates multiple nitrogen management strategies to meet the Town's anticipated MEP Nitrogen Thresholds, including promising pilot technologies that the Town is currently investigating. Conceptual sewer areas for the municipal centralized wastewater collection system included in the Hybrid Approach is outlined in Figure 1.

Table 3 Wellfleet MEP Hybrid Threshold Compliance Approach

Nitrogen Management Strategy	Anticipated Nitrogen Reduction (kg/yr)							
	Herring River	Duck Creek	The Cove	Drummer / Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
I/A Systems Installed for New Construction (Treated Effluent TN = 8 mg/L)[1]	307	65	147	113	153	239	43	**1,069**
Conversion of Existing Title 5 Systems to I/A Systems (Treated Effluent TN = 8 mg/L)[1]	632	397	1,729	133	147	2,634	86	**5,758**
Fertilizer Mitigation (25% of Fertilizer Load)[1]	151	37	107	54	47	133	20	**549**
Stormwater Reductions (25% of Stormwater Loads[1]	164	42	108	55	45	104	16	**534**
Aquaculture / Shellfish Harvest[1]	0	0	0	945	0	600	405	**1,950**
Ecological Restoration[1]	0	0	317	0	0	0	0	**317**
Permeable Reactive Barrier[1]	0	0	0	0	0	0	0	**0**
Centralized Collection and Treatment – Private[1]	0	88	0	0	0	146	0	**234**
Centralized Collection and Treatment – Municipal[1]	0	879	458	0	0	0	0	**1,337**
Treated Effluent Nitrogen Load Recharge to Watershed (Treated Effluent TN = 5 mg/L)[1]	-255	0	0	0	0	0	0	**-255**
Total Anticipated N Reduction (2042)[1]	**999**	**1,509**	**2,866**	**1,300**	**392**	**3,856**	**571**	**11,493**
Anticipated N Reduction Required to Meet MEP Thresholds (2042)[1]	**999**	**1,509**	**2,866**	**1,300**	**392**	**3,856**	**571**	**11,493**

References:

1. 'Wellfleet Harbor Targeted Watershed Management Plan – Draft Final Report', prepared by Scott Horsley, Water Resources Consultant and dated June 15, 2022.

3.4.2 Wellfleet MEP Traditional Threshold Compliance Approach

The Wellfleet MEP Hybrid Threshold Compliance Approach (Table 4) provides a conservative estimate of additional centralized wastewater collection and treatment that would be required if the pilot projects included in MEP Hybrid Threshold Compliance Approach did not perform as anticipated. Conceptual sewer areas for the municipal centralized wastewater collection system outlined in Traditional Approach is outlined in Figure 2.

Table 4 Wellfleet MEP Traditional Threshold Compliance Approach

Nitrogen Management Strategy	Anticipated Nitrogen Reduction (kg/yr)							
	Herring River	Duck Creek	The Cove	Drummer / Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
I/A Systems Installed for New Construction (Treated Effluent TN = 19 mg/L)[1]	106	24	47	40	61	80	14	**371**
Conversion of Existing Title 5 Systems to I/A Systems (Treated Effluent TN = 19 mg/L)[1]	625	0	1	241	331	374	1	**1,573**
Centralized Collection and Treatment – Private[1]	0	88	0	0	0	146	0	**234**
Centralized Collection and Treatment – Municipal[1]	2,460	1,397	2,819	1,019	0	3,256	556	**11,507**
Treated Effluent Nitrogen Load Recharge to Watershed (Treated Effluent TN = 5 mg/L)[1]	-2,192	0	0	0	0	0	0	**-2,192**
Total Anticipated N Reduction (2042)[1]	**999**	**1,509**	**2,866**	**1,300**	**392**	**3,856**	**571**	**11,493**
Anticipated N Reduction Required to Meet Watershed TMDL (2042)[1]	**999**	**1,509**	**2,866**	**1,300**	**392**	**3,856**	**571**	**11,493**

References:

'Wellfleet Harbor Targeted Watershed Management Plan – Draft Final Report', prepared by Scott Horsley, Water Resources Consultant and dated June 15, 2022.

3.5 Conceptual Cost Estimates

3.5.1 Basis of Design – Conceptual

Table 5 outlines the conceptual basis of design that was used to develop conceptual cost estimates for this project.

Table 5 Preliminary Centralized Infrastructure Basis of Design

	MEP Hybrid Threshold Approach	MEP Traditional Threshold Approach
Approximate Number of Properties Connected to Centralized System[1]	278	2,385
Average Annual Raw Wastewater Flow (gpd)[2]	37,000 gpd	318,000 gpd
Maximum Day Raw Wastewater Flow (gpd)[2,3]	59,000 gpd	1,004,700 gpd
Assumed Centralized Treatment Effluent Total Nitrogen Concentration (mg/L)	5 mg/L	5 mg/L

	MEP Hybrid Threshold Approach	MEP Traditional Threshold Approach
Net Nitrogen Removal (kg/yr)[4]	1,082 kg/yr	9,315 kg/yr

Notes:

1. Approximate number of properties connected to the centralized system was calculated based on removal of an average per parcel nitrogen load of 4.73 kg/yr/property through sewering (equivalent to an average single family residential wastewater generation rate of 131 gpd/property). This number will be refined once a collection system technology is selected, and the conceptual layouts outlined in Figures 1 and 2 are refined based on that technology.
2. Flow estimates include only flow from wastewater generation. An estimate for infiltration and inflow (I/I) will need to be incorporated into the flow estimate once a collection system technology is selected and a preliminary layout for that technology is developed.
3. Maximum day flows were estimated using peaking factors of other regional wastewater treatment facilities (WWTFs) of a similar size for each Compliance Approach.
4. Net nitrogen removal = Raw wastewater nitrogen removed from groundwater minus treated effluent nitrogen recharged to groundwater

The following assumptions were used to develop the conceptual cost estimates:

– Centralized Collection System (gravity/low pressure collection system, raw wastewater pump stations, and force main systems)
  - Recent Cape Cod construction bids from Chatham, Barnstable and Falmouth were used to develop an average per parcel construction cost for the collection system. Construction bids used for the analysis included a range of low pressure and gravity main lengths, force main lengths, and number of pump stations in the system, and is intended to estimate an average cost of these types of systems.
  - Anticipated costs to acquire any privately owned land for pump stations was not included in the conceptual cost estimates.
  - The construction cost estimate includes estimated costs for linear infrastructure only within the road right-of-way, not on private property.
  - An allowance of $11,550 (2022$) was carried for sewer lateral installations from the property line to the house for each anticipated connection. The allowance was developed based on regional average costs for single-residential house lateral installations. Lateral installation costs are typically incurred by a property owner (not the Town) – a lateral allowance was included in this analysis to allow for comparison of anticipated costs for centralized treatment versus other nitrogen management strategies.
  - Procurement and installation of grinder pumps required for a low-pressure system are not included in the cost estimate.
  - Estimated costs assume that no hazardous materials or other materials that require special handling are encountered.

– Centralized Wastewater Treatment and Effluent Recharge
  - Cost estimates assume that raw wastewater is pumped to a centralized wastewater treatment facility at the Wellfleet Transfer Station Parcel for treatment and treated effluent recharge through open sand beds at the same site.
    – Since the Wellfleet Transfer Station Parcel is located within the Herring River sub-watershed, which has an MEP Nitrogen Threshold, a facility capable of meeting a TN effluent concentration of 5 mg/L is the basis for this analysis.
    – Effluent recharge through open sand beds.
  - Wastewater Treatment Facility (WWTF) cost estimates were developed based on the planning values outlined in the 'Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod – Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning,' prepared by the Barnstable County Wastewater Cost Task Force – April 2010, updated by AECOM (updated April 2014 v2). These costs were adjusted to 2022 dollars. Once a construction timeframe is known, project costs should be adjusted to the anticipated mid-

point of construction for the project. WWTF cost estimates were compared to regional project cost estimates for similarly sized infrastructure to confirm appropriate order of magnitude.

- Estimated costs assume that no hazardous materials or other materials that require special handling are encountered.

3.5.2 Engineers Opinion of Probable Capital Costs for Centralized Treatment, Collection, and Recharge – Conceptual

The Engineer's opinion of probable capital costs for centralized collection, treatment, and recharge facilities, in 2022 dollars, is outlined in Table 6. The cost estimates represent total estimated project costs with allowances for construction costs for items identified in Section 3.5.1. These costs also include the following:

– 30 percent construction contingency. Because of the conceptual nature of this evaluation, a 30 percent construction contingency is carried for planning purposes since no detailed design and no survey has been performed. As design progresses, a reduced contingency will be carried for variability in bidding climate, project changes before bidding, easements, and change orders due to unforeseen conditions

– 10 percent engineering design allowance.

– A 30 percent allowance for construction phase engineering services, legal/fiscal/permitting/administrative costs, survey and soil borings allowance, and police allowance for linear work (collection system installation) and a 20 percent allowance for construction phase engineering services and legal/fiscal/permitting/administrative costs allowance for wastewater treatment facility work. The allowance for construction phases services for linear work and wastewater treatment facility work are assigned based on the type of infrastructure and are additive in the cost estimate.

  A sewer lateral allowance to allow for comparison to the costs of other nitrogen management strategies (sewer lateral costs from a property line to an individual house are typically incurred by a property owner, not the Town).

Project costs are presented in 2022 dollars. Once a construction timeframe is known, project costs should be adjusted to the anticipated mid-point of construction.

Table 6 Engineers Opinion of Probable Capital Costs (2022$)[1,2]

	MEP Hybrid Threshold Approach	MEP Traditional Threshold Approach
Collection System Construction Total	$9.4 M	$80.4 M
Wastewater Treatment Facility Construction Total	$10.9 M	$32.7 M
Municipal Centralized Infrastructure Construction Total (ENR March 2022 = 12791)	**$20.3 M**	**$113.2 M**
Design Allowance	$2.0 M	$11.3 M
Construction Phase Services, Legal, Fiscal & Engineering allowance, soil borings, survey, and police allowance for linear work plus Construction Phase Services, Legal, Fiscal & Engineering allowance for Wastewater Treatment Facility work[3]	$5.0 M	$30.7 M
Sewer Lateral Allowance[4]	$3.2 M	$27.5 M
Total Municipal Centralized Infrastructure Capital Costs (ENR March 2022 = 12791)	**$30.5 M**	**$182.7 M**

Notes:

1. Total Capital Costs include allowances for construction costs such as: a 30% construction contingency; 10% engineering design allowance; 30% allowance for construction phase services, legal/fiscal/permitting/administrative costs, survey, soil borings, and police allowance for linear work; and a 20% allowance for construction phase services and legal/fiscal/permitting/administrative costs allowance for wastewater treatment facility work.

	MEP Hybrid Threshold Approach	MEP Traditional Threshold Approach

2. GHD has prepared the preliminary cost estimate outlined in this memorandum using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD based on previous Cape Cod bidding prices. The cost estimate has been prepared for the purpose of a preliminary evaluation of alternatives and must not be used for any other purposes. The cost estimate is a preliminary estimate only. Any effect on prices, costs, and other variables arising from the effects of the spread of COVID-19 and its impacts on the supply chain have not been factored into the cost estimate.
3. A 30 percent allowance was included for construction phase engineering services, legal/fiscal/permitting/administrative costs, survey and soil borings allowance, and police allowance for linear work (collection system installation), and a 20 percent allowance was included for construction phase engineering services and legal/fiscal/permitting/administrative costs allowance for wastewater treatment facility work.
4. An allowance of $11,550 (2022$) was carried for lateral installations from the property line to the house for each anticipated connection. The allowance was developed based on regional average costs for single-residential house lateral installations. Lateral installation costs are typically incurred by a property owner (not the Town) – a lateral allowance was included in this analysis to allow for comparison of anticipated costs for centralized treatment versus other nitrogen management strategies.

4. Next Steps

Once an MEP Threshold Compliance Approach is selected as part of the TWMP process, the following steps are recommended to refine the analysis presented in this memorandum:

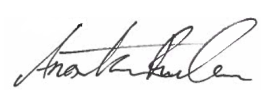
– Initiate design of the collection system in the identified proposed sewer areas. Conduct an analysis to identify potential pump station sites in the identified proposed sewer areas, and develop a SewerCAD model to evaluate the extent to which gravity sewer is feasible within each sewer area. Refine conceptual cost estimates based on selected technology.

– Initiate design and permitting for a future centralized wastewater treatment facility.

5. Scope and Limitations

This technical memorandum has been prepared by GHD for the Town of Wellfleet, MA. The matters discussed in this memorandum are limited to those specifically detailed in the memorandum and are subject to any limitations or assumptions specially set out.

Regards



Anastasia Rudenko PE, BCEE, ENV SP
Project Manager

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001 Feet

GHD

TOWN OF WELLFLEET, MASSACHUSETTS
PRELIMINARY SEWER ANALYSIS

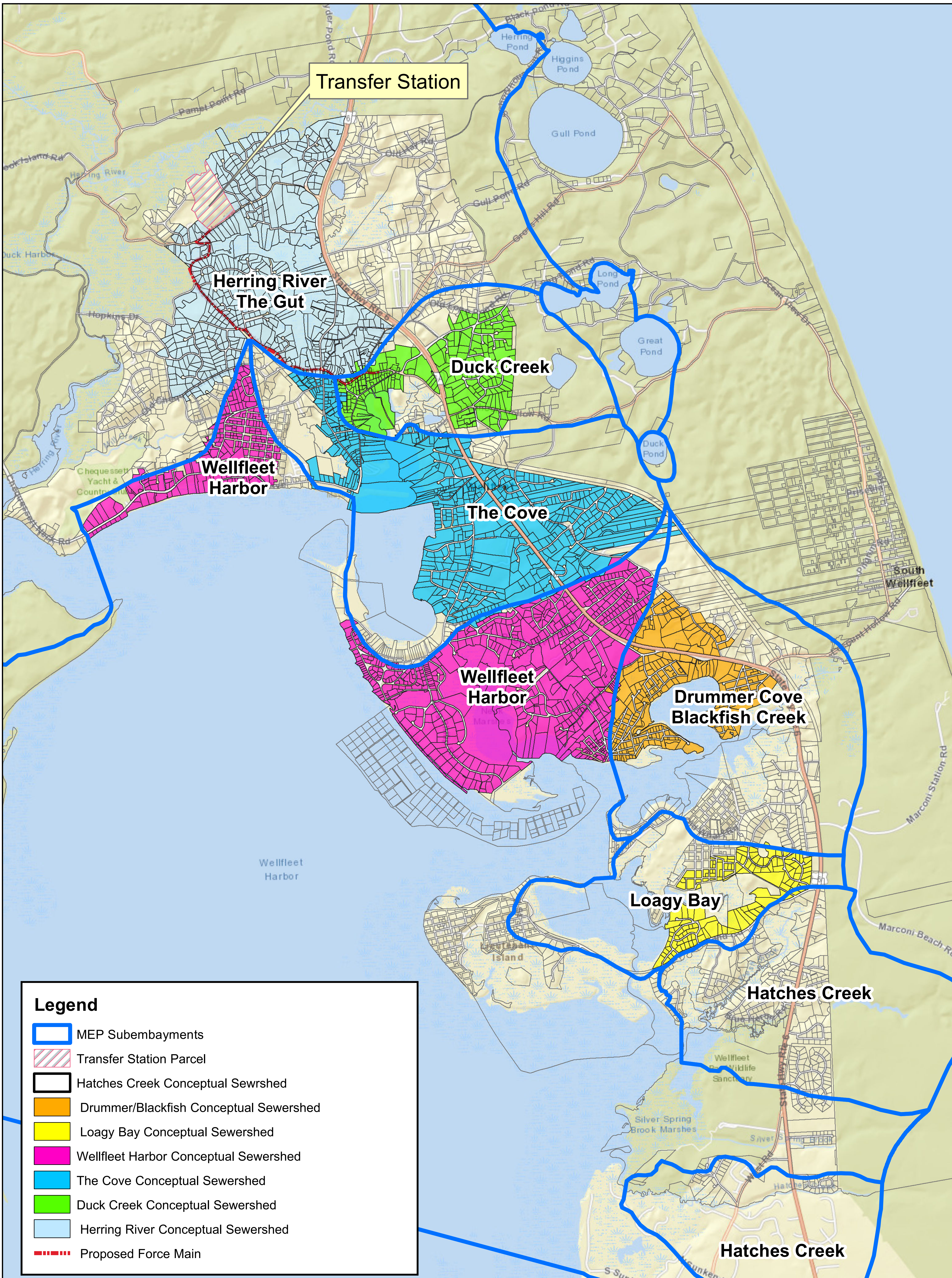
MEP THRESHOLD HYBRID COMPLIANCE APPROACH - CONCEPTUAL SEWERSHED LAYOUT

Project No. 11216492
Revision No. -
Date 05/27/2022

FIGURE 1

C:\data\Wellfleet\FIGURE 1 CONCEPTUAL SEWERSHED LAYOUT.mxd
Print date: 27 May 2022 - 10:37

Data source: MassGIS. Created by: jobrien



Notes:

1. Analysis based on nitrogen reduction estimates calculated by Scott Horsley.
2. Estimated per parcel wastewater generated rates based on 2018-2022 water use data for parcels and MEP assumptions for parcels with private water.

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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001 Feet

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GHD

TOWN OF WELLFLEET, MASSACHUSETTS
PRELIMINARY SEWER ANALYSIS

MEP THRESHOLD TRADITIONAL COMPLIANCE APPROACH - CONCEPTUAL SEWERSHED LAYOUT

Project No. 11216492
Revision No. -
Date 05/27/2022

FIGURE 2

C:\data\Wellfleet\FIGURE 2 CONCEPTUAL SEWERSHED LAYOUT.mxd
Print date: 27 May 2022 - 10:29

Data source: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community. Created by: jjobrien

Shellfish Aquaculture Plan, Years One-Five

Year One:

In the first year of the Shellfish Aquaculture program, the first of the four rotating closure areas will be created in Loagy Bay. Loagy Bay has ~4 acres of usable area in which to culch and seed. The plan then is to close the area for 2-3 years to allow the shellfish to grow and to filter nitrogen from the water column before being opened to harvest. As per the estimated budget, the year one expenses are estimated to be $69,900.

Year Two:

The second year of the Shellfish Aquaculture program will see the Duck Creek area culched, seeded, closed for 2-3 years. In the second year, the quahog input for Loagy Bay will also be increased. Due to many of the startup costs already having been covered in the first year, the estimated budget for the second year is only $26,400.

Year Three:

In year three of the Shellfish Aquaculture program, ~1 acre of The Cove (Chipman's Cove) will be heavily culched, seeded, and closed for 2-3 years. The shellfish in Loagy Bay will be checked to see if they are ready for harvest. If they are, they will then be harvested. If not, they will be harvested the following year. The estimated budget for this year is just $23,200.

Year Four

In year four of the Shellfish Aquaculture program, ~4 acres of Blackfish Creek will be culched, seeded, and closed for 2-3 years. The shellfish in Duck Creek will be checked to see if they are fit to be harvested, and if they are they will then be harvested. If the Duck Creek shellfish are not ready, they will be harvested the following year. The estimated budget for this year is $55,800.

Year Five:

In year five of the Shellfish Aquaculture program, Loagy Bay will be re-culched and seeded and closed again for 2-3 years. At this time the shellfish in Blackfish Creek will be checked to see if they are suitable to be harvested. If they are then the area will be opened to harvest. If they are not, they will be harvested the following year. The estimated budget for this year is $33,400. The total estimated budget for years 1-5 is $208,700.

25 Year Plan

- Areas of Focus: Chipman's Cove (the Cove), Duck Creek, Loagy Bay, Blackfish Creek
- Pilot project years 1 - 5

Budget

<table>
<tr><th>Year</th><th>Plan Outline</th></tr>
<tr><td>1</td><td>Plan: heavily cultch 4 acres of Loagy Bay, close for 2-3 years

Materials and estimated costs for year 1:

Cultch: 8 loads ($1,000 per load)
$8,000
Oyster Seed: 100k pieces, size R12 ($54 per 1,000)
$5,400
Oyster Spawning Stock: 40k legal oysters from farmers ($0.45/piece)
$18,000
Upweller: 1 (~12,000 each)
$12,000
Quahog Seed:
100k pieces, size R 3/4 or largest available ($67 per 1,000)
$6,700
1 million pieces, size 1.5-2 mm ($14 per 1,000)
This will go into the upweller with 60% survivability
It will be ~3 years before we will get full N value per piece (before they can be harvested)
These will be planted on town grant in fall at high density pre-commercial harvest relaying to grow out-site
$14,000
Quahog Spawning Stock: 200 bushels of contaminated quahog ($26 per bushel)
$5,200
Physical gear, rebar, netting, U-hooks, etc ($600)
$600
Employee (Get reporting expectations/time requirements from Scott)
Will need an employee to assist with upweller - likely part-time to start, will depend on monitoring/reporting requirements, etc

Total Expected Cost: $69,900
Expected Landings:
Expected N Attenuation:</td></tr>
</table>

2	Plan: heavily cultch Duck Creek, close for 2-3 years, increase quahog input for the Loagy Bay
	
	Materials and estimated costs for year 2:
	
	● Cultch: 5 loads ($1,000 per load)
	    ○ $5,000
	● Oyster Seed:100k pieces, size R8, purchasing to allow to grow, will use in year 3 as spawning stock ($41 per 1,000)
	    ○ $4,100
	● Oyster Spawning Stock: Will use oyster seed from year one
	    ○ $0
	● Quahog Seed:
	    ○ 1 million pieces, size 1.5-2 mm ($14 per 1,000)
	    ○ This will go into the upweller with 60% survivability
	    ○ It will be ~3 years before we will get full N value per piece (before they can be harvested)
	    ○ These will be planted on town grant in fall at high density pre-commercial harvest relaying to grow out-site
	    ○ Will distribute 500,000 in the Cove 100,000 in Duck Creek from year 2 upweller seed
	    ○ $14,000
	● Physical gear, rebar, netting, U-hooks, etc ($600)
	    ○ $600
	● Spawning Stock: will come from contaminated relay (100 bushels, $27 per bushel)
	    ○ $2,700
	● Employee
	
	Total Expected Cost: $26,400
	Expected Landings:
	Expected N Attenuation:

3	Cultch ~1 acre of the Cove; close for 2-3 years Deploy normal amounts of cultch in the Cove per normal operating procedures (8-10 strips) Materials and estimated costs for year 3: ● Cultch: 2 loads ($1,000 per load) ○ $2,000 ● Oyster Seed:100k pieces, size R8, purchasing to allow to grow, will use in year 4 as spawning stock ($41 per 1,000) ○ $4,100 ● Oyster Spawning Stock: Will use oyster seed from year 2 ○ $0 ● Quahog Seed: ○ 1 million pieces, size 1.5-2 mm ($14 per 1,000) ○ This will go into the upweller with 60% survivability ○ It will be ~3 years before we will get full N value per piece (before they can be harvested) ○ These will be planted on town grant in fall at high density pre-commercial harvest relaying to grow out-site ○ Will distribute 500,000 in the Cove 100,000 in Duck Creek from year 2 upweller seed ○ $14,000 ● Physical gear, rebar, netting, U-hooks, etc ($300) ○ $300 ● Spawning Stock: will come from contaminated relay (100 bushels, $28 per bushel) ○ $2,800 ● Employee Total Expected Cost: $23,200 Expected Landings: Expected N Attenuation:

4	Blackfish Creek, close 2-3 years (4 acres); Harvest Duck Creek Materials and estimated costs for year 4: ● Cultch: 10 loads of cultch ○ $10,000 ● Oyster Seed: 100k pieces, size R12 ($54 per 1,000) ○ $5,400 ● Spawning Stock: Will use oyster seed from year 3 ○ $0 ○ And 40,000 from farmers at 50c/piece ○ $20,000 ● Quahog Seed: ○ 1 million pieces, size 1.5-2 mm ($14 per 1,000) ○ This will go into the upweller with 60% survivability ○ It will be ~3 years before we will get full N value per piece (before they can be harvested) ○ These will be planted on town grant in fall at high density pre-commercial harvest relaying to grow out-site ○ Distribute 600,000 from year 3 to Blackfish Creek ○ $14,000 ● Spawning Stock: 200 bushels of contaminated quahog, ($29 per bushel) ○ $5,800 ● Gear ($600) ○ $600 ● Employee Total Expected Cost: $55,800 Expected Landings: Expected N Attenuation:

5	Harvest Blackfish Creek; Close Loagy Bay
	
	Materials Needed for Year 5:
	
	● Cultch: 8 loads
	    ○ $8,000
	● Oyster Seed: 100k pieces, size R12 ($54 per 1,000)
	    ○ $5,400
	● Spawning Stock: Use oyster seed from year 2
	    ○ $0
	● Quahog Seed:
	    ○ 1 million pieces, size 1.5-2 mm ($14 per 1,000)
	    ○ This will go into the upweller with 60% survivability
	    ○ It will be ~3 years before we will get full N value per piece (before they can be harvested)
	    ○ These will be planted on town grant in fall at high density pre-commercial harvest relaying to grow out-site
	    ○ Distribute 600,000 from year 4 to Loagy Bay
	    ○ $14,000
	● Spawning Stock (quahog): 200 bushels of contaminated quahog ($30 per bushel)
	    ○ $6,000
	● Employee
	
	Total Expected Cost: $33,400
	Total Expected Cost years 1-5: $208,700
	Expected Landings:
	Expected N Attenuation:

10	
15	
20	
25	

SIZE (mm)		PRICE (Per 1,000 SEED)			
Sieve Size (mm)	**Size Range of Seed** Actual Size in Millimeters (mm)	**Quahog** *M.Mercenaria*	**Diploid Oyster** *C.Virginica*	**Triploid Oyster*** *Price* **includes** *15% Triploid Royalty Fee*	**Surf clam** *S.Solidissima*
R-1.5	2.0 – 3.2	$13.40	$11.60	$13.35	$12.40
R-2	3.2 – 4.2	$16.00	$13.40	$15.41	$15.50
R-3	4.2 – 5.3	$18.55	$18.55	$21.33	$17.50
R-4	5.3 – 8.0	$23.20	$24.20	$27.83	$22.70
R-6	8.0 – 11.0	$28.85	$32.00	$36.80	$26.80
R-8	11.0 – 16.4	$38.00	$40.20	$46.23	—
R-12	15.0 – 20.0	$53.50	$53.50	$61.53	—
R-3/4	20.0 – 25.0	$67.00	$67.00	$77.05	—

Summary of Impaired Wetland Sites within the Wellfleet Harbor Watershed East of Mayo Creek

Ryan Curley
12/20/2019

This is a summary of impaired wetlands that may be considered for coastal habitat restorations within the Wellfleet Harbor Watershed, excluding the pre-existing Herring River and Mayo Creek restoration projects. Many of these sites would need to involve the joint participation of MassDOT and the DCR due to constructed infrastructure. MassDOT is responsible for US RT 6 and the culverts running under it. The DCR is responsible for the Cape Cod Rail Trail (CCRT) and its respective culverts. The CCRT runs along a parallel route just east of US RT 6. MassDOT might be able to offset a small portion of the cost along sections that due for maintenance. Both MassDOT and DCR have recent examples of ecosystem restoration projects, Muddy Creek in Chatham and the Bass River bridge in Yarmouth, respectively.

Locations from North to South

Hawes Pond
Eastern Blackfish Creek
Trout Brook, Upper Basin
Fresh Brook
Silver Spring
Hatch's Creek
N. Sunken Meadow

See this for a map if needed.
https://bit.ly/2QbU9b6

Hawes Pond

41.9389, -70.02254

Hawes Pond and the attendant creek runs from the intersection of Main St and Rt 6 directly north. Overall the system comprises 2 1/4 acres and serves as the headwaters of Duck Creek. The current culvert has a duckbill. Over the years, the culvert has been open, closed, opened, and closed, back and forth. There has been a contest for jurisdiction over the culvert. It is my understanding that the Inn (The Wagner) upland of the pond has concerns about water levels. The intersection is due to be rebuilt soon with plans advanced by Mass DOT. I am not aware of any plans to charge the culvert as part of the redesign of the intersection. The wetlands used to be dominated by native cattails, but phragmites have primarily supplanted them. There was an androgynous eel run at the location until recently. There are no measurements on water flow or TN concentrations at this location.

Eastern Blackfish Creek

41.91481, -69.98638

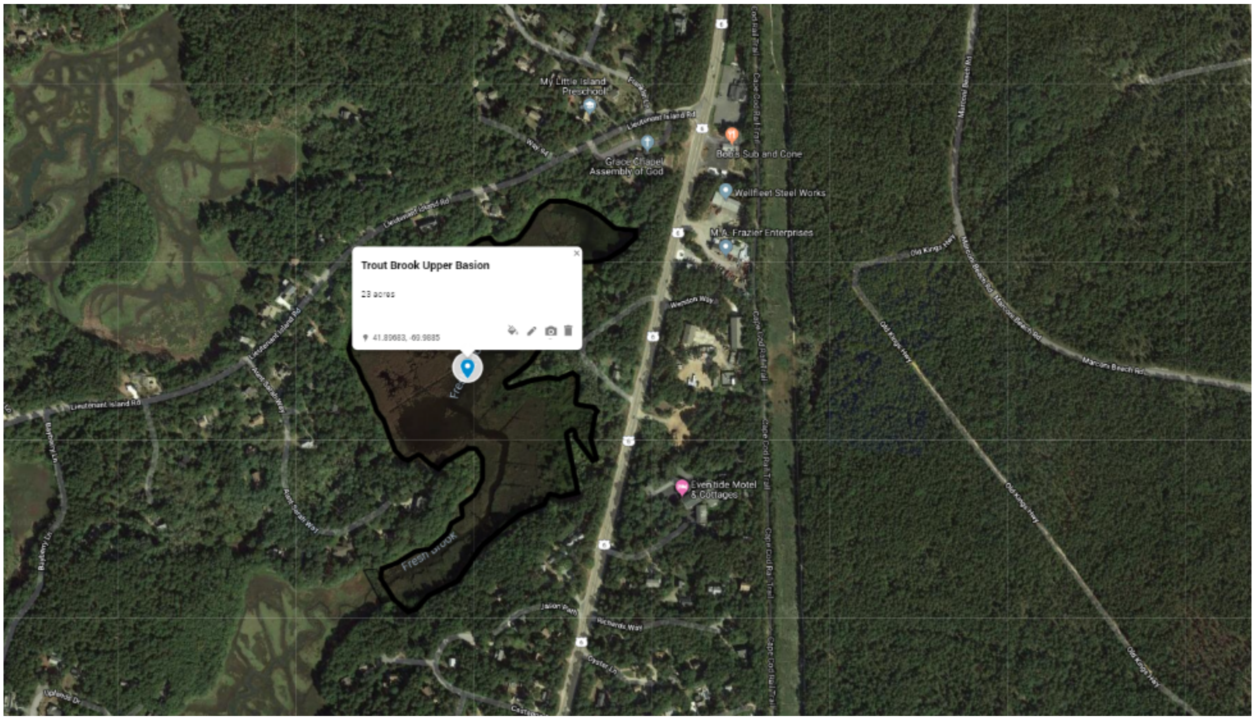
Eastern Blackfish Creek is impounded behind causeways for Rt 6 and the CCRT. It is a degraded freshwater dominated marsh ringed by phragmites. Overall the area is a minimum of 13 acres, with a high estimate is somewhere between 18-20 acres, depending on topography.

There are only two abutters, making it likely that full restoration can be performed. The marsh is owned by a private landowners, the town of Wellfleet, & the Cape Cod National Seashore(CCNS). The RT 6 causeway at this location is vulnerable to flooding and scored a 6 out 10 in terms of risk through the state's MVP program. This stretch of road provides the only connection between Wellfleet, Truro & Provincetown, and the rest of the Cape.

Vehicular access must be maintained throughout any construction. There may be a need to do channel modifications. In terms of nutrient mitigation, there is a limited septic load entering the eastern basin. The MEP subembayments for this area do not provide a basis for estimating the nutrient load within the easternmost segment of the marsh. A quick note directly to the south of this location, there is a small 1/2 acre impounded saltwater pond (41.91042, -69.98582) that sits between RT 6 and the Gestalt International Study Center.

Trout Brook, Upper Basin

41.89683, -69.9885



South of LT. Island Road West of Rt 6.

Trout Brook's upper basin is 23+ acres of a highly degraded marsh. As late as 1944, the area was an active cranberry bog. The entirety of the upper basin is privately owned. There is a dike at the outlet of the upper basin, and the channel is constricted. There are no roadways traversing the system. Phragmites characterize much of the upper basin, with the exception being the areas of standing water. The River mouth is identified in the 2017 MEP report, but no sampling or measurements of streamflow rates were performed. Historically there was an androgynous trout run in the brook. The entirety of Trout Brook has a local anthropocentric load of 562kg/y TN with the build-out scenario adding 505kg/y TN. A rough estimate is that this load is split 50:50 between the upper and lower basin.

Fresh Brook

41.89065, -69.98731

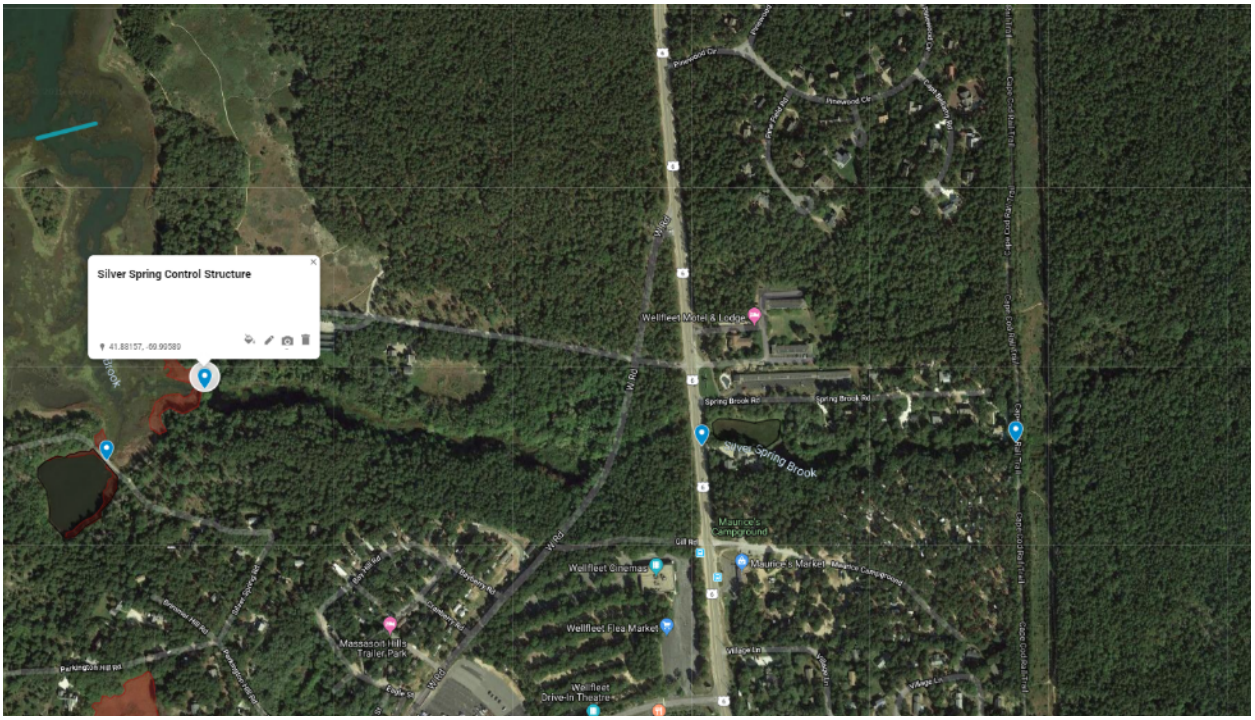
Historically the Fresh Brook was navigable to the now-abandoned Fresh Brook Village, located where Old Kings Highway intersects the brook (41.89116, -69.97483). Upper Fresh Brook was freshwater transitioning to brackish water in the mid to lower reaches. Historically this brook had an androgynous trout run. There are two culverts, one under Rt 6, one under the CCRT, and there might be a third under Old Kings Highway. There is a small retention dam to the immediate east of the CCRT. The area to the east of Old Kings Highway has swamp-like conditions. Phragmites dominate the entirety of the upper stream bed until shortly before Old Kings Highway. Phragmites start to the west of Rt 6, which indicates that the enlarging the culverts would have little effect without channel modifications to increase tidal flow.

MEP measured the flow and nitrogen concentrations at the RT 6 culvert. Fresh Brook has a discharge rate of between 2344-2546m3/d. The measured TN concentration was .561mg/L. The Mass Audubon Wellfleet Bay Sanctuary largely controls the stream bed to the west of RT 6. The Eastern portion is mostly within the CCNS There are 13 privately held lots covering a distance of approximately a quarter of a mile separating the Audubon and the Cape Cod National Seashore. Upper Fresh Brook has an anthropocentric load of 472kg/y TN, with build-out adding and additional 123kg/y. The area East of RT6 is at minimum 9 acres and could be significantly larger

It is highly likely the entirety of the stream bed, and the outer channel would need modifications to restore flow. The brook historically transitioned to freshwater, determining where this occurred would be necessary if the goal is to restore it to its natural state. The low salinity conditions at this transition zone would indicate that a restoration may have minimal impact on the phragmites stands to the east of this transition. The removal of the retention dam could cause drying of some soils. Evaluation of the topography of the stream bed and riparian area to the east of the retention dam is critical.

Silver Spring

41.88157, -69.99589

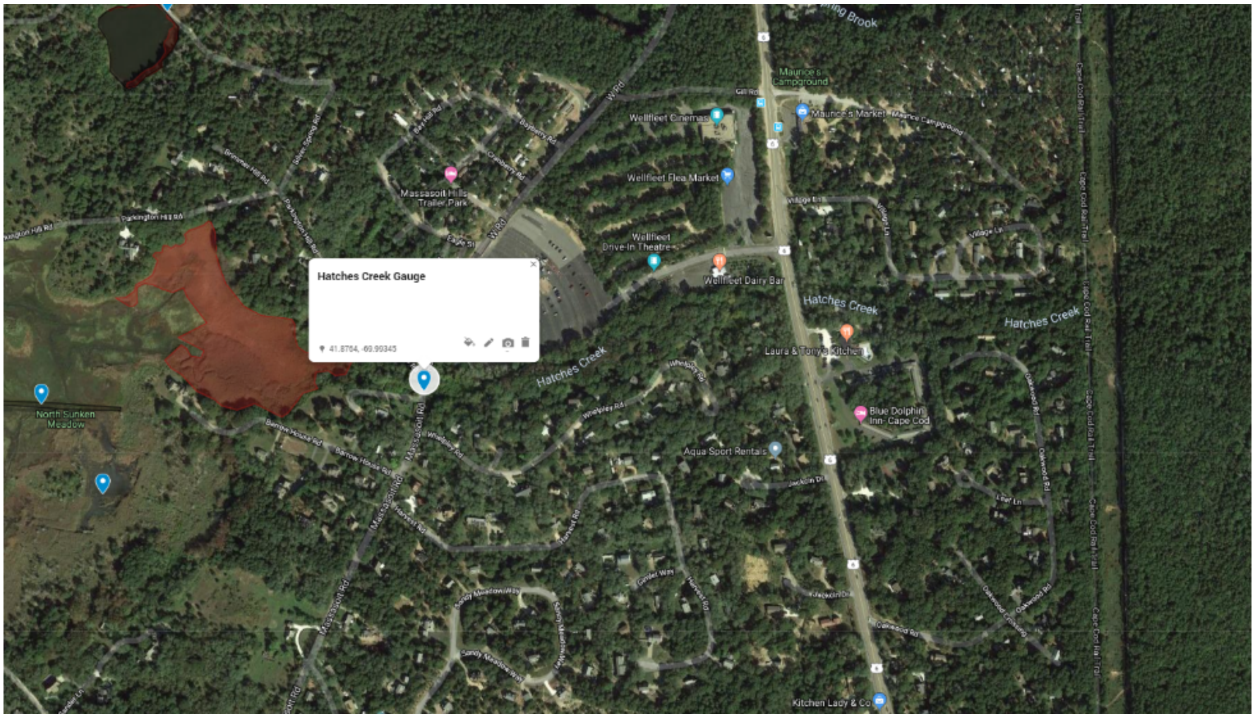


The Mass Audubon Wellfleet Bay Sanctuary, has a control structure on Silver Spring directly south of their facilities. The area upstream of the control structure is freshwater. From this structure, the stream runs for a third of a mile to West Rd. There is a culvert under West Rd and another under RT 6. Directly after Rt 6, there is an out of use cranberry bog of approximately 2/3rds of an acre, and a retention structure. From this point, the stream runs about 1000 ft to the CCRT, where there is another culvert, and the stream peters out within 100 ft. Mass Audubon owns the entirety of the streambed west of Rt 6, east of RT 6 it privately owned until it reaches the CCRT. Current anthropocentric loading is low at 208kg/yr TN. The build-out scenario includes an 889kg increase in load.

The Mass Audubon Wellfleet Bay Sanctuary ultimately controls the stream and might be managing it for a specific habitat type. The riparian zone is the widest west of West Rd. A channel modification would likely be necessary. Converting the cranberry bog to a permanent wetland would be beneficial even without tidal restoration.

Hatch's Creek Gauge

41.8764, -69.99345



Hatch's Creek marks the town line between Wellfleet and Eastham. The system first forks from Hatches Creek, into Hatches Creek and Sunken Meadow, and again into N. Sunken Meadow and Hatches Creek. MEP identifies this sub-basin as "Hatches Creek Gauge," this starts directly to the east of West Rd and consists of a freshwater stream. The creek runs east under West Road alongside the Wellfleet Drive-In to RT 6, where there is a culvert. From there, it travels about 1200ft to the Cape Cod Rail trail where it terminates. Historically the stream continued on for about another 800ft towards old county rd. To the West of West Road, the creek is choked by phragmites until it opens out into a salt marsh. Wellfleet has jurisdiction over the north bank and Eastham of the southern bank. East of West road, there are several houses built on the riparian zone of the stream. The majority of the stream is privately owned.

Hatch's Creek at the gauge has a measured discharge rate 743-836m3/d. The measured TN concentration was TN of 2.613mg/l. The current anthropocentric load is 520kg/yr TN, build-out adds 700 kg/yr TN. The presence of several houses built in the riparian zone and would make any restoration attempt difficult.

N. Sunken Meadow (Eastham)

41.87625, -69.99934

N. Sunken meadow lies directly to the south of Hatch's Creek in Eastham. This marsh is a promising location for a restoration effort. There is ponding on the surface of the marsh and limited flow. There is a raised strip that runs directly east to west (41.87625, -69.99934). The USGS 1:25000-scale Quadrangle for Wellfleet, MA 1972 marks this strip as a dirt road. I have attached the relevant map. This road does not appear on the 1958 map.