Note: Start Time of 7pm

The Wellfleet Selectboard will hold a public meeting on **Tuesday, November 2, 2021, at 7:00 p.m. This meeting will be held via Zoom Video Conference** in accordance with the temporary suspension and enhancement of the Open Meeting Law requirements by Governor Baker. Instructions for a Zoom video conference meeting which also allows phone dial-in are given below:

1. Join the meeting hosted in Zoom by using the following link: https://us02web.zoom.us/j/85689604806?pwd=blplVFFBZzVi[illegible]0xNWkZKMm9iMVdrdz09
2. Audio, video, chat, and screen sharing functions will be disabled during the public session. Request to participate by using the "raise hand" function. **Meeting ID: 856 8960 4806 | Passcode: 611877**
    a. Raise hand in smartphone app – touch bottom of your screen and select "more" - hit "raise hand" button
    b. Raise hand on computer – hit "participants" button on bottom of screen – hit "raise hand" button on bottom of participants panel
    c. Please make sure you properly identify yourself before speaking, rename yourself by selecting the participants button and choosing "more" (or by holding down on your name on a smartphone app) and selecting "rename" - full, legal names only.
    d. Please join the meeting on time.
3. You may also listen to the meeting by calling in on a phone to **+1 929 205 6099** and enter **Meeting ID: 856 8960 4806 | Passcode: 611877** Landline callers can participate by **dialing *9 to raise their hand.**
4. You may submit questions and comments to the Town using the following email: executive.assistant@wellfleet-ma.gov Comments made during the meeting via e-mail will be sent to Selectboard members AFTER the meeting.
5. Meeting materials are attached to this agenda, available online at Wellfleet-ma.gov. It is recommended that phone participants access materials in advance of the meeting.
6. **Please follow the following general instructions:**
    a. Keep your phone muted at all times when not talking; no one is allowed to unmute themselves during the meeting.
        i. Selectboard meetings are NOT interactive. If public comments are allowed that's all, comments only, not questions.
        ii. If the Chair is allowing comments during the meeting the number of comments will be limited and may be **no longer than one minute**.
    b. Do not use speakerphone; do not use Bluetooth devices; mute all background noise.
    c. Please do not speak until the Chair asks for public comments or questions and you have been recognized by the moderator and unmuted.
    d. After the business section is complete no public comments are permitted. Future agenda items are from the Selectboard, no one else.
7. It is anticipated that the meeting will be recorded by the Town. Anyone else desiring to record the meeting may do so only after notifying the chair and may not interfere with the conduct of the meeting in doing so.

I. Announcements, Open Session and Public Comments

Note: Public comments must be brief. The Board will not deliberate or vote on any matter raised solely during Announcements & Public Comments.

II. Consent Agenda Approval without objection is required for the following items.

III. Public Hearings

- FY2022 Tax Rate Classification Public Hearing, Discussion and Vote

IV. Business- Wastewater Planning

- Financing
- Status of 2021 Annual Town Meeting Articles
- Public Participation Components
- Town Planning Process
- Treatments per Subembayment
- Review of Draft Targeted Watershed Plan
- Impact of Sea Level Rise

V. Topics for Future Discussion

VI. Future Meetings

VII. Adjournment

SELECTBOARD

AGENDA ACTION REQUEST
Meeting Date: October 26, 2021

I

ANNOUNCEMENTS, OPEN SESSION & PUBLIC COMMENTS

REQUESTED BY:	**Public in attendance and board members**
DESIRED ACTION:	**No action required**
PROPOSED MOTION: **SUMMARY:**	**Public comments must be brief. The Board will not deliberate or vote on any matter raised solely during Announcements and Public Comments**
ACTION TAKEN:	Moved By: ________________ Seconded By: ________________ Condition(s):
VOTED:	Yea _____ Nay _______ Abstain _________

SELECTBOARD

AGENDA ACTION REQUEST
Meeting Date: October 26, 2021

II

CONSENT AGENDA

REQUESTED BY:	
DESIRED ACTION:	**Approval without objection is required for the following items:**
PROPOSED MOTION:	**NONE** Moved By: _____ _______ Seconded By:
SUMMARY:	Condition(s):
ACTION TAKEN:	
VOTED:	Yea _____ Nay_______ Abstain ________

SELECTBOARD

AGENDA ACTION REQUEST
Meeting Date: October 26, 2021

III

FY 2022 TAX CLASSIFICATION PUBLIC HEARING, DISCUSSION AND VOTE

REQUESTED BY:	**Town Accessor Nancy Vail**
DESIRED ACTION:	**To Approve annual tax classifications**
PROPOSED MOTION:	**TBD**
SUMMARY:	
ACTION TAKEN:	Moved By: ________ Seconded By: ________ Condition(s):
VOTED:	Yea _____ Nay _____ Abstain _____

TOWN OF WELLFLEET
PUBLIC NOTICE

In accordance with Chapter 369 of the Acts of 1982, amending Chapter 797 of the Acts of 1979, notice is hereby given that the Wellfleet Select Board will hold a virtual public hearing on Tuesday, November 2, 2021 at 7:00 p.m. on the issue of allocating the local property tax levy among the five classes for Fiscal Year 2022. (Chapter 40, Section 56 as amended by Chapter 369 of the Acts of 1982)

Options open to the Town will be provided, and any taxpayer wishing to present oral or written information on their views will be recognized by the Chair. At the hearing, the Board of Assessors will provide all information and data relevant to making a final determination on the allocation of the tax burden among the five classes of real property: residential, open space, commercial, industrial, and personal property as set forth in Chapter 40 Section 56.

Instructions for participating will be posted on the Town's website at wellfleet-ma.gov.

WELLFLEET SELECT BOARD

MEMORANDUM

To:	Select Board, Town Administrator
From:	Assessor
Subject:	**Classification Hearing - Fiscal 2022**
Date:	November 2, 2021

The Legislature has given local communities limited flexibility in allocating the tax burden among the various classes of property. The Select Board has the opportunity to lower the tax rate of residential taxpayers and increase the tax rate of commercial and personal property taxpayers. The Town of Wellfleet has always employed one tax rate for all classes of property. At the Classification Hearing, the Select Board must reaffirm or change this position.

The Board of Assessors recommends retaining the unified tax rate for all classes of property. The current split between classes is 96% residential and 4% commercial & personal property. The shift would place an undue burden on 4% of the Wellfleet taxpayers. **To retain the single tax rate, a motion with a favorable vote to "make the Residential Factor the numeral 1 for Fiscal 2022" must be made.**

The Board of Assessors must also inform the Select Board of other options involving the shifting of the tax burden. The following is for information only. **No action need be taken.**

Option One:
There is a Residential Exemption available to those domiciled in Wellfleet. An amount up to 35% of the average assessment of the entire residential class could be deducted from the total assessed value of domiciled taxpayers. The total amount of exempted value would then be allocated among all residential class taxpayers. The net effect is an increase in the tax rate for all residential taxpayers.

The Board of Assessors does not have a recommendation.

Option Two:
The "Open Space Exemption" allows up to 25% of the assessed value of land so designated to be exempt from taxation. The burden would be shifted to all other classes of property.

The Board of Assessors recommends no action. There is no need for an open space exemption at this time as several tax-friendly options are available for those interested in preserving all or part of their property as open space. Parcels that could qualify are currently involved in other programs that have satisfied any need to date.

Option Three:
Small Business Exemption - An amount up to 10% of the assessed value of a small business (less than 10 employees and an assessed value of less than $1,000,000) may be deducted. The total deductions are then shifted to those businesses not classified as "small."

The Board of Assessors recommends no action. The majority of the town's businesses are "small." The additional burden would be shifted to a handful of taxpayers.

MASSACHUSETTS DEPARTMENT OF REVENUE
DIVISION OF LOCAL SERVICES
BUREAU OF ACCOUNTS

Wellfleet

TOWN

CLASSIFICATION TAX ALLOCATION

Fiscal Year 2021

1. The selected Residential Factor is 1.000000

If you desire each class to maintain 100% of its full values tax share, indicate a residential factor of "1" and go to question 3.

2. In computing your residential factor, was a discount granted to Open Space?

Yes _ No X

If Yes, what is the percentage discount? 0

3. Was a residential exemption adopted?

Yes X No _

If Yes, please complete the following:

Class 1 Total Assessed Value	=	2,376,403,422	X	20	=	111,647
Class 1 Total Parcel Count *		4,257		Selected Res. Exemption %		Residential Exemption

* Include all parcels wtih a Mixed-Use Residential designation

Applicable number of parcels to receive exemption 740

VALUE EXEMPTED $82,618,780

Net value to be exempted 2,293,784,642

4. Was a small commercial exemption adopted?

Yes _ No X

% Selected 0

If Yes, please complete the following:

No. of parcels eligible	0
Total value of parcels	0
Total value to be exempted	0

5. The following information was derived from the LA-7. Please indicate in column D percentages (accurate to 4 digits to the right of the decimal point) which result from your selected residential factor. (If a residential factor of "1" has been selected, you may leave Column D blank.)

A Class	B Certified Full and Fair Cash Value Assessments	C Percentage Full Value Shares of Total Tax Levy	D New Percentage Shares of Total Tax Levy
Residential	2,376,403,422.00	95.6234%	95.6234%
Open Space	0.00	0.0000%	0.0000%
Commercial	81,471,998.00	3.2783%	3.2783%
Industrial	1,141,400.00	0.0459%	0.0459%
Personal Property	26,153,240.00	1.0524%	1.0524%
TOTALS	***2,485,170,060.00***	***100.0000%***	***100.0000%***

NOTE : The information was Approved on 11/10/2020

MASSACHUSETTS DEPARTMENT OF REVENUE
DIVISION OF LOCAL SERVICES
BUREAU OF ACCOUNTS

Wellfleet
TOWN

CLASSIFICATION TAX ALLOCATION

Fiscal Year 2022

1. The selected Residential Factor is 1.000000

If you desire each class to maintain 100% of its full values tax share, indicate a residential factor of "1" and go to question 3.

2. In computing your residential factor, was a discount granted to Open Space?

Yes _ No X

If Yes, what is the percentage discount? 0

3. Was a residential exemption adopted?

Yes X No _

If Yes, please complete the following:

Class 1 Total Assessed Value	=	2,676,926,055	X	20	=	125,943
Class 1 Total Parcel Count *		4,251		Selected Res. Exemption %		Residential Exemption

* Include all parcels wtih a Mixed-Use Residential designation

Applicable number of parcels to receive exemption 754

Was a Senior Means Tested exemption adopted?

Yes _ No X

If Yes, please complete the following:

Total Eligible Parcels 0 Total Value Exempted nbsp; 0

Combined Exemptions
Total Value Exempted, Residential + Senior Manes Tested 94,961,022
Total Residential Value after exemption(s) 2,581,965,033

4. Was a small commercial exemption adopted?

Yes _ No X

% Selected 0

If Yes, please complete the following:

No. of parcels eligible	0
Total value of parcels	0
Total value to be exempted	0

5. The following information was derived from the LA-7. Please indicate in column D percentages (accurate to 4 digits to the right of the decimal point) which result from your selected residential factor. (If a residential factor of "1" has been selected, you may leave Column D blank.)

A Class	B Certified Full and Fair Cash Value Assessments	C Percentage Full Value Shares of Total Tax Levy	D New Percentage Shares of Total Tax Levy
Residential	2,676,926,055.00	95.7664%	95.7664%
Open Space	0.00	0.0000%	0.0000%
Commercial	86,415,985.00	3.0915%	3.0915%
Industrial	1,186,800.00	0.0424%	0.0424%
Personal Property	30,738,520.00	1.0997%	1.0997%
TOTALS	***2,795,267,360.00***	***100.0000%***	***100.0000%***

MASSACHUSETTS DEPARTMENT OF REVENUE
DIVISION OF LOCAL SERVICES
BUREAU OF ACCOUNTS

Wellfleet
TOWN

CLASSIFICATION TAX ALLOCATION

Fiscal Year 2022

1. The selected Residential Factor is 1.000000

If you desire each class to maintain 100% of its full values tax share, indicate a residential factor of "1" and go to question 3.

2. In computing your residential factor, was a discount granted to Open Space?

Yes __ No X

If Yes, what is the percentage discount? 0

3. Was a residential exemption adopted?

Yes X No __

If Yes, please complete the following:

Class 1 Total Assessed Value	=	2,676,926,055	X	25	=	157,429
Class 1 Total Parcel Count *		4,251		Selected Res. Exemption %		Residential Exemption

* Include all parcels wtih a Mixed-Use Residential designation

Applicable number of parcels to receive exemption 754

Was a Senior Means Tested exemption adopted?

Yes __ No X

If Yes, please complete the following:

Total Eligible Parcels 0 Total Value Exempted nbsp; 0

Combined Exemptions

Total Value Exempted, Residential + Senior Manes Tested	118,701,466
Total Residential Value after exemption(s)	2,558,224,589

4. Was a small commercial exemption adopted?

Yes __ No X

% Selected 0

If Yes, please complete the following:

No. of parcels eligible	0
Total value of parcels	0
Total value to be exempted	0

5. The following information was derived from the LA-7. Please indicate in column D percentages (accurate to 4 digits to the right of the decimal point) which result from your selected residential factor. (If a residential factor of "1" has been selected, you may leave Column D blank.)

A Class	B Certified Full and Fair Cash Value Assessments	C Percentage Full Value Shares of Total Tax Levy	D New Percentage Shares of Total Tax Levy
Residential	2,676,926,055.00	95.7664%	95.7664%
Open Space	0.00	0.0000%	0.0000%
Commercial	86,415,985.00	3.0915%	3.0915%
Industrial	1,186,800.00	0.0424%	0.0424%
Personal Property	30,738,520.00	1.0997%	1.0997%
TOTALS	***2,795,267,360.00***	***100.0000%***	***100.0000%***

SELECTBOARD

AGENDA ACTION REQUEST

IV

WASTEWATER PLANNING

Guidance on Section 208 Plan Update

Consistency Review Criteria

April 2018

Pursuant to recommendation R3.7 of the approved and certified Cape Cod Area Wide Water Quality Management Plan Update (the "208 Plan Update"), all municipal nutrient management plans in the region shall be prepared and implemented consistent with the 208 Plan Update, and shall be subject to review by the Cape Cod Commission for consistency with the 208 Plan Update. The consistency review shall be the Commission's principal means of reviewing municipal plans. Plans deemed consistent with the 208 Plan Update will, among other things, become eligible for 0% State Revolving Fund (SRF) loans and other financial assistance. DEP will require the Commission's determination that a plan is consistent with the 208 Plan Update pursuant to its watershed permitting program for Waste Treatment Management Agencies (WMAs).

As part of the approved and certified 208 Plan Update, the 15 Cape Cod municipalities were designated as WMAs under Section 208 of the Federal Clean Water Act. A WMA has standing to propose a plan and seek consistency review hereunder.

The following are general 208 Plan Update review criteria:

- ✓ WMA assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction
- ✓ Plan meets applicable nutrient reduction targets
- ✓ Planning occurs at a watershed level with consideration of a hybrid approach
- ✓ Public was engaged to gain plan consensus
- ✓ Plan includes proposed strategies to manage nitrogen loading from new growth
- ✓ Plan includes adaptive management approach
- ✓ Plan includes pre- and post-implementation monitoring program
- ✓ Plan includes a description and assessment of the town's proposed funding strategy
- ✓ WMA commits to regular 208 Plan Update Consistency reviews until water quality goals are achieved, generally reviewed atleast every five years
- ✓ In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions, and cost saving measures

SELECTBOARD

AGENDA ACTION REQUEST

IV

FINANCING - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: ________________ Seconded By: ________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain ________

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 30 years it is estimated this fund could generate in excess of $30 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. It is estimated that lodging establishments in the town of Wellfleet could contribute in excess of $400,000 to this fund once it matures. Over the next 30 years it is estimated this fund could generate in excess of $12 million.

17.3 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.

17.4 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.

17.5 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. Preliminary discussions with representatives from MCWT indicate that the loan program could be applicable to enhanced I&A septic system financing.

Project costs that are not financed through the MCWT can be financed with a General Obligation Bond issue in the capital market. Depending upon the town's current bond rating this could result in 20-year loan rates of approximately in the 4% to 6% range under current market conditions.

17.6 FEDERAL & STATE GRANTS

Most grants available from state and federal agencies for wastewater infrastructure are targeted towards pilot projects and innovative or "green" projects. Grants are typically not available for standard utility infrastructure needs such as sewer mains or building of pump stations. Federal and State assistance has been directed to the MCWT to date which has allowed for the favorable borrowing conditions mentioned previously.

17.7 PROPERTY TAXES

The financial plan includes property taxes as a funding source for the program. It 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.

SELECTBOARD

AGENDA ACTION REQUEST

IV

TOWN PLANNING PROCESS - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: __________________ Seconded By: __________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain ________

4) The public was engaged to gain plan consensus

The local planning process shall engage the public at the watershed level to gain consensus on proposed actions and those included shall represent a range of community stakeholders. The WMA shall engage and educate a wide range of stakeholders, including those within contributing Environmental Justice communities, and encourage comments from all relevant local, state, regional and federal government entities and interested members of the public on the proposed plan.

The WMA shall coordinate where possible with existing watershed associations and/or promote the formation of new associations early in the process to ensure public involvement in the process and public support for implementation. These associations can serve as both advisors and ambassadors of local plans. The range of viewpoints represented will ensure closer coordination between plan development, local need and community values.

Stakeholder Engagement

Six to twelve months prior to expiration of a consistency determination, the WMA(s) shall convene a stakeholder group to discuss implementation activities to date and any potential changes necessary. Stakeholder groups should include representation from town staff, elected officials, local watershed associations, civic groups, and interested professional groups, such as realtors, homebuilders, and/or businesses. The stakeholder group composition is subject to variation. The Cape Cod Commission shall be engaged in this effort.

The purpose of the stakeholder process will be to review implementation efforts, consider changes in water quality as identified through ongoing embayment water quality monitoring, and come to consensus on potential changes to the implementation plan, if necessary.

Based on an agreed upon path forward, the WMA shall develop a public engagement and outreach plan for successful implementation of the revised plan or project. As part of the five-year 208 consistency review, the WMA shall submit the public engagement and outreach plan along with the revised plan or project details.

SELECTBOARD

AGENDA ACTION REQUEST

IV

TOWN PLANNING PROCESS - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: ________________ Seconded By: ________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain _________

Guidance on Section 208 Plan Update

Obtaining a Consistency Determination

April 2018

Exceptional development pressure in the latter half of the 20th century motivated Cape Cod residents to seek a coordinated regional land use approach to protect the region's natural resources from the consequences of uncoordinated growth. As a result, the Cape Cod Commission (Commission) was created by the Cape Cod Commission Act (Act) in January 1990.

The Cape Cod Commission is Barnstable County's regional planning and regulatory agency and, through the Act, is responsible for balancing the protection of the region's unique environmental resources with appropriate economic development.

Specifically, one purpose of the Commission is to protect groundwater, surface water and ocean water quality. Through the Act, the Commission is responsible for furthering the provision of adequate capital facilities, coordinating those facilities with the achievement of other goals, and anticipating, guiding and coordinating the rate and location of development with the capital facilities necessary to support such development.

In 2013, in response to overwhelming evidence that nitrogen from septic systems across the region are impacting coastal water quality, the Commonwealth of Massachusetts directed the Cape Cod Commission to update the Area Wide Water Quality Management Plan (208 Plan), pursuant to Section 208 of the Federal Clean Water Act. Recognizing that Cape Cod communities had, in many cases, identified strategies to address this issue but had struggled with implementation, the Commission committed to an extensive stakeholder engagement process to help identify barriers to success. A key barrier identified was the mismatch between the planning and regulatory framework and the unique and shared nature of the water resources impacted. Planning and regulation traditionally occurred at the town-wide scale; however, 32 of the 53 watersheds to sensitive coastal embayments on Cape Cod are shared by more than one town.

Municipal Comprehensive Wastewater Management Plans (CWMPs) have traditionally been reviewed as Developments of Regional Impact (DRIs), which are defined by the Act as a development which, because of its magnitude or the magnitude of its impact on the natural or built environment, is likely to present development issues significant to or affecting more than one municipality. DRI review is not well-suited for town water quality improvement initiatives which are systemic, not necessarily associated with any particular parcels of land, might not involve 'development' in its traditional sense, and which may not have discrete permitting and implementation timelines. Water quality initiatives are often long-term projects subject to changing conditions over time and include municipal infrastructure necessary to support development. One of the most important determinations the Commission makes during DRI review is whether there are inherent benefits from a project to the region. Given the region's pressing water quality issues, the benefit of these town water quality efforts should be presumed.

The unique and multijurisdictional nature of the issue on Cape Cod called for a new approach. The 208 Plan, which was certified and approved by the Commonwealth of Massachusetts and the Environmental Protection Agency in September 2015, provides a streamlined regulatory pathway for more efficiently and effectively achieving water quality goals through the development of targeted watershed management plans that address nutrient remediation through a variety of approaches.

One aspect of the streamlined regulatory approach is the Commission's review of municipal water quality plans and projects, which are no longer reviewed as DRIs, but instead for consistency with the 208 Plan. The following provides guidance on obtaining and maintaining consistency with the 208 Plan.

DEFINITIONS

The following are definitions of terms referenced in this document.

208 Plan: The Cape Cod Area Wide Water Quality Management Plan, developed pursuant to Section 208 of the Clean Water Act.

Development of Regional Impact (DRI): A development which, because of its magnitude or the magnitude of its impact on the natural or built environment, is likely to present development issues significant to or affecting more than one municipality.

Waste Treatment Management Agency (WMA): The entity, or entities, designated as the responsible party for planning and implementation of local water quality improvement plans, as required by Section 208 of the Clean Water Act. On Cape Cod, the 15 Cape Cod towns are the designated WMAs.

Water Quality Improvement Plan: A plan proposed by a WMA that describes the extent of the nutrient related issues within a town, watershed, or subwatershed and a program for implementing the necessary infrastructure and strategies to reduce nutrient impacts on the quality of coastal waters.

Water Quality Improvement Project: A project proposed by a WMA intended to reduce nutrient impacts on the quality of coastal waters.

REGIONAL REGULATORY REVIEW

The 208 Plan recommended that the Commission revise its regulations to provide a simpler and more supportive process for the review of municipal water quality improvement plans and projects.

After much consideration, it was determined that these types of plans and projects should be reviewed exclusively for consistency with the 208 Plan. The 2017 Implementation Report, an addendum to the 208 Plan which documents successes to date and next steps at the local and regional levels, recommended that the Commission adopt regulatory amendments to allow for

208 Plan consistency review in place of traditional DRI review for municipal water quality and wastewater capital plans and projects.

In February 2018 the Commission proposed amendments to Chapter A of the Cape Cod Commission Regulations: Enabling Regulations Governing Review of Developments of Regional Impact (Enabling Regulations). In April 2018 the amendments were approved by both the Barnstable County Assembly of Delegates and Board of Regional Commissioners.

The revised enabling regulations exempt towns from DRI review for water quality plans and projects that have nutrient remediation as a primary purpose. The amendment applies equally to plans and projects previously reviewed and approved by the Commission as DRIs, and modifications to such plans or projects will not require further DRI review.

The Commission proposed that DRI review be replaced with a Commission staff-level review and approval through a determination by the Commission's Executive Director that local plans and projects are consistent with the 208 Plan.

This new review and approval process allows the Commission to be more supportive and collaborative with towns in their development of solutions to water quality problems. This process also provides a better platform to deal with multiple towns on common water quality solutions in shared watersheds, and promotes public engagement at earlier stages of planning and plan development which should increase community support for these plans and projects.

208 CONSISTENCY CRITERIA

The 2017 Implementation Report provided draft guidance on the specific criteria by which local plans and projects will be reviewed, which include:

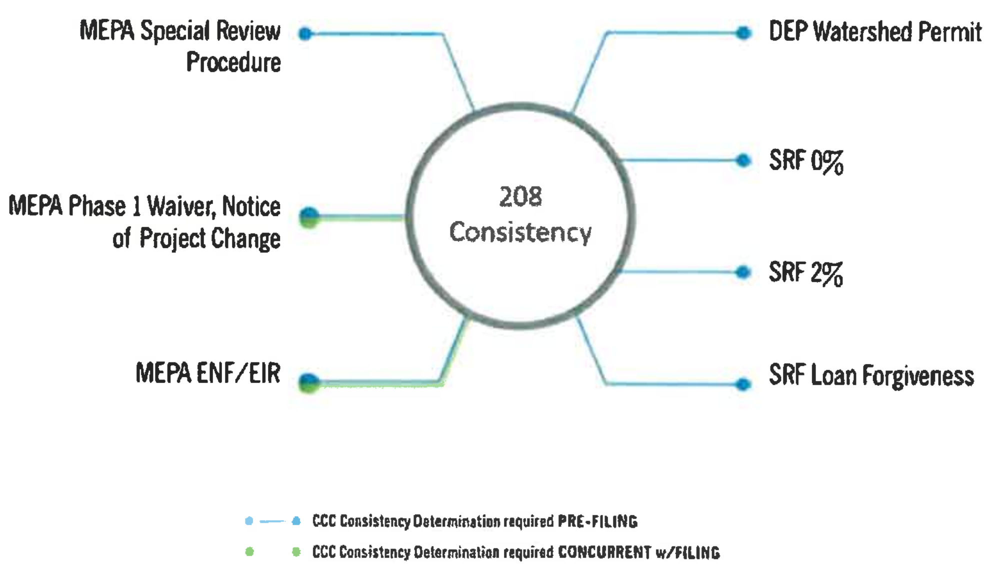
- ✓ WMA assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction
- ✓ Plan meets applicable nutrient reduction targets
- ✓ Planning occurs at a watershed level with consideration of a hybrid approach
- ✓ Public was engaged to gain plan consensus
- ✓ Plan includes proposed strategies to manage nitrogen loading from new growth
- ✓ Plan includes adaptive management approach
- ✓ Plan includes pre- and post-implementation monitoring program
- ✓ Plan includes a description and assessment of the town's proposed funding strategy
- ✓ WMA commits to regular 208 Plan Update Consistency reviews until water quality goals are achieved, generally reviewed atleast every five years
- ✓ In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions, and cost saving measures

Guidance on 208 consistency criteria is attached to this document.

INSTANCES REQUIRING A 208 CONSISTENCY DETERMINATION

There are several instances that will require a WMA to obtain a 208 consistency determination. Depending on the plan or project, a 208 consistency determination may be requested more than once, at different stages of planning, project development and plan implementation. Instances requiring a 208 consistency determination include:

- Modification of an Existing DRI Permit: WMAs with an existing DRI permit will not require further DRI review. Requests for modifications to DRI permits shall undergo 208 consistency review in place of DRI review concurrent with the DRI modification action.
- Massachusetts Environmental Policy Act (MEPA): Water quality improvement plans and projects that require review under MEPA and therefore are typically reviewed by the Cape Cod Commission as a DRI, shall instead be reviewed for consistency with the 208 Plan. This applies to filings of Environmental Notification Forms (ENFs), Environmental Impact Reports (EIRs), Phase 1 and other Waivers, Notices of Project Change, and applications for any special review procedure.
- Massachusetts Clean Water State Revolving Fund (SRF) Loans (310 CMR 44.00, effective January 27, 2017): Plans and projects for which SRF funding is sought must be consistent with the 208 Plan Update. WMAs that choose to request SRF loans for plan or project implementation must first obtain a 208 consistency determination. This applies to 0% and 2% interest loans and eligibility for principal forgiveness.
- Massachusetts Department of Environmental Protection (MassDEP) Watershed Permits: MassDEP has issued guidance on watershed permitting which states that plans and projects for which a WMA is seeking nitrogen credit through a watershed permit require a 208 consistency determination. WMAs seeking a watershed permit with DEP shall also first obtain a 208 consistency determination from the Commission.



Instances requiring a 208 consistency determination. In most cases, a consistency determination is required pre-filing; however, a consistency determination may be obtained concurrent with the MEPA filing of an ENF, EIR, Notice of Project Change or Phase 1 or other Waiver.

REQUESTING A 208 CONSISTENCY REVIEW

Key to ensuring consistency of local plans and projects with the 208 Plan is early consultation with the Commission. Communities initiating planning processes and developing project specific proposals should request a meeting and/or assistance from the Commission in the early phases of plan or project development. Initial review for consistency with the 208 Plan is process oriented, with progress measured and reviewed over time, via reporting on implementation and during the five-year consistency review process. The 208 Plan provides a framework for a process that engages stakeholders in plan development, considers a broad range of strategies and utilizes decision support tools to help determine an approach to the problem that best suits local needs. Early consultation with the Commission will help to ensure appropriate steps are taken at the local level, during the planning process to ensure consistency with the regional plan and public support for implementation.

Through early consultation, Commission staff will work with the WMAs designee(s) to identify 208 consistency criteria applicable to the plan or project and discuss options and opportunities for achieving consistency with those criteria. Applicable criteria may vary from request to request, including for requests made for plans versus projects. For example, a project may be proposed by a WMA that is anticipated to achieve a percentage of the nitrogen reduction required in a given watershed. At the time of consistency review for the project, the Commission will not require that the project fully meet the watershed nitrogen reduction target. However, the Commission would anticipate that the project should ultimately be incorporated as one part of a comprehensive or targeted watershed management plan, which should anticipate achieving the nitrogen reduction required for the respective watersheds addressed in such plans.

Requests for a meeting to discuss consistency criteria applicable to a local plan or project, requests for watershed team technical assistance for plan or project development, and/or requests for a 208 consistency review and determination should be submitted in writing to the Cape Cod Commission Executive Director from the WMA (Town Manager or Administrator, Board of Selectmen, or Town Council). Projects or plans proposed through a cooperative effort by two or more WMAs should be submitted jointly by all parties involved.

WMA(s) may request determinations for individual projects, specific watersheds, or for town wide plans; however, in all cases, the Commission will apply a watershed-based approach to consistency review of such requests.

ISSUANCE OF 208 CONSISTENCY DETERMINATIONS

A 208 consistency determination is effective per the terms, conditions and duration set out in the determination. In most cases, the Commission will issue determinations for plans or projects in recurring five-year intervals. Upon the expiration of the then current effective period, the WMA must submit updates for the respective project or plan, pursuant to its adaptive management plan and other 208 consistency criteria, in order to maintain 208 consistency and obtain an updated determination for the succeeding period. In certain cases, once a 208 consistency determination is issued, subsequent requests for a determination or project or plan updates within the five year timeframe may simply warrant a letter from the Commission confirming that associated plan or project is consistent with the 208 Plan.

MAINTAINING CONSISTENCY WITH THE 208 PLAN

Annual reporting

Each 208 consistency determination will require that the WMA(s) commit to annual reporting. Annual reports shall include data collected during the reporting period, such as technology performance monitoring and/or embayment monitoring data, and a progress update on implementation. Details on data submission requirements may vary based on the proposed project or plan and will be included in the 208 consistency determination.

Annual reports will be used to update watershed reports, which were issued as part of the 2017 Implementation Report. Annual reporting and watershed reports will be used to complete 208 compliance reports. Compliance reports will be issued annually at the OneCape Summit, typically held in the Spring.

Adaptive Management and Five-year Consistency Determinations

To maintain a 208 consistency determination for a given project or plan, the WMA(s) must undergo consistency review atleast every five years until water quality goals are achieved, or as otherwise established by the Commission and the WMA(s) in a determination. The intent of periodic consistency reviews is to allow for adaptive management. WMAs should have the flexibility to be responsive to changes in environmental quality, relative effectiveness of implemented approaches, identification of new technology, and unforeseen community needs. Five-year consistency determinations allow WMAs to change the course of action identified, based on the best available data and stakeholder feedback, and submit a modified implementation plan as part of an adaptive management report, if necessary.

Subsequent consistency determinations will focus on progress toward originally identified goals and changes to the implementation plan outlined through an adaptive management report.

Stakeholder Engagement

Six to twelve months prior to expiration of a consistency determination, the WMA(s) shall convene a stakeholder group to discuss implementation activities to date and any potential changes necessary. Stakeholder groups should include representation from town staff, elected officials, local watershed associations, civic groups, and interested professional groups, such as realtors, homebuilders, and/or businesses. The stakeholder group composition is subject to variation. The Cape Cod Commission shall be engaged in this effort.

The purpose of the stakeholder process will be to review implementation efforts, consider changes in water quality as identified through ongoing embayment water quality monitoring, and come to consensus on potential changes to the implementation plan, if necessary.

Based on an agreed upon path forward, the WMA shall develop a public engagement and outreach plan for successful implementation of the revised plan or project. As part of the five-year 208 consistency review, the WMA shall submit the public engagement and outreach plan along with the revised plan or project details.

Representation on the Cape Cod Water Protection Collaborative

In June 2017, the Cape Cod Water Protection Collaborative (Collaborative) was re-established, following a long-standing history of working with the State's legislative delegation to highlight the need for a broader base of financial support for water quality issues on Cape Cod. The Collaborative's newly stated mission is to protect Cape Cod's shared water resources by promoting and supporting the coordinated, cost-effective and environmentally sound development and implementation of local water quality initiatives, including, but not limited to watershed management plans required by section 208 of the Federal Clean Water Act.

The roles and responsibilities of the Collaborative directly align with implementation of locally developed water quality plans and projects. Each WMA has a seat on the Collaborative's Governing Board and the ability of the Collaborative to support ongoing local and regional water quality initiatives relies on participation from each Cape Cod community. As such, as a condition of 208 consistency, WMAs must appoint a member to the Collaborative Governing Board and must commit to maintaining their representation through reappointments, as necessary. WMAs must prioritize attendance at monthly Governing Board meetings.

SELECTBOARD

AGENDA ACTION REQUEST

IV

TREATMENTS PER SUBEMBAYMENT - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: ___________________ Seconded By: ___________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain _________

APPENDIX B NITROGEN LOAD CALCULATIONS
I&A PERFORMANCE AT 8 MG/LITER (66% REDUCTION)

Scenario 2A - I&A @ 8 mg/liter 2052		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Health Regulation Require IA Future Development		892	222	446	329	447	697	126	3159
Enhanced I&A Up N reduction	MEP/MADEP	270	153	1016	868	242	1992	240	4780
percentage load upgraded		9%	14%	50%	59%	13%	58%	49%	44%
Fertilizer Mitigation 25%	25% CCC 208 Plan	171	40	118	60	52	145	23	610
Stormwater Reductions 25%	25% CCC 208 Plan	186	46	114	61	50	114	17	588
Aquaculture/Shellfish/Harvest 0.13 g/oyster	CC Tech Matrix	277	277	277	277		1385	277	2769
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		347	976					1323
percentage of load flowing to PRB			20%	30%					
Collection & TreatmentN reduction		0	622	0	0	0	146	0	768
95 Lawrence		0		0	0	0	0	0	
Harborside Trailer Park (Upgrade 2012)				0	0		146	0	
Downtown Sewers									
Total Load Reduced		1795	1707	3265	1594	791	4478	684	14315
Remaining Load		0	0	0	0	0	0	0	14315

Sewer-sheds are currently in evaluation

TOWN OF WELLFLEET 1820 INCORPORATED 1763

SELECTBOARD

AGENDA ACTION REQUEST

IV

REVIEW OF DRAFT TARGETED WATERSHED PLAN - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: __________________ Seconded By: __________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain ________

SCOTT HORSLEY
WATER RESOURCES CONSULTANT

WELLFLEET HARBOR TARGETED WATERSHED MANAGEMENT PLAN

DRAFT REPORT

20 OCTOBER 2021

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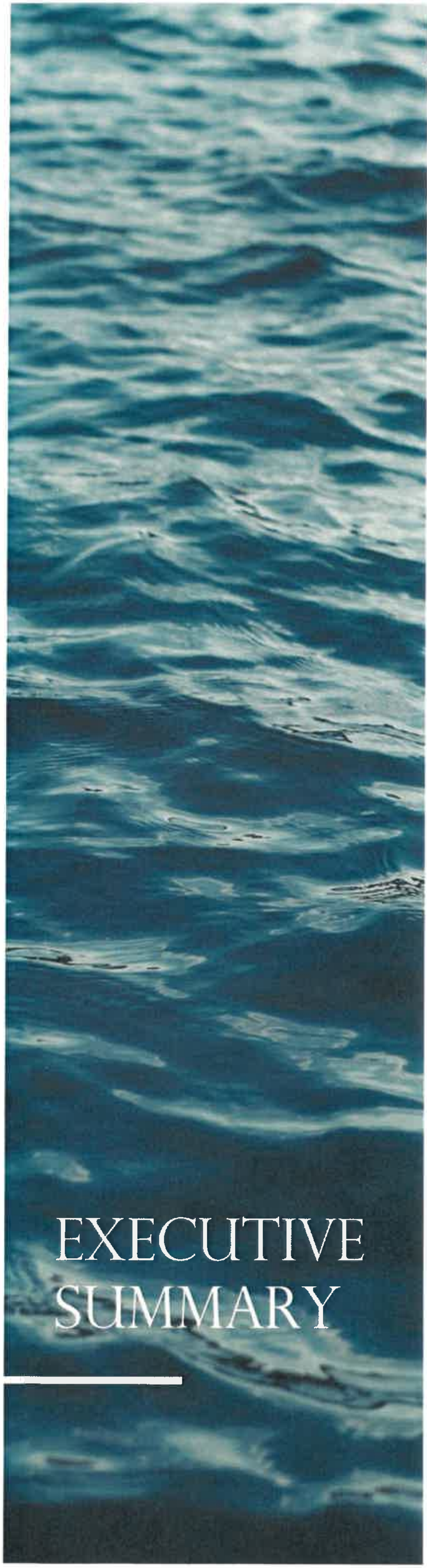


WELLFLEET HARBOR TARGETED WATERSHED MANAGEMENT PLAN

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 emergingnature-based technologies backed up with conventional wastewater treatment systems.

The plan includes six phases (five years each) over a 30-year period. The first phase includes installation of a new generation of innovative & alternative (I&A) septic systems, the development of a permeable reactive barrier (PRB) pilot project along Commercial Street, salt marsh restoration, the development of a sustainable shellfish habitat program, stormwater retrofits at the Main Street and Route 6 intersection, 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 and private homes.

The second and subsequent phases call for expansion of these strategies based upon performance during the first pilot phase. Contingent upon MADEP's approval of the I&A septic technologies for "general use" these systems could be installed for all upgrades, expansions, new construction, and possibly with 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 public and many relevant boards 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 of the Barnstable County Department of Health and Environment and founder of the Massachusetts Alternative Septic System Test Center, and the cooperative assistance provided by the Massachusetts Department of Environmental Protection, Provincetown Center for Coastal Studies, 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 has 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 (2017). 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 course fertilization (9%) landfill (2%), and farm animals (2%)

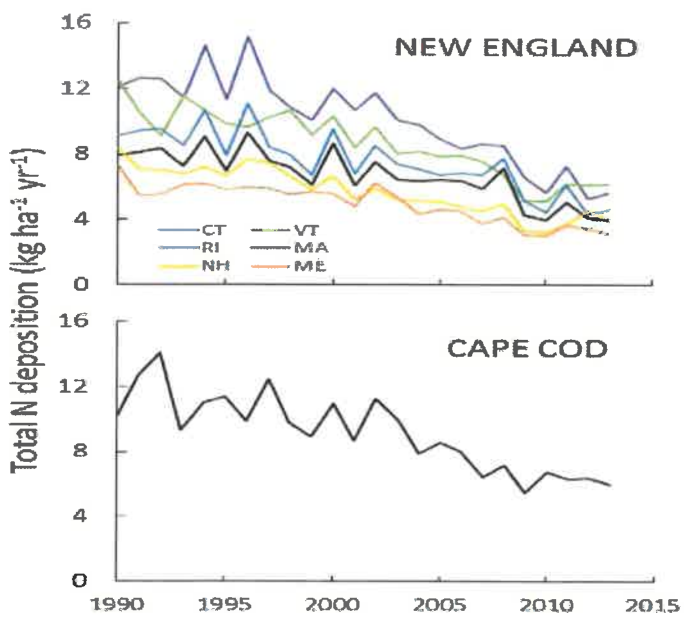
It is also interesting to note that when considering all sources of nitrogen (controllable and non-controllable) to the estuary, wastewater comprises 42% and direct precipitation 40% of the total nitrogen loads to the system. Recent research suggests that nitrogen concentrations (and loads) from precipitation 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 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, 2016)



4.0 NITROGEN LOADS, THRESHOLDS, AND REMOVAL REQUIREMENTS

The existing, buildout, and threshold (target) nitrogen loads can be found in the MEP report (2017). Table VIII-3 of the MEP report identifies "present" daily loads as of 2008-2010 when the land use analysis was 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 (2021) we compiled building permit data from the 2011 – 2020 period and applied the MEP nitrogen loading coefficients. This analysis indicates that 247 additional septic systems (and associated lawns and impervious surfaces) were added during this time period resulting in an estimated current nitrogen load of 30,228 kg/year (see Table 1 and Figures 3 and 4).

	Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Current Watershed Loads (2021)	10435	2050	3743	2803	3612	6646	939	30228
Projected Loads 2052 (30 years)	11332	2273	4192	3135	4061	7347	1066	33405
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 (2021)	533	1393	2633	1128	159	3492	505	9843
Reduction Required (2052)	1430	1616	3082	1460	608	4193	632	13020
Reduction Required from Buildout	3282	2026	4296	2314	1956	5285	1095	20254

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

An additional nitrogen loading analysis was prepared for the thirty-year planning period (2022 – 2052) 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 2052 is estimated at 33405 kg/year requiring a reduction of 13,020 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 20,385 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 present (2021), 2052, and buildout conditions.

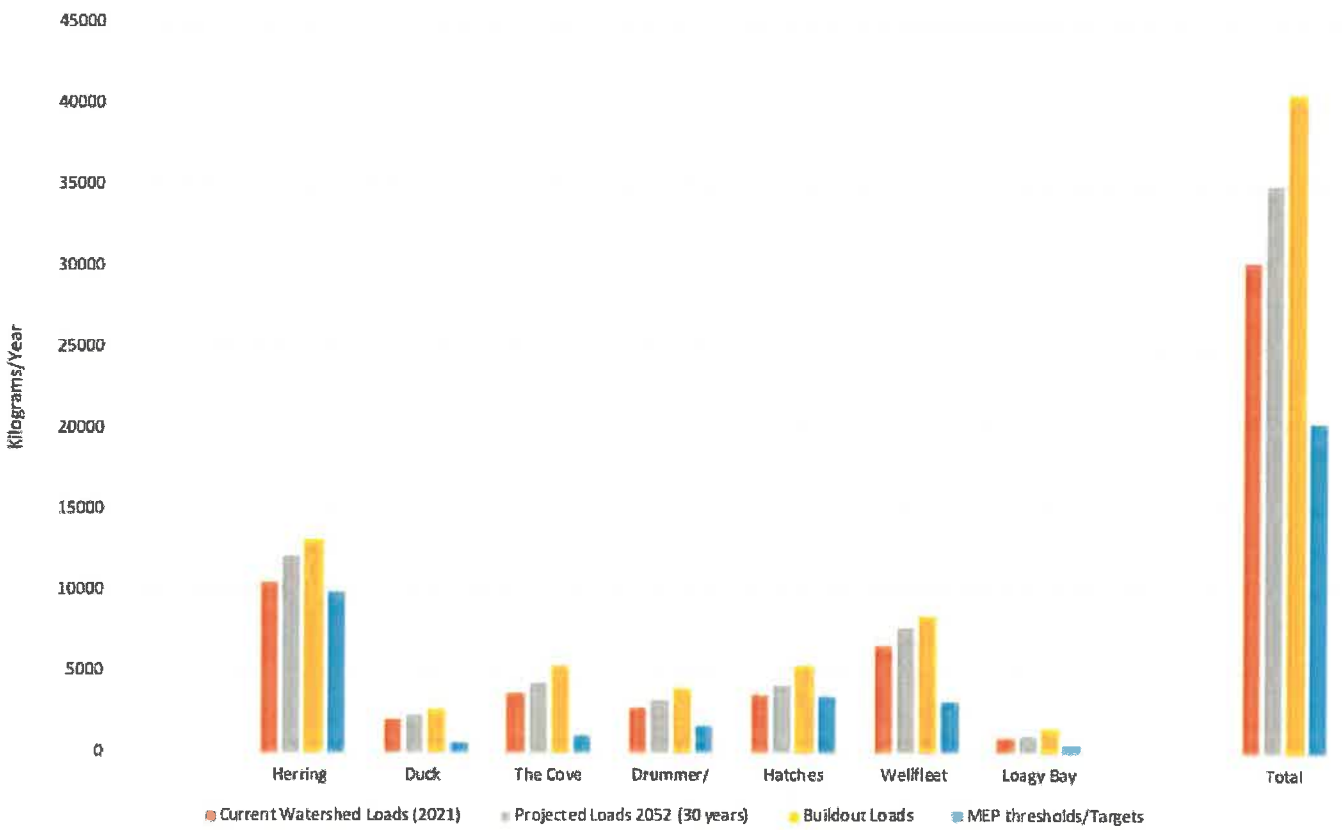


Figure 2 - Required Nitrogen Loads and MEP Thresholds

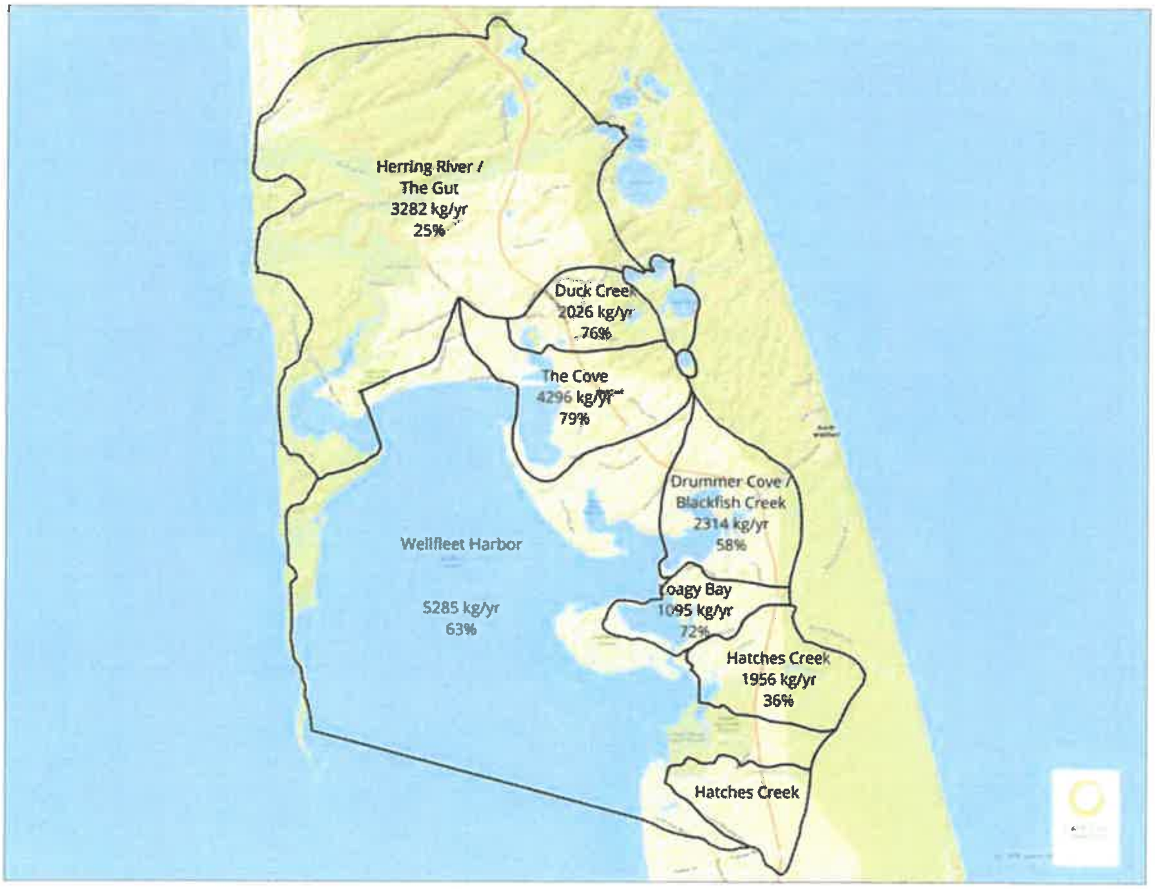


Figure 3 - MEP subwatersheds and required nitrogen loading reductions (at buildout)

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 two 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.

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.

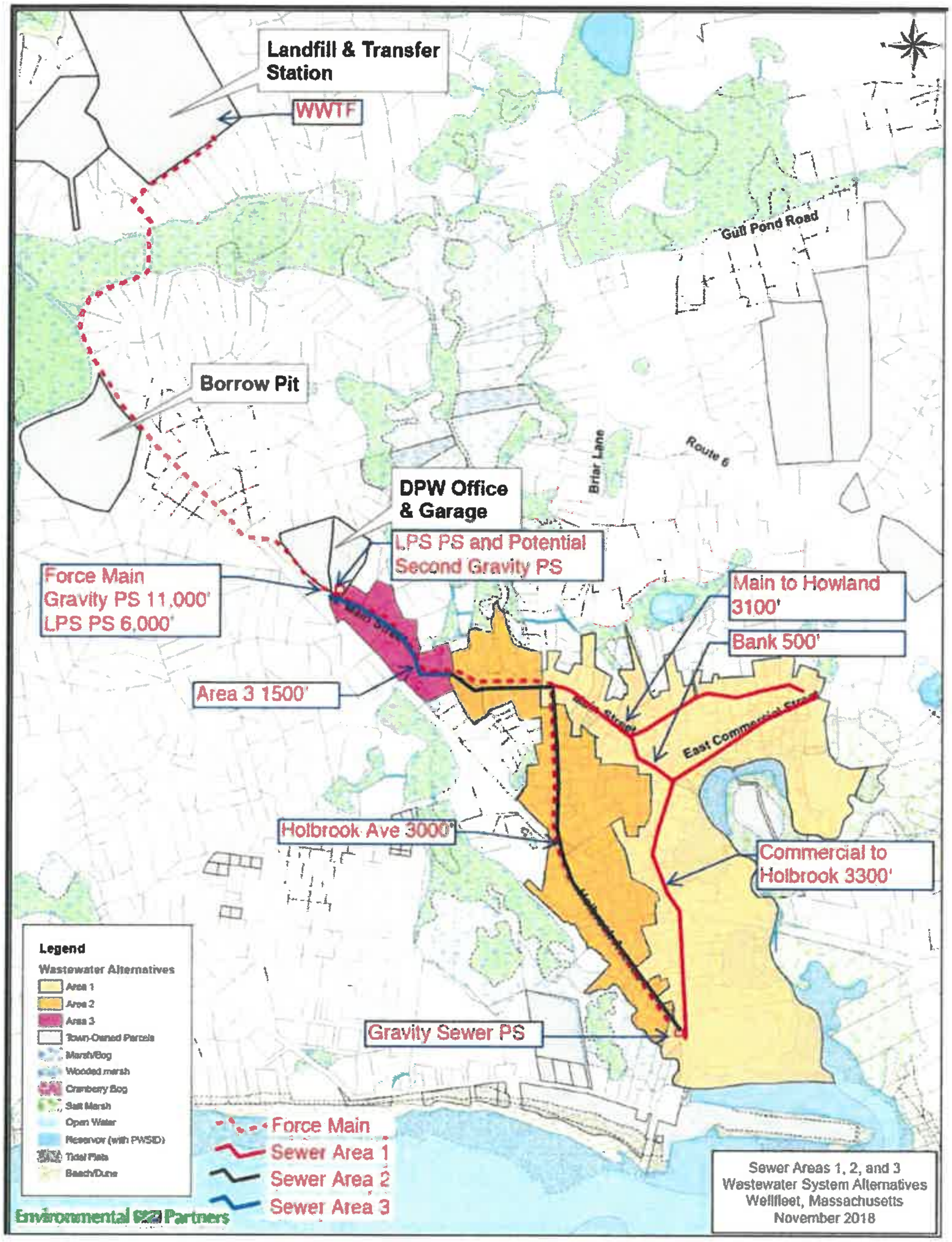


Figure 4 - Potential Sewer Collection Areas (Environmental Partners, 2018)

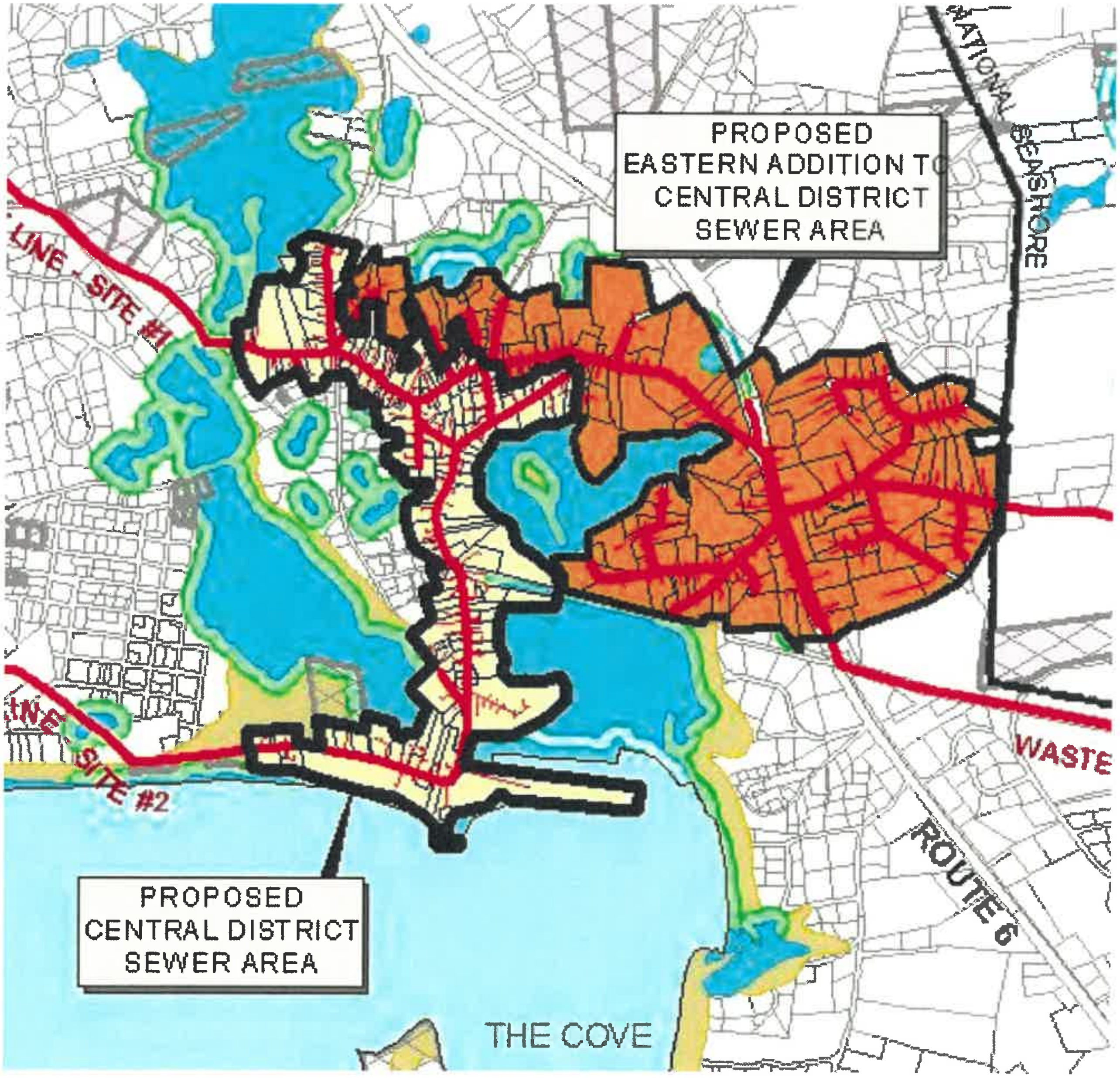


Figure 5 - Potential Sewer Collection Areas (Woodard and Curran, 2001

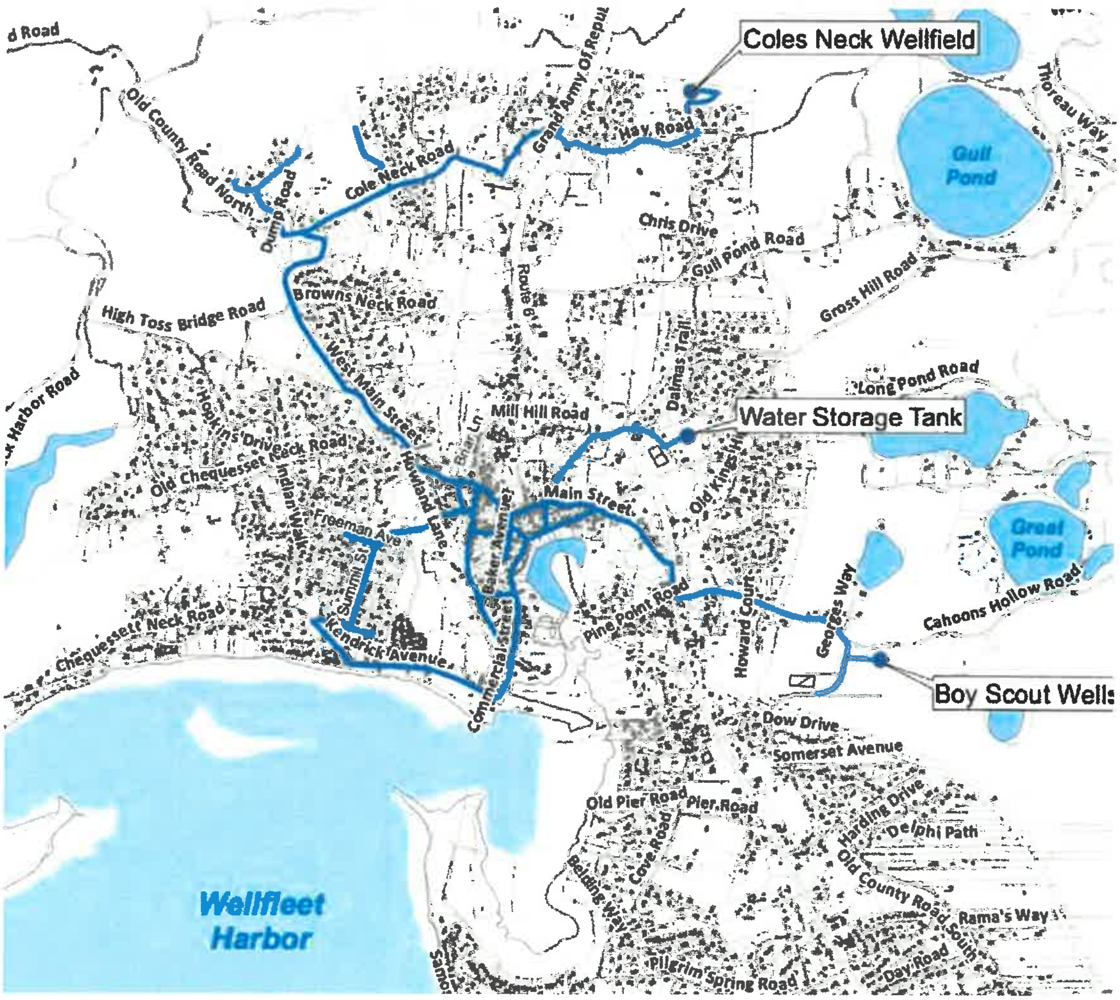


FIGURE 6 - PUBLIC WATER SUPPLY DISTRIBUTION SYSTEM

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 permeable reactive barriers and shellfish restoration pilot projects conducted by the towns of 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, 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 a sewer collection system, treatment plant and disposal site in accordance with the town's prior reports prepared by Woodard and Curran and Environmental Partners. After evaluating several potential sites, 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 (see figure 7). 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. The analysis provided by Bohler Engineering suggests that this project can provide nitrogen removal at approximately $250/kg. This is a favorable cost efficiency. This approach was supported at Wellfleet Town Meeting 2021 at which funding was appropriated for the design and permitting of the wastewater treatment facility.

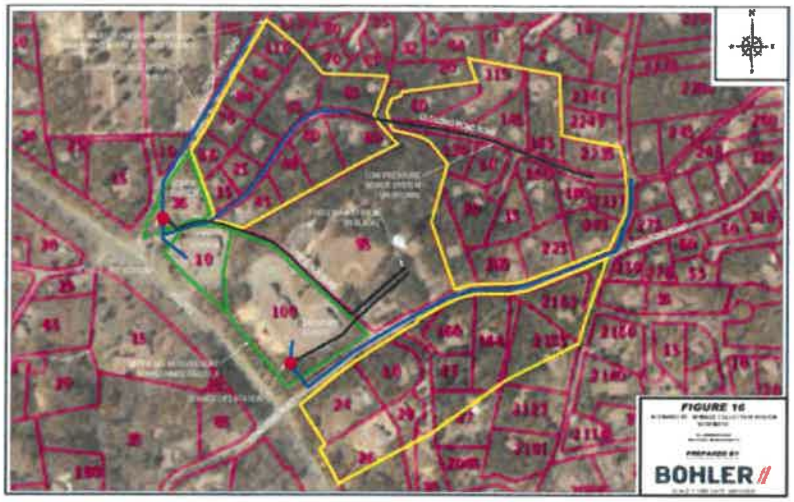


Figure 7 - 95 Lawrence Road project - Neighborhood Wastewater

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.

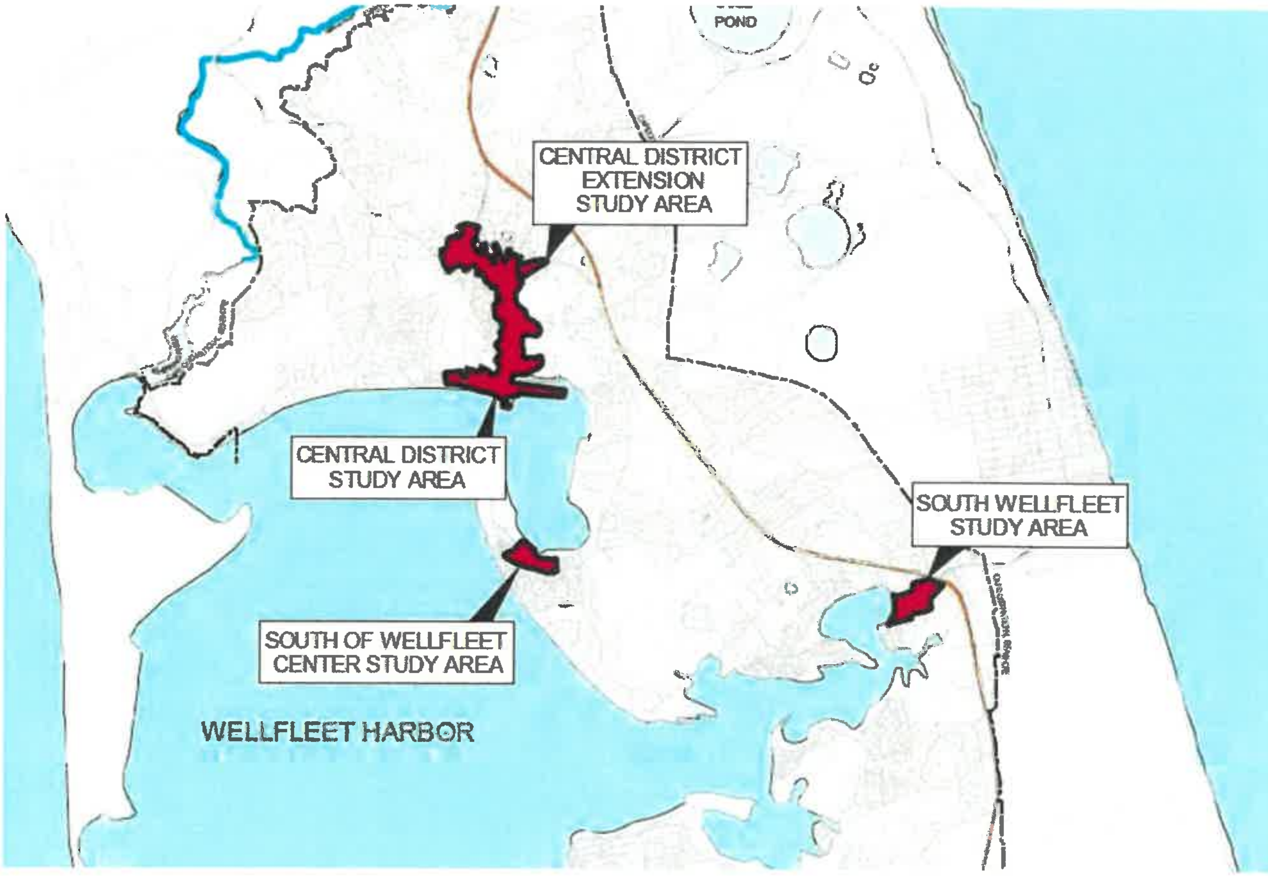


Figure 8 -Wastewater Study Areas (Woodard & Curran, 2001)

8.2 NON-TRADITIONAL TECHNOLOGIES:

An alternative plan has been developed using non-traditional (or nature-based) solutions. These technologies were evaluated and identified as viable nitrogen reduction tools as part of the Cape Cod Commission's Cape Cod 208 Water Quality Update (2015).

The non-traditional strategies discussed at the public meetings have 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 reductions to the embayments.

However, several newer 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. There have been significant advances and improvements over the last twenty years. 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.

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.

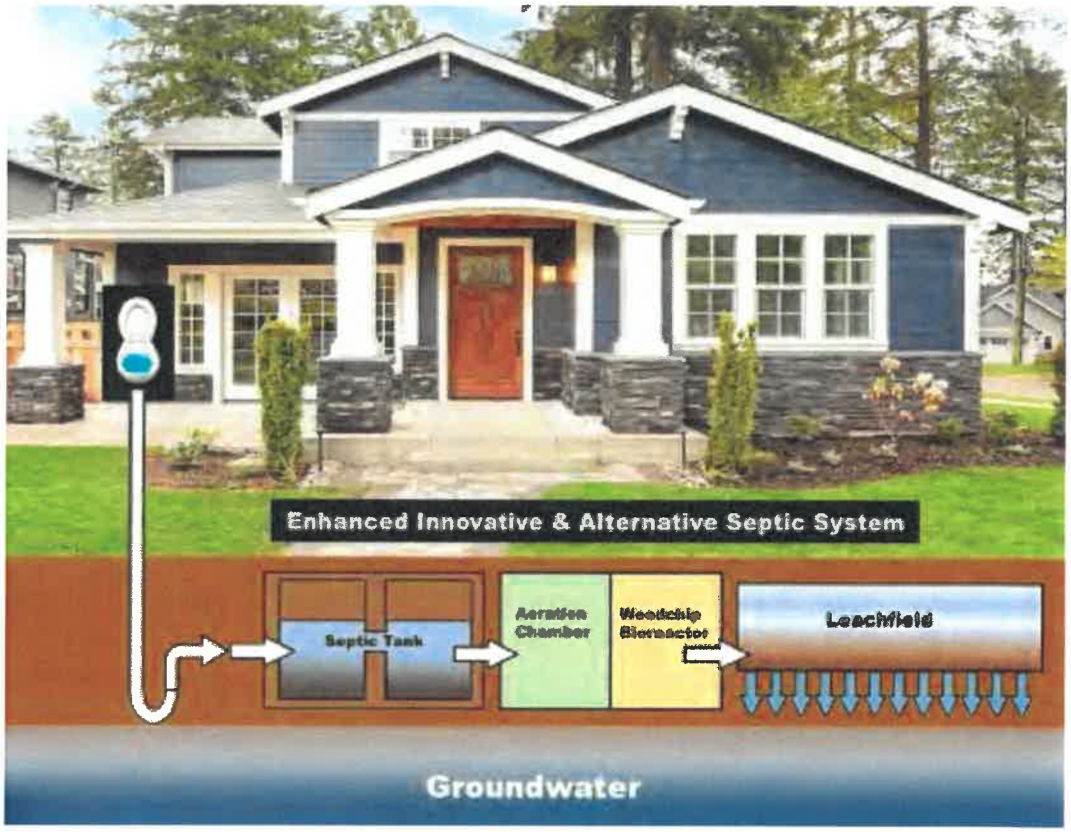


Figure 9 - Enhanced I&A Septic System

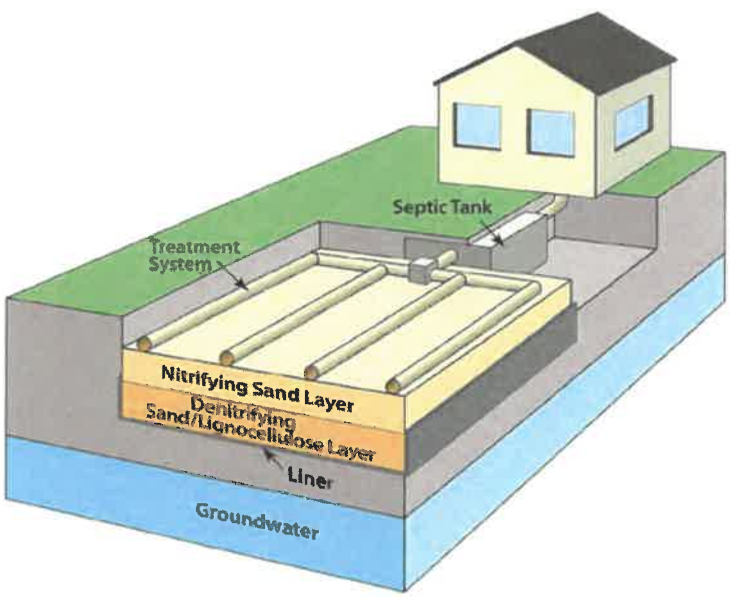


Figure 10 – Non-proprietary woodchip "layer cake" septic system design (MASSTC)

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 also indicates 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 (days instead of hours).

The Buzzards Bay Coalition installed six enhanced I&A septics in the West Falmouth watershed and studied their performance. The installations included Nitroe, Fast, Eliminate, and Perc-Rite systems and averaged 67% removal with the Nitroe system achieving a 92% removal rate (Buzzards Bay Coalition, 2020). This study documented installation costs at $17,500 for a retrofit (retaining the existing septic tank and leach field) and $28,111 for a full replacement. The study also provided cost estimates on operation and maintenance estimated at $2404 for the first year and $1468 for the second year.

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 Shubael's 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 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 14-16). 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.

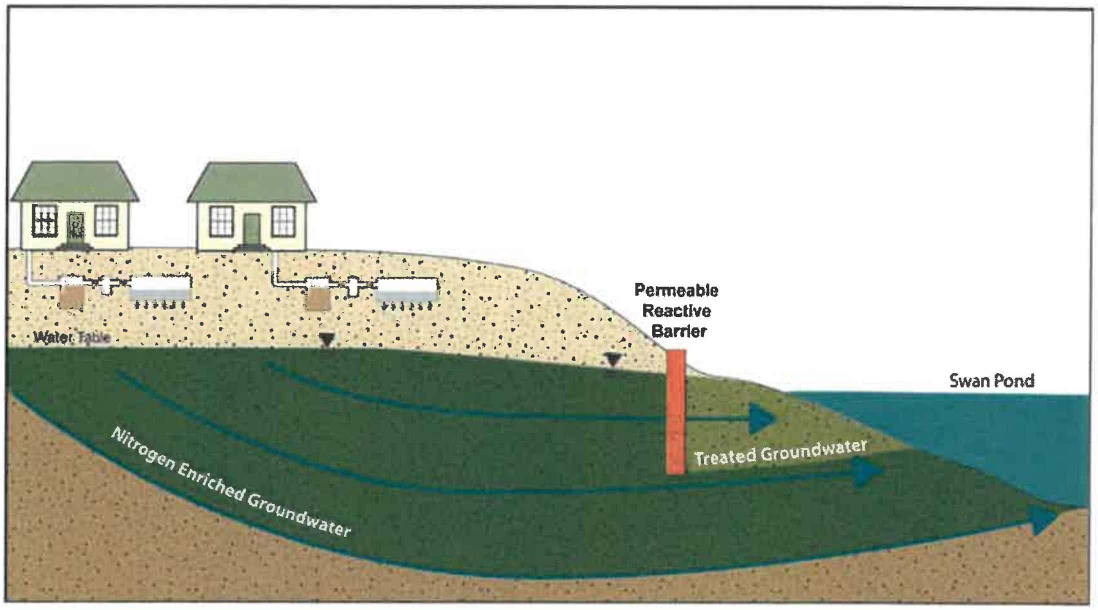


Figure 12 - Permeable Reactive Barrier (Trench Method)

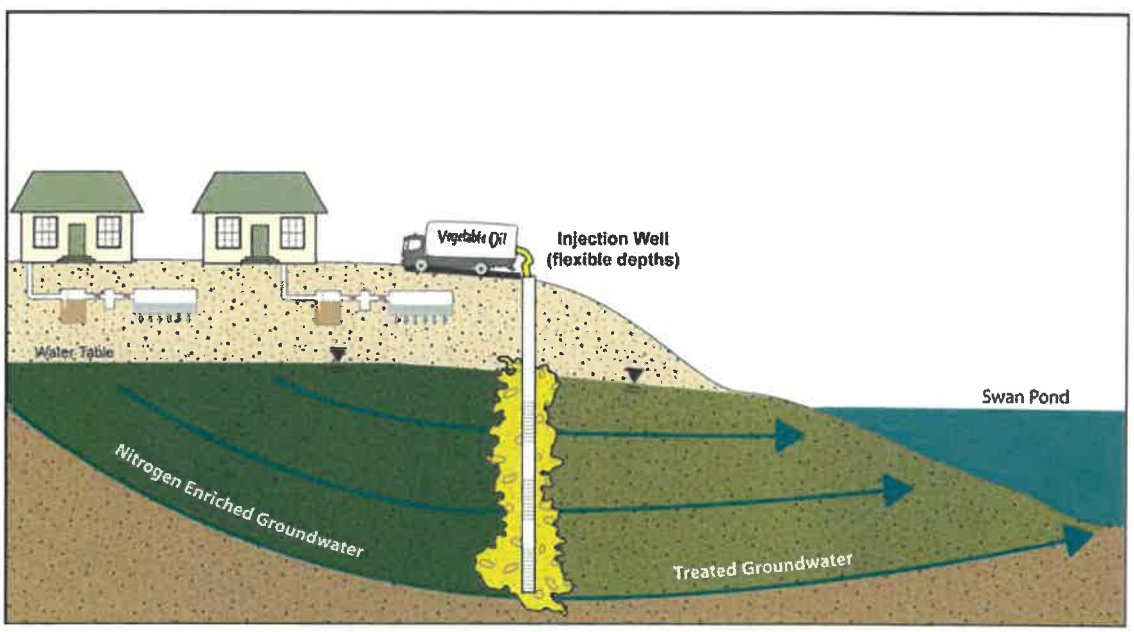


Figure 13 - Permeable Reactive Barrier (Injection Well Method)

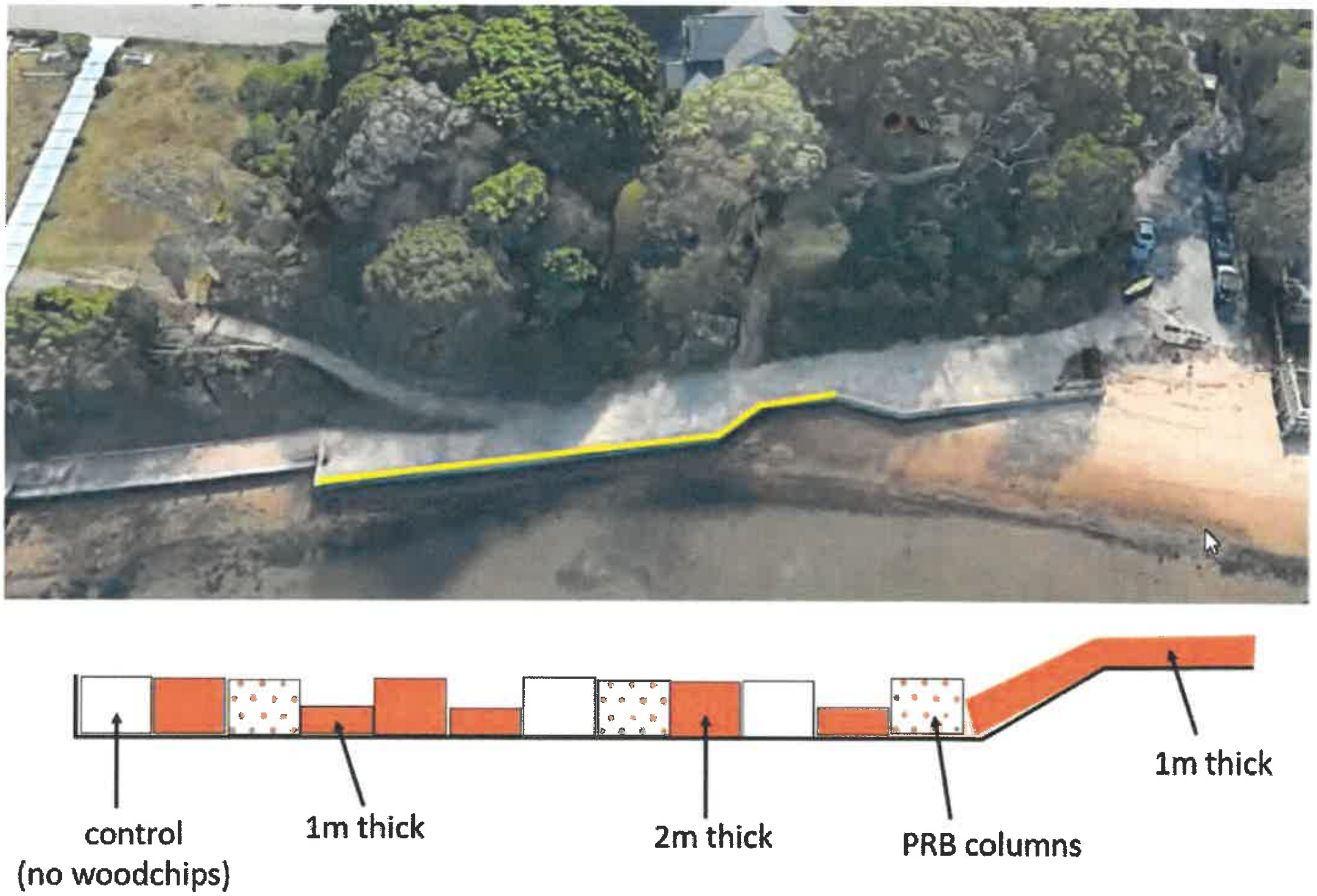


Figure 14 - Permeable Reactive Barrier (Bulkhead Method)

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: 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. 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.

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

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

To apply these nitrogen removal rates to actual shellfish harvest (landings) rates reported for the 2005 – 2018 period the Cape Cod Commission's Technology Matrix data were converted to a per-organism basis and then multiplied times the reported landings data provided through the Massachusetts Division of Marine Fisheries (see figure 18). The data shows a decline in hardshell clams but an increase in oysters. Overall, this analysis indicates that nitrogen attenuation has increased from 5875 kg/year in 2005 to 7798 kg/year in 2018 or an average annual rate of increase of 92.3 kg/year.

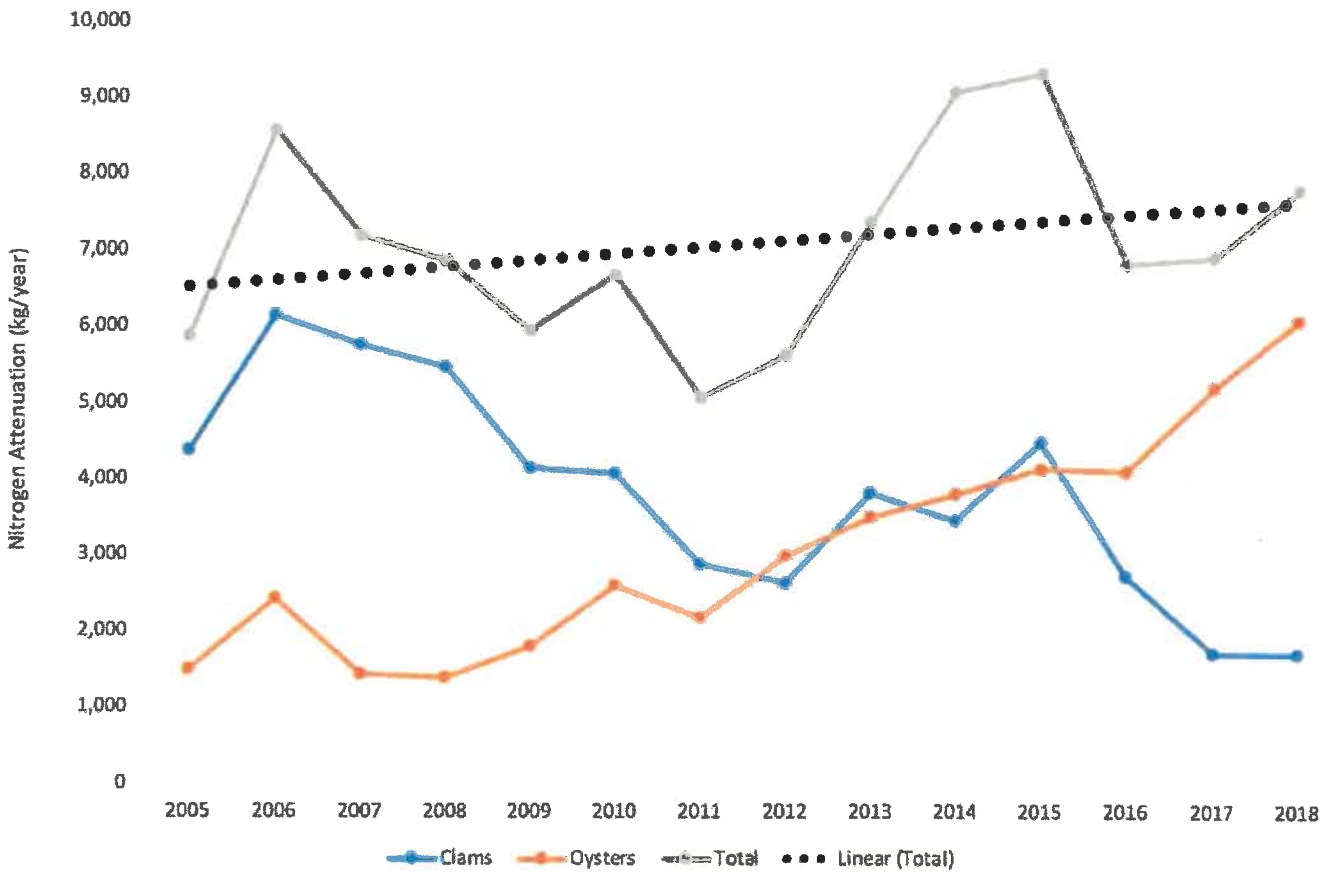


Figure 18 - Shellfish Landings and Nitrogen Uptake Rates

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 Falmouth and Orleans. A recent publication prepared by University of Massachusetts SMAST (2019) reports denitrification rates referred to as "oyster effect" of 24 – 36% (compared to the harvest removal rates) during the first two years of a study in Lonnies Pond in Orleans associated with the biodeposits.

To determine the potential for a sustainable expansion of the shellfishery several meetings were conducted with the Shellfish Constable and the Shellfish Advisory Committee. As a result of these discussions a plan is being developed to target a continued, sustainable expansion of the shellfishery at the growth rate of 92.3 kg/year consistent with the 2005 – 2018 period of record. Recent discussions indicate that the plan will include the development of several "no take" propagation areas and moderate increases in seed purchase and distribution.

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.

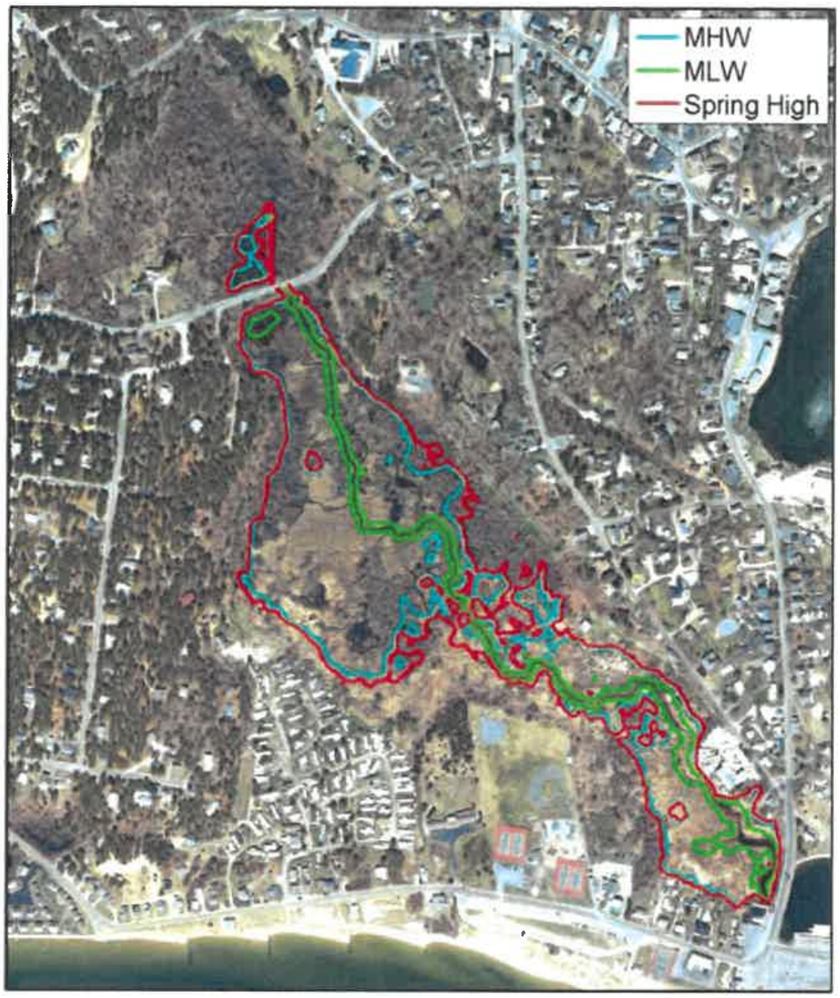


Figure 19 - Mayo Creek Restoration Project (Woods Hole Group, 2016)

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 19). 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.

A current stormwater project is under study by the MADOT at the intersection of Route 6 and Main Street (see figure 20). Two meetings were conducted with town officials and MADOT staff. We provided recommendations to integrate green infrastructure practices into the project and are awaiting a response from MADOT to discuss these in more detail.

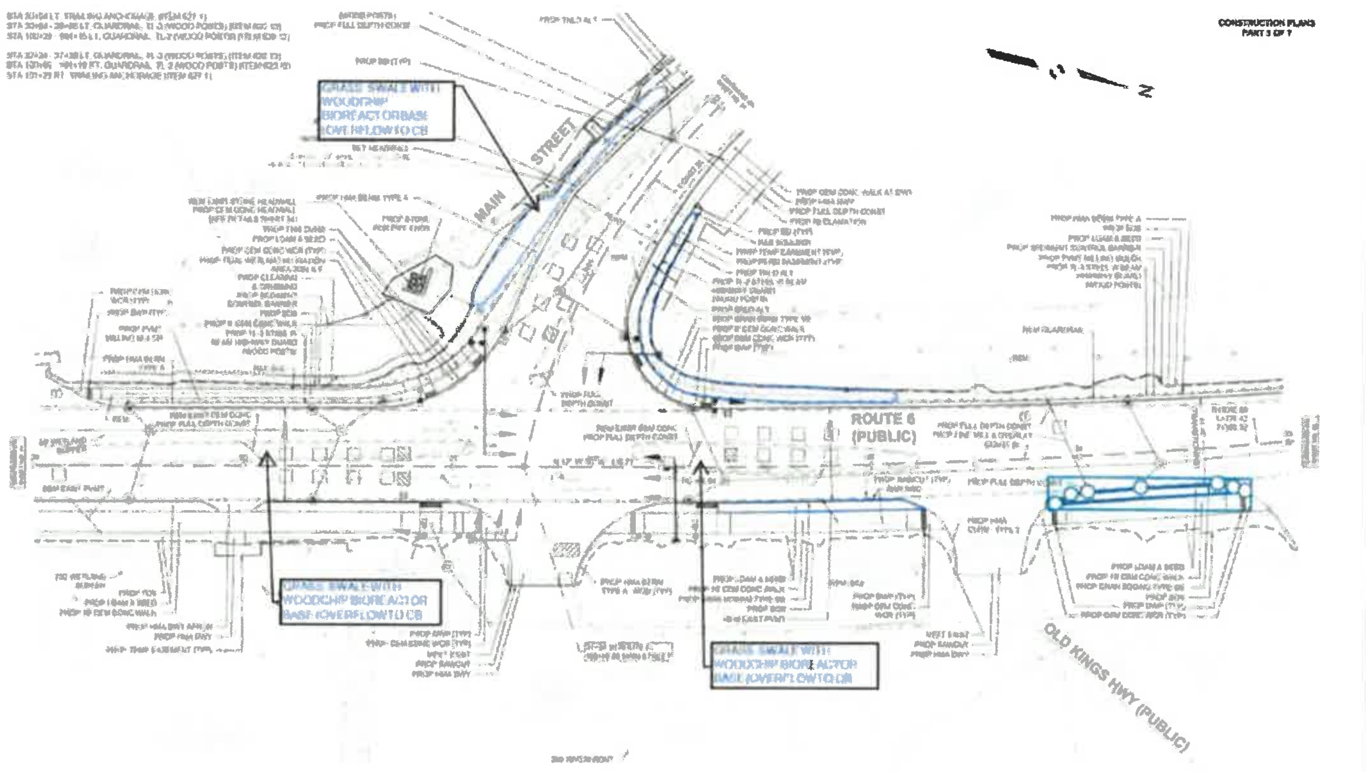


Figure 20 - MADOT Route 6/Main Street Project (Green Infrastructure Options)

8.3. HYBRID PLAN

To integrate both traditional and non-traditional approaches to nitrogen reductions we have prepared a hybrid plan. The 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.

The plan includes six phases (five years each) over a 30-year period. The first phase includes both traditional and non-traditional technologies. It includes the construction of a neighborhood-scale wastewater collection and treatment system to facilitate an affordable housing project that includes connection to neighboring municipal facilities and homes and will result in a net reduction on nitrogen loading to Duck Creek. It also contains a series of pilot projects including the installation of enhanced I&A septic systems, the development of a permeable reactive barrier pilot project along Commercial Street, the development of a shellfish management program to further evaluate the actual performance and costs of these strategies.

The second and subsequent phases call for expansion of these strategies based upon performance during the first pilot phase and choices made by the town. Depending upon the results of the pilots and preliminary test results, subsequent phases could include the construction of a full-scale permeable reactive barrier along Commercial Street to intercept and treat nitrogen-enriched groundwater currently discharging into Duck Creek and The Cove, two of the most impaired embayments in the Wellfleet Harbor system. The PRB's proximity to the shoreline will result in immediate improvements in coastal water quality.

Contingent upon the test results of the enhanced I&A systems during the first phase and MADEP's approval of them for "general use" these systems could be required in all upgrades, expansions, new construction, and possibly real estate transfers. By timing the implementation of these systems with individual property owners needs this will provide for improved social acceptability 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. It is anticipated that these two drivers would result in a sufficient number of upgraded (enhanced) I&A systems to meet the MEP target reductions over the planning period.

The hybrid plan also will include preliminary sewer plans for the downtown area and beyond. GHD is currently under contract with the town to evaluate these areas and to provide preliminary wastewater collection system layouts. These layouts will be included in this plan once they are developed. The hybrid plan will also include the potential expansion of the collection system beyond the downtown area to additional target areas that are determined to be unable to achieve compliance with the MEP thresholds. Comparative costs of the sewering options will also be provided.

Figure 21 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 along Commercial Street, 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.

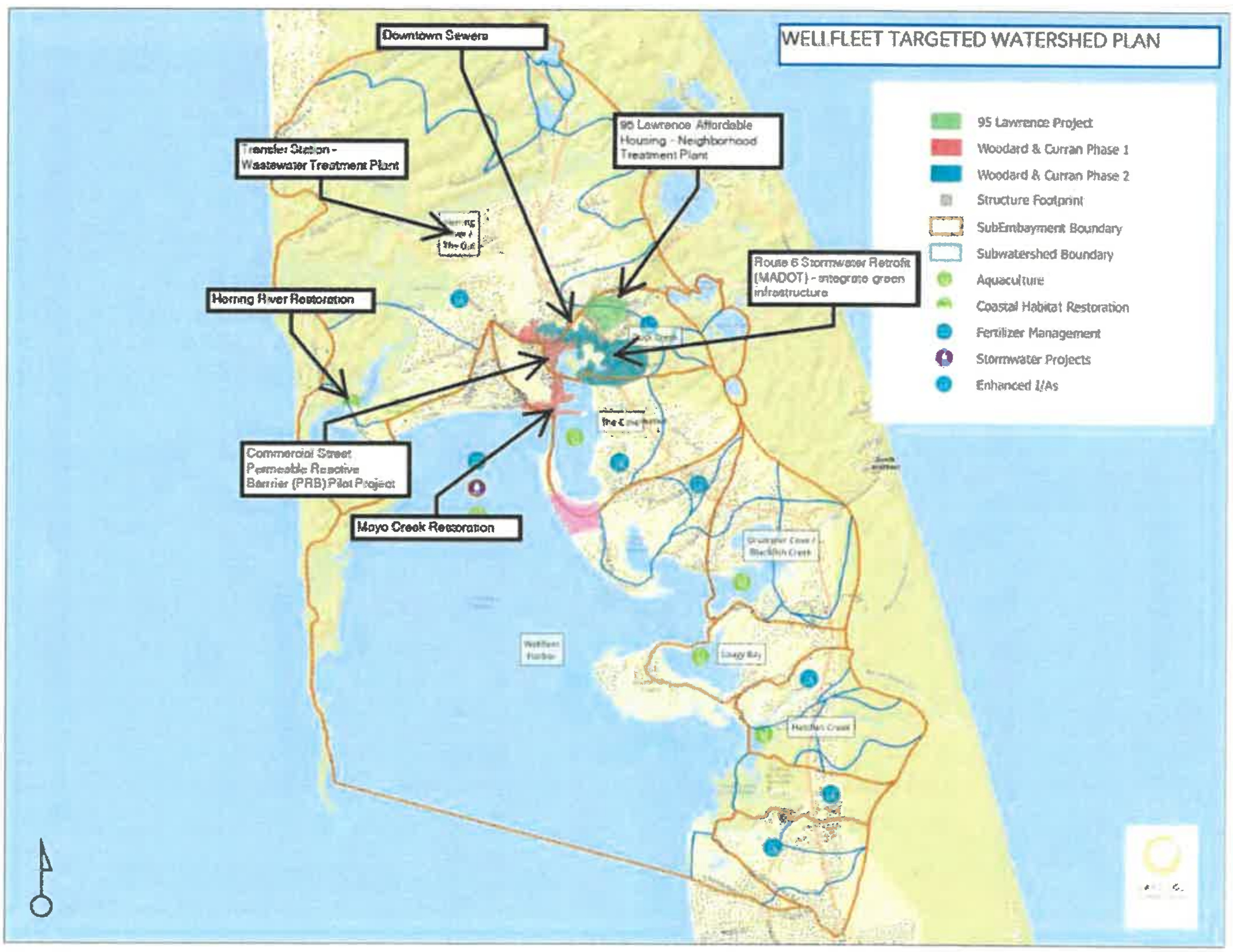


Figure 21 -Watershed Strategy Overview

Sensitivity Analysis: To evaluate the potential outcomes of this hybrid approach we have conducted sensitivity analyses for several possible scenarios. These include 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. These scenarios also include conservative estimates of nitrogen attenuation performance of the other associated technologies (including the 95 Lawrence Road wastewater treatment facility, permeable reactive barriers, stormwater management, shellfish/aquaculture, and ecological salt marsh restoration).

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 effluent concentration of approximately 6 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.

The results of the sensitivity analysis are summarized in Figure 22 and are provided in the Appendix and indicate that the MEP thresholds can be achieved in all of the subwatersheds using the enhanced I&A septic systems for both the 30-year (2052) planning period and full buildout conditions with performance at both the 5 mg/liter and 8 mg/liter levels. If the enhanced I&A septic systems perform at an average concentration of 11 mg/liter the MEP nitrogen thresholds can be achieved for the 30-year (2052) planning period. However, at 11 mg/liter additional management measures would be required in some of the watersheds under the buildout scenario. These additional measures could growth management to limit or redirect future growth and/or sewer collection and treatment systems.

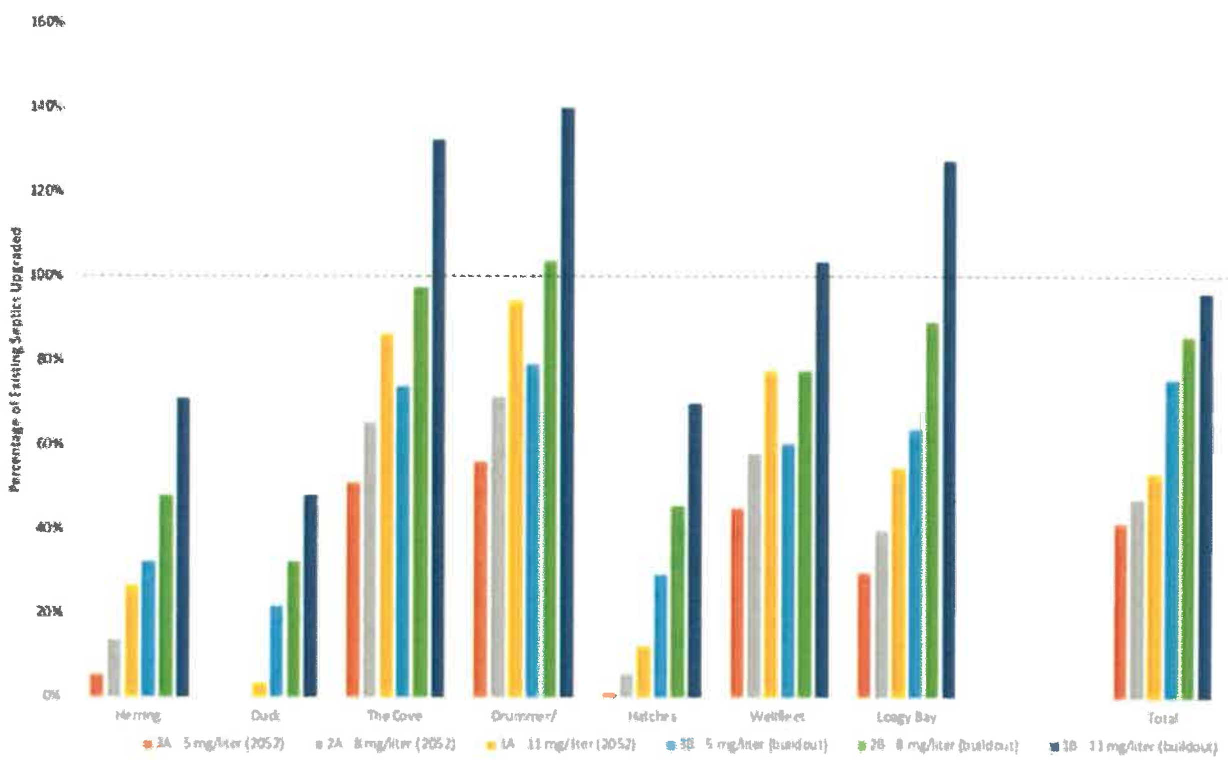


Figure 22 - Sensitivity Analysis

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 thirty-year planning period (2022 - 2052) and 2) buildout conditions.

Thirty-Year Growth Projection (2022 – 2052): To provide a projection for future growth during the 30-year planning period recent building permits were reviewed and added to the MEP existing loads (that were based upon 2010 land use data). The Wellfleet Housing Needs Assessment and Action Plan (2017) provides construction data during the 2000-2016 period (see figure 23). This study indicated that there were 427 building permits issued during the 2000-2016 period (average 27.6 per year). The study also indicated that approximately half of these permits represented new homes, the other half were expansions of existing homes.

The Wellfleet Board of Health files provide the most recent data on new construction during the 2017-2019 period. According to these records there was an average of 52 new or upgraded septic systems per year during this three-year period. To provide a thirty-year projection the actual housing figures were added for the 2011- 2016 period and a growth rate of 27.6 permits per year was utilized to project the 2017-2052 period. In accordance with the Housing Plan half of these permits were assumed to be new homes and half expansions of existing homes. This results in 828 building permits or an increase of 414 new buildings and 414 expansions over the planning period to the date of 2052. To estimate future increases in nitrogen loading during the 30-year planning period 414 new homes were added at a rate of 4.73 kg/year-home. Nitrogen load increases associated with expansions was estimate at half of this rate at 2.37 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

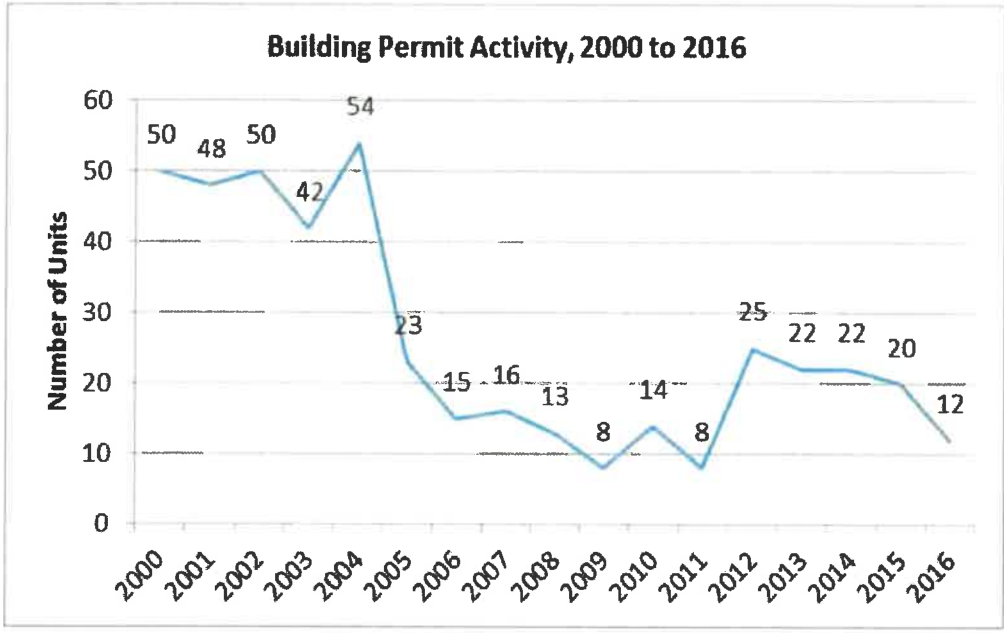


Figure 23 - Housing Growth 2000 - 2016 (Wellfleet Affordable Housing Plan, 2017)

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 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

At the core of this plan is the potential application of enhanced I&A septic systems.

A recent project conducted by the Buzzards Bay Coalition in Falmouth investigated both performance and costs of installing these I&A systems in the West Falmouth watershed where MEP nitrogen loads exceeded the targets. As of the date of this report thirty properties have been identified for construction and ten installations hav been completed. The report indicates that the average cost for a new replacement system is $28,111 (including new septic tank and leaching field) and the average cost for an upgrade (addition of a treatment unit to an existing septic tank and leaching field) at $17,567. For the purpose of this plan we are assuming that 25% of the systems will be upgrades and 75% will be full installations with new septic tanks and leaching facilities. This results in a blended average capital cost of $25,475 per system.

The Buzzards Bay Coalition report also provided costs for operation and maintenance (O&M). The average cost for annual operation and maintenance was estimated at $750/year. During the first phase of the plan when the enhanced I&A systems will be operating under provisional permit quarterly sampling will be required at a cost of $1000/year. Once general approval is obtained (assumed at the end of Phase 1) long-term monitoring costs are estimated based upon the Pleasant Bay Watershed Permit and MADEP's recommended monitoring plan of sampling 10% of the systems each month at an estimated average cost of $250/system-year. Together the average annual operation, maintenance, and monitoring (OMM) costs are estimated at $1700/year for the first five years and subsequently at $1000/year per system for the remaining 25-years of the plan. This represents an average annual lifecycle OMM cost of $1100/year per system. On-going discussions with MASSTC suggest that OMM costs could be further reduced with the implementation of a responsible management entity (RME), remote monitoring of pump systems, and remote water quality screening utilizing EPA's recently developed nitrogen sensor.

Cost estimates for other portions of the plan are under preparation. GHD is currently preparing preliminary wastewater collection and treatment options and associated cost estimates. 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. Cost estimates for the 95 Lawrence project have been provided in a report prepared by Bohler

Engineering.

11.0 IMPLEMENTATION SCHEDULE

The proposed plan is organized into a 30-year implementation framework, consisting of six, five-year periods (see Table 3). Each phase identifies specific project implementation elements for each subwatershed. As stated earlier in this report Phase 1 includes several pilot projects including enhanced I&A septic systems, a permeable reactive barrier, and a neighborhood cluster wastewater treatment system. Phase 1 also includes the Mayo Creek restoration project, continued growth of the shellfish industry, and stormwater remediation projects.

Subsequent phases include the construction of targeted sewering areas in the higher density downtown areas and the deployment of enhanced I&A septic systems in other areas. 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 reductions.

Table 3 – Targeted Watershed Plan Implementation Schedule

Phase	Years	Nitrogen Reduction Strategies: Wastewater Treatment	kg/yr	Stormwater	kg/yr	Fertilizer	k/gyr	Permeable Reactive Barrier	kg/yr	Shellfish	kg/yr	Ecological Restoration	kg/yr	TOTAL kg/yr
1	2022 - 2026	Establish Responsible Management Entity (RME) and Install 25 - 30 EIA systems/year 95 Lawrence - Permit, Design & Construct Phase 1 (Housing & Municipal Properties)	494 341	Rte 6 MADOT Integrate N attenuation	102	Implement Fertilizer Controls	98	Pilot Project Bank/Commercial Street (50 feet)	20	Sustainable growth at 94 kg/year	462	Mayo Creek. Design, Permit & Construction	317	1834
2	2027 - 2031	95 Lawrence - Design & Construct Phase 2 (Connect Neighborhood Homes) Adaptive Management Install 66 - 77 EIA systems/year; Design & Construct Downtown Sewers Phase 1	281 1278	Additional Stormwater Retrofits	102	Adaptive Management Implement Fertilizer Controls	98	Construct Commercial Street/Duck Creek (1000 feet)	235	Sustainable growth at 94 kg/year	462	Herring River		2456
3	2032 - 2036	Install 66 - 77 EIA systems/year; Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Construct The Cove PRB projects (2000 feet)	970	Sustainable growth at 94 kg/year	462	Sunken Meadow (Hatches Creek)		2910
4	2037 - 2041	Install 66 - 77 EIA systems/year; Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462	Trout Brook (Upper Basin)		1940
5	2042 - 2046	Install 66 - 77 EIA systems/year; Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462	Eastern Blackfish Creek		1940
6	2047 - 2051	Install 66 - 77 EIA systems/year; Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462			1940
N reduction			7506		612		588		1225		2772		317	13020

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. In preparation for town meeting the following votes were taken by town boards and commission:

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.

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 24). The first phase of the plan includes several pilot projects including installation of enhanced I&A septics, a permeable reactive barrier, and construction of a wastewater collection and treatment system. 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.

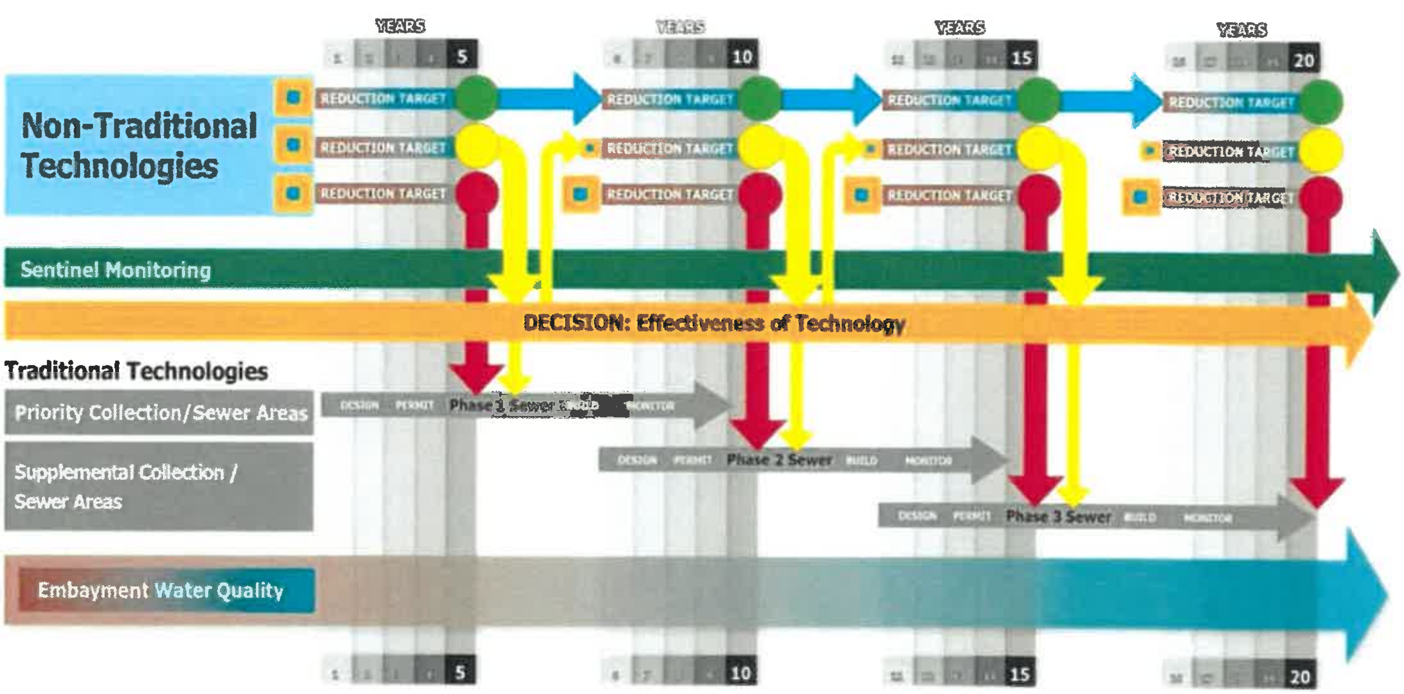


Figure 24: Adaptive Management

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.

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APPENDIX A - NITROGEN LOAD CALCULATIONS - I&A PERFORMANCE AT 5 MG/LITER (79% REDUCTION)

Scenario 1A - I&A @ 5 mg/liter 2052	Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Health Regulation Require IA Future Development	1068	265	534	394	535	834	151	3782
Enhanced I&A Up N reduction MEP/MADEP	94	119	972	803	154	1855	215	4211
percentage load upgraded	3%	9%	40%	46%	7%	45%	36%	39%
Fertilizer Mitigation 25% 25% CCC 208 Plan	171	40	118	60	52	145	23	610
Stormwater Reductions 25% 25% CCC 208 Plan	186	46	114	61	50	114	17	588
Aquaculture/Shellfish/Harvest 0.13 g/oyster- CC Tech Matrix	277	277	277	277		1385	277	2769
Ecological Restoration 40% CCS/WHG			317					317
Permeable Reactive Barrier 72.5% CC Tech Matrix		337	932					1270
percentage of load flowing to PRB		19%	28%					
Collection & Treatment N reduction	0	622	0	0	0	146	0	768
95 Lawrence	0		0	0	0	0	0	
Harborside Trailer Park (Upgrade 2012)			0	0		146	0	
Downtown Sewers								
Total Load Reduced	1795	1707	3265	1594	791	4478	684	14315
Remaining Load	0	0	0	0	0	0	0	14315

Scenario 1B - Downtown Sewers and I&A @ 5 mg/liter Buildout	Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Transfer of Development Rights to Downtown Sewers (Treatment in Herring River)								0
Health Regulation Require IA Future Development	1786	411	1080	770	1166	1165	383	6761
Enhanced I&A Up N reduction MEP/MADEP	819	227	1328	1075	662	2071	334	6515
percentage properties upgraded	23%	18%	55%	61%	30%	50%	56%	60%
Fertilizer Mitigation 25% 25% CCC 208 Plan	169	45	145	72	65	158	31	685
Stormwater Reductions 25% 25% CCC 208 Plan	184	51	140	73	63	124	24	658
Aquaculture/Shellfish/Harvest 0.13 g/oyster- CC Tech Matrix	324	324	324	324		1621	324	3243
Ecological Restoration 40% CCS/WHG			317					317
Permeable Reactive Barrier 72.5% CC Tech Matrix		345	962					1307
percentage of load flowing to PRB		17%	24%					
Collection & Treatment N reduction		622	0	0	0	146	0	768
95 Lawrence		622						622
Harborside Trailer Park (Upgrade 2012)						146		146
Downtown Sewers								0
Total Load Reduced	3282	2026	4296	2314	1956	5285	1095	20255
Remaining Load	0	0	0	0	0	0	0	20254

APPENDIX B - NITROGEN LOAD CALCULATIONS - I&A PERFORMANCE AT 8 MG/LITER (66% REDUCTION)

Scenario 2A - I&A @ 8 mg/liter 2052		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Health Regulation Require IA Future Development		892	222	446	329	447	697	126	3159
Enhanced I&A Up N reduction	MEP/MADEP	270	153	1016	868	242	1992	240	4780
percentage load upgraded		9%	14%	50%	59%	13%	58%	49%	44%
Fertilizer Mitigation 25%	25% CCC 208 Plan	171	40	118	60	52	145	23	610
Stormwater Reductions 25%	25% CCC 208 Plan	186	46	114	61	50	114	17	588
Aquaculture/Shellfish/Harvest	0.13 g/oyster- CC Tech Matrix	277	277	277	277		1385	277	2769
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		347	976					1323
percentage of load flowing to PRB			20%	30%					
Collection & Treatment N reduction		0	622	0	0	0	146	0	768
95 Lawrence		0		0	0	0	0	0	
Harborside Trailer Park (Upgrade 2012)				0	0		146	0	
Downtown Sewers									
Total Load Reduced		1795	1707	3265	1594	791	4478	684	14315
Remaining Load		0	0	0	0	0	0	0	14315

Scenario 2B - Downtown Sewers and I&A @ 8 mg/liter Buildout		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
									0
Health Regulation Require IA Future Development		1492	344	902	643	974	973	320	5648
Enhanced I&A Up N reduction	MEP/MADEP	1112	280	1418	1202	854	2262	397	7525
percentage loads upgraded		37%	26%	70%	82%	46%	65%	80%	70%
Fertilizer Mitigation 25%	25% CCC 208 Plan	169	45	145	72	65	158	31	685
Stormwater Reductions 25%	25% CCC 208 Plan	184	51	140	73	63	124	24	658
Aquaculture/Shellfish/Harvest	0.13 g/oyster- CC Tech Matrix	324	324	324	324		1621	324	3243
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		360	1050					1410
percentage of load flowing to PRB			18%	26%					
Collection & Treatment N reduction			622	0	0	0	146	0	768
95 Lawrence			622						622
Harborside Trailer Park (Upgrade 2012)							146		146
Downtown Sewers									0
Total Load Reduced		3282	2026	4296	2314	1956	5285	1095	20255
Remaining Load		0	0	0	0	0	0	0	20254

APPENDIX C - NITROGEN LOAD CALCULATIONS - I&A PERFORMANCE AT 11 MG/LITER (53% REDUCTION)

Scenario 3A - I&A @ 11 mg/liter 2052

Health Regulation Require IA Future Development		716	178	358	265	359	560	101	2537
Enhanced I&A Up N reduction	MEP/MADEP	466	188	476	933	331	2131	265	4791
percentage load upgraded		19%	22%	29%	79%	22%	77%	67%	44%
Fertilizer Mitigation 25%	25% CCC 208 Plan	150	40	117	59	51	143	23	583
Stormwater Reductions 25%	25% CCC 208 Plan	186	46	114	61	50	114	17	588
Aquaculture/Shellfish/Harvest	0.13 g/oyster- CC Tech Matrix	277	277	277	277		1385	277	2769
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		356	1005					1361
percentage of load flowing to PRB			20%	31%					
Collection & Treatment N reduction			622	600			146		1368
95 Lawrence			622				146		
Harborside Trailer Park (Upgrade 2012)				600					
Supplemental Sewers									
Total Load Reduced		1795	1707	3265	1594	791	4478	684	14315
Remaining Load		0	0	0	0	0	0	0	14315

Scenario 3B - Downtown Sewers and I&A @ 11 mg/liter Buildout		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
									0
Health Regulation Require IA Future Development		1198	276	724	516	783	782	257	4536
Enhanced I&A Up N reduction	MEP/MADEP	1406	333	1136	1128	1046	2454	380	7883
percentage properties upgraded		58%	39%	70%	95%	70%	88%	96%	73%
Fertilizer Mitigation 25%	25% CCC 208 Plan	169	45	145	72	65	158	31	685
Stormwater Reductions 25%	25% CCC 208 Plan	184	51	140	73	63	124	24	658
Aquaculture/Shellfish/Harvest	0.13 g/oyster- CC Tech Matrix	324	324	324	324		1621	324	3243
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		375	1109					1484
percentage of load flowing to PRB			19%	27%					
Collection & Treatment N reduction			622	400	200	0	146	80	1448
95 Lawrence			622						622
Harborside Trailer Park (Upgrade 2012)							146		146
Supplemental Sewers				400	200			80	680
Total Load Reduced		3282	2026	4296	2314	1956	5285	1095	20254
Remaining Load		0	0	0	0	0	0	0	20254

Scenario 3C - Transfer Development Rights and I&A @ 11 mg/liter Buildout		Herring River	Duck Creek	The Cove	Drummer/ Blackfish	Hatches	Wellfleet Harbor	Loagy Bay	Total
Transfer of Development Rights to Herring River Watershed				800	340			180	1320
Health Regulation Require IA Future Development		1198	276	300	336	783	782	161	3836
Enhanced I&A Up N reduction	MEP/MADEP	2396	663	1281	1169	1046	2454	375	9384
percentage properties upgraded		98%	77%	79%	99%	70%	88%	95%	87%
Fertilizer Mitigation 25%	25% CCC 208 Plan	169	45	145	72	65	158	31	685
Stormwater Reductions 25%	25% CCC 208 Plan	184	51	140	73	63	124	24	658
Aquaculture/Shellfish/Harvest	0.13 g/oyster- CC Tech Matrix	324	324	324	324		1621	324	3243
Ecological Restoration	40% CCS/WHG			317					317
Permeable Reactive Barrier	72.5% CC Tech Matrix		375	989					1363
percentage of load flowing to PRB			19%	24%					
Collection & Treatment N reduction			622				146		768
95 Lawrence			622						622
Harborside Trailer Park (Upgrade 2012)							146		146
Downtown Sewers									0
Total Load Reduced		4272	2356	4296	2314	1956	5285	1095	20255
Remaining Load		0	0	0	0	0	0	0	21574

SELECTBOARD

AGENDA ACTION REQUEST

IV

IMPACT OF SEA LEVEL RISE - WASTEWATER

REQUESTED BY:	
DESIRED ACTION:	
PROPOSED MOTION:	
SUMMARY (Optional)	
ACTION TAKEN:	Moved By: ________________ Seconded By: ________________ Condition(s):
VOTED:	Yea _____ Nay_______ Abstain ________

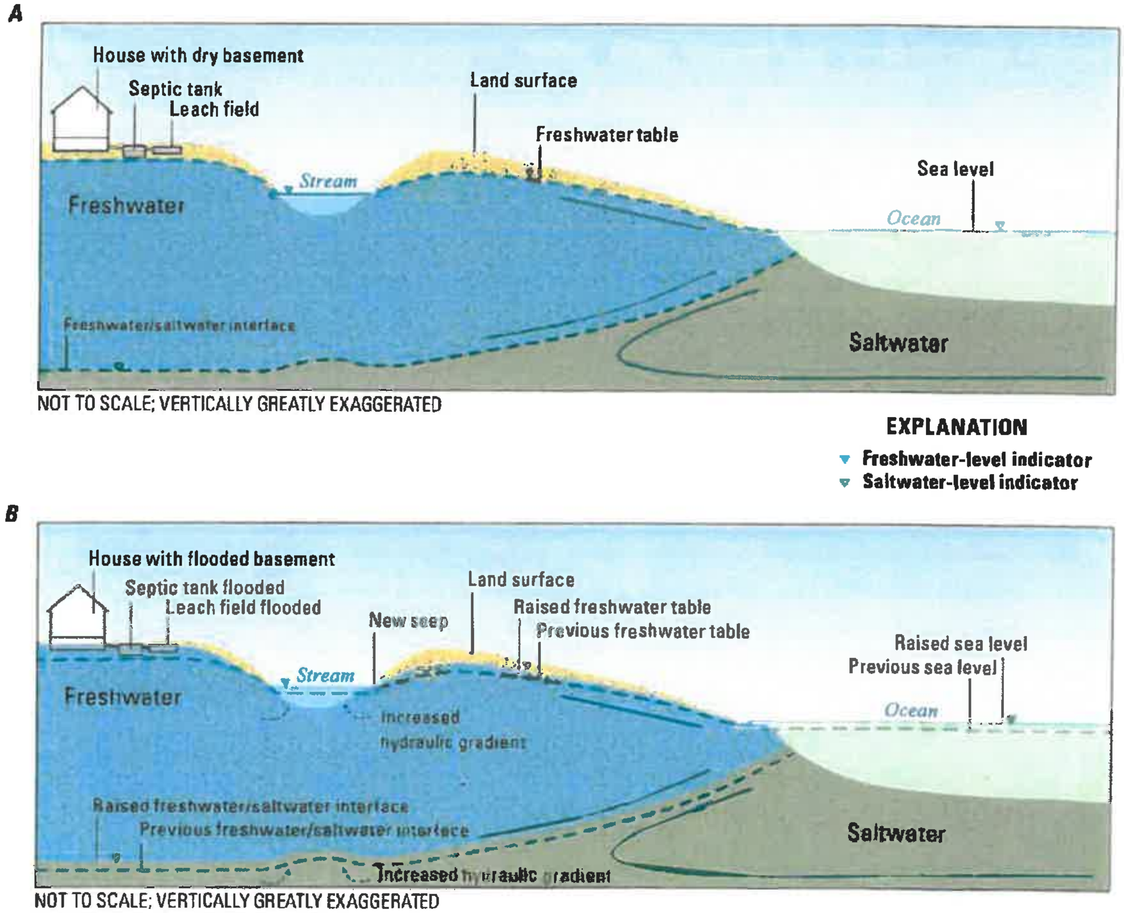

Figure 3. An unconfined coastal aquifer system, similar to the aquifer underlying Cape Cod, Massachusetts, *A*, at static conditions and *B*, after elevation of the sea level.

The analytical steps for evaluating depths to water for a given sea level are as follows:

- Coastline geometry determined from 1-m-resolution lidar was used to modify the geometry of hydrologic boundaries in the 2D numerical model.
- Specified heads at the boundaries were modified to represent the new sea level and a new freshwater/saltwater interface was simulated.
- This interface position, simulated at a 100-ft resolution, was spatially averaged to 400 ft and incorporated into the 3D groundwater-flow model as a no-flow boundary.
- Hydrologic boundaries of the groundwater-flow model were modified using the same lidar-derived coastal geometry and the new sea level.
- The groundwater-flow model configured for a given sea level was used to simulate the new water table for that sea level.
- The model-calculated water table altitudes, at a discretization of 400 ft, were linearly interpolated to a resolution of 100 ft, the same as the spatially averaged lidar land surface altitudes.
- The two surfaces of the model-calculated water table altitudes and the spatially averaged lidar land surface altitudes were used to determine depths to water for the sea level of interest.
- Depths to water were estimated for the 2011 sea level and for sea levels 2, 4, and 6 ft above the 2011 sea level.

ground water

Effects of Sea-Level Rise on Ground Water Flow in a Coastal Aquifer System

by John P. Masterson[1] and Stephen P. Garabedian[2]

Abstract

The effects of sea-level rise on the depth to the fresh water/salt water interface were simulated by using a density-dependent, three-dimensional numerical ground water flow model for a simplified hypothetical fresh water lens that is similar to shallow, coastal aquifers found along the Atlantic coast of the United States. Simulations of sea-level rise of 2.65 mm/year from 1929 to 2050 resulted in an increase in water levels relative to a fixed datum, yet a net decrease in water levels relative to the increased sea-level position. The net decrease in water levels was much greater near a gaining stream than farther from the stream. The difference in the change in water levels is attributed to the dampening effect of the stream on water level changes in response to sea-level rise. In response to the decreased water level altitudes relative to local sea level, the depth to the fresh water/salt water interface decreased. This reduction in the thickness of the fresh water lens varied throughout the aquifer and was greatly affected by proximity to a ground water fed stream and whether the stream was tidally influenced. Away from the stream, the thickness of the fresh water lens decreased by about 2% from 1929 to 2050, whereas the fresh water lens thickness decreased by about 22% to 31% for the same period near the stream, depending on whether the stream was tidally influenced. The difference in the change in the fresh water/salt water interface position is controlled by the difference in the net decline in water levels relative to local sea level.

Introduction

Residents of coastal areas are becoming increasingly concerned about the effects of sea-level rise. These concerns include possible higher rates of erosion than at present, flooding from higher storm surges (Theiler and Hammar-Klose 2000), and landward intrusion of sea water in coastal marshes and wetlands (Nuttle and Portnoy 1992; Donnelly and Bertness 2001). The National Oceanic and Atmospheric Administration (2003) reports a rising trend in sea level at the Boston Harbor tidal gauge, Boston, Massachusetts, which has been in operation since 1921, of about 2.65 +/−0.1 mm/year. The Intergovernmental Panel on Climate Change (IPCC) predicts that global seas may rise by an additional 0.2 to 1.0 m by 2100, with a best estimate of 0.5 m (IPCC 2001). This rate of rise would be nearly double the rate of rise observed at Boston Harbor over the past 80 years.

Previous studies from the Godavari Delta and Agatti Island in India (Bobba 1998, 2002) and in the coastal areas of the Netherlands (Oude Essink 1999) have determined that increased flooding from a rising level of saline surface water in areas of low topographic relief will result in contamination of underlying fresh water coastal aquifers. These coastal aquifers are affected by the mixing from above of saline water that has either inundated low-lying coastal areas or encroached upon large riverine systems. It is believed that some coastal aquifers such as those of Cape Cod, Massachusetts (Figure 1) are not susceptible to salt water intrusion from a rising sea level because they are not dominated by large, tidally influenced riverine systems that extend inland to great distances and are not areas of low topographic relief (Theiler and Hammar-Klose 2000).

The Cape Cod aquifer system consists of six hydrologically separate flow lenses that are underlain by thick deposits of sand, gravel, silt, and clay similar to the

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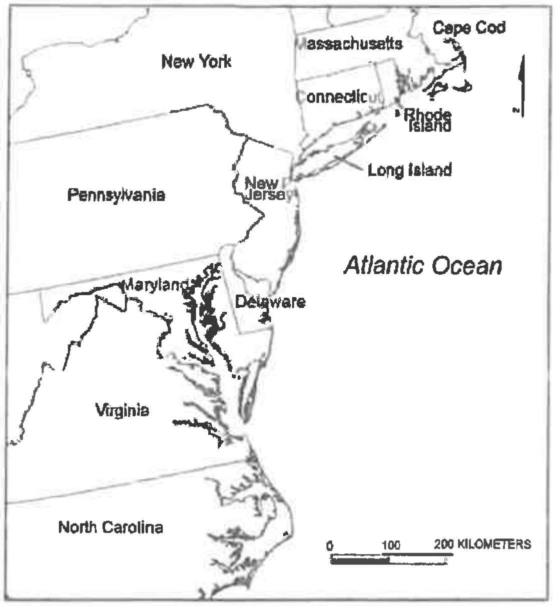

Figure 1. Location of a portion of the Atlantic coastline of eastern United States.

coastal aquifer systems found in eastern Long Island, New York, and the barrier island complexes along the Atlantic coast of the United States (Figure 1) (Barlow 2003; Trapp and Meisler 1992). The northeastern portion of Cape Cod is narrow, and the depth to bedrock is generally > 150 m (Oldale 1969). As a result, the fresh water lenses in this aquifer system are bounded below by salt water similar to an island aquifer system (Figure 2). The transition between fresh water and salt water is narrow relative to the total thickness of the fresh water lenses on Lower Cape Cod and, therefore, is often referred to as the fresh water/salt water interface (Guswa and LeBlanc 1985; LeBlanc et al. 1986; Masterson 2004).

In general, the depth to the fresh water/salt water interface bounding the flow lenses of Lower Cape Cod is

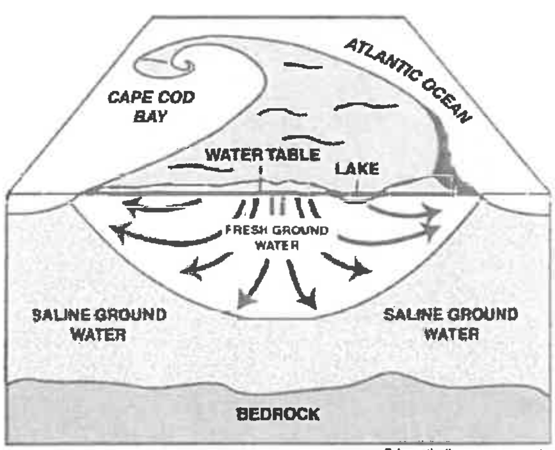

Figure 2. Schematic diagram of the Lower Cape Cod Aquifer system, Cape Cod, Massachusetts (modified from Strahler 1972).

directly proportional to the altitude of the overlying water table such that if the altitude of the water table above sea level (z_w) is lowered by 1 m, the depth to the fresh water/salt water interface below sea level (z_s) decreases by 40 m (Ghyben 1888; Herzberg 1901): $z_s = 40z_w$.

The Ghyben-Herzberg relation is based on the density difference between fresh and salt water and is a general approximation, subject to many simplifying assumptions, of the actual interaction between fresh water and salt water flow. For instance, the assumption that hydrostatic heads exist in the vertical dimension results in an overprediction of the depth of the fresh water/salt water interface near the center of the flow lens where downward flow is substantial, and underpredicts the depth of the fresh water/salt water interface near the coast where upward flow is substantial. Anisotropic conditions in the aquifer also exacerbate these errors, as do the vertical flow conditions beneath large pumping wells or surface water bodies.

Because the fresh water lenses of northeastern Cape Cod are bounded laterally and below by salt water, it is generally assumed that the water levels in the fresh water aquifers will rise in unison with the rising sea level, resulting in no change in the height of the water table above local sea level and, therefore, no change in the depth to the fresh water/salt water interface below sea level. This hypothesis is supported in part by the analysis of the long-term change in water levels at a USGS observation well about 300 m from Cape Cod Bay in northeastern Cape Cod. McCobb and Weiskel (2003) calculated a rate of water level rise of about 2.1 mm/year at this observation well from 1950 to 2001 relative to the National Geodetic Vertical Datum of 1929 (NGVD 29). This rate is similar to the rate of sea-level rise observed at Boston Harbor about 80 km northwest of the well site across Cape Cod Bay (National Oceanic and Atmospheric Administration 2003); however, no corresponding information on the depth of the fresh water/salt water interface was available for the area near this well.

Masterson (2004) reported that the observed water table altitudes at most other long-term monitoring wells not affected by pumping or other stresses are increasing with time in the northeastern portion of the Cape Cod aquifer. This increase in water levels may be a response to rising sea level, and the magnitude of the increase appears to be related to the proximity to nontidal portions of ground water fed streams. What has not been determined at these sites is whether sea-level rise over time could affect the position and movement of the underlying fresh water/salt water interface.

This article presents an analysis of a hypothetical aquifer consisting of a shallow, permeable, fresh water lens system similar to those found along the Atlantic coast of the United States to demonstrate that the nontidal portions of ground water fed streams can affect the changes in nearby water levels and the depth to the underlying fresh water/salt water interface resulting from sea-level rise. For the purpose of this analysis, a future rate of sea-level rise from 2005 to 2050 was based on the average measured rate of rise (2.65 mm/year) at the Boston Harbor tide gauge from 1921 to 2000 (National Oceanic and Atmospheric Administration 2003).

Method of Analysis

A numerical model of ground water flow was developed to simulate fresh water and salt water flow in a hypothetical aquifer surrounded by and underlain by salt water similar to those found in fresh water lenses of Lower Cape Cod, Massachusetts (Masterson 2004), and the eastern forks of Long Island, New York (Misut et al. 2004). The USGS computer program SEAWAT-2000 (Langevin et al. 2003) was used for this analysis. SEAWAT-2000 simulates variable-density, transient ground water flow in three dimensions based on the empirical relation between salt concentration and salt water density developed by Baxter and Wallace (1916): $\rho = \rho_f + EC$, where the density of salt water (ρ) is calculated by adding the product of salt concentration (C) multiplied by a dimensionless constant (E) of about 0.7143 (for salt concentrations ranging from zero to that of sea water [35 kg/m^3]) to the density of fresh water (ρ_f:1000 kg/m^3).

The simulation of solute transport was made by using an implicit finite-difference solution with advective transport only (no specified dispersion) to calculate the position and movement of the transition zone between fresh water and salt water. The numerical dispersion in these simulations produced a transition zone similar in thickness to the observed transition zone from the field data (generally < 12 m thick) on Cape Cod for nonpumping conditions (LeBlanc et al. 1986). In these instances, we assumed that the 50% salt concentration contour was a reasonable approximation of the interface between fresh water and salt water for the purpose of determining changes in the position of the interface with time.

The measured sea-level rise data were incorporated into the model simulations by specifying an annual increase of 2.65 mm/year in the simulated mean sea-level altitude, which is a model boundary condition. This rate resulted in a total increase of 0.32 m from 1929 to 2050. These simulations were made to assess the effects of the changing salt water boundary condition on water levels, streamflow, and the position of the fresh water/salt water interface in response to sea-level rise.

The effect of increases in stream stage with rising sea level was also considered in this analysis. In one scenario, it was assumed that the stream was not affected by increases in mean sea level and that the stream stage remained constant throughout the simulation period. In a second simulation, the stream stage and the area that is tidally affected increased in response to increases in mean sea level.

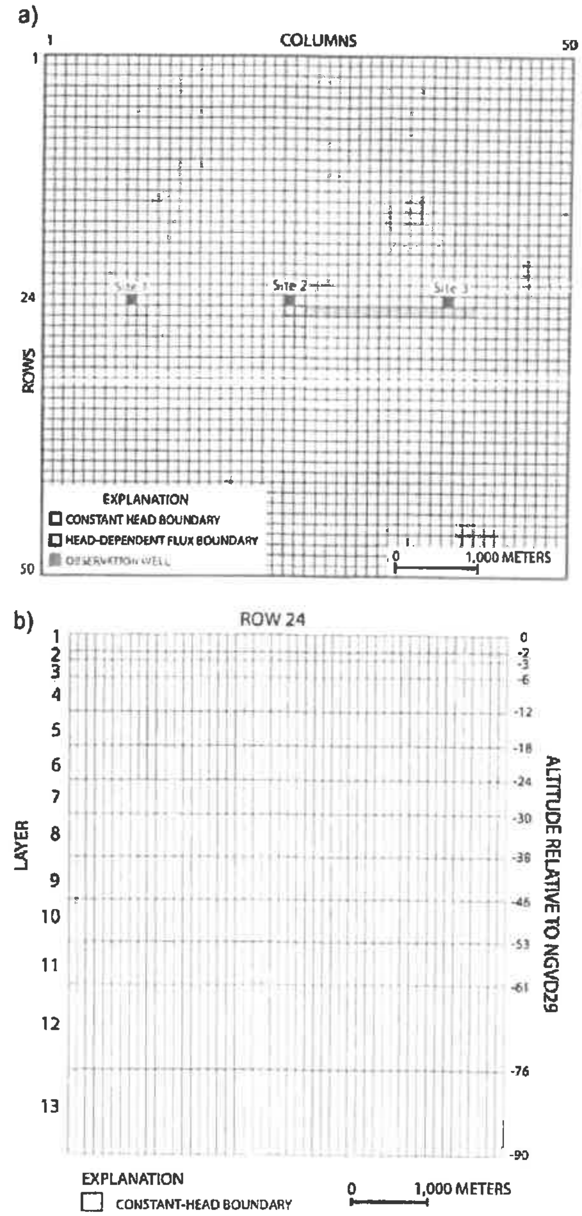

Figure 3. (a) Model extent, location of sites 1, 2, and 3 and distribution of simulated boundary conditions of ground water flow model. (b) Vertical discretization and distribution of simulated boundary conditions along row 24 of ground water flow model.

Model Description

The finite-difference grid for the numerical model consists of uniformly spaced model cells that are 120 m on a side (Figure 3a). The grid consists of 50 rows, 50 columns, and 13 layers that extend from the water table to a uniform depth of about 90 m below NGVD 29, with the thickness of the layers ranging from about 2 to 15 m (Figure 3b).

The simulated area is similar in size and thickness to the northernmost fresh water lenses of the Cape Cod aquifer system. Although the unconsolidated sand and gravel and silt and clay sediments that constitute the northern part of the Cape Cod aquifer system extend to bedrock, the depth to bedrock is in most places much greater than the depth to the fresh water/salt water interface (Figure 2). Therefore, the fresh water flow system is bounded below by the transition between fresh water and underlying salt water rather than bedrock.

The boundaries of the numerical model represent the physical boundaries of an island aquifer system similar to the hydraulically independent fresh water flow lenses of northeastern Cape Cod. The upper boundary of the model is the water table, which is a free-surface boundary that receives a spatially uniform recharge rate of about 70 cm/year which is consistent with the assumed recharge rate in coastal aquifers along the Atlantic coast of the United States (Trapp and Meisler 1992; Masterson 2004; Misut et al. 2004; Walter and Whelan 2004).

The lower boundary of the fresh water flow system is the transition between fresh water and salt water; the position of this boundary was calculated by the numerical model. An arbitrary bottom altitude of about 90 m below NGVD 29 was specified as a no-flow boundary for this analysis because it was similar to that of northeastern Cape Cod (Masterson 2004) and is sufficiently deep to not affect the model-calculated position and movement of the fresh water/salt water interface.

The lateral boundaries of the model are the coastal discharge areas that represent the salt water-surface water bodies which surround coastal island systems. These discharge areas are represented as constant head/constant concentration boundaries in the top model layer (Figure 3a) and laterally along the outermost extent of the model in each of the underlying layers (Figure 3b). The fresh water equivalent heads were accounted for and increased with depth along these lateral model boundary cells.

A fresh water stream was simulated in layer 1 of the model as a head-dependent flux boundary that receives ground water discharge and removes it from the aquifer. The stream extended 2 km from the center of the island to the coast (Figure 3a) with a total change in stage of about 1 m (Figure 4).

Two scenarios were simulated to determine what effect increases in stream stage may have on the flow system as sea level rises. In the first simulation, we assumed that the stream was not tidally influenced and, therefore, the stream stage remained constant throughout the simulation period. In the second simulation, the stream stage was increased with time to account for the effect of a laterally encroaching tidal prism as sea level rose. We assumed that the tidal effect of a mean sea level of 0 m in 1929 (NGVD 29) on stream stage would extend about 60 m upstream from the coast. By 2005, the tidal effect of a mean sea level of 0.2 m above NGVD 29 would extend upstream to about 430 m, and by 2050, this tidal effect would extend 670 m upstream for a mean sea level altitude of 0.32 m above NGVD 29 (Figure 4).

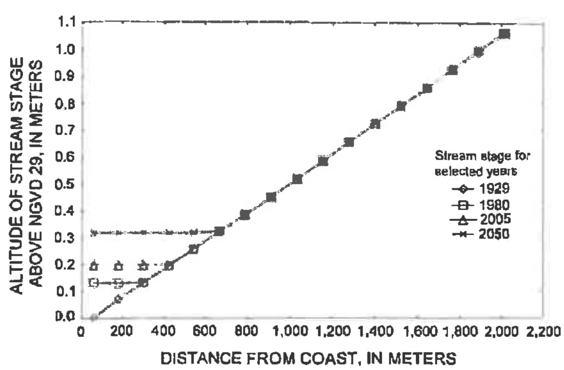

Figure 4. Change in stream stage with distance from coast. As sea level rises with time, the stream stage increases and the tidal effect progresses inland with the rising sea level.

Hydraulic Properties

The aquifer hydraulic properties required as input data for the ground water model in this investigation are horizontal hydraulic conductivity, vertical hydraulic conductivity, porosity, specific yield, and storage coefficient. The hydraulic properties simulated in this analysis were based largely on the previous investigation of eastern Cape Cod (Masterson 2004); however, we greatly simplified the distribution of these hydraulic properties in our model simulations to avoid the site-specific effects on our results of the complex hydrogeologic framework of Cape Cod. As a result, our simulations included a uniform distribution of a hydraulic conductivity value of 0.106 cm/s with an anisotropy ratio of 3:1, a porosity value of 0.3, a specific yield value of 0.25, and a specific storage value of 1×10^{-5}.

The simulated streambed hydraulic conductance (C) of 2208 m^2/d was derived from an assumed stream width (W) of 3 m, a length (L) of 120 m, a thickness (M) of 1.5 m, and a vertical hydraulic conductivity (K) of 9.2 m/d:

$$C = \frac{KLW}{M}$$

[Correction added after online publication January 30, 2007: KLM corrected in this equation to KLW.] These parameters are consistent with estimates of streambed characteristics from previous modeling investigations on Cape Cod (Guswa and LeBlanc 1985; Masterson 2004; Walter and Whelan 2004).

Initial Conditions

The analysis of changes owing to sea-level rise must be compared to a physically realistic starting condition. To obtain this condition, a quasi-steady state simulation was made that began with an initial estimate of the altitude of the interface between fresh water and salt water (Langevin et al. 2003). The initial position of the interface was assumed to be vertical at the coast to a uniform altitude of the bottom of the lens of about 50 m below NGVD 29.

A transient simulation was made for 200 years from this initial condition until the model reached a quasi-steady state condition with respect to the simulated change in solute mass with time. The resulting distribution of water levels and position of the fresh water/salt water interface was assumed to represent our initial estimate of hydrologic conditions in equilibrium with a sea-level position of 0 m above NGVD 29. This initial condition then was used for the subsequent analysis of changing sea level from 1929 to 2050.

Simulation of the Effects of Sea-Level Rise

The effects of sea-level rise on water levels, streamflow, and the position and movement of the fresh water/salt water interface were determined by simulating a change in the altitude of sea level of 2.65 mm/year from 1929 to 2050. The effect of the resulting increase in tidal influence in the stream with rising sea level was determined by two simulations—stream stage remaining constant through the simulation period and stream stage increasing with an increase in sea level.

In the first simulation, it was assumed that the stream was not tidally influenced and, therefore, the stream stage was held constant for the simulation period. This condition may occur in areas where tidal gates are used to restrict the inland encroachment of salt water to control mosquito populations and to allow for development in low-lying coastal areas. Numerous examples of tidally restricted streams and estuaries can be found along the eastern seaboard of the United States (Roman et al. 1984; Portnoy 1999).

In the second simulation, we allowed the stream stage and the upstream extent of the tidal influence to increase as sea level rises. We assumed that in 1929, the tidal effect on stream stage extended upstream by about 60 m. By 2005, this tidal effect was extended upstream to about 430 m, or about 21% of the entire stream reach, and by 2050, the portion of the stream that was assumed to be tidally affected was 670 m upstream from the coast, about 33% of the total stream reach (Figure 4).

The equivalent fresh water head in the stream was recomputed for each stress period using the calculated salinity of the model cells containing the stream and the specified stream stage. The calculated salinity in the stream increased from a uniform salinity concentration of 0.0 kg/m^3 in 1929 to salinity concentrations in 2050 that ranged from 25 kg/m^3 near the coast to 7 kg/m^3 about 670 m upstream from the coast.

A potential third scenario, one that was not simulated in this analysis, would be if the tidal effect extends upstream for the entire stream reach. Under this condition, the stream presumably would be a saline surface water body with a stage that likely will rise in conjunction with sea level at a rate equal to the rise in water levels in the aquifer. As a result, any changes in ground water discharge because of increasing ground water levels would be negligible, especially in comparison to that of nontidal surface water bodies.

Effects on Water Levels and Streamflows

Results of the model simulations indicate that the water levels in both simulations increased from 1929 to 2050 in response to the increase in sea level from 0.0 m in 1929 to 0.32 m above NGVD 29 in 2050. The extent to which the water levels increased was directly related to location within the aquifer, distance from the stream, and whether the stream was tidally influenced. Three sites (1, 2, and 3) were selected to assess changes in water levels and the position of the fresh water/salt water interface. Sites 1 and 3 are each about 300 m from the coast, and site 2 is located in the center of the island (Figure 3a).

In first simulation, where it was assumed that the stream was not tidally influenced, the water table altitude at site 1, located away from the stream, increased by 31 cm, about 97% of the simulated 32 cm of regional sea-level rise from 1929 to 2050. At site 2, in the center of the island, the water table altitude increased by 20 cm, about 63% of the simulated 32 cm of regional sea-level rise. At site 3, located adjacent to the stream, the water table altitude increased 17 cm, about 53% of the simulated 32 cm of regional sea-level rise (Figure 5).

Although the water levels increased at each of the three sites from 1929 to 2050, the net change in water levels is negative because the simulated local sea-level position is 32 cm higher in 2050 than it was in 1929. For example, the increase in water levels of 31, 20, and 17 cm relative to NGVD 29 at the three sites actually are net declines of about 1, 12, and 15 cm relative to the increased sea level in 2050 (Figure 6).

The decline in the water table altitude relative to local sea level can be explained by the presence of the ground water fed stream, which prevents the surrounding water table from rising appreciably above the altitude of the streambed. As the water table rises in response to sea-level rise, the amount of ground water discharge to the stream increases because the increased height of the water table adjacent to the stream results in increased streamflow rather than a higher water table altitude at the stream.

The amount of increased streamflow depends on the magnitude of water table rise in response to the sea-level change. The model-calculated ground water discharge to the stream nearly doubled from 3445 to 6814 m^3/d in response to sea-level rise from 1929 to 2050. This increase in streamflow is directly related to the increased water table altitude in the vicinity of the river. As a result, the water levels have risen by a much lower rate at site 3 (1.41 mm/year) than at site 1 (2.56 mm/year) because of the proximity of site 3 to the stream.

The rate of rise at site 1, however, is still slightly less than the simulated rate of sea-level rise of 2.65 mm/year. This difference suggests that although site 1 is farther from the stream than site 3, the effect of the increased

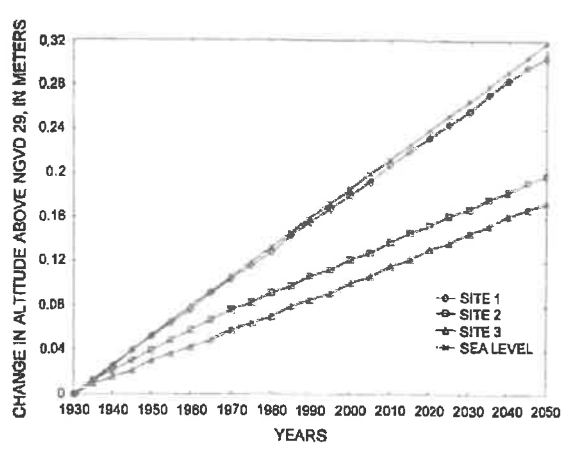

Figure 5. Changes in model-calculated water levels at sites 1, 2, and 3 in response to a simulated sea-level rise of 2.65 mm/year from 1929 to 2050.

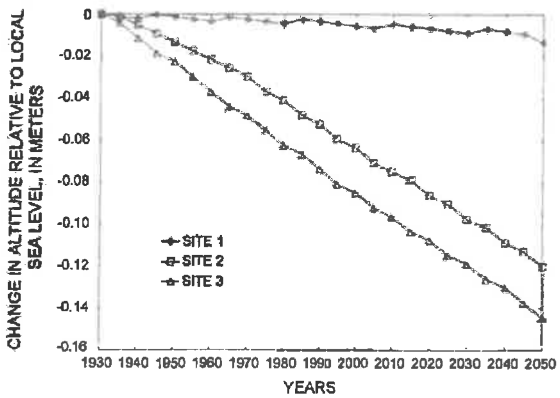

Figure 6. Changes in the model-calculated water levels at sites 1, 2, and 3 relative to local sea level in response to a simulated sea-level rise of 2.65 mm/year from 1929 to 2050.

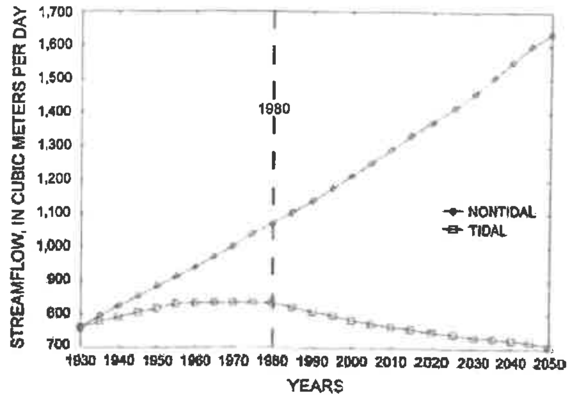

Figure 7. Changes in model-calculated streamflow in the lower stream reach for tidal and nontidal conditions from 1929 to 2050.

streamflow with sea-level rise has a regional effect on water levels throughout the island aquifer system.

The effect of rising sea level on water levels and streamflows is complicated by the fact that the stream stage may increase, and the areas of the stream affected by this change could extend inland from the coast as sea level rises. This condition was simulated in the second scenario and compared to the first scenario in which the stream stage was held constant.

Results indicate that although streamflow continues to increase as sea level rises and the extent of the tidal influence propagates farther inland, there is an overall difference in streamflow of about 15% between the nontidal and tidal simulations by 2050. The total decrease of 1050 m^3/d between the nontidal and tidal simulations occurred in the tidally influenced portion of the stream, indicating that as the stream stage rose with the rising sea level, there was successively less ground water discharge occurring in the stream.

The difference in the amount of ground water discharge to the stream between the nontidal and tidal simulations is reflected in the change in streamflow in a portion of the stream from the coast to about 300 m upstream, adjacent to site 3 (Figure 3a). Although ground water discharge continues to increase along this portion of the stream until about 1980, it does so at a much lower rate for the tidal simulation as compared to the nontidal simulation (Figure 7). After 1980, the year in which the tidal influence propagates upstream to the position of site 3 (Figure 4), the entire lower reach of the stream is tidal and ground water discharge to the stream begins to decrease as stream stage begins to rise (Figure 7).

Water levels in the surrounding aquifer rise as the stream stage rises because less ground water discharge occurs along the lower stream reach. This effect is illustrated in a comparison of water table altitudes calculated for site 3 for tidal and nontidal simulations (Figure 8). The water table altitude at site 3 rises at a rate of 2.13 mm/year from 1980 to 2050 for the tidal simulation compared to a rate of rise of 1.48 mm/year for the nontidal simulation. By comparison, the rate of stream stage rise in the stream adjacent to site 3 is 2.65 mm/year, the simulated rate of sea-level rise. Because the rates of rise at site 3 for the tidal and nontidal simulations are less than that of sea level, there is a net decrease in the water table altitude at this site for both conditions relative to sea level (Figure 9).

The difference in the rates of rise between site 3 in the tidal simulation and that of the stream stage suggests that the surrounding water table near the stream has not yet reached equilibrium with the rising stream stage and, therefore, the decrease in streamflow in the lower stream reach (Figure 7) will continue in the future. Once the water table altitude and the stream stage are in equilibrium, such that they both rise at a rate comparable to that of sea level, streamflow will no longer change with time. The rate of constant ground water discharge to this lower reach of the stream will be determined by the steady-state difference in water table altitude and the adjacent stream stage.

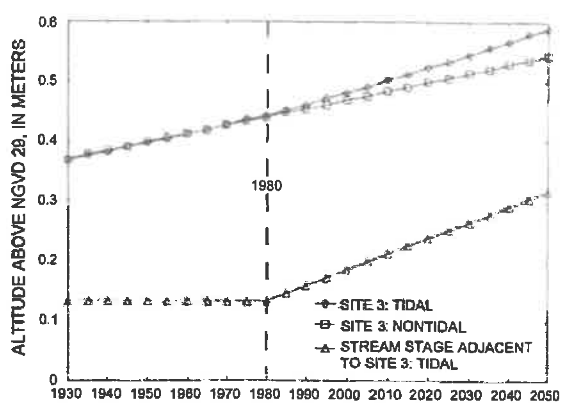

Figure 8. Model-calculated changes in water table altitude at site 3 for tidal and nontidal conditions from 1929 to 2050. As the tidal effect on stream stage extends inland, the water table altitude increases at a greater rate than for nontidal conditions.

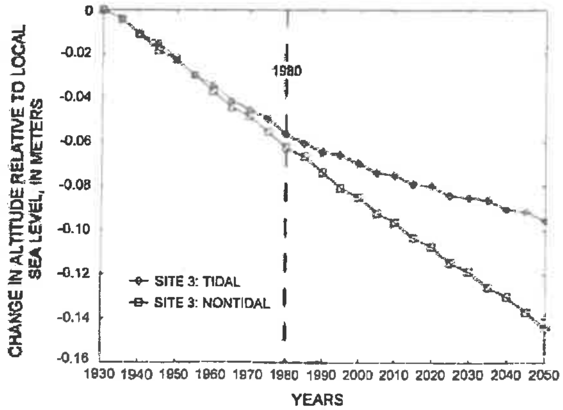

Figure 9. Changes in the model-calculated water levels at sites 3 relative to local sea level in response to tidal and nontidal conditions with a simulated sea-level rise of 2.65 mm/year from 1929 to 2050.

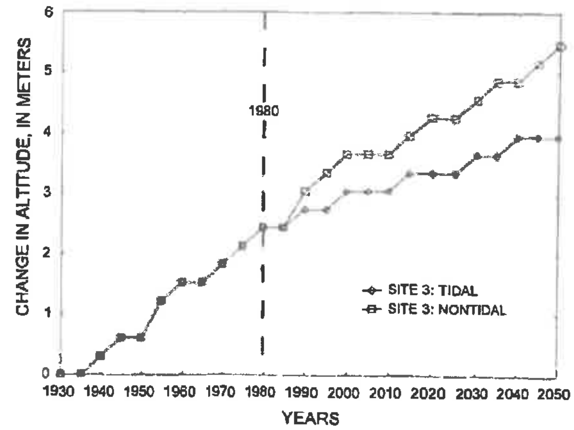

Figure 10. Changes in the model-calculated position of the fresh water/salt water interface beneath site 3 in response to tidal and nontidal conditions with a simulated sea-level rise of 2.65 mm/year from 1929 to 2050.

Effects on Fresh Water/Salt Water Interface

The flow model was used to analyze the position and movement of the fresh water/salt water interface beneath the three sites to determine the response of the interface to the rise in sea level from 0.0 m in 1929 (NGVD 29) to its projected altitude of +0.32 m (NGVD 29) in 2050. The position of the interface beneath sites 1, 2, and 3 in 1929 was calculated to be about 26.2, 43.6, and 16.8 m below NGVD 29, respectively. The altitude of the interface increased at the three sites by about 0.8, 5.8, and 5.5 m in response to a rise in sea level of 0.32 m for the simulation in which it was assumed that the stream was not tidally influenced.

Correcting for the increased sea level altitude of 0.32 m, the net change in the position of the fresh water/salt water interface beneath sites 1, 2, and 3 relative to the local sea level in 2050 is about 0.5, 5.5, and 5.2 m, respectively. These simulated changes in the position of the fresh water/salt water interface are similar in magnitude to the 0.2, 4.5, and 5.5 m values predicted by the Ghyben-Herzberg relation, showing that this relation is a reasonable approximation of the change in interface position in response to changes in the altitude of the water table.

In the second scenario, when stream stage increased with the rising sea level, the altitude of the fresh water/salt water interface increased by the same amount at sites 1 and 2 as in the nontidal scenario. At site 3, the difference in the interface altitude was about 1.5 m by 2050 between the tidal and nontidal simulations (Figure 10). From 1929 to 1985, the change in the altitude of the fresh water/salt water interface was the same between the tidal and nontidal simulations. After 1985, the interface rose at lower rate for the tidal simulation than the nontidal simulation (Figure 10). This difference in the interface altitude at site 3 between the two simulations coincides with the change in net water table altitude at site 3 (Figure 9) and streamflow in the lower stream reach (Figure 7). The net decrease in water table altitude relative to local sea level lessened as streamflow decreased, resulting in a lower rate of rise in the altitude of the fresh water/salt water interface.

The results of the analysis described previously suggest that sea-level rise over time results in a thinning of the fresh water lens in this hypothetical coastal aquifer. This thinning occurs because the rate at which the water table rises is less than the rate at which sea level rises. The disparity in these rates results a net decline in the water table altitude relative to local sea level and a corresponding increase in the altitude of the fresh water/salt water interface. The areas where the effects on the position of the fresh water/salt water interface is greatest are those areas where the water table rise is limited by the presence of the nontidally influenced portion of a ground water fed stream.

A similar effect on the depth to the fresh water/salt water interface possibly could occur beneath low-lying areas such as wetlands and inland marshes, where the depth to water is shallow and increases in the water table altitude may result in enhanced evapotranspiration; however, this potential effect was not addressed in this analysis.

Discussion

The model simulations that incorporated an increase in the altitude of sea level with time revealed a corresponding increase in ground water levels and streamflow, yet a decrease in the depth to the fresh water-salt water interface. Proximity to a ground water fed stream and whether the stream was tidally influenced had the largest effect on the changes in water levels and the position of the fresh water/salt water interface. In our simulations, we assumed that for nontidal conditions, the stream stage remains unchanged with time and any increases in ground water discharge to the stream with time will result in more streamflow with no appreciable change in stage. For tidal conditions, we assumed that the stage in lower reach of the stream increased in response to increases in mean sea level. In 1929, this effect only extended upstream by 60 m, and by 2050, as mean sea level rose 0.32 m above NGVD 29, the tidal effect extended upstream about 670 m, or 33% of the entire stream reach (Figure 4).

Although water levels in both simulations increase with time relative to the fixed datum of NGVD 29 (Figure 5) in response to the rising sea level, the actual change in the water levels is a net decrease relative to the increased local sea level (Figure 6). This net decrease in water level relative to local sea level was much greater at the sites close to a ground water fed stream (sites 2 and 3) than at the site farther from the stream (site 1).

Ground water fed, or gaining, streams prevent the adjacent water table from rising much above the altitude of the streambed. As the water table rises in response to sea-level rise, the amount of ground water discharge to the stream increases because the increased height of the water table adjacent to the stream generates more streamflow rather than a higher water table altitude.

Our simulation results show that the discharge to this stream when we assumed that the stream was not tidally influenced nearly doubled in response to sea-level rise from 1929 to 2050. As stream stage rose in the lower reach of the stream during the tidal simulation, there was a corresponding decrease in streamflow. The difference in total streamflow between the tidal and nontidal simulations was about 15% by 2050.

The depth to the fresh water-salt water interface also decreased in response to the decreased water level altitudes relative to local sea level at the three sites. The difference in the model-calculated change in the depth of the fresh water-salt water interface among the sites is controlled by the differences in the net decline in water levels relative to local sea level. Because the greatest net declines in water level were calculated for sites 2 and 3, the greatest decreases in the depth to the interface also occurred beneath these sites.

In our simulation of tidal conditions where stream stage increased in the lower reach of the stream with rising sea level, the effect on water levels and the position of the fresh water/salt water interface differed between the two sites near the stream. In the case of site 2 at the headwaters of the stream near the center of the island. the change in water level and position of the interface was unaffected by the changing stream stage in the lower reach of the stream in response to rising sea level. The change in water level and the depth of the fresh water/salt water interface responded the same as in the nontidal simulation, resulting in a total decrease in the depth of the fresh water/salt water interface in the center of the island of about 5.8 m. This change in the depth of the interface, once corrected for a local sea level of 0.32 m above NGVD 29, is a reduction of the fresh water lens of about 13% by 2050.

In the case of site 3, which is adjacent to the lower reach of the stream, the change in water level and the position of the fresh water/salt water interface increased similar to that of the nontidal condition until the simulated tidal influence extended upstream near site 3. At that point, the rate of net decrease in water table altitude and the resulting rate of increase in altitude of the fresh water/salt water interface began to lessen (Figures 9 and 10).

The resulting effect of the increased tidal influence on the water table altitude and position of the fresh water/salt water interface is attributed to the decreased rate of ground water discharge to the stream as the stream stage increases at a rate greater than that of surrounding water table (Figure 8). Once the changes in stream stage and water table altitude are in equilibrium, ground water discharge to the stream will remain constant and the altitude of the fresh water/salt water interface relative to local sea level will not change. The depth of the interface beneath site 3 by 2050 for the tidal simulation was about 4 m above the position of 1929, which when corrected for local sea level in 2050 is about a 22% reduction in the thickness of the fresh water lens as compared to the 31% reduction determined for the nontidal simulation.

The results from our analysis of a hypothetical island flow system indicate that the change in the depth to the fresh water/salt water interface occurred rapidly with the changes in water levels and streamflow brought on by the change in sea level. The analysis of the Cape Cod aquifer reported in Masterson (2004) showed that although water levels and streamflows responded rapidly to simulated sea-level rise, the change in position of the underlying fresh water/salt water interface did not become substantial until many years into the future. The model-calculated lag in the response of the fresh water/salt water interface in the Cape Cod aquifer may be the result of the slow movement of fresh and saline water in the low-transmissivity zone simulated deep in the aquifer and, therefore, may be a function of the subsurface geology. Similarly, Kooi and Groen (2000) have determined that salt water encroachment can significantly lag behind sea-level rise, depending on the aquifer substrate.

The effect of the subsurface geology is more pronounced in the complex Atlantic Coastal Plain aquifer system where thick, layered aquifers are separated by intervening confining units. In the New Jersey Coastal Plain aquifer, Pope and Gordon (1999) report that the position of the fresh water/salt water interface is still responding to changes in sea level from the effects of the last glaciation approximately 71,000 years ago in which the position of the interface is much deeper and seaward of where it would be if it were in equilibrium with current sea level.

Conclusions

The assumption that the primary threat to coastal aquifer systems from rising sea levels is the increased potential for surface inundation of saline water in low-lying areas does not consider the potential for a decrease in fresh water lens thickness from a net decrease in water levels relative to an increased sea-level position. This net decrease in water levels results in a decrease in the depth to the fresh water-salt water interface as described by the Ghyben-Herzberg relation.

The extent to which water level altitudes decline relative to an increased sea-level position is directly related to the proximity of ground water fed streams and whether the streams are tidally influenced. As the water table rises in response to a rise in sea level, the amount of ground water discharge to streams increases because the increased height of the water table adjacent to the streams generates more streamflow rather than a higher water table altitude. The effect that ground water fed streams have on water levels and the depth to the fresh water-salt water interface diminishes as the extent of tidal influence in streams propagates inland with the rising sea levels.

Acknowledgments

The authors wish to thank the following individuals for their thoughtful and insightful review comments and assistance with this analysis: Denis LeBlanc, Chris Langevin, Kathyrn Hess, John Guswa, Jerry Ayers, and one anonymous reviewer. This work was supported by the USGS Ground Water Resources Program.

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SELECTBOARD

AGENDA ACTION REQUEST

IV

APPENDIX

Guidance on Section 208 Plan Update Obtaining a Consistency Determination

9.29.21 presentation_to_wellfleet_select_board_scott_horsley_0_curt_felix

Guidance on Section 208 Plan Update Obtaining a Consistency Determination

Guidance on Section 208 Plan Update

Consistency Review Criteria

April 2018

Pursuant to recommendation R3.7 of the approved and certified Cape Cod Area Wide Water Quality Management Plan Update (the "208 Plan Update"), all municipal nutrient management plans in the region shall be prepared and implemented consistent with the 208 Plan Update, and shall be subject to review by the Cape Cod Commission for consistency with the 208 Plan Update. The consistency review shall be the Commission's principal means of reviewing municipal plans. Plans deemed consistent with the 208 Plan Update will, among other things, become eligible for 0% State Revolving Fund (SRF) loans and other financial assistance. DEP will require the Commission's determination that a plan is consistent with the 208 Plan Update pursuant to its watershed permitting program for Waste Treatment Management Agencies (WMAs).

As part of the approved and certified 208 Plan Update, the 15 Cape Cod municipalities were designated as WMAs under Section 208 of the Federal Clean Water Act. A WMA has standing to propose a plan and seek consistency review hereunder.

The following are general 208 Plan Update review criteria:

- ✓ WMA assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction
- ✓ Plan meets applicable nutrient reduction targets
- ✓ Planning occurs at a watershed level with consideration of a hybrid approach
- ✓ Public was engaged to gain plan consensus
- ✓ Plan includes proposed strategies to manage nitrogen loading from new growth
- ✓ Plan includes adaptive management approach
- ✓ Plan includes pre- and post-implementation monitoring program
- ✓ Plan includes a description and assessment of the town's proposed funding strategy
- ✓ WMA commits to regular 208 Plan Update Consistency reviews until water quality goals are achieved, generally reviewed atleast every five years
- ✓ In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions, and cost saving measures

The following pages provide additional detail on each of the general review criteria.

Applicable criteria may vary based on the type of plan or project proposed. Early consultation with Commission staff will be necessary to identify applicable criteria. If the applicant is engaged with a Watershed Team, this discussion and the identification of applicable criteria will be inherent in that process. All other applicants should notify the Commission of the need for a consistency review as early as possible in the planning process. A pre-application meeting or series of meetings, as necessary, will be held to discuss plan or project goals, a schedule for planning and submission for review, and applicable criteria. The following provides a list of criteria that are likely to be included based on plan type.

- Targeted Watershed Plans (TWMP) will typically be reviewed based on all criteria included in this document.
- Municipal-wide Comprehensive Wastewater Management Plans (CWMPs) will typically be reviewed based on criteria 1 through 9; however, criteria 10 (collaborating with neighboring WMAs) must be addressed. Should the applicant choose not to collaborate with neighboring communities, the applicant provide an explanation of this decision and shall quantify in the CWMP the cost differential associated with a municipal plan versus a shared watershed plan for each watershed not solely within the jurisdiction of the applicant.
- Projects seeking SRF funding but are not part of a TWMP or CWMP, or projects that are moving forward prior to submission of a complete TWMP or CWMP will typically be reviewed based on criteria 1, 4, 6, and 7 and will be considered in the context of the TWMP or CWMP, where applicable.

In instances where a municipal plan has previously been approved by the Commission under Development of Regional Impact review and is in its implementation phase, the Commission may vary application of the following criteria on a case by case basis.

1) WMA assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction

The 208 Plan Update assigns nitrogen load responsibility for each subembayment watershed to WMAs based on the existing, controllable nitrogen load, in kilograms, from contributing homes and businesses and other land uses within their jurisdictional boundaries. In areas where attenuation information is available, the WMAs percentage contributions are based on the existing attenuated nitrogen load. The subembayment watershed is used for the purposes of assigning responsibility as it is consistent with the approach that the Massachusetts Estuaries Project (MEP) uses to establish nitrogen thresholds. The detailed methodology for assigning responsibility is described in Chapter 8 of the 208 Plan Update, beginning on page 8-7, and the complete breakdown of nitrogen responsibility for each town can be found in Appendix 8C of the 208 Plan Update and the Watershed Reports in Appendix B of the 2017 Implementation Report. Data used to inform the calculations of Appendix 8C will be updated every five years and allocations will be reissued, as needed and appropriate.

A WMA shall assume its nitrogen loading responsibility as set out in the 208 Plan Update, unless otherwise determined through the Process for WMAs to Revise Nitrogen Load Allocation outlined in the 208 Plan Update and discussed below. A WMA shall establish in its plan a nitrogen design load based on such nitrogen allocation, and any additional nitrogen load for planned or anticipated development, and other specific municipal needs or objectives identified in the plan. Controllable nitrogen sources that a WMA may manage to achieve identified load allocation reductions include septic, wastewater treatment facility discharges, fertilizer and stormwater runoff, landfill leachate, and agricultural operations.

Process for WMAs to Revise Nitrogen Load Allocation

In the event that one or more WMAs disagrees with the nitrogen load allocation set forth in the 208 Plan Update there are two methods by which they may request a revision to the Commission. A WMA or WMAs may request a revision by mutual agreement with all of the WMAs with jurisdiction within a respective shared watershed, or a WMA may submit an individual application for a revision to its allocation. If said revision is agreed upon and approved, the Commission will amend said Appendix 8C of the 208 Plan Update to reflect said revision, and the revision and supporting information shall be incorporated into the WMAs plan accordingly.

Revision by Mutual Agreement

Requesting a revision by mutual agreement requires that each WMA with jurisdiction over land in the respective subembayment watershed be party to a binding agreement that specifies an agreed upon nitrogen load allocation for each WMA. This agreement may be in the form of a memorandum of understanding, intermunicipal agreement or through the issuance of a DEP watershed permit.

Individual Application for Revision

A request for a revision to the nitrogen load allocation in a specific watershed may be submitted by an individual WMA for one of the following three reasons:

- New or better data is available, including actual data where estimates were previously used
- A correction to the data is requested
- There is a disagreement about or a suggestion to improve the methodology for calculation of the allocation.

The request must include the supporting data or suggested calculation methodology. It will be reviewed by a 208 Technical Review Group (TRG) that consists of representatives designated by US EPA, MassDEP, and the Cape Cod Commission, with at least one representative from each agency and which may be augmented by one or more members designated by the TRG, as necessary and appropriate. To be deemed complete the applicant must provide the proposed data, provide a narrative justification for the correction, and/or propose an alternative methodology, depending on the reason for the application.

In the event that actual data becomes available where estimates were previously used, and where no target has been established by a Massachusetts Estuaries Project (MEP) report or Total Maximum Daily Load (TMDL), an amendment to Appendix 8C of the 208 Plan Update will be issued and the newly adopted information shall be incorporated into the town's planning, regulatory and consistency documents. In all other cases of updated or corrected data the TRG will review and, upon agreement of the group that an update to the data is necessary or a correction should be made, Appendix 8C in the 208 Plan Update will be amended and the newly adopted information shall be incorporated into the town's planning.

If the application for revision concerns the methodology by which the WMA's nitrogen load allocation has been established under the 208 Plan Update, a WMA may suggest an alternative methodology which will be reviewed and considered for approval by the TRG. In the case of a shared watershed, if the group agrees that a revised methodology is appropriate such revised methodology may only be allowed by mutual agreement between all of the WMAs with jurisdiction over lands in the respective subembayment watershed.

2) Plan meets applicable nutrient reduction targets

All plans shall achieve the nitrogen load reduction required, either as allocated in the 208 Plan Update, or as agreed upon and approved via the allocation revision process outlined in section 1 herein.

3) Planning occurs at a watershed level with consideration of a hybrid approach

Planning and analysis shall be on a subembayment watershed basis. The goal of watershed based planning is to focus solutions on the jurisdiction of the problem (watershed boundaries) rather that municipal boundaries.

The 208 Plan Update requires a broad alternatives analysis culminating in the development of a "hybrid" plan for each watershed. This is to ensure that all potential solutions are considered and that taxpayers understand the costs and effectiveness of different strategies and the tradeoffs between those strategies. Ultimately it is expected that hybrid solutions will result in the most effective and cost-efficient solutions to achieve water quality goals. A WMA shall provide a broad Alternatives analysis of potential approaches. A collection scenario and a non-collection, or non-traditional, scenario shall be developed. At least one hybrid watershed scenario shall be developed following the hybrid watershed scenario planning process outlined in the 208 Plan Update that integrates reduction, remediation and restoration technologies and approaches.

The WMA shall include MS4 permit requirements and other stormwater management controls and approaches as part of the plan.

Policies and structural and non-structural strategies to manage fertilizer nitrogen contributions shall be discussed and included in the plan.

4) The public was engaged to gain plan consensus

The local planning process shall engage the public at the watershed level to gain consensus on proposed actions and those included shall represent a range of community stakeholders. The WMA shall engage and educate a wide range of stakeholders, including those within contributing Environmental Justice communities, and encourage comments from all relevant local, state, regional and federal government entities and interested members of the public on the proposed plan.

The WMA shall coordinate where possible with existing watershed associations and/or promote the formation of new associations early in the process to ensure public involvement in the process and public support for implementation. These associations can serve as both advisors and ambassadors of local plans. The range of viewpoints represented will ensure closer coordination between plan development, local need and community values.

5) Plan includes proposed strategies to manage nitrogen loading from new growth

A WMA shall calculate its future nitrogen loading responsibility for the watershed(s) in question based on buildout, and based on unattenuated nitrogen loads (in contrast to existing loads which are calculated based on attenuated loads). Buildout is the state of maximum development permitted by zoning and other regulations. Alternative strategies for controlling the nitrogen that results from growth are summarized in Chapter 7 of the 208 Plan Update.

The WMA shall submit for review proposed strategies to handle nitrogen loading from new growth (a Nutrient Growth Management Plan) as discussed in Chapter 3 of the 208 Plan Update and in Appendix H of the 2017 Implementation Report.

6) Plan includes an adaptive management approach

As watershed plans will include numerous and alternative strategies and approaches proposed to achieve required nitrogen reduction and other goals, these plans shall also include an adaptive management plan to guide a WMAs future decision-making with respect to plan implementation. AMPs shall contain specific milestones and triggers for decision-making, undertaking actions, and reporting relative to plan implementation for the respective watershed.

As part of the AMP, a traditional collection and treatment plan, including future expansion or phases of any core collection system, shall be proposed or considered for future phases of the watershed plan if the non-traditional technologies do not perform as anticipated, and adequately to achieve the WMA's required nitrogen reduction within the time periods set out in the AMP. A traditional sewering plan, including future expansion, or phases, of the core collection system, will serve as the backup plan for future phases of the watershed plan in the event that the non-traditional practices do not perform adequately.

The adaptive management plan shall be structured in five-year increments, enabling time for the design, permitting and construction of technologies and a for testing and monitoring.

The WMA shall establish a process for evaluating the performance of deployed technologies at the completion of each five-year period, including an assessment of the achieved nutrient removal, cost, and other associated benefits or relevant consequences of the technology. In instances where it is determined that the success of a particular technology has not been fully realized as intended, the AMP process shall include an evaluation of possible adjustments and improvements and potential continuation of the technology. Where it is determined that a particular technology has not performed, and likely will not perform, as intended and a WMA chooses not to pursue such technology any longer, a process for decommissioning or abandoning the technology, as deemed necessary, shall be included in the AMP.

A process for evaluating and integrating embayment water quality monitoring data with technology performance data shall be outlined in the AMP.

The AMP shall also guide a WMA's decision-making about the siting of proposed technologies. A WMA shall consider, discuss and address in its AMP potential construction and operational impacts on the built and natural environment associated with preferred siting, and alternative siting scenarios that might limit, minimize or avoid such impacts. Considerations shall include:

- Effects of technologies on drinking water resources
    - Nitrogen
    - Contaminants of Emerging Concern
- Effects of technologies on Fresh surface waters
    - Phosphorous loading
- Effects on saltwater resources
    - Salt marsh
    - Brackish waters and tributaries
- Disposal locations
- Construction Impacts

7) Plan includes a pre- and post-implementation monitoring program

An ongoing monitoring program for technology performance shall be included in the plan. At a minimum, the monitoring program shall address nitrogen, but may include other compounds.

The performance monitoring protocol(s) shall include an assessment of downgradient resources or sensitive receptors; assessment of nitrogen concentrations in water bodies that are located in or contribute to the respective watershed; placement of monitoring stations; parameters of evaluation; methods for collecting and analyzing data; and frequency of data collection, and shall be consistent with the Monitoring Protocols issued by the 208 Plan Update Monitoring Committee as appropriate (See Appendix C of the 2017 Implementation Report).

Plans shall include monitoring for the impacts of stormwater and the efficacy of fertilizer management strategies, and a process for integrating this data with embayment water quality data and improvements.

Embayment monitoring shall rely on the current MEP monitoring locations and protocols unless and until they are altered via the ongoing efforts to regionalize and standardize monitoring as may be recommended by the Monitoring Committee and Cape Cod Commission and thereafter adopted by the Cape Cod Commission and MassDEP, or if new or revised protocols are required by a watershed permit or another regulatory scheme.

The WMA shall enter into a Data Sharing Agreement with the Cape Cod Commission to house data, technical studies, reports and maps and other relevant information that is generated as a result of data analysis associated with this plan in a regional data warehouse that will maintain water quality data sets and make them publicly available. In addition, the Data Sharing Agreement includes a process for the sharing of building permit data to identify and quantify land uses that increase water use on any parcel.

8) Plan includes a description and assessment of the town's proposed funding strategy

In order for the town(s) to be able to implement water quality plans and projects they must address the development of a funding strategy.

All plans shall include a fiscal analysis of the town's ability to pay for the projects proposed. Potential local revenue sources and outside sources of funding should be identified and schedules for financing over the life of the project(s) should be included.

The town should describe their overall approach to pay for proposed project(s). Town(s) should include a discussion on which of the variety of financing tools will be used, such as debt, betterments, general tax revenues, or others, along with an explanation as to why the approach was chosen. If the town(s) anticipates seeking outside funds identify the sources being considered. The amounts and timelines should be described. The town should also describe which parts of the plan/which projects each source will fund.

The town(s) should describe the impact of the overall approach on all property owners. It is suggested that a discussion be included on how primary homeowners, second homeowners and commercial property owners will contribute and how each group might be impacted over time.

The town(s) should describe how the approach fits into the context of long-term town capital planning needs. The expected impact of the chosen funding strategy on the town's ability to provide expected town services should be addressed.

Given the adaptive management approach encouraged by the 208 Plan, it is recognized that town(s) may not know everything upon initial submission. Updates and additional detail will be required at each 5-year check-in.

9) WMA commits to regular 208 Plan Update Consistency reviews until water quality goals are achieved, generally reviewed atleast every five years

The WMA shall commit to submitting all future plans and material changes to existing plans to the Cape Cod Commission for consistency review at least every five years.

10) In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions, and cost saving measures

In shared watersheds, and in circumstances where nitrogen management infrastructure or approaches may be shared, an effort shall be made to engage neighboring and other appropriate WMAs and cooperate on solutions.

Treatment and disposal capacity shall be preserved where feasible in shared watersheds, or a fiscal analysis of additional costs of limiting infrastructure to the WMA boundaries has been conducted and distributed as part of the planning and public participation process.

In the event a municipality determines that it will not pursue available opportunities to design, construct and operate shared infrastructure or other nitrogen mitigation measures, it shall conduct and present a fiscal analysis of potential additional costs associated with constructing infrastructure limited to town boundaries.

WMA requests a Watershed Team Technical Assistance for Watershed Plan Development

As described in Chapter 5 of the 208 Plan Update, beginning on page 5-15, and Chapter 8, on page 8-10, of the 208 Plan Update, WMAs may request a Watershed Team through the Watershed Team Technical Assistance Program to assist with the development of watershed-based solutions.

Watershed Teams are designed to supplement local capacity and can assist in the areas of water resources, GIS, land use and economic development planning, finance modeling, legal and regulatory issues and 208 consistency, infrastructure and technologies, outreach and consensus building, as requested.

Requests for Watershed Team assistance should be directed to the Cape Cod Commission Executive Director from the respective Town Manager or Administrator, in writing, and should specify the type(s) of assistance requested.

The amount and level of assistance by the Watershed Team allocated to a WMA might vary, and is based on a number of considerations including but not limited to:

- The WMA's required nitrogen load reduction and degree of water quality impairment it must address,
- Level of community plan support,
- Level of collaboration and cooperation with appropriate WMAs,
- Potential for the plan to facilitate information transfer around new technologies and approaches,
- Future growth and economic development potential facilitated by the plan,
- Planning that addresses Title 5 failures and septic variances issued,
- Planning that addresses pond recharge areas,
- Estimated and desired times to realize water quality improvements, and
- Ongoing implementation of other capital projects.

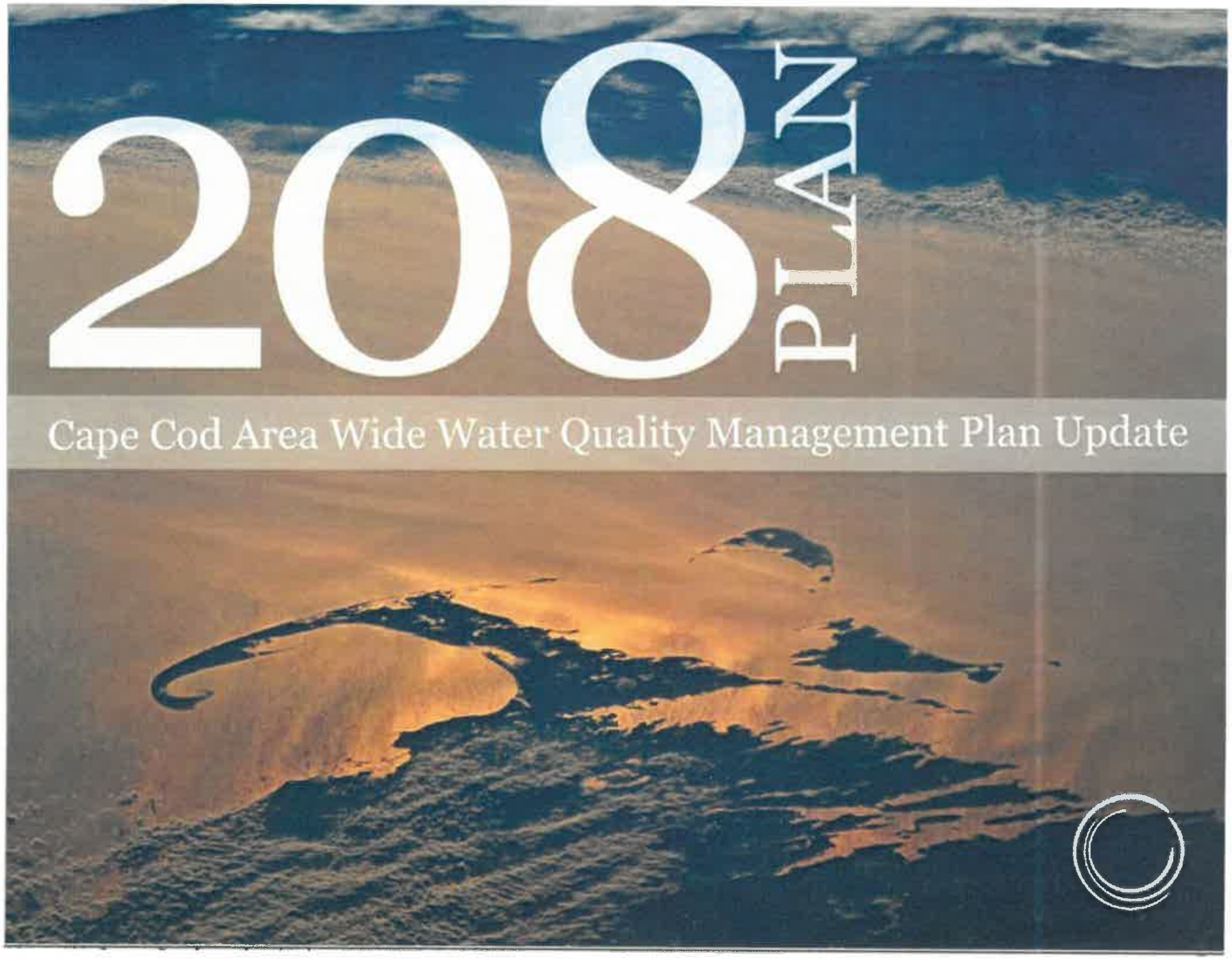
9.29.21 Presentation to Wellfleet Selectboard Scott Horsley, Curt Felix

Wellfleet Targeted Watershed Plan
Update – September 29, 2021

Scott Horsley
Water Resources Consultant

Goals of Targeted Watershed Plan

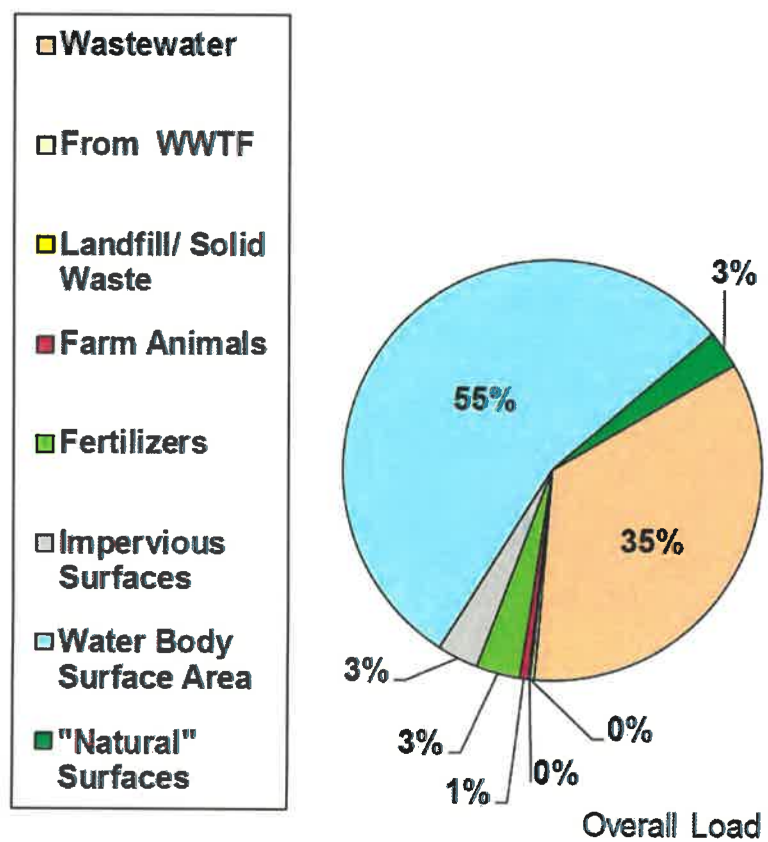
- Restoration of Ecosystems & Water Quality
- Compliance with Clean Water Act
- Quicker Results
- Reduced Costs
- Promote Affordable Housing
- Maximize Local Co-Benefits (including jobs)
- Minimize Climate Impacts

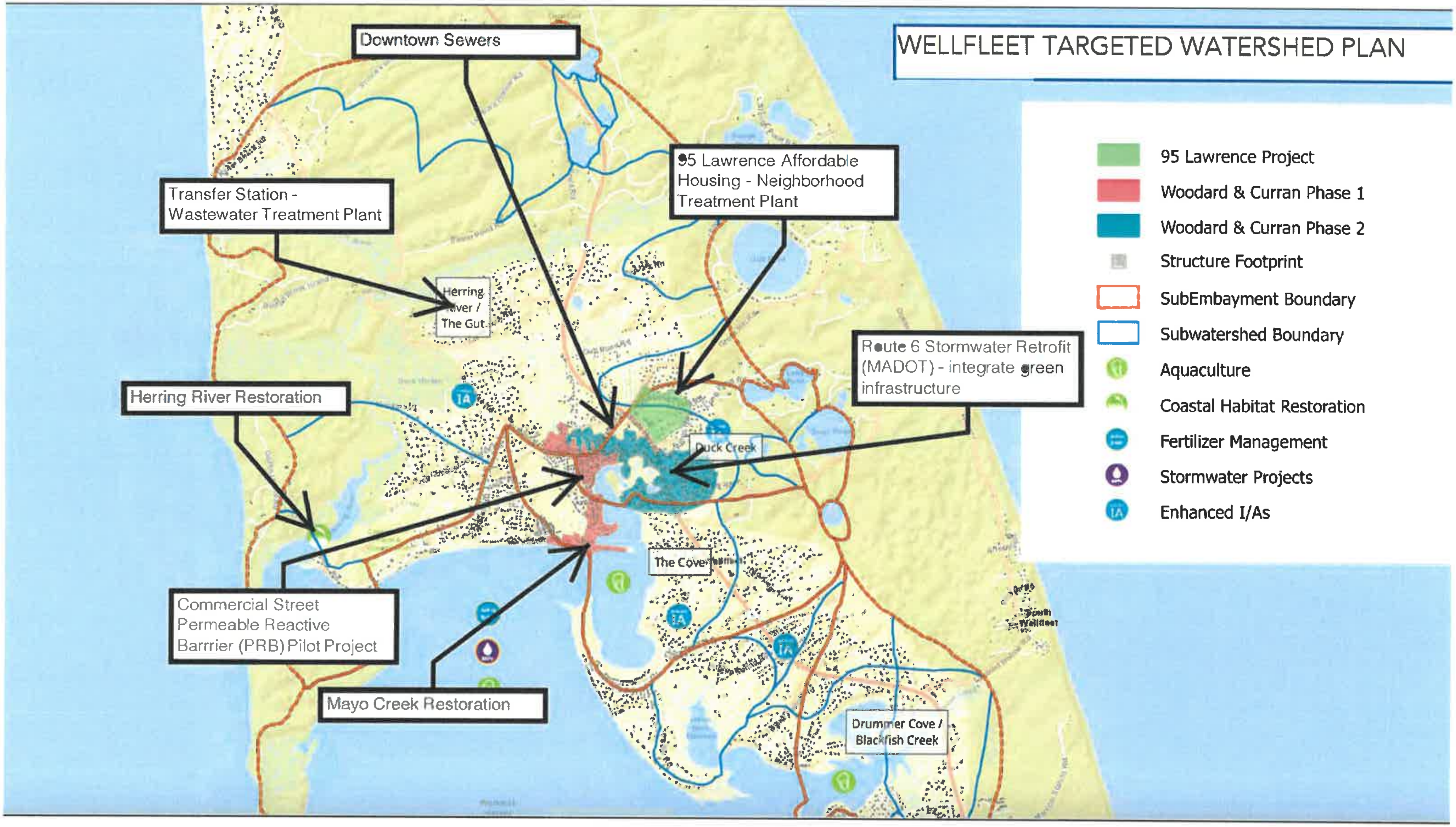

208 PLAN
Cape Cod Area Wide Water Quality Management Plan Update


Site Scale
Neighborhood
Watershed
Cape-Wide
Prevention
Reduction
Remediation
Remediation of Existing Development
Transfer of Development Rights
TDR
Fertilizer Management
Stormwater BMPs
Compact Development
Title 5
Standard Title 5 Systems
IA
I/A Title 5 Systems
I/A Enhanced Systems
Toilets Urine Diverting
Toilets Composting
Toilets Packaging
Toilets Incinerating
Cluster & Satellite Treatment Systems
Wastewater Collection Systems
Constructed Wetlands Surface Flow
Constructed Wetlands Subsurface Flow
Stormwater: Bioretention / Soil Media Filters
Stormwater: Wetlands
Conventional Treatment
Advanced Treatment
Effluent Disposal Systems
Phytoirrigation
Eco Machines & Living Machines
EM
Phytobuffers
PRB
Permeable Reactive Barrier
Fertigation Wells
Shellfish and Salt Marsh Habitat Restoration
Aquaculture/Shellfish Farming
Inlet / Culvert Widening
Pond and Estuary Dredging
Constr. Wetlands - Groundwater, Salt Water, Floating
Wastewater
Existing Water Bodies
Stormwater
Regulatory


Herring River /
The Gut
3282 kg/yr
25%
Duck Creek
2026 kg/yr
76%
The Cove
4296 kg/yr
79%
Drummer Cove /
Blackfish Creek
2314 kg/yr
58%
Wellfleet Harbor
5285 kg/yr
63%
oagy Bay
1095 kg/yr
72%
Hatches Creek
1956 kg/yr
36%
Hatches Creek

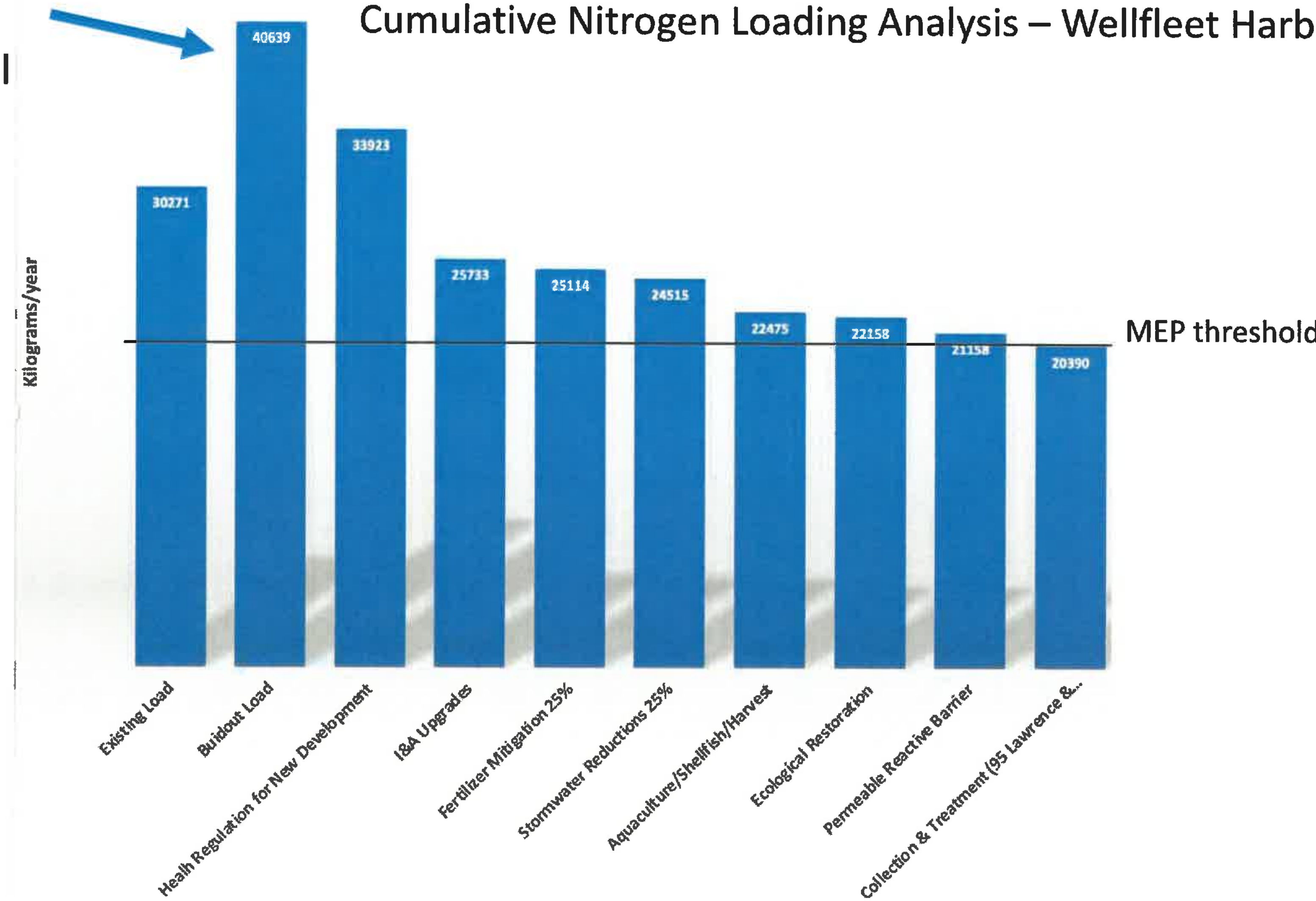
Sources of Nitrogen to Wellfleet Harbor Embayments (MEP, 2017)

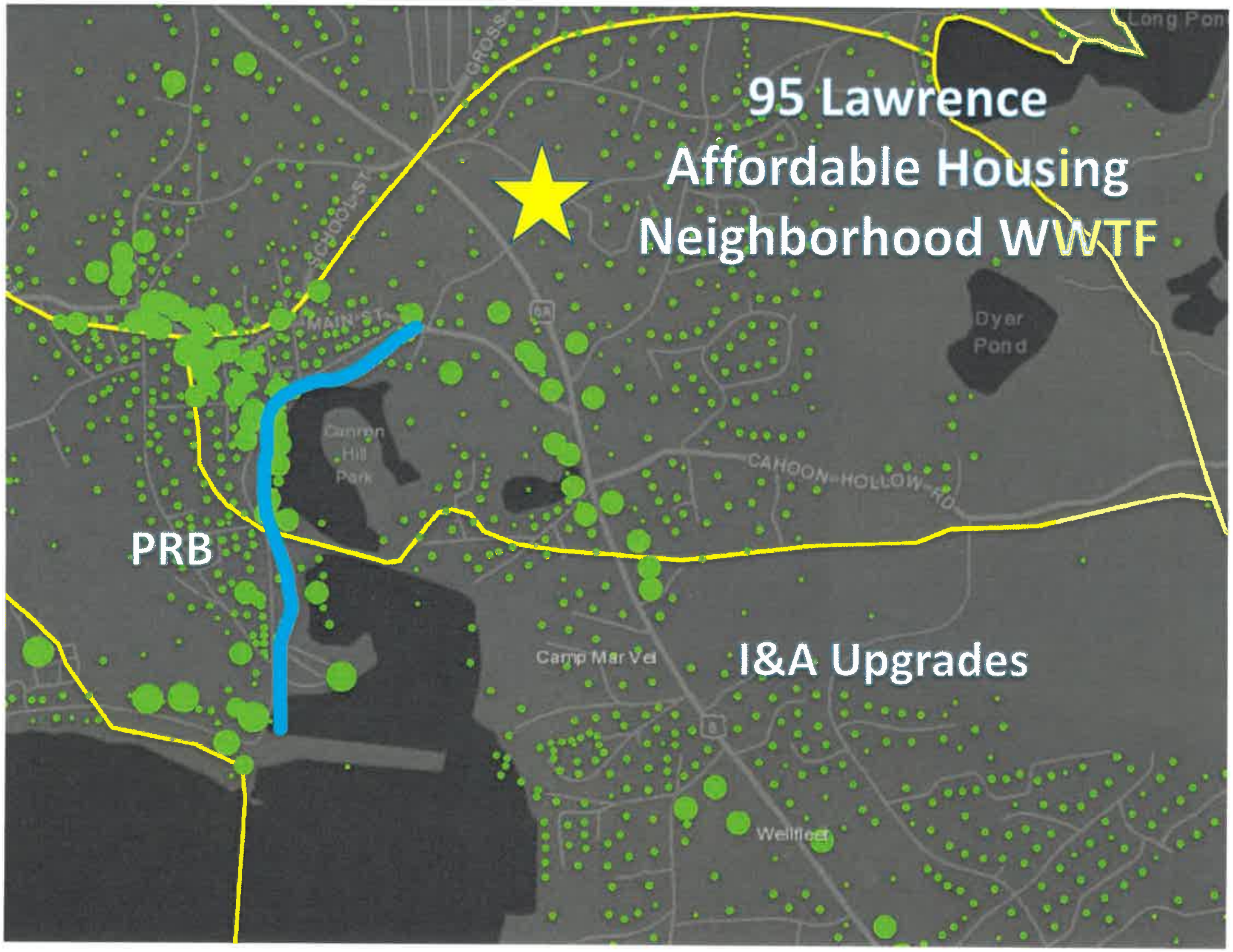



WELLFLEET TARGETED WATERSHED PLAN
95 Lawrence Project
Woodard & Curran Phase 1
Woodard & Curran Phase 2
Structure Footprint
SubEmbayment Boundary
Subwatershed Boundary
Aquaculture
Coastal Habitat Restoration
Fertilizer Management
Stormwater Projects
Enhanced I/As
Downtown Sewers
Transfer Station - Wastewater Treatment Plant
95 Lawrence Affordable Housing - Neighborhood Treatment Plant
Route 6 Stormwater Retrofit (MADOT) - integrate green infrastructure
Herring River Restoration
Commercial Street Permeable Reactive Barrrier (PRB) Pilot Project
Mayo Creek Restoration
Duck Creek
The Cove
Drummer Cove / Blackfish Creek

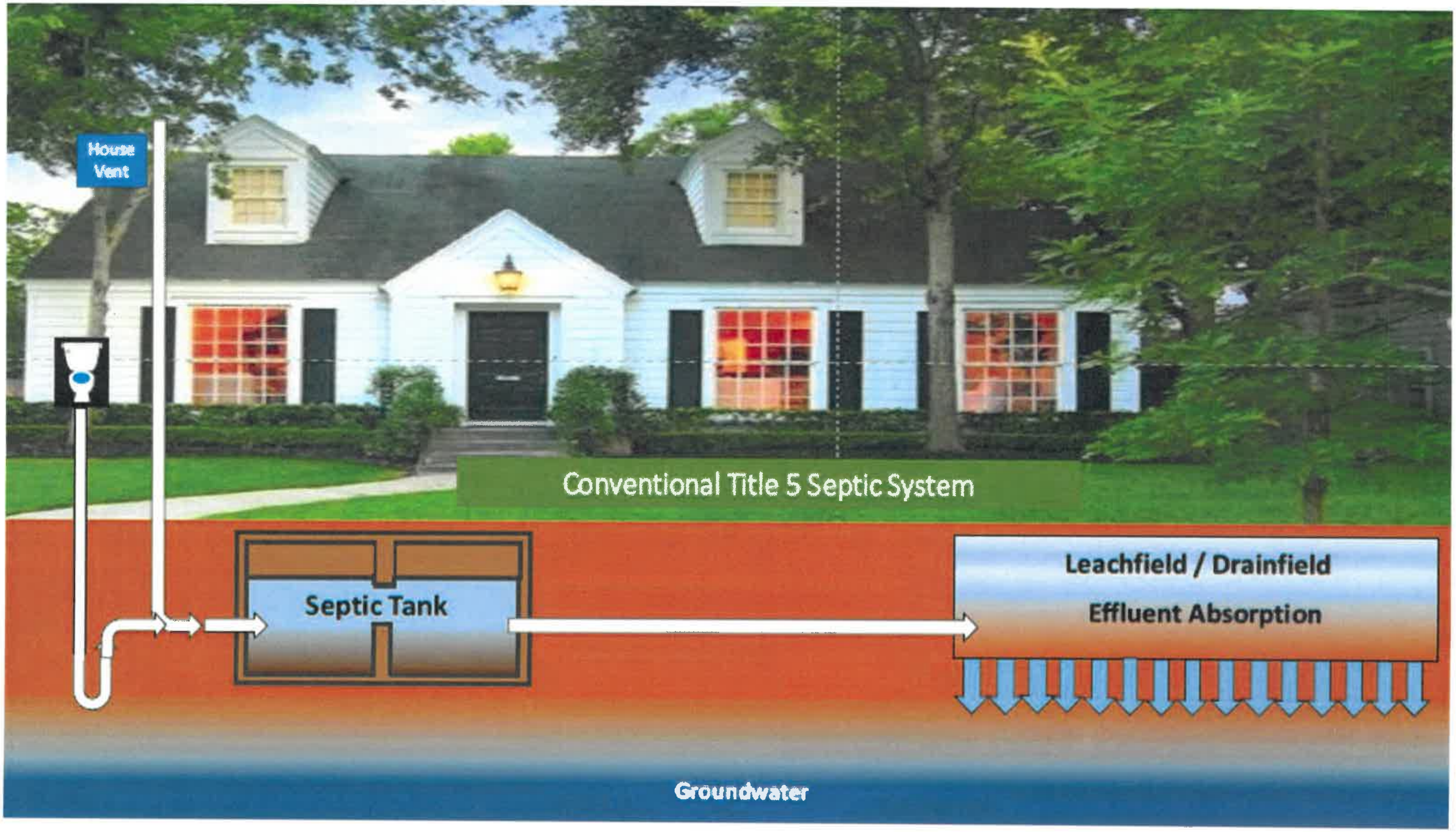
Continued Use of Conventional Title 5 Systems

Cumulative Nitrogen Loading Analysis – Wellfleet Harbor



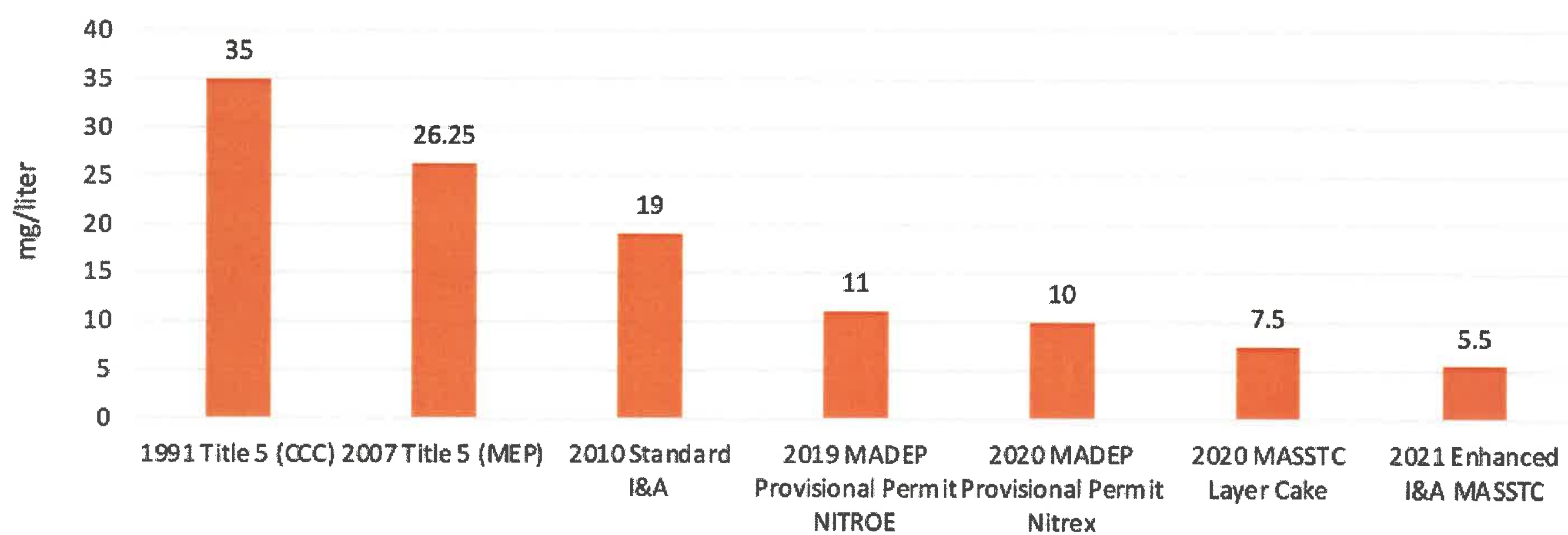


Pilot Projects
funded at Wellfleet
Town Meeting 2021

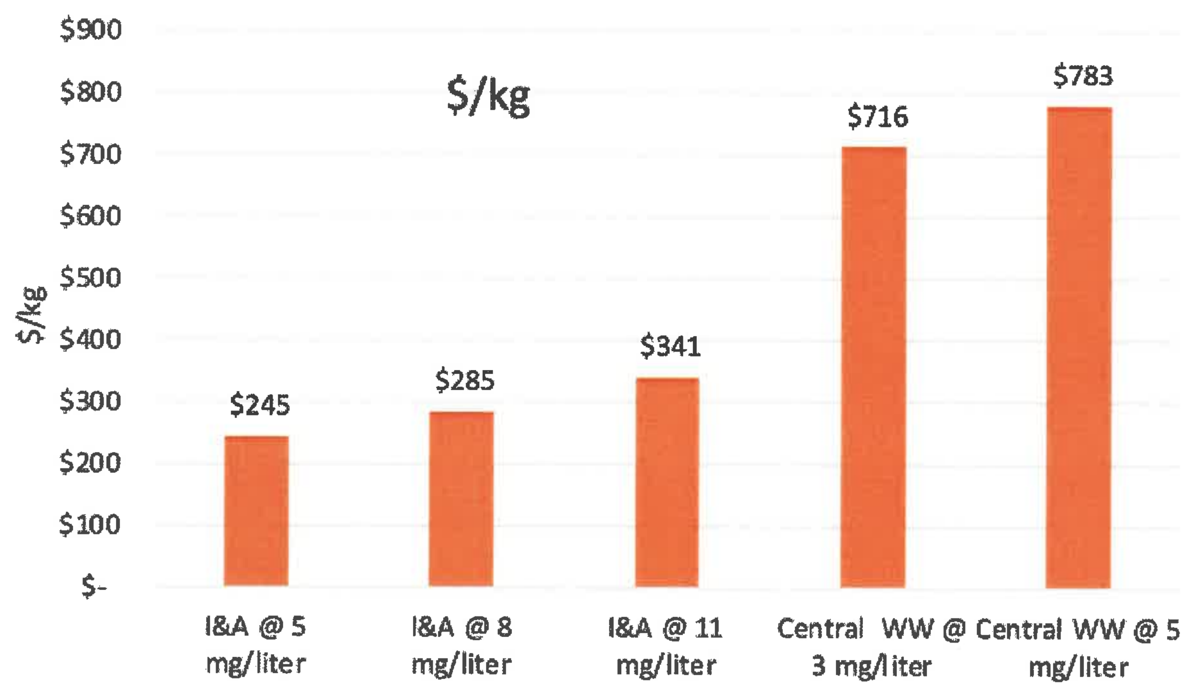

House Vent
Conventional Title 5 Septic System
Septic Tank
Leachfield / Drainfield
Effluent Absorption
Groundwater

Enhanced I&A Septic Systems

On-Site Septic System Performance Progress



Cost Effectiveness of Wastewater Treatment Options



Cost of Enhanced I&A = $28,111

Cost of Central Sewer and Treatment = $90,000

WELLFLEET HEALTH REGULATION (Draft for Discussion)

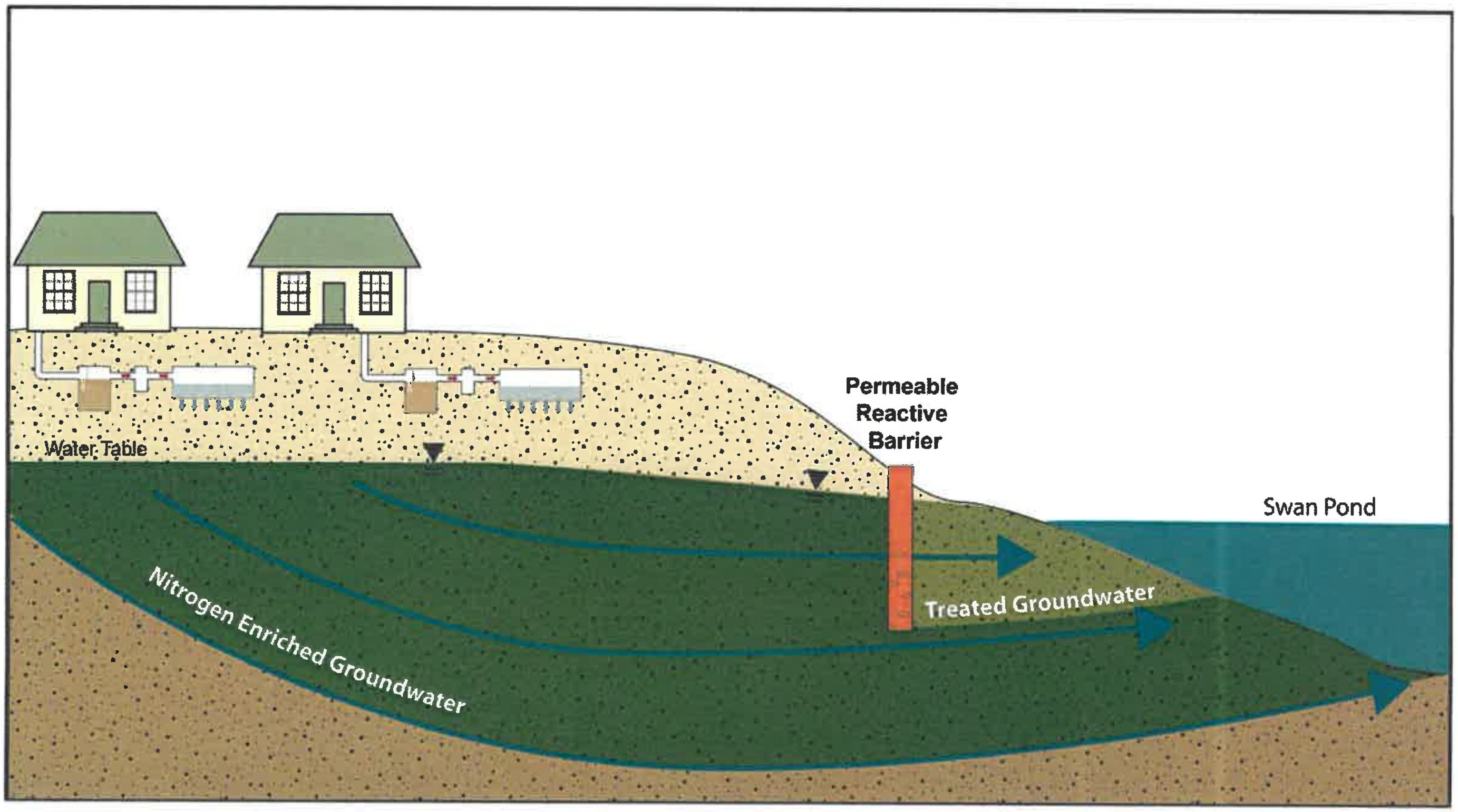
Purpose: To reduce nitrogen loading to Wellfleet's coastal waters by providing the best available technology.

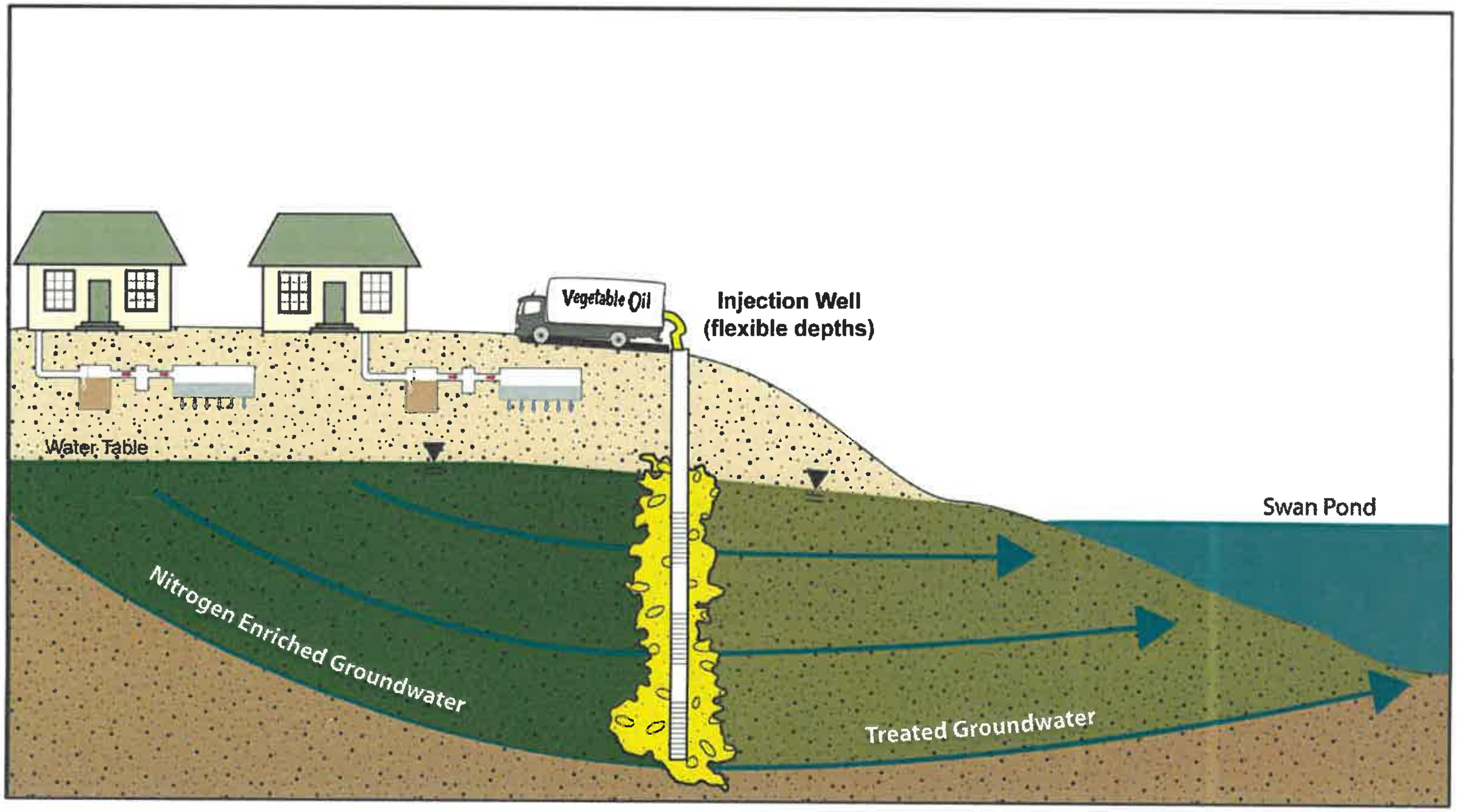
608. The use of enhanced innovative & alternative (I&A) septic systems are required for new, repairs, upgrades, and property transfers.

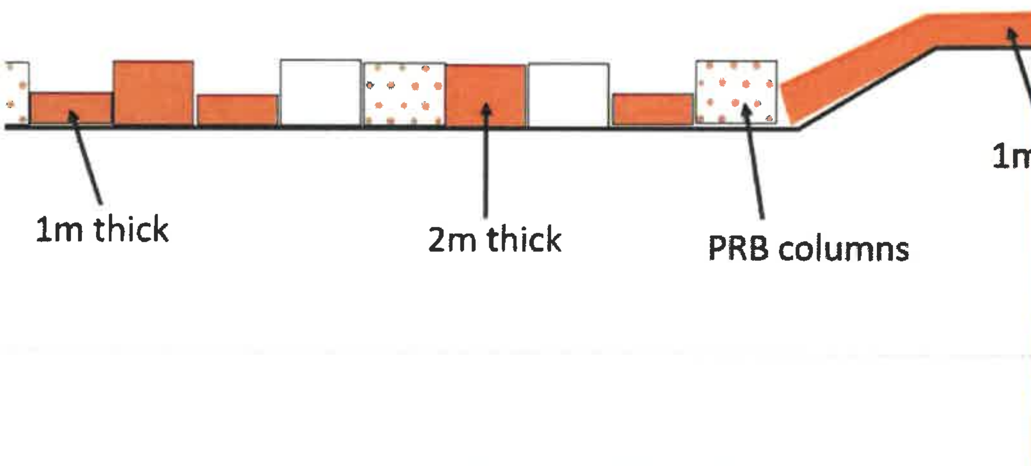
609. Enhanced I&A septic systems are defined as those technologies that have average nitrogen effluent concentrations less than 10 mg/liter or greater as demonstrated by third-party testing. Currently the Board of Health recognizes the following technologies as enhanced: NITRO, NITREX, and the sawdust-based system known as the "Layer Cake" technology (Heufelder, 2019). Other technologies may be petitioned by applicants for review by the Board of Health and must present third-party testing data.

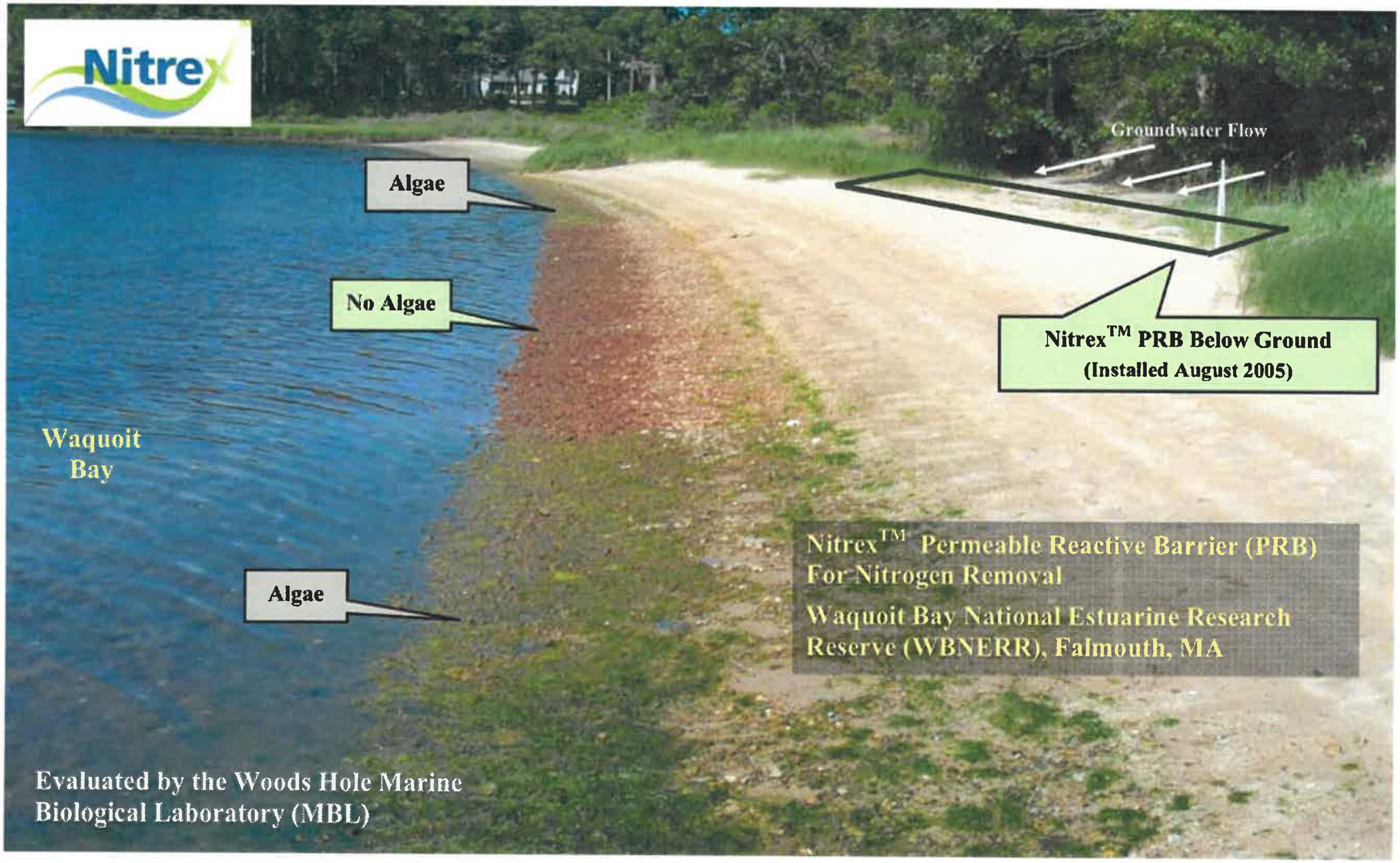
610. Any property owner who has installed an alternative septic system may, upon approval by the Board of Health, defer connection to town sewer to allow them to utilize their alternative septic system.

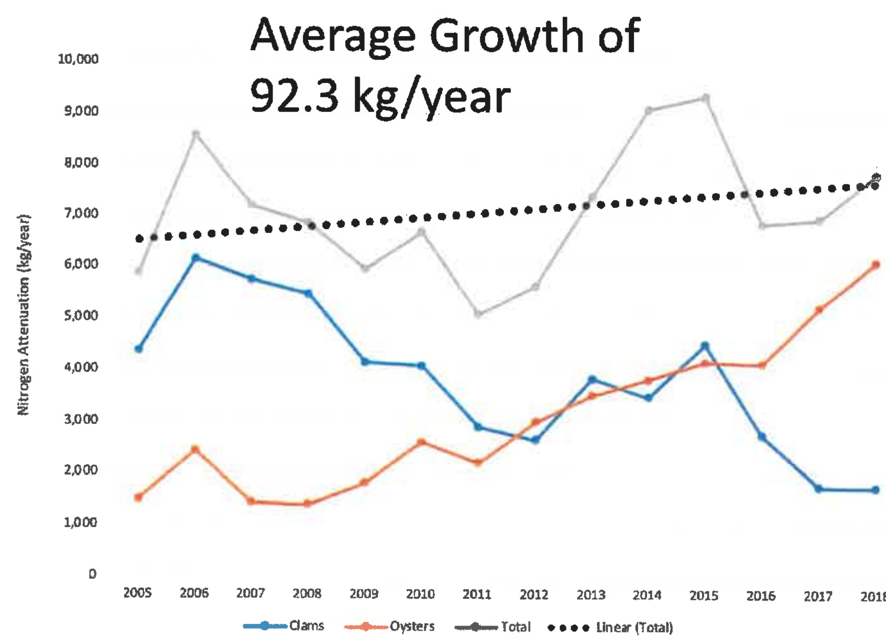
Note: The 2021 Wellfleet Town Meeting authorized $250,000 to assist property owners up to $12,500 per installation.


Water Table
Permeable
Reactive
Barrier
Swan Pond
Treated Groundwater
Nitrogen Enriched Groundwater


Vegetable Oil
Injection Well
(flexible depths)
Water Table
Swan Pond
Nitrogen Enriched Groundwater
Treated Groundwater


1m thick
2m thick
PRB columns
1m


Nitrex
Groundwater Flow
Algae
No Algae
Nitrex™ PRB Below Ground
(Installed August 2005)
Waquoit
Bay
Algae
Nitrex™ Permeable Reactive Barrier (PRB)
For Nitrogen Removal
Waquoit Bay National Estuarine Research
Reserve (WBNERR), Falmouth, MA
Evaluated by the Woods Hole Marine
Biological Laboratory (MBL)



Average Growth of
92.3 kg/year
Nitrogen Attenuation (kg/year)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Clams
Oysters
Total
Linear (Total)

Stormwater Remediation Projects

Stormwater Retrofits with Green Infrastructure

Coastal Ecosystem Restoration

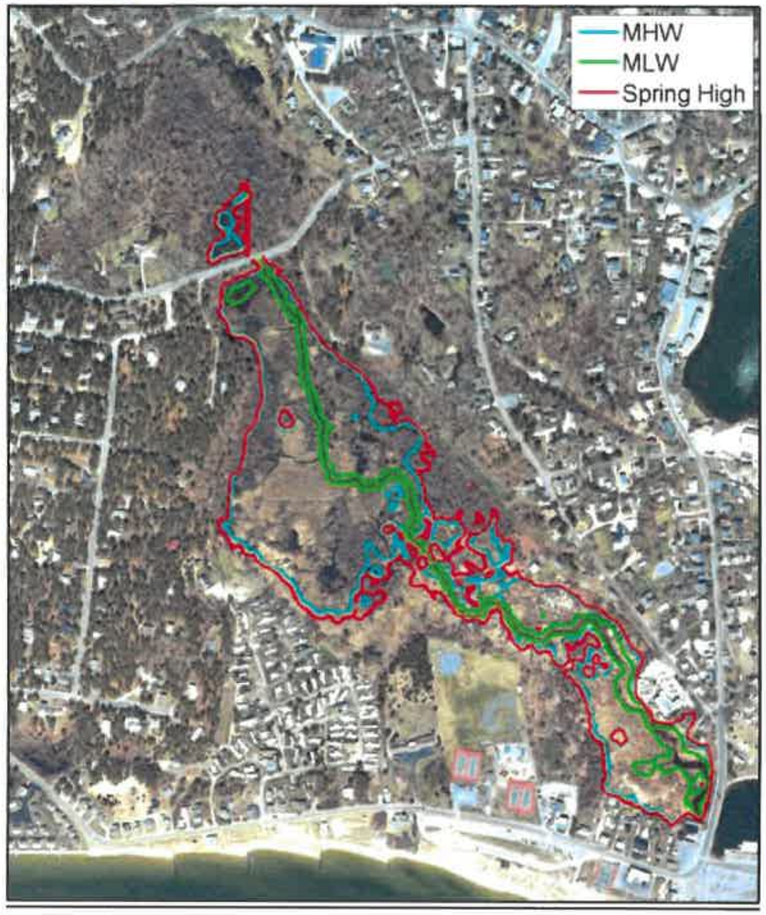
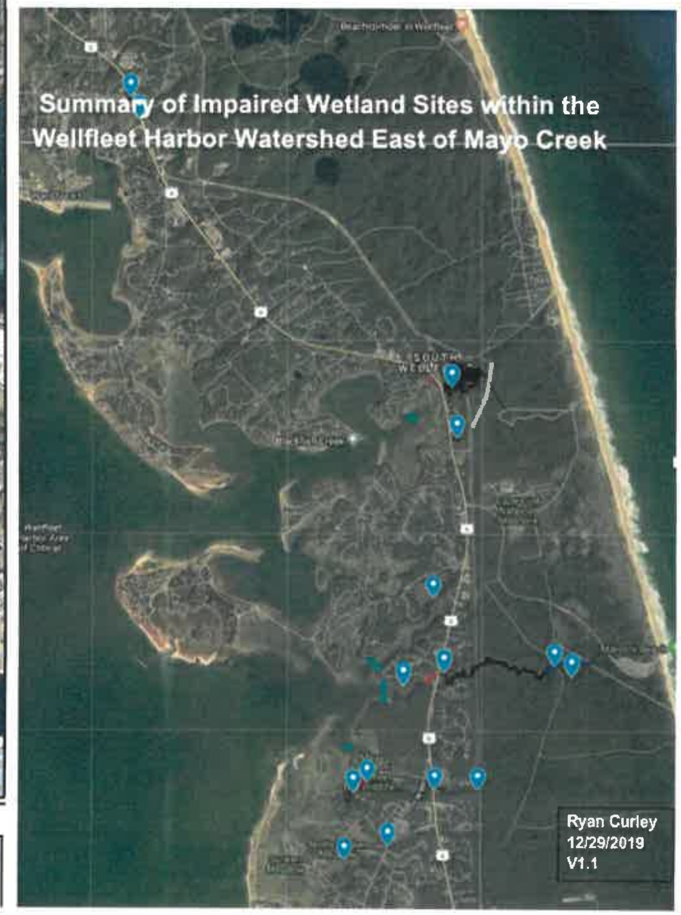
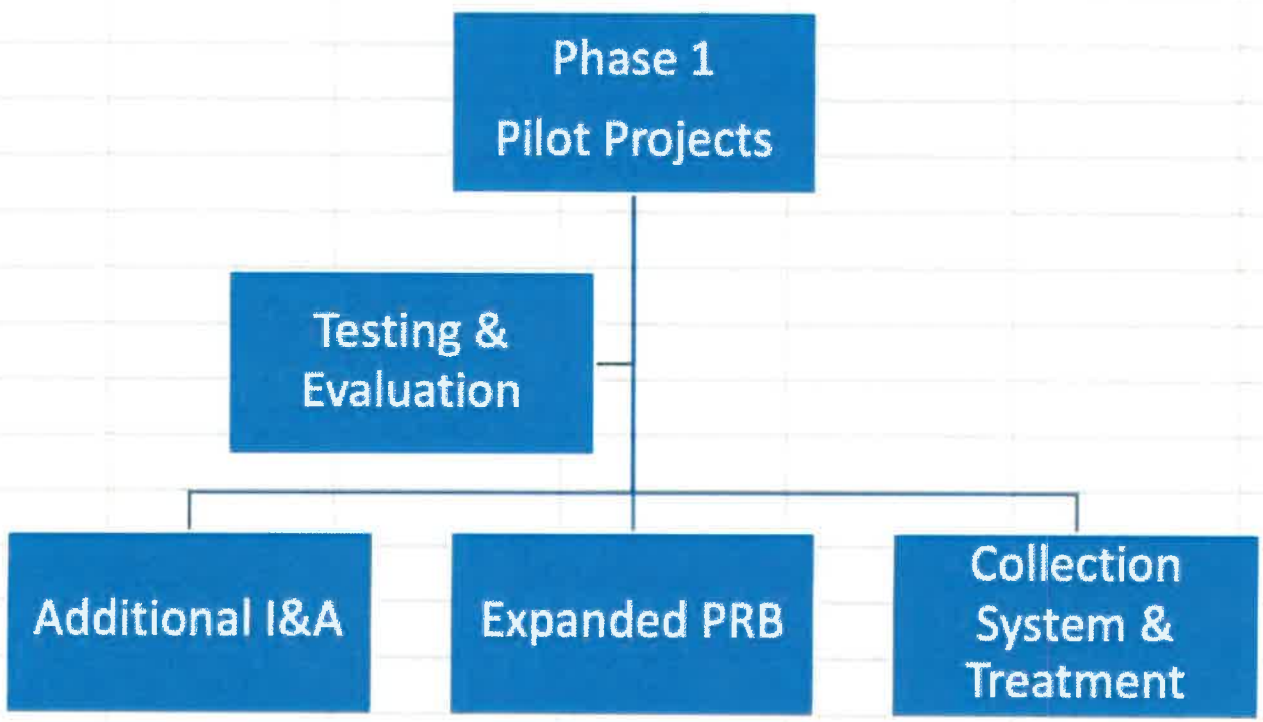


Figure 6. Aerial view of Mayo Creek showing the extent of mean high water (MHW), mean low water (MLW) and spring high tide under a scenario that maximizes salt-marsh restoration without flooding existing infrastructure (Woods Hole Group 2016).



Plan Implementation - Adaptive Management



Wellfleet Targeted Watershed Plan

Phase	Years	Nitrogen Reduction Strategies: Wastewater Treatment			Stormwater		Fertilizer		Permeable Reactive Barrier		Shellfish		Ecological Restoration		TOTAL
				kg/yr		kg/yr		k/gyr		kg/yr		kg/yr		kg/yr	kg/yr
1	2022 - 2026	Establish Responsible Management Entity (RME) and Install 25 - 30 EIA systems/year		494	Rte 6 MADOT integrate N attenuation	102	Implement Fertilizer Controls	98	Pilot Project Bank/Commercial Street (50 feet)	20	Sustainable growth at 94 kg/year	462	Mayo Creek: Design, Permit & Constructio n	317	1834
		95 Lawrence - Permit, Design & Construct Phase 1 (Housing & Municipal Properties)		341											
2	2027 - 2031	95 Lawrence - Design & Construct Phase 2 (Connect Neighborhood Homes)		281			Adaptive Management								
		Adaptive Management Install 66 - 77 EIA systems/year	Design & Construct Downtown Sewers Phase 1	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Construct Commercial Street/Duck Creek (1000 feet)	235	Sustainable growth at 94 kg/year	462	Herring River		2456
3	2032 - 2036	Install 66 - 77 EIA systems/year	Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Construct The Cove PRB projects (2000 feet)	970	Sustainable growth at 94 kg/year	462	Sunken Meadow (Hatches Creek)		2910
4	2037 - 2041	Install 66 - 77 EIA systems/year	Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462	Trout Brook (Upper Basin)		1940
5	2042 - 2046	Install 66 - 77 EIA systems/year	Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462	Eastern Blackfish Creek		1940
6	2047 - 2051	Install 66 - 77 EIA systems/year	Design & Construct Supplemental Sewers and/or Neighborhood Cluster Systems	1278	Additional Stormwater Retrofits	102	Implement Fertilizer Controls	98	Additional PRBs?		Sustainable growth at 94 kg/year	462			1940
N reduction				7506		612		588		1225		2772		317	13020

Town of
WELLFLEET
Massachusetts

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- 95 Lawrence Rd. Information
- Atlas Poster
- Enhanced Innovative & Advanced
- Lawrence Road Housing Project
- PRB
- Presentations
- Reports & Documents
- Salt Marsh Restoration
- Shellfish
- Storm Water
- Wellfleet Watershed Plan

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Clean Water Advisory Committee

Executive Summary

The goal of this plan is to mitigate water quality impairments, restore marine habitats, and to bring the coastal waters associated with Wellfleet Harbor into compliance with the Clean Water Act. The plan is the product of over ten 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.

Thank you for your attention!

Questions?

Thank you for your attention.

Questions?

Slides for Curt Felix - Financing

Wellfleet Targeted Watershed Plan

Non-Traditional			Traditional	
Enhanced I&A	19 - 45		95 Lawrence	4.0
95 Lawrence	4.0		Sewers Town-Wide	153 - 203
PRB	4.8			
Stormwater	2.0			
Salt Marsh Restoration	1.0			
Shellfish	2.0			
TOTAL CAP COST ($M)	33 - 59			157 - 207
Cost ($/kg)	59 - 109			305 – 405

Capital Plan - $6,431,886

(recommend borrowing authorization for **1st five years**)

- Innovative & Alternative (I&A) Septic Systems - $3,750,000
  - Health Regulation Subsidy $12,500 x 60 systems x 5 years = $3,750,000
- 95 Lawrence Neighborhood Wastewater Treatment Project - $1,931,886
  - Groundwater Discharge Permit $150,000
  - Incremental cost of Cluster Sewer System $1,781,886 capital
- Permeable Reactive Barrier (PRB) Pilot Project – Commercial St. - $450,000
  - Hydrogeologic Investigation $100,000
  - Pilot Project Design, Construction & Monitoring $350,000
- Salt Marsh Restoration - $300,000
  - Hawes Pond (Self-Regulating Tide Gate) $150,000
  - Mayo Creek (Self-Regulating Tide Gate) $150,000

O&M Plan $432,746

(recommended appropriation for 1st 5 years)

- Innovative & Alternative (I&A) Septic Systems - $100,000
  - Responsible Management Entity Contract $100,000 (Sub Contract)
- 95 Lawrence Neighborhood Wastewater Treatment Project - $52,746
  - Incremental cost of cluster O&M $52,746
- Shellfish Propagation - $80,000
  - Additional Cultch & Seed $40,000
  - Rotating 3-year closure program $40,000
- Project Management - $200,000
  - Grant Writer
  - Water/Wastewater Director
  - Monitoring, Testing, Compliance

Preliminary Grant/Revenue Sources 25-75%

- Advanced Septic Systems - $3,750,000
  - Short-term rental tax revenue (~$500,000/yr)
  - SRF Smart Growth – 25% forgiveness
  - USDA Rural – 50-75% grant
  - Cape Cod Water Protection Fund – 50% projects under $1 million
  - Rural/Small Town Growth Initiative $50,000-$400,000
  - Section 319 Federal Grants (non-point source) up to $500K
  - Privatized Cost to regulation.
- 95 Lawrence Neighborhood Wastewater Treatment Project - $1,931,886
  - SRF/USDA
  - Rural/Small Town
  - Massworks
- Permeable Reactive Barrier (PRB) Pilot Project – Commercial St. - $450,000
  - DEP/EPA Grant (they have already expressed interest in support)
  - All of the above
- Salt Marsh Restoration - $300,000
  - All of the Above (MassDOT will cover engineering & permit costs for Hawes Pond; construction?)
- Shellfish Propagation - $80,000
  - All of the above

Benefits

- Lower Cost
  - $28,000 per residence vs. over $90,000
  - Likely $20-$40 million financed in increments over time vs.
  - $100-$200 million immediately in tax base
- Greater financial control with annual financial discussion
- No risk of "overbuild"
- Maintains local control and local jobs
- 50% reduction in leachfields aids all residential and commercial permit applicants
- More immediate watershed benefits
- Lower
  - energy,
  - water and
  - climate change impact required by 2020 ATM vote
- Very little long-term O&M