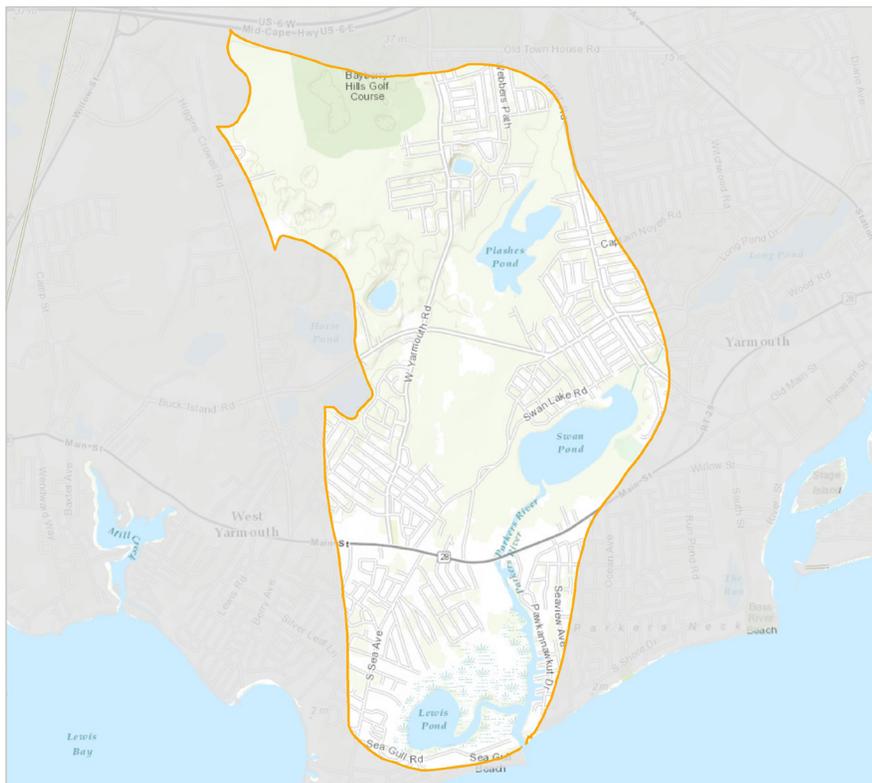
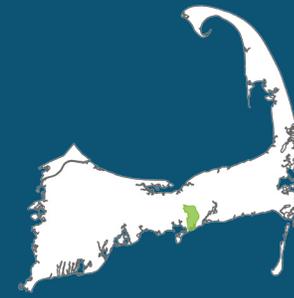


# Parkers River

YARMOUTH

HIGH



Parkers River Watershed

## Introduction to the Watershed Reports

In 2001, the Massachusetts Estuaries Project (MEP) was established to evaluate the health of 89 coastal embayment ecosystems across southeastern Massachusetts. A collaboration between coastal communities, the Massachusetts Department of Environmental Protection (MassDEP), the School of Marine Science and Technology (SMASST) at the University of Massachusetts-Dartmouth, the US Environmental Protection Agency (US EPA), the United States Geological Survey (USGS), the Massachusetts Executive Office of Energy and Environmental Affairs (EEA), and the Cape Cod Commission, the purpose of the MEP is to identify nitrogen thresholds and necessary nutrient reductions to support healthy ecosystems.

The Cape Cod 208 Plan Update, certified and approved by the Governor of the Commonwealth of Massachusetts and the US EPA in 2015, provides an opportunity and a path forward to implement responsible plans for the restoration of the waters that define Cape Cod.

On Cape Cod there are 53 embayment watersheds with physical characteristics that make them susceptible to nitrogen impacts. In its 2003 report, “The Massachusetts Estuaries Project – Embayment Restoration and Guidance for Implementation Strategies”, MassDEP identifies the 46 Cape Cod embayments included in the

MEP. Thirty-three embayments studied to date require nitrogen reduction to achieve healthy ecosystem function. A Total Maximum Daily Load (TMDL) has been established (or a draft load has been identified and is under review) for these watersheds. For those embayments not studied, the 208 Plan Update recommends planning for a 25% reduction in nitrogen, as a placeholder, until information becomes available.

The 208 Plan Update directs Waste Treatment Management Agencies (WMAs) to develop watershed reports within 12 months of certification of the Plan Update. The Watershed Reports outline potential “bookend” scenarios for each watershed that include two scenarios to meet water quality goals in the watershed – a traditional scenario, which relies completely on the typical collection and centralized treatment of wastewater, and a non-traditional scenario, which uses remediation, restoration, and on-site reduction techniques to remove nutrients from raw and treated wastewater, groundwater and affected waterbodies.

The intent of the Watershed Reports is to outline two distinct approaches for addressing the nutrient problem. The reports are not intended to identify preferred and detailed plans for each watershed, but to facilitate discussions regarding effective and efficient solutions, particularly in watersheds shared by more than one town. In some cases, towns have provided information on collection areas and non-traditional technologies that have been specifically considered by that town.

The 208 Update developed a regionally consistent database of the nitrogen load entering each watershed. This data set includes estimates of wastewater, stormwater and fertilizer loads - similar to methodologies used by the MEP. Using this regionally consistent database, the Watershed MVP tool (wMVP) was developed so that different strategies (i.e., bookend scenarios) to reduce excess nitrogen load

could be evaluated. The Watershed Reports use the MEP recommendations for the required nitrogen load reductions necessary to meet the threshold loads (that serve as the basis for nitrogen management), and then use the wMVP and the regionally consistent database values to develop bookend scenarios. There are variations of load between the MEP and wMVP, primarily due to differences in comparing older and newer databases.

## Terms Defined

**Total nitrogen load:** the nitrogen load from the watershed contributed by septic, wastewater, fertilizer, stormwater, golf course, landfill, and natural sources.

**Attenuated nitrogen load:** the nitrogen load from the watershed that reaches the embayment after the effect of natural attenuation in wetlands, ponds or streams.

**Threshold:** the amount of nitrogen that a water body can receive from its watershed and still meet water quality goals; this number is based on MEP technical reports or Total Maximum Daily Load (TMDL) reports.

**Reduction target:** an approximation of the amount of nitrogen that needs to be removed from the watershed to achieve the threshold; this number is calculated by subtracting the threshold number from the attenuated total watershed load, and is for planning purposes only.

**Percent contribution:** the percent of attenuated nitrogen load that a town contributes to the watershed.

**Kilogram responsibility:** is calculated by applying the percent contribution to the reduction target and indicates the amount of nitrogen, in kg, that a community is responsible for addressing.

**Total Maximum Daily Load:** a regulatory term in the Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Establishing a TMDL is necessary when a water body has been listed on the 303D list of impaired waters.

# Parkers River

## YARMOUTH



Parkers River is an estuary with shoreline located entirely within the Town of Yarmouth. Parkers River estuary extends inland approximately 2 miles to Swan Pond. Tidal flushing of the upper reach of the Parkers River and Swan Pond is impeded by a culvert beneath Route 28. A small tributary emerges from Long Pond that drains to Swan Pond. Parkers River supports a variety of recreational uses including boating, swimming, shell fishing and fin fishing; however, the upper portion experiences exceptional eutrophic conditions. Upper reaches of the system are more sensitive to nitrogen additions than the lower reaches due to dampened tidal signal in the upper reaches.

## The Problem

The Massachusetts Estuaries Project (MEP) technical report (available at <http://www.mass.gov/eea/agencies/massdep/water/watersheds/the-massachusetts-estuaries-project-and-reports.html>) indicates that the Parkers River system exceeds its critical threshold for nitrogen, resulting in impaired water quality. An MEP technical report has been completed and a draft Total Maximum Daily Load (TMDL) for nitrogen is under public review.

- **MEP TECHNICAL REPORT STATUS:** Final
- **TMDL STATUS:** Pending

Watershed nitrogen load characteristics were published in the 2010 MEP report for Parkers River, reflecting current conditions at the time of writing:

- **TOTAL ATTENUATED NITROGEN LOAD (MEP CHAPTER VIII):** 24,481 Kg/Y
- **SOURCES OF ATTENUATED WATERSHED NITROGEN LOAD:**
  - 85% Septic Systems
  - 7% Fertilizer
  - 7% Stormwater from Impervious Surfaces
  - 1% Wastewater Treatment Facilities

Since the MEP report, the Commission compiled the following updated water use and nitrogen loads using the regional wMVP database (see page 2), enabling a more current estimate of nitrogen loading. Towns have also submitted watershed characteristics that may differ from wMVP. Differences may be explained by different source years of water use data, or other assumptions. Both values are presented, when provided:

### ■ REGIONAL DATABASE (WMVP)

- See figure on page 1 for watershed boundary delineation
- Total Wastewater Flow: 210 MGY (million gallons per year)
- Treated Wastewater Flow: 0.4 MGY
- Septic Flow: 209 MGY
- Total Attenuated Nitrogen Load: 24,156 Kg/yr

### ■ TOWN OF YARMOUTH/CDM REPORTED VALUE

- Total Wastewater Flow: 237 MGY
- Treated Wastewater Flow: 28 MGY

## CONTRIBUTING TOWNS

Percent contributions listed below are the aggregate sub-embayment contributions identified in Appendix 8C of the Cape Cod Section 208 Plan Update (contributions are based on attenuated load where available). See Appendix 8C for detailed town allocations by sub-embayment.

- **YARMOUTH:** 100%

■ **BARNSTABLE:** <1%\*

\*Under existing conditions, the load contributed by Barnstable is so small that reductions are not necessary at this time; however, growth management measures should be taken to ensure that the contribution does not increase. Contributions will be reevaluated at least every five years, based on updated data.

## THE MEP RESTORATION SCENARIO

■ **WATERSHED TOTAL NITROGEN REDUCTION**

**TARGET:** 80% with existing culvert opening and 53% with increased culvert opening.

■ **WATERSHED SEPTIC REDUCTION TARGET:** 96%

with existing culvert opening and 67% with increased culvert opening.

The 53% total watershed load and 67% septic load reduction target listed above reflect an alternative MEP scenario that was run to assess the beneficial effect of increased tidal flow from a proposed widening of the culvert under Route 28.

The planned culvert widening is applied as a non-traditional intervention later in the document toward achieving the 80% reduction in total watershed nitrogen load.

## PARKERS RIVER ESTUARY

■ **EMBAYMENT AREA:** 74 acres

■ **EMBAYMENT VOLUME:** 29 million cubic feet

■ **2014 INTEGRATED LIST STATUS:** Category 4a for fecal coliform

■ Category 4a: TMDL is completed

■ [www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf](http://www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf)

## PARKERS RIVER WATERSHED

General watershed characteristics according to the current wMVP regional database (see figure on page 1 for watershed boundary) follow. Towns have also submitted watershed characteristics that may differ from wMVP. Differences may be explained by changes due to development in the intervening years, or other assumptions. Both values are presented, when provided:

■ **WATERSHED CHARACTERISTICS**

**Regional Database (wMVP)**

- 2,729 Acres
- 3,318 Parcels
- 92% Residential Parcels
- 0.82 acres per parcel (approx.)

**Town of Yarmouth/CDM Reported Values**

- 3,108 Acres
- 4,416 Parcels
- 85% Residential Parcels
- 0.70 acres per parcel (approx.)

## Freshwater Sources

### PONDS

■ **IDENTIFIED SURFACE WATERS:** 14

■ **NUMBER OF NAMED FRESHWATER PONDS:** 4

■ **PONDS WITH PRELIMINARY TROPHIC CHARACTERIZATION:** 0

■ **2014 INTEGRATED LIST STATUS:** None listed

The Long Pond subwatershed has high density flows split between the Parkers River and Bass River watersheds. 85% of the flow from the Long Pond watershed discharges to Bass

River with the remaining flow discharging to Parkers River. Long Pond attenuates 89% of the load in this flow.

Yarmouth has participated in the Pond and Lake Stewardship (PALS) program that has helped establish baseline water quality.

### STREAMS

■ **SIGNIFICANT FRESHWATER STREAM OUTLETS:** 3

Forest Road:

- Average Flow: 823 cubic meters per day (m3/d)
- Average Nitrate Concentrations: 0.46 milligrams per liter (mg/L)

Plashes Brook:

- Average Flow: 3,107 m3/d
- Average Nitrate Concentrations: 0.41 mg/L

Grays Brooks:

- Average flow and average nitrate concentrations were not evaluated

Stream data from MEP technical report. Nitrate concentrations higher than 0.05 mg/L background concentrations, evident in public supply wells located in pristine areas, provide evidence of the impact of non-point source pollution on the aquifer and receiving coastal water bodies.

### DRINKING WATER SOURCES

■ **WATER DISTRICTS:** 1

- Yarmouth Water Department

■ **GRAVEL PACKED WELLS:** 5

- 1 has nitrate concentrations between 0.5 and 1 mg/L
- 2 have nitrate concentrations between 1 and 2.5 mg/L
- 1 has nitrate concentrations between 2.5 and 5 mg/L
- 1 has no nitrate concentration data

■ **SMALL VOLUME WELLS:** 0

## Degree of Impairment and Areas of Need

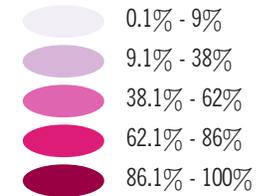
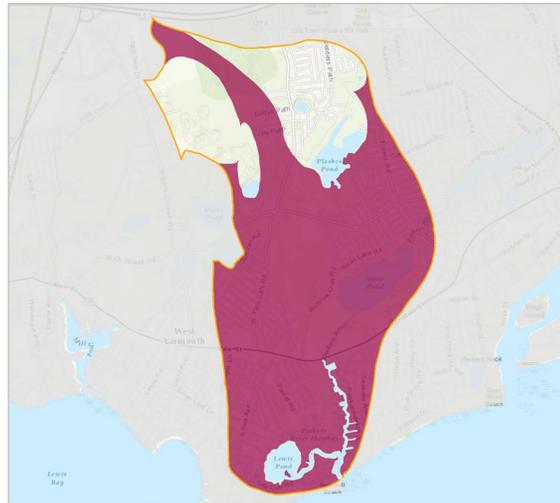
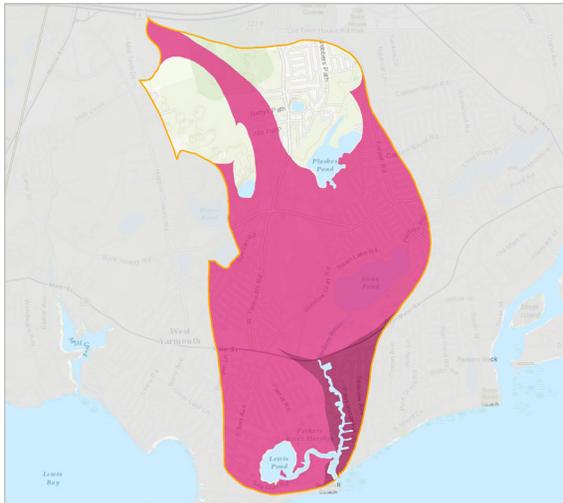
For the purposes of the Section 208 Plan Update, areas of need are primarily defined by the amount of nitrogen reduction required as defined by the TMDL and/or MEP technical report. These reductions are identified above as 80% of the total watershed nitrogen load and 96% of the septic nitrogen load, and more specifically as the targeted amount of nitrogen reduction required by subembayment (see figures on following page, Subwatersheds with Total Attenuated Watershed Removal Targets and Subwatersheds with Septic Attenuated Removal Targets).

The load from the Parkers River watershed exceeds the nitrogen threshold, resulting in impaired water quality. Seine Pond is significantly impaired relative to infaunal habitat. Lower reaches of the system have been deemed by the MEP to be severely degraded due to the absence of eelgrass where it historically occurred. The ecological health of a water body is determined from water quality, extent of eelgrass, assortment of benthic fauna, and dissolved oxygen and ranges from severe degradation, significantly impaired, moderately impaired, or healthy habitat conditions.

## ECOLOGICAL CHARACTERISTICS AND WATER QUALITY

The MEP report provides the following characterization of the estuary's health:

- **OVERALL ECOLOGIC CONDITION:** Healthy to Significantly Impaired
- **UPPER REACH**
  - Mill Pond: Significantly Impaired
  - Follins Pond: Significantly Impaired
  - Dinah Pond: Moderately to Significantly Impaired
  - Kelleys Bay: Significantly Impaired
- **MID REACH**
  - Mid River: Significantly Impaired
  - Grand Cove: Significantly Impaired
- **LOWER REACH**
  - Lower River: Significantly Impaired
  - Weir Creek Basin: Healthy to Moderately Impaired
- **SENTINEL STATION:**
  - Total Nitrogen Concentration Threshold: 0.42 mg/L
  - Total Nitrogen Concentration Existing: 0.64 mg/L (As reported at the MEP sentinel water-quality monitoring station)

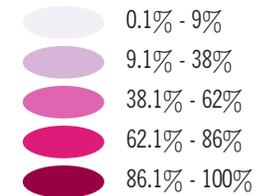
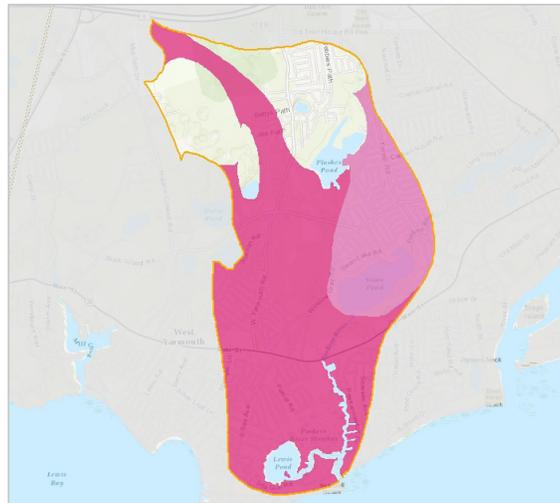
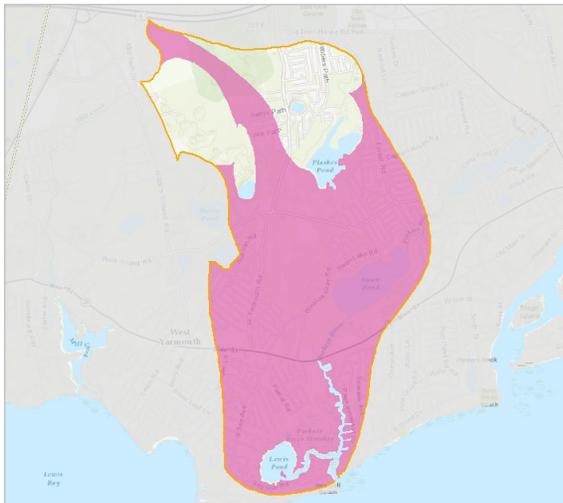


**Subwatersheds with Total Attenuated Watershed Removal Targets**

(Left) Benthic and atmospheric loads directly on embayments are not included.

**Subwatersheds with Septic Attenuated Nitrogen Removal Targets**

(Right)



**Subwatersheds with Total Attenuated Watershed Removal Targets - Optimized Culvert Threshold**

(Left) Benthic and atmospheric loads directly on embayments are not included.

**Subwatersheds with Septic Attenuated Nitrogen Removal Targets - Optimized Culvert Threshold**

(Right)

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## Traditional & Non-Traditional Scenarios

### SCENARIO DEVELOPMENT

Through the 208 Stakeholder process, the Commission developed “bookend” scenarios – one looking at a possible solution using traditional collection and treatment, the other examining a possible suite of non-traditional technologies – to address the nitrogen management needs in each watershed. These bookend scenarios provide guidance for communities as they continue to discuss alternatives, priorities, and opportunities for identifying well-considered solutions that will address communities’ needs and interests.

### REGIONAL DATA

In preparation for this effort, the Commission collected regionally consistent data for the purposes of watershed scenario development. Both parcel data and water use data was identified and collected for the entire region. While the scientific basis for planning is the thresholds identified in the MEP technical reports, each report uses data from different years, and in some cases the MEP data used are 10 or more years old. In addition, there are watersheds on Cape Cod without the benefit of an MEP report; therefore, similar data was not available for planning purposes.

The updated regional data set was used to estimate wastewater, stormwater and fertilizer loads, using the same methodologies as the MEP. This approach allows for a reevaluation of existing development, which may have changed in the last 10 years. Parcel data included in the regional database is from 2010-2012 and water use data is from 2008-October 2017

2011, depending on the water supplier and based on best available data. This approach allows for regionally consistent watershed scenario development.

### WATERSHED SCENARIOS

The watershed scenarios that follow outline possibilities for the watershed. A series of non-traditional technologies that might be applicable are included, as well as the amount of residential load that would need to be collected if a traditional collection system and treatment facility was implemented. The pie charts show the load to be collected for treated effluent disposal both inside and outside the watershed.

Site specific analyses of collection areas may result in the need to collect wastewater from more or fewer parcels to meet the nitrogen reduction target. The scenarios presented are conceptual and are meant to inform discussions regarding effective and efficient solutions; they are not specific recommendations and should be viewed as resource information for additional and more detailed wastewater management planning.

In Parkers River, the Town of Yarmouth has done additional and more detailed planning. Included in the last section of this report is a description of their efforts, along with details of plans developed to date.

#### TOTAL ATTENUATED WATERSHED NITROGEN LOAD VALUES (FROM WMVP)

Parkers River Nitrogen Sources	Total Attenuated Watershed Nitrogen Load (kg-N/yr)
Wastewater <sup>1</sup>	19,183
Fertilizer <sup>2</sup>	2,252
Stormwater	2,254
Other <sup>3</sup>	468
<b>TOTAL WATERSHED LOAD</b>	<b>24,156</b>
Total Watershed Threshold	4,913
<b>TOTAL ATTENUATED LOAD TO BE REMOVED</b>	<b>19,243</b>

1. Includes nitrogen loads from septic systems and wastewater treatment facilities.
2. Includes nitrogen loads from lawns, cranberry bogs, and golf courses.
3. Includes nitrogen loads from landfills and atmospheric deposition to vacant land.

## Traditional & Non-Traditional Scenarios

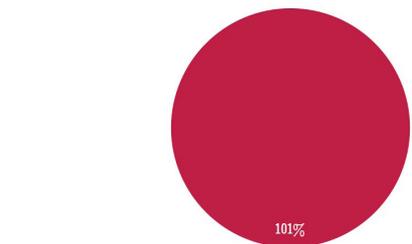
### Non-Traditional

UNIT OF APPLIED TECHNOLOGY	ATTENUATED NITROGEN REMOVED IN KG/Y
 25 % Nitrogen Reduction - Fertilizer Management	563
 25 % Nitrogen Reduction - Stormwater Mitigation	563
 7,500 Linear Feet - Permeable Reactive Barrier (PRB) (Capture load calculated by wMVP: 7,200 kg/Y)	5,220
 15 Acres - Aquaculture/Oyster Beds	3,850
 6,250 Square Feet - Floating Constructed Wetlands	2,500
 Inlet Widening	6,673
 39 Units - Ecotoilets (UD & Compost)	100
<b>TOTAL</b>	<b>23,549</b>

A summary of the approach and methodology that was applied using non-traditional technologies follows at the end of this report.

### Traditional

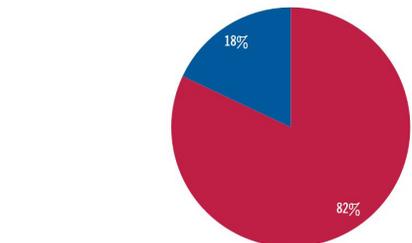
#### CENTRALIZED TREATMENT WITH DISPOSAL OUTSIDE THE WATERSHED



The MEP watershed nitrogen threshold cannot be met by collecting 100% of the septic load in the Parkers River watershed and returning the treated load to the watershed.

 Septic Load to be Removed  
 Remaining Septic Load

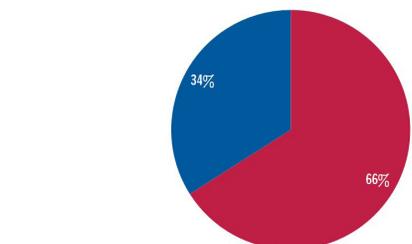
#### POST-CULVERT WIDENING CENTRALIZED TREATMENT WITH DISPOSAL INSIDE THE WATERSHED



Assumes load to be collected and treated is disposed in the watershed, requiring additional collection to offset the load.

 Septic Load to be Removed  
 Remaining Septic Load

#### POST-CULVERT WIDENING CENTRALIZED TREATMENT WITH DISPOSAL OUTSIDE THE WATERSHED



Assumes that the load to be collected and treated is removed from the watershed so no offset is required.

 Septic Load to be Removed  
 Remaining Septic Load

## Town of Yarmouth Local Progress

In 2010, the Town of Yarmouth submitted its Comprehensive Wastewater Management Plan (CWMP) as a Draft Environmental Impact Report (DEIR). The draft CWMP targeted areas that would require wastewater collection to restore water quality in the Lewis Bay and Parkers River watersheds and deal with the Title 5 constraints on economic redevelopment in the area of Route 28. The town's plan included approximately 125 miles of sewer lines and the collection of 2.75 million gallons per day (MGD) of wastewater to be treated at a single facility in the Parkers River watershed. The ability of the Parkers River watershed to receive transported load from out of its watershed is predicated on a new culvert opening at Route 28 that will increase tidal flushing. Even with the tidal flushing increase the proposed plan would have used nearly all of the Parkers Rivers capacity to assimilate nitrogen. The project would ultimately serve 9,580 properties by 2035. Phase 1 of the plan would begin with the treatment facility and main trunk line sewer to serve Route 28 and portions of the Parkers River and Lewis Bay watershed.

The plan relies on gravity, pressure, and vacuum sewers. The MEP nitrogen reduction goals were the primary factor in choosing sewerage locations. The phasing of these sewerage areas also takes the town's economic goals into consideration.

The town submitted its Final Environmental Impact Report (FEIR) and received Massachusetts Environmental Policy

Act (MEPA) approval in July 2011, but did not complete the Cape Cod Commission Development of Regional Impact (DRI) process before going to September 2011 Town Meeting to seek Phase 1 design and construction funds. Phases 1 through 5 were scheduled to be implemented over a 25-year period. The estimated cost of the total plan was \$275 million. The first phase had an estimated cost of \$55 million. Town Meeting did not approve the expenditure. The town withdrew the CWMP from the DRI review process.

Wastewater planning in the community had effectively come to a stop prior to the development of the 208 Plan Update, with the exception of the route 28 culvert opening project. Since the town meeting vote to deny funding for phase 1, the town received funding to reconstruct the culvert beneath Route 28 in order to improve tidal flushing in the Parkers River. In May 2016, the Town voted to appropriate \$1.6 Million in funding to supplement \$3.4 Million in Hurricane Sandy grant funding.

In January 2016 town staff met with the Board of Selectmen to discuss a new financing plan for implementation of a program that would meet water quality standards in all of their watersheds.

The recommended plan includes a combination of traditional sewerage methods with centralized treatment facilities as well as non-traditional nitrogen management options including a permeable reactive barrier (PRB) at the Buck Island Road

effluent recharge site. The Town of Yarmouth is proposing a phased wastewater program that includes a collection system, a conveyance system and a centralized treatment facility, each constructed over several years. In addition to the proposed sewerage, the recommended plan involves public outreach to promote nitrogen reduction and to prevent sewer system inflow, zoning modifications for growth management and establishment of the activity centers, development of sewer ordinances, and continued maintenance of Title 5 and I/A systems in the northern and western areas of the town that will not be served by the proposed wastewater collection system. The town also plans to implement stormwater and fertilizer improvement programs. As suggested in the 208 Plan Update, up to a 25% nitrogen reduction credit can be obtained by towns that implement stormwater and fertilizer management programs to reduce nitrogen contributions to each watershed. To achieve a 25% nitrogen reduction from stormwater in the Lewis Bay watershed, 50% of the total roads in the watershed are assumed to require stormwater best management practices (BMPs). Yarmouth plans to achieve 25% nitrogen reduction in fertilizers by implementing a town-wide fertilizer education program.

During the spring 2016 town meeting, the town approved \$200,000 for additional CWMP planning.

## Town of Yarmouth Watershed Scenario Details

NAME OF TECHNOLOGY	CREDITS		REDUCTION TECHNOLOGIES			REMEDIATION AND RESTORATION TECHNOLOGIES			REMOVAL
	% Nitrogen Reduction	Load Reduction (kg-N/yr)	# Properties / Units	Flow Collected (gpd)	Load Reduction (kg-N/yr)	# Units Proposed	Unit Metric	Load Reduction (kg-N/yr)	Total Scenario Load Reduction (kg-N/yr)
Scenario									16,720
Fertilizer Management	25%	560							
Stormwater Mitigation	25%	560							
Centralized Sewer			3,100	710,787	15,600				

In April 2016, Yarmouth submitted a request for assistance to continue CWMP development and town staff met with the Commission to discuss the request in early May.

In June 2016, Yarmouth received \$35,000 from the Commission for the Towns of Dennis, Harwich and Yarmouth for a regional treatment facility cost study. Funding was part of \$142,149 in local grants made by the Commission in support of 208 Plan implementation.

At the Spring 2017 Town Meeting appropriated \$200,000 for wastewater planning and engineering services including engineering studies and evaluation of recharge sites; updating, modification, and pre-implementation services for the Comprehensive Wastewater Management Plan and support for related filings with the Massachusetts Environmental Policy Act office and the Cape Cod Commission.

NOTES:

\* Average daily flow collected includes buildout and estimated inflow and infiltration.

\*\* Fertilizer and stormwater credits will be built into the updated recommended plan for Yarmouth when the NPC is submitted for the Final CWMP.

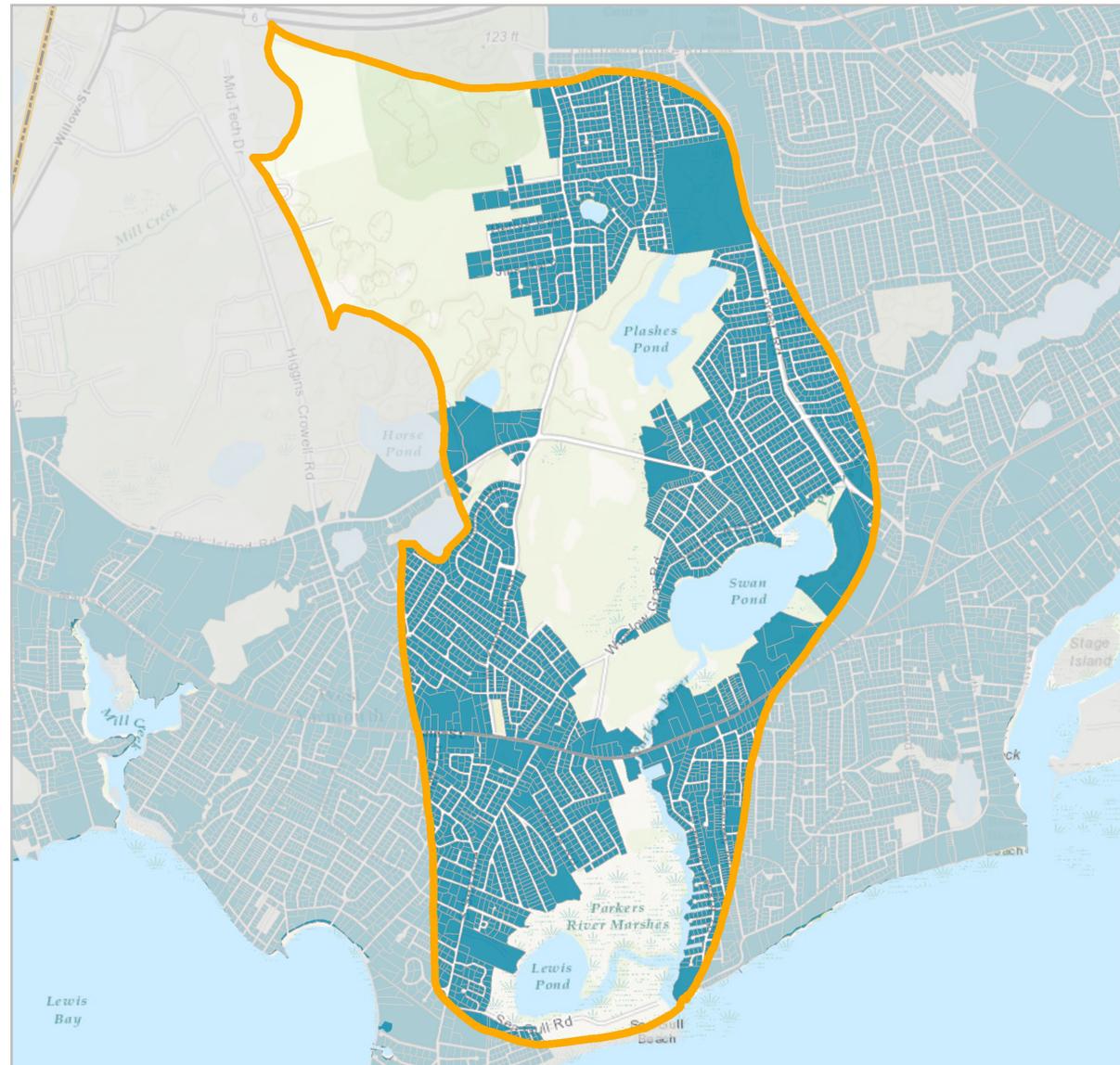
## Scenario Maps

### Parkers River Watershed Scenario YARMOUTH

Representative locations of conceptually proposed infrastructure

#### Legend

-  Town Lines
-  Embayment Watersheds
-  Proposed Sewershed



## Methodology for Selecting Non-Traditional Technology Scenarios

This section summarizes the approach and methodology that was applied during the 208 Update to develop plans for reducing nitrogen loading to estuaries using non-traditional (NT) technologies. It includes descriptions of regional credits for stormwater and fertilizer reductions, regional screening for potential sites for several technologies, and site-specific analyses for others. Nitrogen attenuation rates for each technology were derived from the Technologies Matrix. The nitrogen thresholds for each embayment were determined from the Massachusetts Estuaries Project (MEP).

This section summarizes the approach and methodology that was applied during the 208 Update to develop plans for reducing nitrogen loading to estuaries using non-traditional (NT) technologies. It includes descriptions of regional credits for stormwater and fertilizer reductions, regional screening for potential sites for several technologies, and site-specific analyses for others. Nitrogen attenuation rates for each technology are noted below, based on the Technologies Matrix or newer data. The nitrogen thresholds for each embayment were determined from the Massachusetts Estuaries Project (MEP).

Regional credits were developed for potential stormwater retrofits and fertilizer reductions. They were calculated as a percent reduction of existing nitrogen loads as identified in the MEP reports and updated GIS data developed by the Cape Cod Commission.

- **STORMWATER MANAGEMENT:** Most Cape communities have already begun the process of identifying significant untreated stormwater discharges and developing appropriate mitigation projects. With the prospect of the MS4 regulatory requirements it was assumed that additional mitigation efforts would be implemented. Based upon the evidence developed by the University of New Hampshire Stormwater Center that several vegetated stormwater management practices (including bioretention and constructed wetlands) are able to achieve nitrogen reductions of 50% or more and the assumption that only a portion (estimated at 50%) of identified sites would be retrofitted a 25% nitrogen reduction credit was assumed for each watershed. Specific locations and number of locations were not identified; this was deferred to individual towns to consider as part of the suite of nitrogen management strategies.
- **FERTILIZER REDUCTIONS:** Based upon the success of most Cape Cod towns to implement either regulatory or non-regulatory fertilizer management programs and the efforts of the Cape Cod Extension Service in

educating homeowners a 25% reduction in fertilizer applications was assumed for each watershed.

Regional GIS screening methods were developed to identify locations for some non-traditional technologies. A GIS viewer was developed as an on-line tool for staff and consultants to utilize during the watershed planning process.

- **CONSTRUCTED WETLANDS/ PHYTOREMEDIATION:** A GIS-based screening method was developed by the Cape Cod Commission to identify and rank parcels of land that have potential for the location of constructed wetlands and phytoremediation. The ranking utilized parcel size and ownership, depth to groundwater, suitable soils, distance from wetlands, and undeveloped parcels. A nitrogen removal rate of 500 kg/Y/acre and 532 kg/Y/acre was used for Constructed Wetlands and Phytoremediation, respectively.
- **PERMEABLE REACTIVE BARRIERS (PRBS):** A GIS-based screening method was developed to identify existing roads that are proximate to receiving waters, downgradient of high density development, run perpendicular to groundwater flow (to have the highest potential to intercept nutrients in groundwater), and where the depth to groundwater is relatively shallow to maximize the area of saturated thickness treated in the aquifer.

## Methodology for Selecting Non-Traditional Technology Scenarios

■ **FERTIGATION WELLS:** Golf courses were mapped to identify areas where fertigation wells could be utilized to recapture nitrogen-enriched groundwater and re-apply it to the managed turf areas to serve both irrigation and fertilization needs. Most golf courses were assumed to be eighteen holes with a fertilized area of 75 acres. Fertigation water was assumed to have an average concentration of 5 mg/liter. An uptake/attenuation rate of 80% was applied resulting in an assumed nitrogen reduction of 300 kg/year for each golf course with effectively located fertigation wells. In some cases other irrigated areas (such as athletic fields and cemeteries) were identified as potential fertigation locations. Assuming the use of 730 gpd/acre for turf areas, a nitrogen removal rate of 4 kg/y/acre was used for fertigation of turf areas. Assuming a higher flow rate of 2,200 gpd/acre for cranberry bogs, a 12 kg/y/acre removal rate was used for fertigation of cranberry bogs.

The MVP tool and other site-specific tools were utilized to quantify nitrogen load reductions for several potential NT interventions.

■ **PERMEABLE REACTIVE BARRIERS:** for each PRB that was identified during the prior GIS-screening process an approximate capture area was identified using available water table maps and the wMVP tool. Upgradient contributing areas were digitized within wMVP and the nitrogen load was calculated. A nitrogen

reduction of 72.5% was applied (calculated as an average of the reported attenuation range from the Technologies Matrix).

■ **CONSTRUCTED WETLANDS (WITH COLLECTION):** Constructed wetlands were considered as a tertiary, polishing treatment for existing wastewater treatment plants. This included small-scale wastewater treatment systems. A nitrogen removal rate of 500 kg/Y/acre was used.

■ **AQUACULTURE/OYSTER REEFS:** Potential areas for aquaculture and/or oyster reef restoration were considered based upon discussions with town representatives and review of maps to identify potential areas for these operations without significant conflicts to navigation. In some cases actual recent aquaculture expansions were included where they were developed after the MEP reports were prepared. An assumption of 1 million oysters per acre was used with a nitrogen removal rate of 250 kg/Y/acre.

■ **FLOATING CONSTRUCTED WETLANDS:** Potential areas for floating wetlands were considered in areas where no conflicts with navigation or swimming areas were identified. A nitrogen removal rate of 0.4 kg/Y/sq foot was used.

■ **INLET WIDENING AND COASTAL HABITAT RESTORATION:** Only considered in areas where these projects were identified by towns or state agencies and where detailed hydrologic investigations and modeling

had been performed due to wide variations in nitrate load reduction, flushing impacts, impacts on flooding, and costs (dredging only, replacing infrastructure, removing and replacing roadways or bridges, etc.). Nitrogen removal rates were based on MEP or other studies.

■ **INNOVATIVE & ALTERNATIVE SEPTIC SYSTEMS AND ECOTOILETS:** In most cases specific locations for these technologies were not identified. Rather general estimates for the percent adoption were provided based upon discussions with the stakeholder groups and their views on potential adoption rates. In some watersheds a 5% adoption rate was included based upon this stakeholder input. In a limited number of instances specific locations for these technologies were included based upon town input and suggestions. A nitrogen removal rate of 1.658 kg/Y for each system was used for I&A Septic Systems, and 2.984 kg/Y for enhanced I&A systems. A removal rate of 2.542 kg/Y was used for each home installation of an Ecotoilet, and 0.467 kg/Y for installation of urine diversion toilets in public settings.

Finally, the locations of specific technologies were discussed during the 208 stakeholder engagement process. Stakeholders across the Cape 'groundtruthed' potential NT locations and NT scenarios were adjusted accordingly.