1 Introduction

1.1 Project Identification and Purpose

The Town of Mashpee initiated a Watershed Nitrogen Management Plan (WNMP) in 1999 in order to address the need for reducing nitrogen impacts to coastal embayments and to evaluate options for restoring those embayments. Because the contributing areas to the estuaries (watersheds) are shared by multiple towns, Mashpee's WNMP Project Planning Area includes the Town of Mashpee and the portions of neighboring towns (Barnstable, Falmouth, and Sandwich) that fall within the Popponesset Bay and Waquoit Bay East watersheds. The Project Planning Area is illustrated in Figure 1-1. The WNMP is intended to provide an environmentally and economically sound plan for nitrogen reduction, wastewater treatment, and treated water recharge in the Project Planning Area.

The purpose of the Alternatives Screening Analysis Report is to supplement the Draft Alternative Scenarios Evaluation and Site Evaluation Report issued in March 2008 and to expand on those results by evaluating three additional scenarios/options in order to make recommendations as the Town of Mashpee moves towards development of a Recommended Plan.

The first major deliverable for the WNMP was the Needs Assessment Report (NAR), issued in April 2007. The Needs Assessment Report was designed to develop the understanding of existing and future conditions in the Project Planning Area. The Needs Assessment Report summarized information on existing wastewater facilities (septic systems and small treatment plants), physical/environmental features, land use patterns, and regulatory issues affecting wastewater facilities. The Needs Assessment Report identified future conditions for the Project Planning Area relating to population, growth, and the potential effects of that growth on any proposed wastewater collection, treatment, and disposal facilities.

The second major deliverable was the Technology Screening Report—issued in November 2007—which outlined various centralized and decentralized wastewater collection, treatment, and disposal technologies, and the advantages and disadvantages of each. It provided recommendations of technologies to be considered for use in the development of the scenarios, and ultimately the Recommended Plan for addressing nitrogen. The Technology Screening Report, and the Alternative Scenarios Analysis and Site Evaluation Report findings and updates have been combined with additional items outlined in the scope to create this Alternatives Screening Analysis Report for Massachusetts Environmental Policy Act (MEPA) submittal and review.

The third major deliverable was the Draft Alternative Scenarios Analysis and Site Evaluation Report, issued in March 2008, which was the preliminary evaluation of potential recharge sites and development of alternative scenarios to meet the nitrogen removal needs of the Project Planning Area.

Since the start of this project two notices of project change have also been issued and their certificates and response to comments are included in Appendix ES-1.

The Town has also contracted with other consultants and received additional reports that will be used by the Town in developing their Recommended Plan in addition to information freely solicited from equipment suppliers and vendors. These reports and documents are outside of those identified in the MEPA plan of study and scope of services.

1.2 Massachusetts Estuaries Project (MEP) Findings

The MEP program was developed to evaluate the health of Massachusetts' estuaries and to establish nitrogen loading thresholds that can be used as management goals for a watershed. The MEP approach and results are discussed in detail in Chapter 4 of the Needs Assessment Report. In addition, the following reports and documents relevant to the Project Planning Area have been produced as part of MassDEP, University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST), and MEP work:

- "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Popponesset Bay, Mashpee and Barnstable, Massachusetts" Final Report – September 2004.
- "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Quashnet River, Hamblin Pond, and Jehu Pond, in the Waquoit Bay System of the Towns of Mashpee and Falmouth, MA" Final Report – January 2005.
- "FINAL DRAFT: Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen" October 14, 2005.
- "FINAL: Popponesset Bay Total Maximum Daily Loads for Total Nitrogen" December 5, 2006.
- MEP Technical Memo "Popponesset Bay: Results Pilot Modeling Scenarios – Final" June 15, 2006.
- MassDEP "Inter-municipal Watershed Planning and TMDL Implementation to Restore Embayment Water Quality on Cape Cod: Three Case Studies of Towns Sharing Coastal Watersheds" November 2008.
- MEP Technical Memo "Report on Unified Database and Requested MEP Scenarios", November 13, 2009.
- MEP Technical Memo "Report on Revised MEP Scenario 3 for Eastern Basins of Waquoit Bay System", February 9, 2010.
- "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Waquoit Bay and Eel Pond Embayment System – Towns of Falmouth and Mashpee, Massachusetts" Revised Draft Report – May 2012.
- MEP Technical Memo " Scenarios Results for Popponesset Bay and Waquiot Bay based on MEP Linked Models", November 15, 2012 (revised).

Results obtained through the MEP monitoring and modeling are used to provide one possible scenario (as presented by MEP) to achieve the nitrogen limits for a given estuary. Table 1-1 summarizes the suggested nitrogen removal rates from septic systems in the subwatersheds of Popponesset Bay and Waquoit Bay East under "existing" (2001) conditions as presented as part of the original reports and as updated based on the 2012 Revised Draft MEP Report for Waquoit Bay.

Table 1-1 Percent Nitrogen Removals from Septic Systems

Embayment System	Embayment	Percent Removal to Meet Threshold [3]	Updated Percent Removal to Meet Threshold [3]
Popponesset Bay System[1]	Popponesset Bay	0%	0%
	Popponesset Creek	100%	100%
	Pinquickset Cove	0%	0%
	Ockway Bay	100%	100%
	Mashpee River	100%	100%
	Shoestring Bay	100%	100%
	Mashpee River [4]	49%	49%
	Santuit River [4]	35%	35%
	Quaker Run River [4]	0%	0%
Waquoit Bay System[2] [6]	Hamblin Pond	75%	100%
	Upper Hamblin Pond	75%	100%
	Little River	75%	100%
	Lower Great River	100%	100%
	Upper Great River	100%	100%
	Jehu Pond	100%	100%
	Upper Quashnet River	67%	67%
	Lower Quashnet River	67%	67%
	Red Brook [4]	75%	90%
	Quashnet River [4, 5]	67%	67%

Notes:

1. Source: Table B-1 of *Final Popponesset Bay Total Maximum Daily Loads for Total Nitrogen*, April 10, 2006, no change in the "updated column".
2. Source: Table B-1 of *Final Draft Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen*, October 14, 2005.
3. Based on one MEP developed scenario, that is considered one of many potential scenarios to achieve the target concentration.
4. Indicates a surface water source.
5. MEP report lists this as Moonakis River. However, based on information provided by the Mashpee Town Planner, Moonakis River is only the lower, brackish portion of this river (Moonakis referring to the name given to the river in the Town of Falmouth).
6. Source: Updated Column Table VIII-2 of *Revised Draft Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Waquoit Bay and Eel Pond Embayment System Towns of Falmouth and Mashpee, Massachusetts,* May 2012.

Figure 1-2 shows the various subwatersheds and the updated removal percentages identified in Table 1-1. These percent removals form the initial basis for the alternative scenarios and options developed to date, and evaluated in detail in this report. However, the scenarios and options were also based on the findings of the Needs Assessment Report and therefore were a combination of the information presented in Table 1-1 and the findings summarized in the following section.

1.3 Needs Assessment Report Findings

The Needs Assessment Report (April 2007) discussed the environmental resources, existing and future development conditions, and nitrogen removal needs. In addition, various factors were identified to aid in determining priority areas for nitrogen removal and development of a management plan. The factors that were used in identification of priority areas included:

- MEP calculations of necessary nitrogen removal for estuary health.
- Wastewater nitrogen loading per acre.
- Seasonality (seasonality was identified for towns outside of Mashpee for comparison only—the other towns may not consider this a priority when developing their town-wide management plans).
- Other Town considerations (phosphorus, previous studies, etc.).

Planning zones were grouped into primary, secondary, and tertiary priority areas based on the criteria listed above. Figure 1-3 summarized the initial 2007 Needs Assessment classification of the priority areas throughout the Project Planning Area. It should be noted that the identification of these priority areas was performed as a planning tool to identify areas with high nitrogen removal needs. Table 1-2 (Table 9-1 of the Needs Assessment Report) outlines the various priority areas and the criteria used in the identification of these areas.

Table 1-2 Priority Area Criteria Summary

Priority Area Name	MEP Removal Rate	Nitrogen Loading Rates	Year-Round	Other Town Considerations	Zone II
Primary Priority Areas					
M-1 – Johns Pond	√	√	√		
M-2 – Mashpee Central	√	√	√		
M-3 – Shoestring Bay	√	√	√		√
Secondary Priority Areas					
M-4 – Santuit Pond		√	√	√	√
M-5 – Mashpee River			√	√	√
M-6 – Jehu Pond	√	√			
M-7 – Popponesset Creek	√	√			
S-4 – Sandwich Quashnet		√	√		√
F-1 – Red Brook	√	√			
Tertiary Priority Areas					
M-8 – Mashpee-Wakeby Pond			√		
M-9 – MMR			√		
M-10 – Mashpee East			√		√

Priority Area Name	MEP Removal Rate	Nitrogen Loading Rates	Year-Round	Other Town Considerations	Zone II
M-11 – Quashnet River			√		√
M-12 – Mashpee South			√		√
M-13 – New Seabury		√			√
B-1 – Barnstable Fresh Water			√		√
B-2 – Shoestring Bay (Barnstable)	√		√		√
B-3 – Pinquickset Cove					
B-4 – Popponesset Bay	√				
S-1 – Sandwich West			√		√
S-2 – J Well			√		√
S-3 – Snake Pond			√		√
S-5 – Sandwich Popponesset			√		√
F-2 – Falmouth Quashnet	√				
F-3 – Falmouth North			√		√

Note: Prioritization is based on build-out conditions.

1.3.1 Needs Assessment Report Revisions

The Needs Assessment Report included two tables summarizing nitrogen loads: Table 7-9 summarized load by town; and Table 8-2 summarized load by planning area (both included in Appendix A) as broken down by Town and watershed. These tables outline how the nitrogen loads are attributed to the various priority areas. The tables identify the average annual nitrogen load (in kg/yr) as generated by wastewater sources (septic systems, small wastewater treatment plants) and non-wastewater sources (fertilizer, run-off, natural deposition). These tables were developed based on 35 mg/L total nitrogen from septic systems and did not account for attenuation. The loads were adjusted for nitrogen reduction through the leaching facilities to an estimated concentration of 26.25 mg/L according to MassDEP and MEP. Upon further analysis of the data, it was noted that there was a difference in how nitrogen loads to golf courses were determined. The nitrogen loads were recalculated using methodology consistent with MEP calculations for golf courses. The tables were reissued as an addendum to the original report.

This information was initially intended to form the basis for developing scenarios to address nitrogen within the watersheds.

These adjusted nitrogen loads at the 26.25 mg/L concentration are later entered into the MEP “rainbow” spreadsheets (Table IV-5 from the MEP technical reports for each estuary). Once entered into the “rainbow” tables, the same attenuation factors applied as part of the MEP work were able to be applied to the new estimates of wastewater nitrogen load (including septic and wastewater treatment recharge) to estimate the load each estuary may see.

In addition to the changes to the tables discussed above, there was further input from the Town of Barnstable regarding priority areas. Three areas within Area B-2 “Shoestring Bay (Barnstable)” were identified during the Town of Barnstable’s facilities planning process as “Areas of Concern” (designated in that report as C3, C4, and C5). Therefore, additional consideration should be made as part of the scenarios development to incorporate solutions for these areas.

In the six-plus years since the NAR was originally produced and reviewed, the Town and Sewer Commission have requested adjustments to the approach and additional data has come from MEP and other sources. The scenarios discussed later in this report reflect these changes.

1.4 Technology Screening Report Summary

1.4.1 Introduction

The Technology Screening Report (November 2007) identified a group of alternative wastewater management options to meet the Project Planning Area’s wastewater treatment and disposal needs. This section summarizes the findings presented as part of the 2007 Technology Screening Report. This complete report is included on compact disc (CD) as Appendix J.

The Technology Screening Report identified specific technologies associated with:

- Decentralized technologies including:
  - Individual Innovative and Alternative (I/A) septic systems.
  - Cluster systems:
    - Those serving flows less than 10,000 gallons per day (gpd).
    - Those requiring a groundwater discharge permit (small wastewater treatment plants).
- Centralized facilities:
  - Those facilities serving large areas of Town. These facilities are often municipally run and typically treat wastewater flows greater than 150,000 gpd.

Some additional components that are associated with cluster systems and centralized facilities were evaluated in this report. Those components included:

- Collection systems.
- Disinfection technologies.
- Effluent disposal (treated water recharge).
- Water reuse technologies.

In addition, the report examined other methods of reducing nitrogen through stormwater control, fertilizer management, oyster/shellfish propagation, and groundwater treatment. All of these non-wastewater related methods can provide a positive means of reducing nitrogen (to varying degrees), but they would be difficult to rely on or quantify for consistent, widespread performance to achieve a Total Maximum Daily Load (TMDL). It is important to state that a number of these nitrogen reduction measures will vary in their nitrogen removal performance because of their reliance on natural systems and highly variable loadings. Many are not currently credited with nitrogen removal by regulatory agencies; and therefore additional public education, management structure, and enforcement would be required in order for them to be

considered a reliable, long-term means of nitrogen removal, however they are all considered potential parts of any adaptive management plan.

1.4.2 Findings

The findings and recommendations from the Technology Screening Report are summarized in the following sections.

1.4.2.1 Decentralized Treatment Alternatives

All of the technologies identified by MassDEP as I/A technologies and that are approved for use (whether Pilot, Provisional, or General Use) are considered feasible for use in the Project Planning Area. Although none of these technologies are ruled out completely, some of these technologies have shown better performance (based on the Barnstable County Report) on Cape Cod. The following technologies are considered the most favorable for nitrogen removal applications within the Project Planning Area:

- Fixed Activated Sludge Treatment (FAST)
- Recirculating Sand Filters (RSF)
- Bioclere™
- Nitrex™ combined with Omni RSF (or other nitrifying process)
- RUCK®
- Amphidrome®
- Waterloo Biofilter®
- Norweco Singulair®

Other technologies either have very limited performance data or other considerations that make them less favorable.

1.4.2.2 Small Wastewater Treatment Facilities and Cluster Systems

Small wastewater treatment facilities and cluster systems, similar to a number of facilities found in Mashpee, utilize biological nitrogen removal (BNR) processes that are compact in size and are generally more mechanized than the individual and multiple-home, on-site type systems (not requiring a groundwater discharge permit) discussed in the Technology Screening Report. These wastewater treatment facilities can produce a treated effluent that meets the permitted standards of 30 mg/L Biochemical Oxygen Demand (BOD_5), 30 mg/L Total Suspended Solids (TSS), and 10 mg/L nitrate-N. Rotating biological contactors (RBCs), sequencing batch reactors (SBRs), Amphidrome®, and MBR systems were recommended for further consideration due to the flexibility in relation to providing treatment for relatively small wastewater flows and their current (or proposed) use throughout Mashpee. SBRs are often more expensive for smaller flows but become more cost-effective as the flows increase due to the change from precast structures to cast-in-place concrete; they also remain fairly compact and have other process advantages over some of the more package type systems like Bioclere™, Amphidrome®, and FAST systems. Those package type systems are often more cost-effective at lower flows but are less flexible when it comes to any potential expansion.

Bioclere™ and FAST systems would not be recommended for use (as small wastewater treatment facilities) in the Project Planning Area as they would be introducing another technology into a planning

area that already has a variety of systems. If the Town of Mashpee (or an existing or future district) were to take over management of the existing facilities, the best option would be to minimize the number of different systems and maximize common components, spare parts, and operational requirements to simplify the operations and maintenance activities for multiple wastewater treatment facilities.

1.4.2.3 Centralized Treatment Facilities

Centralized facilities capable of treating larger wastewater flows (considered greater than 150,000 gpd for the purpose of this report) were discussed separately from the small/cluster package plants discussed in the Technology Screening Report. The following list summarizes those that were recommended for further consideration as the WNMP process continues:

- Activated Sludge/Extended Aeration (AS/EA)
- Sequencing Batch Reactor
- Membrane Biological Reactor (MBR)
- Denitrification Filters (in combination with other centralized technologies)

RBCs, although very common in Mashpee, may become cost-prohibitive for a large-scale wastewater treatment facility (as flows exceed 0.5 mgd) because of the large structure required to house such a facility and to shelter components in winter conditions. On the other hand, the recommended technologies can have large open tanks or—in the case of MBRs—a smaller footprint, reducing the cost of structures. Therefore, RBCs would not be considered for a centralized facility, unless site conditions or other conditions are identified during final design.

1.4.2.4 Disinfection Alternatives

It is very likely that any treatment facilities constructed in the Project Planning Area will be required to provide disinfection. The disinfection technologies considered in the Technology Screening Report were:

- Chlorination
- Ozonation
- Ultraviolet (UV) radiation

Based on the higher costs and safety concerns associated with chlorination and ozonation, UV disinfection was the only technology that is recommended.

1.4.2.5 Collection System Technologies

Prior to reaching a treatment facility, wastewater flows through a collection system. The following collection system technologies were discussed in the Technology Screening Report:

- Gravity sewers and lift stations
- Pressure sewers and grinder pumps
- Septic tank effluent sewers (pump and gravity systems)
- Vacuum sewers
- Combination of technologies

Many collection systems involve a combination of the various technologies. One possible combination that will be practical for use in the Project Planning Area involves gravity and low pressure systems, as

discussed in the Sewer Modeling and Preliminary Design Evaluations Guidance Document and Case Study Report prepared for Barnstable County. Since the development of this report, the Town also received “complementary” evaluations from various manufacturers (AIRVAC, E-One, and Orenco representing STEP/STEG systems).

When a project area consists of rolling terrain and large numbers of properties located in low areas along ponds, wetland, rivers, and estuaries, a combination of technologies is typically most cost-effective. The most common technology combination is gravity and pressure sewers, although other technologies can be considered.

Although other options like vacuum sewers and septic tank effluent pump (STEP)/septic tank effluent gravity (STEG) systems can also be used; for the purpose of developing order of magnitude costs for this report, gravity and pressure were used. The Mashpee Sewer Commission has requested that all collection system technologies remain under consideration as the scenarios are refined and a Recommended Plan is developed.

1.4.2.6 Treated Water Recharge (Effluent Discharge) Technologies

All wastewater treatment facilities require a means of discharging and/or reusing treated effluent. The technology selected for treated water recharge needs to be specific to the discharge site to minimize the impacts of treated water on nearby surface waters and groundwater, while utilizing the unique features of any potential site. Land availability, nearby land use, discharge technology, and distance from the treatment plant also play a role in determining suitable effluent discharge sites.

The alternatives that were recommended for further consideration include:

- Wetland restoration
- Sand beds
- Subsurface infiltration
- Drip irrigation

The Mashpee Sewer Commission has also expressed interest in further consideration of wick-well technology. It was identified that one of the reasons it was screened out had to do with the limited number of facilities, limited performance data, and the potential for redundant systems to be installed as a backup for treated water recharge. Therefore, this technology will remain under consideration, and a determination will be made as part of the Recommended Plan as to its use for the Project Planning Area.

1.4.2.7 Stormwater Treatment Technologies

Stormwater runoff is typically a significant nitrogen source, although this depends on the amount of impervious area (roofs, driveways, roads, parking lots, etc.) in a planning zone. Reduction of impervious areas can reduce the resulting pollutant loads. Town bylaws can be used to encourage Low Impact Development (LID), to regulate amounts of impervious areas, and to reduce the amount of runoff that flows to Town paved roads from individual properties. However, runoff from paved roads is also a significant contributor to nitrogen loads.

The Technology Screening Report included a discussion on various nitrogen removal alternatives that do not involve wastewater management, including stormwater technologies. The stormwater management alternatives that were evaluated and screened include:

- Dry extended detention basins
- Wet retention ponds
- Infiltration basins
- Stormwater wetlands
- Submerged gravel wetlands
- Bioretention (rain gardens)
- Water quality swales
- Porous pavement
- Infiltration trenches

As presented earlier, the use of other non-wastewater related methods of reducing nitrogen through stormwater control, fertilizer management, oyster/shellfish propagation, and groundwater treatment has its limitations when trying to achieve a regulated limit. Best management practices for stormwater control, fertilizer management, and other innovative non-wastewater approaches can provide a positive means of reducing nitrogen but are difficult to rely on for consistent performance. It is important to identify that a number of these nitrogen control measures will vary in their nitrogen removal performance because of their reliance on natural systems and highly variable loadings. Many are not currently credited with nitrogen removal by regulatory agencies and would therefore require additional public education, management structure, and enforcement to be considered a reliable/long-term means of nitrogen removal.

1.4.3 Summary

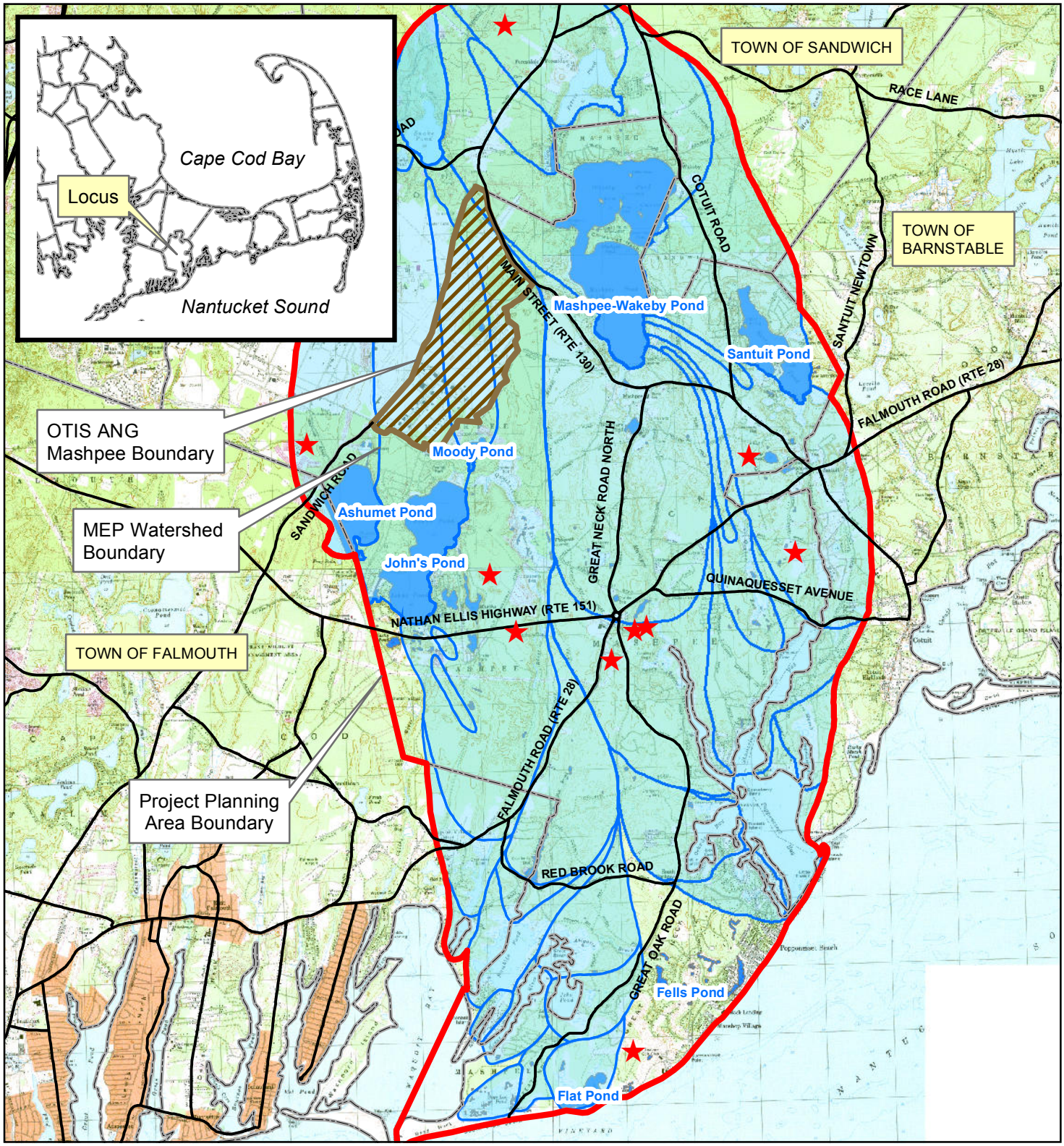
Appendix B includes the technology summary tables from the original report:

- Table 4-2 Summary of Decentralized Treatment Technologies
- Table 5-1 Small Wastewater Treatment Facilities (Package Plants)
- Table 5-3 Summary of Secondary/Advanced Treatment Technologies
- Table 5-4 Summary of Disinfection Technologies
- Table 6-1 Summary of Sewer System Technologies
- Table 6-2 Summary of Effluent Discharge Technologies
- Table 7-1 Summary of Stormwater Treatment Technologies

Since the six-plus years following the submittal of the final Technology Screening Analysis Report, the Town and Sewer Commission have identified the desire to keep as many technologies open for consideration with increased interest in some of the newer—or in some cases less traditional—options including:

- MBRs
- Nitrex™ denitrifying filters
- Permeable Reactive Barriers (PRBs)
- Vacuum Sewers
- STEP Sewers
- Shellfish propagation

However, they understand that other more traditional technologies will need to be used and the Town will need to work to take advantage of as much existing infrastructure as they can.



LEGEND

★ WWTF Location

***The Project Area is the combination of the Town of Mashpee area and the watersheds of Popponesset Bay and Waquoit Bay-East as delineated by the Massachusetts Estuaries Project (MEP)**

Paper Size ANSI A

0 0.375 0.75 1.5 Miles

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

N

Town of Mashpee Sewer Commisiion
Watershed Nitrogen Management Plan

LOCUS MAP

Job Number	86-12001
Revision	A
Date	07 Aug 2013

Figure 1-1

1545 Iyannough Road, Hyannis Massachusetts 02601 USA T 1 508 362 5680 F 1 508 362 5684 E hyamail@ghd.com W www.ghd.com

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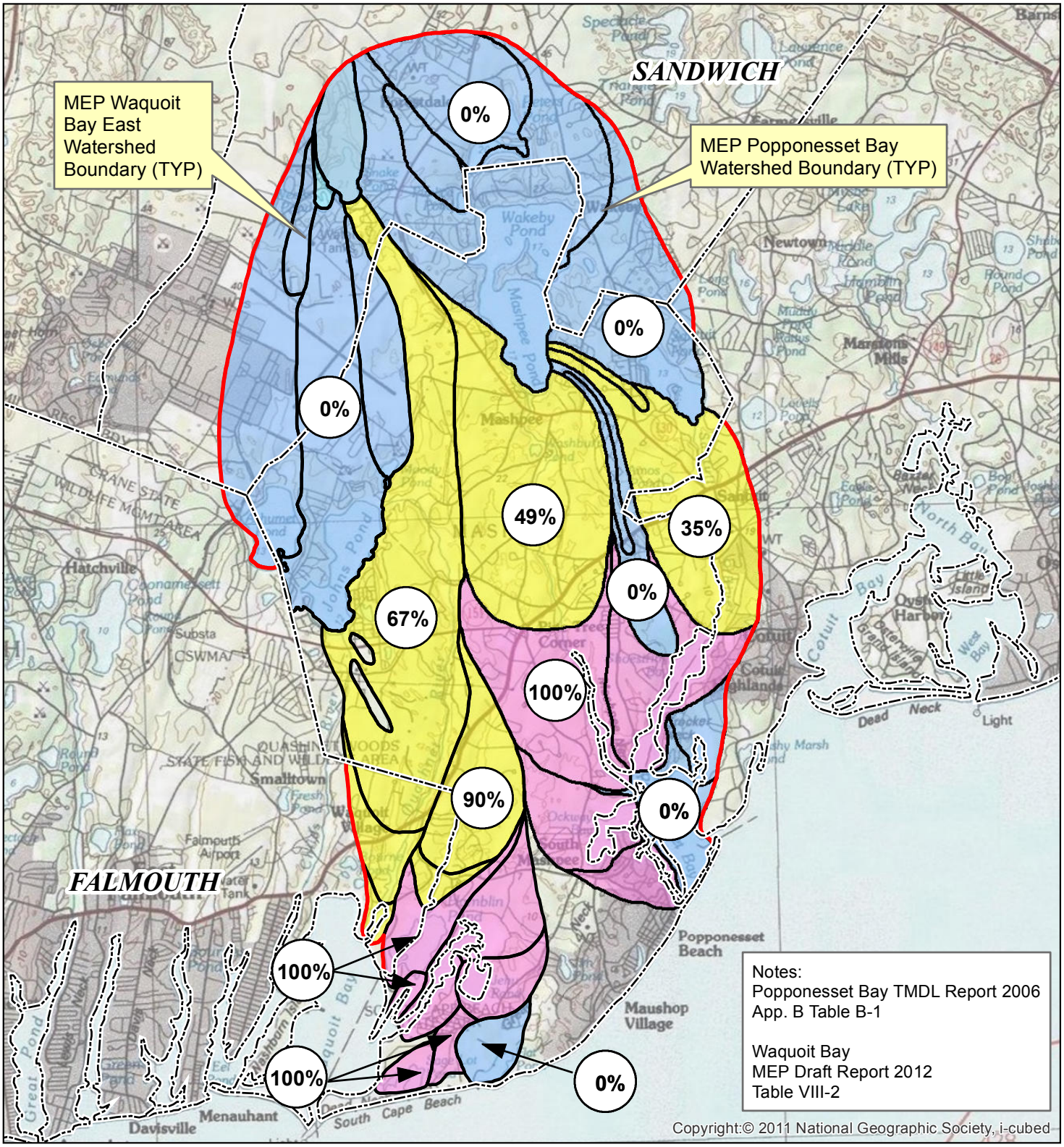

LEGEND

100% Percentage of Wastewater Nitrogen Removal Suggested by MEP (Septic Only)

0% Removal | 1-99% Removal | 100% Removal

The "Project Area" is the combination of the Town of Mashpee and the watersheds of Popponesset Bay and Waquoit Bay East as delineated by the Massachusetts Estuaries Project (MEP). Updated for draft MEP report May 2012

Paper Size ANSI A

0 0.5 1 2 Miles

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

N

Town of Mashpee Sewer Commission
Watershed Nitrogen Management Plan

MEP Percent Septic (only) Removals

Job Number 86-12001
Revision A
Date 17 Apr 2013

Figure 1-2

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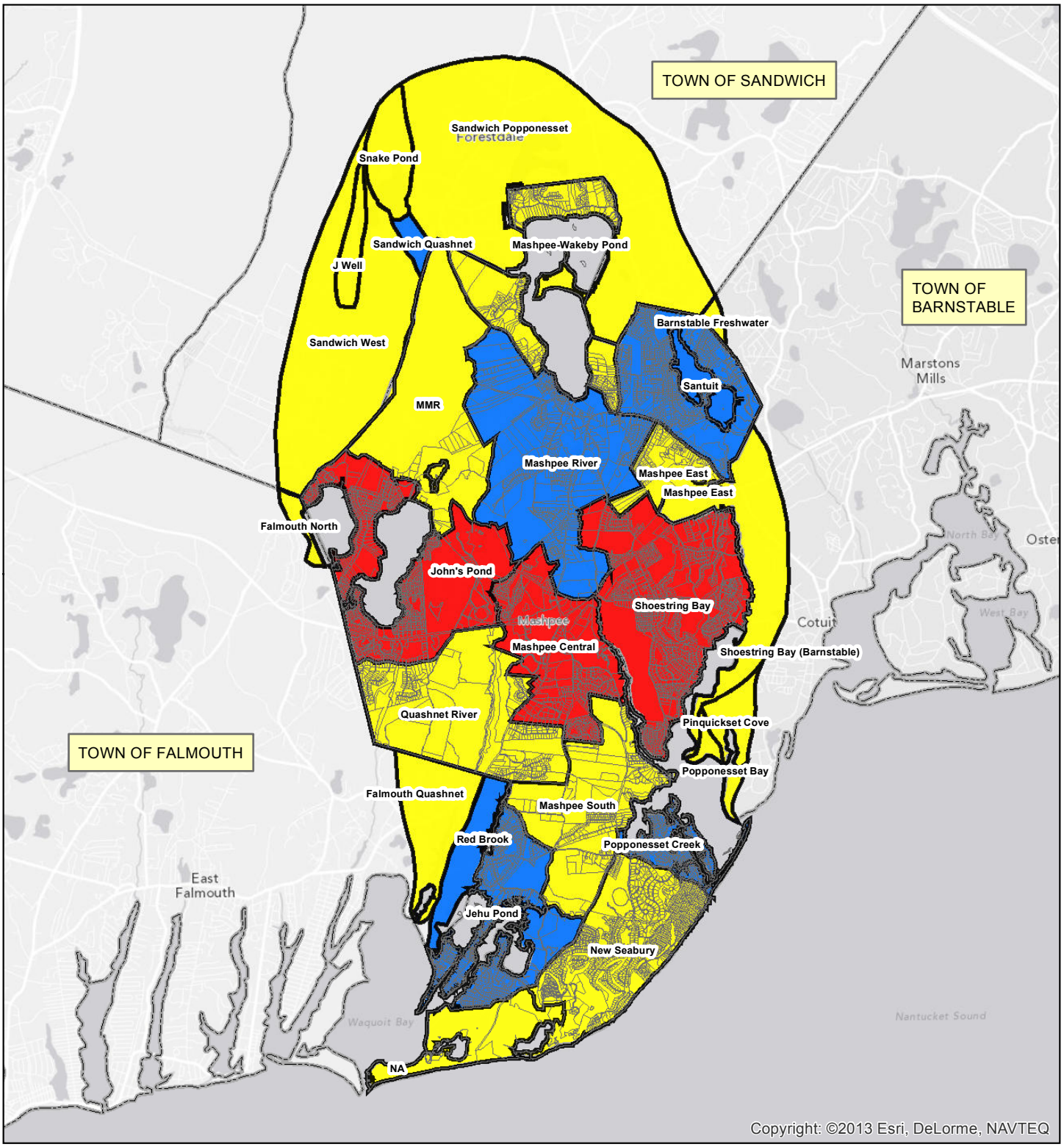

Legend

Priority Area

Primary | Secondary | Tertiary

Paper Size ANSI A

0 0.5 1 2 Miles

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

N

Town of Mashpee Sewer Commission
Watershed Nitrogen Management Plan

Priority Areas

Job Number	86-12001
Revision	A
Date	17 Apr 2013

Figure 1-3

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G:\86\12001\GIS\00074 Mashpee\2013\Updated Figures-Title Blocks\86-12001-F1-3 Priority Areas.mxd

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