DRAFT REPORT

WATERSHED NITROGEN MANAGEMENT PLAN
DRAFT ALTERNATIVE SCENARIOS ANALYSIS AND SITE EVALUATION REPORT

TOWN OF MASHPEE, POPPONESSET BAY & WAQUOIT BAY EAST WATERSHEDS

Prepared for

TOWN OF MASHPEE SEWER COMMISSION

MARCH 2008

WATERSHED NITROGEN MANAGEMENT PLAN
DRAFT ALTERNATIVE SCENARIOS ANALYSIS AND
SITE EVALUATION REPORT

TOWN OF MASHPEE, POPPONESSET BAY,
& WAQUOIT BAY EAST WATERSHEDS

Prepared for
MASHPEE SEWER COMMISSION

Prepared by

Stearns & Wheler, LLC
ENVIRONMENTAL ENGINEERS & SCIENTISTS
1545 Iyannough Road
Hyannis, Massachusetts 02601

March 2008
Project No. 00074

EXECUTIVE SUMMARY

ES.1 REPORT AND PROJECT BACKGROUND

The Alternative Scenarios Analysis and Site Evaluation Report is the third report developed as part of the Watershed Nitrogen Management Plan (WNMP). The Town of Mashpee Sewer Commission initiated the 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 Alternative Scenarios Analysis and Site Evaluation Report is to develop various management plans with a goal of reducing nitrogen from the build-out conditions in the watersheds to levels established by the Massachusetts Estuaries Project (MEP) studies and the Massachusetts Department of Environmental Protection (MassDEP) total nitrogen Total Maximum Daily Load (TMDL) reports.

The WNMP Needs Assessment Report, issued April 2007, developed 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 WNMP Technology Screening Report, released November 2007, outlined various centralized and decentralized wastewater collection, treatment and recharge technologies and the advantages and disadvantages of each. It provided recommendations of technologies to be considered for use in the development of the scenarios that make up this Alternative Scenarios Analysis and Site Evaluation Report.

This report provides a summary of the analysis performed for four of the five alternative scenarios identified as a means to achieve the total nitrogen TMDL requirements. Mashpee Sewer Commission identified five different management scenarios (scenarios) that would be pursued for evaluation and analysis. The five scenarios are:

- Scenario 1 – No expansion of existing wastewater treatment facilities
- Scenario 2 – Upgrade and expansion of existing facilities to a practical extent
- Scenario 3 – Nitrex™ decentralized approach (prepared by others)
- Scenario 4 – Fair Share
- Scenario 5 – Centralized approach

Scenario 3 has been prepared and evaluated by others (and presented to the Mashpee Sewer Commission under separate cover) therefore the term “Scenarios” in this report will refer to those evaluated by Stearns & Wheler. These include Scenarios 1, 2, 4 and 5.

ES.2 SITE EVALUATIONS

This report also summarizes the site evaluations performed for sites being considered for wastewater treatment facilities and treated water recharge sites. Some sites were only considered for recharge, while others were considered for both. The following sites were identified:

- Site 1 – Heritage Park Ball Fields
- Site 2 – Ashumet Road
- Site 3 – Old Town Dump
- Site 4 – Transfer Station
- Site 5 – High School Ball Fields
- Site 6 – Keeter Property
- Site 7 – New Seabury Country Club
- Site 8 – Great Neck South
- Site 9 – Great Hay Road
- Site 10 – 72 Cotuit Rd – Sandwich

- Site 11 – 168 Route 130 – Sandwich
- Site 12 – Bartlett Property
- Site 13 – Adjacent High School Parcel

The sites are shown on Figure 2-1.

These sites were then evaluated based on several criteria including, ownership, landuse, proximity to sensitive receptors, and then a smaller group of sites was identified for further consideration as part of the development of Scenarios. These sites are:

- Site 1 - Heritage Park Ball Fields – drip irrigation and subsurface infiltration
- Site 2 - Ashumet Road – open sand beds and wastewater treatment
- Site 4 - Transfer Station – open sand beds and subsurface infiltration and wastewater treatment
- Site 5 - High School Ball Fields – drip irrigation and subsurface infiltration
- Site 6 - Keeter Property – open sand beds and wastewater treatment
- Site 7 - New Seabury Country Club – drip irrigation and subsurface infiltration
- Site 11 -168 Route 130 (Sandwich) – open sand beds and wastewater treatment
- Site 12 - Bartlett Property – open sand beds
- Site 13 - Adjacent High School Parcel – open sand beds and subsurface infiltration

ES.3 SCENARIOS

In general, each scenario was prepared under a set of constraints as described below. Each scenario relied on the use of sewersheds (common to each scenario) from which wastewater would be collected from. Each scenario also relied on a portion or all of the wastewater generated within the Falmouth portions of the Project Planning Area to be addressed outside of the Project Planning Area. Falmouth is currently developing their own comprehensive wastewater management plan which will address this same area. Each scenario also had the same sites available to it for wastewater treatment facilities and treated water recharge.

Scenario 1 involves the continued operation of existing private WWTFs and construction of additional treatment facilities as needed to achieve the nitrogen TMDLs. The areas identified for wastewater management through I/A systems and wastewater treatment plants are shown on Figure 3-2. Under this scenario 62 sewersheds were identified for sewering. This equated to approximately 70 miles of gravity sewer, 100 miles of low pressure sewers and 40 miles of force mains to connect potential pumping stations to proposed WWTFs and connecting these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 2, 4, 6, and 11 with new treated water recharge at sites 1, 2, 4, 7, and 11. The scenario also includes approximately 380 properties on new I/A systems.

Scenario 2 is similar to Scenario 1 - Existing WWTFs address those properties originally identified as being connected (now or in the future) to that WWTF. This scenario varies from the first one in that the existing WWTFs are expanded to the extent feasible to address neighboring sewersheds and the treatment process is improved to achieve an effluent nitrogen concentration of 3 mg/L under the future condition.

The areas identified for wastewater management are shown on Figure 3-4. Under this scenario 61 sewersheds were identified for sewering. This equated to approximately 70 miles of gravity sewer, 90 miles of low pressure sewers and 40 miles of force mains to connect potential pumping stations to proposed WWTFs and connecting these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 2, 4, 6, and 11 with new treated water recharge at sites 2, 4, 7, and 11. The scenario also includes approximately 50 properties on new I/A systems.

Scenario 4 is based on evaluations initially considered as part of the MassDEP-funded Mashpee Pilot Project. The Pilot Project team determined that a 49.2 percent reduction of all existing (2001) nitrogen sources (not including benthic flux or atmospheric deposition directly onto the embayment) throughout the entire Popponesset Bay watershed would achieve the nitrogen reduction necessary to restore estuary health. Once this homogeneous reduction rate was decided upon, the scenario was evaluated by the MEP, and it was concluded that this reduction would achieve the MEP goals. A similar analysis that attempted to mimic the Popponesset Bay "fair share reduction" scenario was applied to the Waquoit Bay East watershed as well. The calculations for that watershed (under existing conditions) resulted in a fair share reduction of approximately 63 percent.

With existing condition established, the loads were adjusted based on build-out conditions and the scenario is based on this revised condition.

The areas identified for wastewater management are shown on Figure 3-6. Under this scenario 58 sewersheds were identified for sewering. This equated to approximately 65 miles of gravity sewer, 90 miles of low pressure sewers and 35 miles of force mains to connect potential pumping stations to proposed WWTFs and connecting these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 4, 6, and 11 with new treated water recharge at sites 4, 7, and 11. The scenario also includes approximately 130 properties on new I/A systems.

Scenario 5 involves wastewater treatment by means of centralized (municipal) wastewater treatment facilities. Although this scenario proposes that the flow from both watersheds be treated at a WWTF located on Site 4 (in the Popponesset Bay watershed), treated water recharge occurs at multiple sites within the two watersheds, with the intention of reducing the impact of significant changes to the volume of groundwater flow in either watershed.

This scenario includes the conversion of each of the existing private WWTFs (with the exception of New Seabury) within the Popponesset Bay and Waquoit Bay East to a pumping station. Wastewater treatment activities would cease at these facilities. New Seabury has significant capacity, is outside of the watersheds, and has the potential to service sewersheds that are at significant distances from proposed centralized facilities; therefore the continued use of this facility is recommended. The Forestdale School would serve as a pumping station to pump flow to a new WWTF located in Sandwich (Site 11).

The areas identified for wastewater management are shown on Figure 3-8. Under this scenario 61 sewersheds were identified for sewering. This equated to approximately 70 miles of gravity sewer, 75 miles of low pressure sewers and 35 miles of force mains to connect potential pumping stations to proposed WWTFs and connecting these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 4 and 11 with new treated water recharge at sites 1, 4, 5, 7, and 11. The scenario also includes approximately 120 properties on new I/A systems.

ES.4 COSTS

Each scenario could conceivably use any number of technologies identified and recommended as part of the Technology Screening Report analysis, specific technologies were identified in this report so that preliminary (order of magnitude) costs could be developed. The intent of the cost comparison is to be able to compare each of these first cut of scenarios that have been identified by the Sewer Commission for MEP analysis. This analysis is not intended to represent the final cost or selection of technologies, only to provide a common basis for evaluating Scenarios 1, 2, 4, and 5. The technologies used as the basis for the cost evaluation are as follows:

- Gravity and pressure (grinder pump) collection systems
- Sand infiltration and subsurface leaching facilities
- Sequencing Batch Reactors and denitrification filters for new facilities
- Allowance for process expansion and modification at existing facilities

The technologies selected are applied to each scenario equally. Therefore, it is the intent of this analysis that if vacuum or STEP sewer systems were used in place of pressure sewers and gravity that these changes would be made in all scenarios and the relative change would not impact the findings of the evaluation, only impact the bottom line costs. Same is true for the consideration of other wastewater technologies in place of SBRs. The ultimate goal of the development of these scenarios is to achieve the total nitrogen TMDLs. If each scenario achieves the TMDLs following MEP modeling, then the relative cost comparisons will be used as a guide for refining and selecting new scenarios to be evaluated further. As developed, the costs are intended to only provide another means of side by side comparison.

Additional detailed analysis and cost evaluations will be developed as these scenarios are refined, and when a recommended technology is selected and approved by the Sewer Commission. The refined cost evaluations for future scenarios and ultimately the recommended plan will be based on those findings.

Estimated capital costs for each scenario (1, 2, 4, and 5) were developed for the following:

- Individual I/A system costs
- Upgrades to existing facilities
- Collection system costs
- New wastewater treatment facilities
- Treated water recharge facilities

The following table summarizes the estimated capital costs for each scenario based on the future condition.

ESTIMATED CAPITAL COSTS IN MILLIONS				
TYPE	**SCENARIO 1**	**SCENARIO 2**	**SCENARIO 4**	**SCENARIO 5**
Collection Systems	*$430*	*$400*	*$380*	*$400*
Wastewater Treatment Facilities	*$ 94*	*$83*	*$80*	*$70*
Individual I/A Systems	*$11*	*$1.5*	*$3.8*	*$3.6*
Total (2008)	**$540**	**$480**	**$460**	**$470**

Operations and Maintenance costs are also developed for each scenario and then used to generate a total present worth. The following table summarizes the total present worth by scenario.

ESTIMATED TOTAL PRESENT WORTH COST IN MILLIONS				
TYPE	**SCENARIO 1**	**SCENARIO 2**	**SCENARIO 4**	**SCENARIO 5**
Total Capital Cost	$540	$480	$460	$ 470
O&M Costs (annual)	*$8*	*$5.6*	*$5.4*	*$5*
Present Worth of O&M	$99	$70	$69	$64
Total Present Worth (2008)	**$640**	**$550**	**$530**	**$530**

ES.5 MEP MODELING

Each scenario is developed with the intent of being modeled through the MEP modeling system to determine if the amount of nitrogen removed through wastewater treatment under future build-out conditions will allow the estuaries to return to the threshold nitrogen concentration at their respective sentinel stations.

Results of the modeling efforts will then be used to prepare recommended scenarios for further evaluation and conceptual design. The scenarios evaluated in the next phase will either be carried over from those modeled as part of this phase of the project or will be a modification of the five scenarios listed above. Because four of the five scenarios (1, 2, 4, and 5) were developed with a singular approach to allow a reasonable side by side comparison individually, they may not represent the most efficient and cost effective means of achieving the goal of the total nitrogen TMDLs. The four scenarios described in this report are limited in their ability to take advantage of favorable characteristics present in each of the five scenarios. Scenario 4 allowed for the greatest level of combination of approaches (i.e. improving some of the existing

WWTF's while leaving some facilities unchanged, etc.), and therefore allowed for a higher level of flexibility with respect to implementation.

The findings from the comparison of these five scenarios and the results of the MEP modeling efforts on the effectiveness of each approach will be used to identify and develop two to three scenarios for further evaluation in the next phase of the project. Modifications to any of the scenarios presented above will be based on the results of the MEP modeling efforts and selection of the most favorable components of each of the original five approaches.

ES.6 SUMMARY

Overall each scenario was compared based on monetary and non-monetary considerations. Although final recommendations will not be made until the results of the MEP modeling (as identified in Chapter 5) are received.

Based on the order of magnitude costs developed as part of this phase – Scenarios 4 and 5 appear to be more cost effective. However, none of the scenarios present the estimated costs associated with Falmouth's wastewater management (beyond collection system costs), as Falmouth is currently proceeding with their own facilities planning and that information has not been published. Also, under Scenario 4, the costs for Barnstable to treat and recharge its wastewater have not been identified. The Town of Barnstable is currently proceeding with their own Nutrient Management Planning for the western portions of their Town. No sites were identified within this portion of Cotuit therefore, treatment and recharge of wastewater under this scenario would fall outside the Project Planning Area and costs were not developed.

Scenario 5, although it has the second lowest capital cost, would require the abandonment of much of the existing wastewater treatment infrastructure within Mashpee and would require a much larger centralized facility. This provides consolidation of facilities and would likely reduce operations and maintenance costs, it is unlikely that this option would be considered except under a phased approach where there may be economic benefits to the long term phasing out of smaller facilities and bringing that flow to a larger centralized facility.

Scenario 1, has high relative costs based on limited future use of the facilities and no anticipated improvement in performance over their current permit levels. This burdens a larger area with sewering and creation of a new larger facility to make up the balance. The advantage is that if the existing facilities remain private, the Town is not burdened with operation and maintenance of a large number of wastewater treatment facilities.

Scenarios 1, 2 and 5 would require the development of inter-municipal agreements or creation of a sewer district to manage wastewater between the Towns of Barnstable, Sandwich and Mashpee. Where as Scenario 4 allows each Town to manage wastewater within their borders. Town appropriations and approvals may be simplified, however MassDEP has expressed an interest in Town's seeking regional approaches and there may be the opportunity in the future to seek greater funding or lower interest loans for those projects with regional solutions.

Scenarios selected to be carried forward in the next phase of the project will be identified following the completion of the MEP modeling efforts. This information will be used in the identification of additional scenarios to be evaluated for completion of the Alternatives Screening Analysis Report.

At the point where the final recommendation is developed, the phasing, implementation and monitoring plans will be developed. This will allow the Town(s) to focus their efforts on those areas of the Project Planning Area that are currently developed and producing wastewater nitrogen loads. As the Town moves through its implementation and monitoring schedule, water quality data, future developments and related capital improvements projects should be considered in the ultimate implementation schedule. These and other considerations will be discussed as part of the Draft and Final Recommended Plan and Environmental Impact Report.

With the completion of this draft report, and without model results from MEP, the following are the recommendations for the next steps in the process:

- Submit the draft report and necessary data to MEP so that each of the scenarios as currently drafted can be modeled to determine their effectiveness in achieving the nitrogen threshold concentrations and total nitrogen TMDLs.
- Begin field evaluations of Site 4 – Transfer Station. This site is a key component to each of the identified scenarios.

- Sewer Commission should review the remaining sites identified in the report and provide recommendations and guidance on which sites also should be considered for field evaluations. It is recommended at this time that field work at any additional sites not begin until MEP model results are received.

MASHPEE SEWER COMMISSION
DEVELOPMENT AND EVALUATION OF ALTERNATIVE SCENARIOS
WATERSHED NITROGEN MANAGEMENT PLAN

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF APPENDICES

GLOSSARY OF COMMON ACRONYMS

BNR	Biological Nitrogen Removal
BOD	Biochemical Oxygen Demand
FAST	Fixed Activated Sludge Treatment
GIS	Geographic Information Systems
gpd	gallons per day
gpm	gallons per minute
GWDP	Groundwater Discharge Permit
I/A	Innovative/Alternative
kg/yr	kilograms per year
LID	Low Impact Development
MassDEP	Massachusetts Department of Environmental Protection
MBR	Membrane Biological Reactor
MEP	Massachusetts Estuaries Project
MEPA	Massachusetts Environmental Policy Act
mgd	million gallons per day
mg/L	milligrams per liter
NAR	Needs Assessment Report
NTU	Nephelometric Turbidity Units
O&M	Operation & Maintenance
PPA	Project Planning Area
RBC	Rotating Biological Contactor
RSF	Recirculating Sand Filter
SBR	Sequencing Batch Reactor
STEG	Septic Tank Effluent Gravity
STEP	Septic Tank Effluent Pump
TMDL	Total Maximum Daily Load
TSR	Technology Screening Report
TSS	Total Suspended Solids
USGS	United States Geological Survey
UV	Ultraviolet
WNMP	Watershed Nitrogen Management Plan
WWTF	Wastewater Treatment Facility

Chapter 1

Introduction

CHAPTER 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 Alternative Scenarios Analysis and Site Evaluation Report is to develop various management plans with a goal of reducing nitrogen in the watersheds to levels established by the Massachusetts Estuaries Project (MEP) studies and the Massachusetts Department of Environmental Protection (MassDEP) total nitrogen Total Maximum Daily Load (TMDL) reports. This will be the third major deliverable prepared as part of the WNMP planning process.

The first major deliverable for the WNMP was the Needs Assessment Report (NAR), released 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, released 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 five scenarios that make up this Alternative Scenarios Analysis. The Technology Screening Report and the Alternative Scenarios Analysis and Site Evaluation Report will ultimately be combined with additional items outlined in the scope (yet to be completed) to create an Alternatives Screening Analysis Report for Massachusetts Environmental Policy Act (MEPA) submittal and review.

1.2 MASSACHUSETTS ESTUARIES PROJECT FINDINGS

The MEP 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 relevant to the Project Planning Area have been produced as part of MassDEP 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: Popponesset Bay total Maximum Daily Loads for Total Nitrogen" April 10, 2006.
- "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.

Results obtained through the MEP monitoring and modeling are used to provide one possible scenario 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.

Figure 1-2 shows the various subwatersheds and the removal percentages identified in Table 1-1. These values form the basis for the majority of the development of the alternative scenarios that will be presented in this report. However, the new scenarios will also be based on the findings of the Needs Assessment Report and therefore will be 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 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 (phosphorous, previous studies, etc.)

Planning zones were grouped into primary, secondary, and tertiary priority areas based on the criteria listed above. Figure 1-3 summarizes the 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.

The primary, secondary, and tertiary Priority Areas are identified below. Table 1-2 (Table 9-1 Needs Assessment Report) outlines the various priority areas and the criteria used in the identification of these areas.

A. **Primary Priority Areas.** These Areas are identified in red on Figure 1-3:

- *Area M-1 "Johns Pond"*

- *Area M-2 “Mashpee Central”*
- *Area M-3 “Shoestring Bay”*

B. **Secondary Priority Areas.** These Areas are identified in blue on Figure 1-3:

- *Area M-4 “Santuit Pond”*
- *Area M-5 “Mashpee River”*
- *Area M-6 “Jehu Pond”*
- *Area M-7 “Popponesset Creek”*
- *Area F-1 “Red Brook”*
- *Area S-4 “Sandwich Quashnet”*

C. **Tertiary Priority Areas.** These Areas are identified in yellow on Figure 1-3:

- *Area M-8 “Mashpee-Wakeby Pond”*
- *Area M-9 “MMR”*
- *Area M-10 “Mashpee East”*
- *Area M-11 “Quashnet River”*
- *Area M-12 “Mashpee South”*
- *Area M-13 “New Seabury”*
- *Area F-2 “Falmouth Quashnet”*
- *Area F-3 “Falmouth North”*
- *Area S-1 “Sandwich West”*
- *Area S-2 “J Well”*
- *Area S-3 “Snake Pond”*
- *Area S-5 “Sandwich Popponesset”*
- *Area B-1 “Barnstable Freshwater”*
- *Area B-2 “Shoestring Bay Barnstable”*
- *Area B-3 “Pinquickset Cove”*
- *Area B-4 “Popponesset Bay”*

Mashpee planning zones 3451 and 3381 were not included in the Priority Areas due to the lack of wastewater nitrogen loads. These areas are predominantly beach area.

D. **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. These tables were developed based on 35 mg/L total nitrogen from septic systems and did not account for attenuation. 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 and are also included in this report.

The nitrogen loads listed in the following table will be used as the basis for calculations performed as part of the scenario evaluation analysis. 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. Table 1-3 provides a summary of the existing and future nitrogen loads as broken down by Town and watershed. The table identifies 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). However, the table does not account for attenuation.

Table 1-4 outlines how the nitrogen loads outlined in Table 1-3 are attributed to the various priority areas. This information will 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 MEP could be applied to the new estimates of wastewater (including septic and wastewater treatment recharge) nitrogen load to estimate the load each estuary may see. This part of the evaluation is discussed in Chapter 5 of this Report.

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 will be made as part of the scenarios development to incorporate solutions for these areas. Figure 1-4 shows the Areas of Concern from Barnstable's facilities plan.

1.4 TECHNOLOGY SCREENING REPORT SUMMARY

A. **Introduction.** The Technology Screening Report identified a group of alternative wastewater management options to meet the Project Planning Area's wastewater treatment and disposal needs. Information developed for the Technology Screening Report and this Alternative Scenarios Analysis will be combined to create the Alternative Screening Analysis Report required as part of the Project's MEPA review process.

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 include:

- 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 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 for consistent, widespread performance. 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.

B. **Findings.** The findings and recommendations from the Technology Screening Report are summarized in the following section.

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.

2. **Small Wastewater Treatment Facilities.** Small wastewater treatment facilities, 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 discussed in the Technology Screening Report. These 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 Zenon are 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 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 a future sewer 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.

3. **Centralized Treatment Facilities.** Centralized facilities capable of treating larger wastewater flows (typically greater than 150,000 gpd) were discussed separately from the package plants in the Technology Screening Report. The following list summarizes those that are recommended for further consideration as the WNMP process continues.

- Activated Sludge/Extended Aeration
- 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.

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 is the only technology that is recommended.

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. The most likely 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.

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 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 selected. The Mashpee Sewer Commission has requested that all collection system technologies remain under consideration until the scenarios are refined and a recommended plan is developed. At that time the specifics of technologies will be identified.

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 any potential site's unique features. 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 are recommended for further consideration include:

- Wetland restoration
- Sand beds
- Subsurface infiltration
- Spray/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.

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 paved roads. 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 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.

Chapter 2

Preliminary Site Evaluation and Design

CHAPTER 2

PRELIMINARY SITE EVALUATION AND DESIGN

2.1 INTRODUCTION

As part of the identification of scenarios proposed to be evaluated as part of this report, it is necessary to evaluate potential effluent (treated water) recharge sites that would be used in conjunction with these alternative scenarios. This Chapter identifies a number of sites located within the Project Planning Area that were considered as possible recharge sites.

The process of identifying sites began in 2003 when several sites were identified and those considered most favorable were modeled through the efforts of United States Geological Survey (USGS) and services provided through the Cape Cod Commission to various Towns on the Cape. Since that time, additional sites were identified or reconsidered and are identified in this Chapter.

This Chapter will identify sites that were initially considered, provide background information and site characteristics. Preferable sites are again identified and preliminary designs are prepared for each site being considered, identifying the technology and estimated recharge capacity of the site. Order of magnitude costs are developed and discussed as part of the scenarios evaluations in Chapter 4. These findings and the results of the scenarios evaluations will identify those sites requiring additional site-specific analysis. More detailed evaluations will be prepared in subsequent phases of the project as the preferred scenarios are refined and identified.

2.2 TREATED WATER RECHARGE TECHNOLOGIES

The second report issued as part of the WNMP was the Technology Screening Report. This report identified the various alternatives available for treated water recharge. The technologies evaluated included sand infiltration beds, subsurface infiltration, spray irrigation, drip irrigation, deep well injection, wick wells, ocean outfall, and wetland restoration. The Technology Screening Report recommended the following technologies for further consideration:

- Sand infiltration beds
- Subsurface leaching
- Spray irrigation (in conjunction with other technologies for winter discharge)
- Drip irrigation
- Wetland restoration (if appropriate sites are available)

For detailed descriptions of the technologies and discussions of the advantages and disadvantages of each technology, please refer to the Technology Screening Report. The site evaluation process performed as part of the Scenario Evaluation took into consideration which of these technologies would be most appropriate for each particular site. Estimates were determined for the recharge capacity of each site with the appropriate technology, which is discussed in detail further in this chapter.

2.3 PRELIMINARY SITE EVALUATIONS

A. **Introduction.** Several potential treated water recharge sites were identified early on in the WNMP process. Sites were selected based on ownership, open area, lack of conservation restrictions, etc. as identified by the Mashpee Town Planner. The initial identification of potential sites resulted in the selection of 12 properties within the Town of Mashpee. These sites are identified in green on Figure 2-1 and include:

- Heritage Park Ball Fields
- Ashumet Road Property
- Wampanoag Rod and Gun Club
- Old Town Dump
- Transfer Station
- NStar Substation
- High School Ball Fields
- Clipper Ship Village
- Wading Place Road
- Keeter Property
- Bartlett Property

- New Seabury Country Club

Preliminary estimates of the application area of each of these sites was determined by assuming a 100-foot buffer from the property line on undeveloped parcels and a 50-foot buffer from the property line on developed parcels (ball fields, golf course, etc.). Once this initial area was determined, the area available for recharge was reduced by 10 percent to account for berms, access roads, pumps, and any other required infrastructure. The available area was used to estimate potential recharge capacity of each of the sites based on use of subsurface infiltration or sand beds.

Table 2-1 provides a summary of the preliminary capacities identified for each parcel. In cases where multiple technologies were considered feasible, capacities are listed by technology. Subsurface recharge flow and area requirements are estimated to be the same between subsurface leaching facilities and drip irrigation, based on information from drip irrigation manufacturers. Therefore the term subsurface is intended to represent both technologies. Because costs (discussed in Chapter 4) are intended to be "order of magnitude" type costs for comparing scenarios against each other, a more conservative cost of subsurface leaching trenches was assumed over drip irrigation.

This preliminary analysis indicated that the Heritage Park Ball Fields, the Ashumet Road site, the Transfer Station, the High School Ball Fields, and the Keeter site had the largest potential capacities (800,000 gpd or greater). On the other hand, the Old Town Dump, the NStar Substation, the Clipper Ship Village property, the Wading Place Road property, and the Bartlett property had relatively minimal capacity (less than 500,000 gpd). The New Seabury Country Club was estimated to have a moderate potential of 500,000 gpd.

The number of sites was reduced based on recharge capacity and other considerations, such as potential issues due to the ownership of the property, prior to having USGS modeling performed. The sites that were eliminated were the Wampanoag Rod and Gun Club, NStar Substation, Clipper Ship Village, Wading Place Road, and Bartlett properties.

Table 2-2 lists the remaining sites and their recharge capacities, as proposed for USGS modeling. Of greatest interest were sites outside of the Popponesset Bay and Waquoit Bay East watersheds due to advantage of recharging directly into Nantucket Sound, where the effects of nitrogen on the estuaries are minimized.

USGS modeling of the remaining recharge sites was developed to investigate mounding impacts and to determine the likely pathway of infiltrated water. The potential max month flows are the maximum flows that were used in the various model runs requested of USGS, as discussed in the following section.

2.4 USGS MODELING EFFORTS

Beginning in 2004 the Town of Mashpee began working with the USGS to perform groundwater modeling of various recharge sites in Mashpee as described above. The modeling was also used to evaluate the effects of various treated water recharge scenarios on the groundwater.

The USGS model reflects groundwater contours as a function of pumping from production wells and the recharge from various small wastewater treatment plants located within Mashpee, including: Stratford Ponds condominiums, Willowbend Development, Windchime Point condominiums, Southport condominiums, Mashpee Commons shopping center, South Cape Village shopping center, Mashpee High School, and New Seabury. The USGS model also accounts for natural recharge and discharge and recharge from septic systems.

The existing USGS model provides a tool to evaluate the effects of treated water recharge from a centralized facility at various candidate sites. The USGS model can also generate information on mounding, flow direction, travel time, and discharges to surface waters.

The following section summarizes the site specific information developed for the Project Planning Area and the scenarios run by the USGS program.

A. **USGS Modeling Results.** Information was provided to USGS on pumping rates for existing and future water supply wells, potential treated water recharge site locations, and existing recharge from the several small wastewater treatment plants located in the Project Planning Area.

Table 2-2 summarizes the effluent discharge site locations considered and their potential loading rates.

These seven sites became the basis for the recharge scenarios submitted to USGS for modeling. The following is a summary of the USGS modeling scenarios requested by the Mashpee Sewer Commission.

1. Model Run 1 – Existing Conditions. Included modeling well pumping rates, existing effluent recharge sites for small wastewater treatment facilities, on-site septic system recharges, and particle tracks to sensitive receptors.

2. Model Run 2 – Future Well Conditions. Included the addition of two new wells.

3. Model Run 3 – Future Well Conditions with 0.5 million gallons per day (mgd) discharge at Site 7 (New Seabury). This scenario assumed no effluent recharge at Mashpee Commons, Windchime Point and South Cape Village discharge locations.

4. Model Run 4 – Future well conditions with new discharge alternative "A".

    a. 0.5 mgd discharge at Site 7 (New Seabury), 1.0 mgd discharge at Site 2 (Ashumet Road).

    b. Any remaining Mashpee flow is returned through residential septic systems outside the "100 percent sewer subwatersheds" and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point and South Cape Village discharge locations.

5. Model Run 5 – Future well conditions with new discharge alternative "B".

    a. 1.0 mgd discharge at Site 7 (New Seabury), 1.0 mgd discharge at Site 5 (High School Ball Fields).

    b. Any remaining Mashpee flow is returned through residential septic systems outside the "100 percent sewer subwatersheds" and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point and South Cape Village discharge locations.

6. Model Run 6 – Future well conditions with new discharge alternative “C”.

   a. 0.5 mgd discharge at Site 7 (New Seabury), 1.0 mgd discharge at Site 1 (Heritage Park Ball Fields).

   b. Any remaining Mashpee flow is returned through residential septic systems outside the “100 percent sewer subwatersheds” and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point, and South Cape Village discharge locations.

7. Model Run 7 – Future well conditions with new discharge alternative “D”

   a. 0.5 mgd discharge at Site 7 (New Seabury), 0.3 mgd discharge at Site 3 (Old Town Dump), 0.8 mgd discharge at Site 4 (Transfer Station).

   b. Any remaining Mashpee flow is returned through residential septic systems outside the “100 percent sewer subwatersheds” and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point and South Cape Village discharge locations.

8. Model Run 8 – Future well conditions with new discharge alternative “E”

   a. 0.5 mgd discharge at Site 7 (New Seabury), 1.0 mgd at Site 6 (Keeter Property).

   b. Any remaining Mashpee flow is returned through residential septic systems outside the “100 percent sewer subwatersheds” and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point, and South Cape Village discharge locations.

9. Model Run 9 – Future well conditions with new discharge alternative “F”

   a. 0.8 mgd at Site 4 (Transfer Station) and 1.0 mgd at Site 6 (Keeter Property).

   b. Any remaining Mashpee flow is returned through residential septic systems outside the “100 percent sewer subwatersheds” and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point, and South Cape Village discharge locations.

10. Model Run 10 – Future well conditions with new discharge alternative “G”

    a. 0.3 mgd discharge at Site 7 (New Seabury), 0.5 mgd at Site 2 (Heritage Park), 0.3 mgd at Site 4 (Transfer Station), 0.3 mgd at Site 5 (High School Ball Fields), and 0.2 mgd discharge at Site 6 (Keeter Property).

    b. Any remaining Mashpee flow is returned through residential septic systems outside the “100 percent sewer subwatersheds” and Mashpee River subwatersheds. No discharge from Mashpee Commons, Windchime Point, and South Cape Village discharge locations.

USGS ran these scenarios and the draft particle tracking results are presented in Figures 2-2 through 2-11. It is noted that the results presented are the Draft results that were provided in February 2005. Final results were not issued.

Of particular interest were model runs 3-9, which incorporated the various potential recharge sites. The following is a general summary of the results observed from the model runs.

- Model Run 3 – This run included recharge at the New Seabury site. Groundwater recharged at this site apparently flows south to Nantucket Sound without entering either of the watersheds.
- Model Run 4 – The run included recharge at the Ashumet Road site in addition to the New Seabury site. The model indicates that groundwater recharged at Site 2 flows south from the site for 5-10 years before heading east to the Mashpee River. The model indicates that a proposed future well (P-11) would be in the flow path at a distance that requires approximately 10 years’ travel time for the groundwater.
- Model Run 5 – This run includes recharge at the High School Ball Fields. Recharged water at this site appears to head east towards the Quashnet River. The flow is in the opposite direction of the many nearby existing wells and proposed wells.
- Model Run 6 – Run 6 includes recharge at the Heritage Park Ball Fields. Recharged water apparently flows generally south before heading east to the Mashpee River. Two proposed wells appear to be in the flow path of recharged effluent. Proposed

well P-1 is at an approximate 10-year travel time from the site and the proposed well at the Belcher Site is at a distance approximately 50-100 years' travel time.

- Model Run 7 – This run included three recharge sites – the Old Town Dump, the Transfer Station, and New Seabury. Groundwater flows south from Site 3 (Old Town Dump), then heads west to the Mashpee River. The Proposed Meetinghouse Well is downstream approximately 5 years' travel time from the site. Flow from Site 4 (Transfer Station) generally flows in a southwesterly direction to the Mashpee River. Recharge at this site does not seem to flow in the direction of any existing or proposed wells.
- Model Run 8 – This run includes recharge at the New Seabury Site and at the Keeter property. Although the Keeter property is located outside of both the Waquoit Bay East and Popponesset Bay watersheds (as indicated by MEP), the majority of the recharged groundwater from this site flows to both watersheds, with the recharge location located within the Popponesset Bay watershed. Two water supply wells are located at a distance of approximately 50-100 years' travel time from the site.
- Model Run 9 – This run includes recharge at the Transfer Station and the Keeter property, which have already been discussed.
- Model Run 10 – Recharge sites at New Seabury, Ashumet Road, the Transfer Station, the High School, and the Keeter property were considered for this run. All of these sites have been discussed previously. This run is slightly different in that the flows to the sites are different from other runs. Under this potential scenario, the recharged groundwater does not flow toward any proposed or existing water supply wells, with the exception of the Ashumet Road site, which flows toward proposed well P-11.

The results of the modeling will be used as part of the WNMP to develop alternative solutions and a recommended plan for the Town.

2.5 2007 SITE EVALUATIONS

As discussed in previous reports, the WNMP process began in earnest in 2005, after the MEP reports for Popponesset Bay and Waquoit Bay East were released. During the Scenario Evaluation, the potential recharge sites were re-evaluated and a search was made for any additional properties that could possibly be used. Using Geographic Information Systems (GIS) mapping, assessor's information, site visits, and discussions with Town officials, 13 sites were identified in the Project Planning Area (PPA). Eleven of the 13 sites are located within Mashpee and two within Sandwich. No properties were identified within Falmouth or Barnstable.

The Town of Falmouth is proceeding with its own facilities planning process concurrently with this project and at the time of this report Falmouth has identified their alternatives to manage wastewater along their southern coastline, including the Waquoit Bay East watershed. Therefore no additional sites were considered in the relatively small portion of Falmouth within the PPA.

The Town of Barnstable is also, at the time of this report, preparing to move forward with nutrient management planning in its western watersheds. The portion of Cotuit located within the PPA is small and no potential recharge sites were identified in discussions with Barnstable. The Town did identify a former cranberry bog property purchased by Barnstable that is located within the Town of Mashpee. However, that site would only be considered as part of a wetland restoration alternative, one of the identified technologies that may be considered.

The seven properties identified in conjunction with USGS modeling were included in the 13 sites. In addition, the Mashpee Sewer Commission requested two additional sites be added to the list – the Bartlett property (which had been eliminated prior to the USGS modeling) and the property adjacent to the Mashpee High School. Each of these sites is identified in Table 2-3 and shown on Figure 2-1. Table 2-3 summarizes some of the major physical features and site specific criteria that were used to evaluate each site.

The sites that were identified are shown on Figure 2-1 and included:

- Site 1 – Heritage Park Ball Fields
- Site 2 – Ashumet Road
- Site 3 – Old Town Dump
- Site 4 – Transfer Station
- Site 5 – High School Ball Fields
- Site 6 – Keeter Property
- Site 7 – New Seabury Country Club
- Site 8 – Great Neck South
- Site 9 – Great Hay Road
- Site 10 – 72 Cotuit Rd – Sandwich
- Site 11 – 168 Route 130 – Sandwich

- Site 12 – Bartlett Property
- Site 13 – Adjacent High School Parcel

The sites were then ranked based on this initial analysis to determine the top candidate sites for further evaluation. The summary of this evaluation is presented in Table 2-4. The results of this analysis were reviewed with the Mashpee Sewer Commission and nine sites were identified for further evaluation. Sites 8 and 9 were identified as conservation lands and were thus eliminated from further evaluation. Discussions with the Town of Sandwich indicated that Site 11 was a feasible possibility for further consideration. The nine sites (7 owned by a municipality, 1 privately owned, and 1 held in conservation according to available GIS data) retained for further evaluation include:

- Site 1 – Heritage Park Ball Fields
- Site 2 – Ashumet Road
- Site 4 – Transfer Station
- Site 5 – High School Ball Fields
- Site 6 – Keeter Property
- Site 7 – New Seabury Country Club
- Site 11 – 168 Route 130 – Sandwich
- Site 12 – Bartlett Property
- Site 13 – Adjacent High School Parcel

Sites are highlighted in either yellow or green on Figure 2-1.

All of the recommended recharge technologies were considered for each site. Selection of the most appropriate technology for each site was then based on considerations of location, capacity, feasibility and general acceptance. The following technologies were evaluated for each site:

- Heritage Park Ball Fields – drip irrigation and subsurface infiltration
- Ashumet Road – open sand beds
- Transfer Station – open sand beds and subsurface infiltration
- High School Ball Fields – drip irrigation and subsurface infiltration
- Keeter Property – open sand beds
- New Seabury Country Club – drip irrigation and subsurface infiltration
- 168 Route 130 (Sandwich) – open sand beds

- Bartlett Property – open sand beds
- Adjacent High School Parcel – open sand beds and subsurface infiltration

Open sand beds were considered as much as possible because they provide significantly greater recharge capacity. Subsurface infiltration was considered on parcels where there may be aesthetic impacts on surrounding properties but where irrigation is not currently used. Subsurface leaching and drip irrigation were considered for the properties that are currently used for recreational activities.

Figures 2-12, 2-13, and 2-14 illustrate the general layout of each technology that was used as a basis for determining recharge capacity at the various sites. Figure 2-12 shows the area that was assumed for berms and access roads between sand beds.

The following section describes in greater detail the sites that are being evaluated further.

A. **Site 1 – Heritage Park Ball Fields.** This site, shown on Figure 2-15, is a 27-acre parcel that runs between Main Street (Route 130) and Ashumet Road in Mashpee. The site, which has access points from both Main Street and Ashumet Road, is currently used as public ball fields. There are baseball/softball fields, playgrounds, parking and other recreational facilities. Additional ball fields are being constructed on the portion of the site abutting Ashumet Road. With the exception of a small portion of the western corner of the site, this property is within the Popponesset Bay watershed.

The surrounding properties are primarily commercial lots; most of the neighboring residential properties are along Ashumet Road. Although not located within a Zone II area, the site is within a Town-designated water protection district. Additionally, the western portion of the site is identified as estimated rare species habitat by the Massachusetts Division of Fisheries and Wildlife.

Based on existing records of test pits in the area, the soils on the site consist primarily of coarse and medium sands beyond a depth of 3-feet. Water is estimated to be at a depth of 58-feet below the surface.

Due to the existing uses of this site, open sand beds were not considered. Treated water recharged at this site would benefit from additional nitrogen removal by means of natural attenuation as it travels to the estuary. Another advantage of this site is the fact that it is already cleared and developed so additional clearing would not be necessary.

The disadvantages of the site include its limited options for recharge technologies. Although subsurface technologies allow for secondary use of the land, the loading rates are significantly lower than loading rates for open sand beds. Additionally, new ball fields are currently under construction on the site, which could create reluctance to excavate and disturb the area in the near future. Drip irrigation is another low impact alternative to subsurface leaching facilities for this area. Another advantage to drip irrigation is that it reduces the demand on water supply wells that would otherwise be used for irrigation.

Based on preliminary layouts that were developed for this analysis (see Figure 2-16), it is estimated that this site would be suitable for recharging up to 640,000 gpd if subsurface infiltration is used.

B. **Site 2 – Ashumet Road.** This site is a 19-acre open space parcel that runs between Ashumet Road and Otis Air Force Base property. It is on the opposite side of Ashumet Road from the backside of the Heritage Park Ball Fields site and lies within the Waquoit Bay East watershed (with the exception of a small corner on the eastern side of the parcel).

There are a limited number of residential properties (approximately 8) on Ashumet Road both east and west of this side. However, much of the surrounding land is open space and the only way to access the parcel is along Ashumet Road. The entire property has been identified as estimated rare species habitat. The site is also located within both a drinking water Zone II area and a Town-designated groundwater protection district, as seen on Figure 2-17.

The site is currently located upgradient of a contaminant plume from the neighboring Air Force Base. The plume is identified as FS-1; the contaminant of concern is ethylene dibromide. This plume is currently being mitigated/treated as part of the work of the Air Force Center for Engineering and the Environment. Treatment of this plume began in 1999 and is expected to continue until 2030.

Soils at this site are anticipated to be similar than those described for Site 1 – primarily medium and coarse sands beyond 3-feet of depth. Groundwater is estimated to be at a depth of at least 58-feet, although a monitoring well south of the site indicates a depth of 30-feet to groundwater.

This site was considered suitable for open sand beds. A conceptual layout is shown in Figure 2-18. This layout would be suitable to handle a maximum of 1.7 mgd, which would also allow sufficient space on the site for a new Wastewater Treatment Facility (WWTF).

The main advantage of this site is the abundance of undevelopable conservation land or Air Force Base land in the vicinity, which reduces the aesthetic impact as seen by residential neighbors. It is also located far enough upstream in the watershed that natural attenuation occurs as groundwater flows toward the Waquoit Bay East estuary.

C. **Site 4 – Transfer Station.** Thirteen acres on the eastern side of the Mashpee municipal landfill/transfer station property is currently undeveloped open space in the Popponesset Bay watershed. This was considered as a potential treated water recharge site. The western half of the site is the location of the capped municipal landfill and the Mashpee transfer station. The remaining three sides of the site are bordered by residential properties, including a housing complex directly to the east. Because the potential recharge area is bordered by roads on three sides and the transfer station on the fourth side, sufficient access is available for this site as can be seen in Figure 2-19.

Due to the relatively central location of this site and the available area, it was considered as a potential site for a future WWTF as well as open sand beds. A conceptual layout of what the open sand beds would look like is shown on Figure 2-20. This layout provides an estimated 1.0 mgd capacity. The northern portion of the undeveloped area is assumed to be the site of new WWTF buildings.

The majority of the transfer station site that is being considered for recharge is located within the Town-designated groundwater protection district creating a major disadvantage. The number of surrounding residential properties is the other major disadvantage of this site.

The advantages of this site include the generally flat topography, central location, and the lack of rare species habitat. Groundwater flow from this site also receives some natural attenuation prior to reaching Popponesset Bay.

D. **Site 5 – High School Ball Fields.** The Mashpee High School Ball Fields are located to the east of the High School building on Old Barnstable Road. The southern portion of the site contains a utility easement for the power lines; the eastern side of the site (which borders the Quashnet River) has a conservation restriction and is undevelopable. The only way to access the site is through the school's main entrance on Old Barnstable Road, which is shown in Figure 2-21. The High School property is within the Waquoit Bay East watershed.

Due to its proximity to the Quashnet River, most of the surrounding properties are conservation lands or open space. Although some residential properties are located to the west of this property, the school building is situated between the potential recharge site and the residential area. This site was identified as estimated rare species habitat; it is within Zone II and groundwater protection district areas.

Information obtained from existing records of test pits north of the High School indicate that sand and gravel are encountered at a depth of 2.5-feet below the surface. Records from the test pits indicate that groundwater was not encountered, indicating that groundwater is at a depth greater than 13-feet. The Groundwater Discharge Permit (GWDP) requirements for the High School WWTF include sampling of monitoring wells in the vicinity of the effluent recharge location. Monitoring reports indicate that groundwater is at a depth of 40- to 50-feet below the ground surface.

The ball fields were considered as a site for drip irrigation or subsurface leaching facilities. Although preliminary evaluations estimated a recharge potential of 1.3 mgd, preliminary layouts were developed as part of this analysis and resulted in an estimated potential recharge of 0.58 mgd. The layouts provide a more accurate estimate of capacity because they account for needed spacing and consider existing structures (dugouts, bleachers, etc.). A conceptual subsurface infiltration layout is illustrated in Figure 2-22.

E. **Site 6 – Keeter Property.** This 28-acre site is on the north side of Red Brook Road in the southern portion of Mashpee. A small triangle in the western corner of the site is in the Waquoit Bay East watershed; approximately 12 acres are within the Popponesset Bay watershed; the remainder of the parcel lies between the two watershed boundaries. A fire station is currently proposed toward the western edge of the property. Otherwise, the property is undeveloped open space. The only side of the property which provides access to the site is along Red Brook Road, as shown on Figure 2-23.

The property is bordered by a mix of conservation/open space area and residential properties. The site is located entirely within an estimated rare species habitat and is within a Zone II/groundwater protection district.

The size of this property and its location outside of either watershed make this a favorable site to consider effluent recharge via open sand beds as well as the potential for a WWTF. This site has an estimated 1.0 mgd recharge potential. This estimate is based on construction of open sand beds only in the portion of the site outside of watershed lines. During early discussions with the Mashpee Sewer Commission, it was noted that a drinking water supply well is located down-gradient from Site 6. As a result, the recharge capacity of this site was revised to include recharge only within the Popponesset Bay watershed, thereby reducing potential impacts on the down-gradient water supply wells. The scenarios, as discussed in Chapter 3, would require a maximum of 300,000 gpd of recharge at this site. Figure 2-24 provides a conceptual layout of open sand beds to recharge 300,000 gpd.

F. **Site 7 – New Seabury Country Club.** The eighteenth hole of the New Seabury Country Club golf course was one of the sites initially identified as a potential effluent recharge site. The site consists of approximately 16 acres in the very southern end of Mashpee, outside of either MEP watershed.

In addition to being identified as estimated rare species habitat, there is a certified vernal pool on the site. The rolling topography reduces its favorability for traditional treated water recharge technologies. Site access is fairly limited due to the nearby residences; the primary access point is the side of the site that is closest to the New Seabury Country Club (see Figure 2-25).

Existing test pit records from a site north of Site 7 indicate the soils are medium and fine sand beginning at a depth of 4-feet. Water was not encountered during digging of the test pit, indicating that groundwater is at a depth greater than 13-feet.

Treated water recharge options for this site consisted only of subsurface technologies (drip irrigation and subsurface leaching). A preliminary layout is shown in Figure 2-26. Estimates of recharge capacity based on this layout are approximately 0.25 mgd. This is also a reduced number from the preliminary site evaluations that were provided to USGS.

G. **Site 11 – 168 Route 130 (Sandwich).** This site, often referred to as the "Golden Triangle," is located between Quaker Meeting House Road, Forestdale Road (Route 130), and Cotuit Road. More than 63 acres of this 117-acre site are located in the Popponesset Bay watershed. The western portion of this site is within estimated rare species habitat; the property is also within multiple Zone IIs. The site is currently undeveloped land and is slated for as-yet-undetermined municipal use. Quaker Meeting House Road and Forestdale Road serve as two of the borders of this site, which would provide sufficient site access (see Figure 2-27).

The eastern corner of this site was considered for both a WWTF and open sand beds. The eastern corner was chosen because of its location outside of rare species habitat and the minimal amount of residential development surrounding this corner of the site. The greatest advantage of this site is the natural attenuation that occurs as groundwater flows to the estuary. It is also a relatively centralized parcel in relation to all of the Sandwich parcels in the Project Planning Area. This would be advantageous if the towns decide to proceed on an individual town basis rather than a watershed-based approach.

This site has the potential to recharge 1.2 mgd, based on the preliminary layout shown in Figure 2-28. Open sand beds were the basis of this layout.

H. **Site 12 – Bartlett Property.** This 10-acre site is located to the west of Great Neck Road South and to the south of Great Pines Drive. It is surrounded completely by conservation/open space land. The site is currently open space in the Popponesset Bay watershed and no development is planned for the site. Site access is fairly limited; there appears to be a fire road or utility road to the west of the site (see Figure 2-29).

Two isolated rare species habitats/wetlands are located to the south of the potential site. A semicircle of the habitat crosses onto the Bartlett property, as shown on Figure 2-29; however, the majority of the site is not located within the priority habitat. About one third of the site is within a Zone II/groundwater protection district.

Test pit information was obtained for a parcel north of the Bartlett property. The test pit indicated that medium sand was encountered beginning at a depth of 3-feet. Groundwater was not encountered during the testing; therefore groundwater was estimated at a depth of greater than 10-feet. A well log for a nearby property indicates that groundwater is at a depth of 30-feet below the surface. The well log indicated that the primary soil type to a depth of 50-feet is coarse sand.

Open sand beds were the only technology considered for this site because of the lack of residential properties surrounding the site. The conceptual layout shown in Figure 2-30 would provide a potential for 0.6 mgd.

I. **Site 13 – Adjacent to High School.** This site is the parcel to the southwest of the High School property. It is currently an undeveloped parcel in the Waquoit Bay East watershed. The only apparent potential access point is a short stretch of Old Barnstable Road that is one of the property boundaries (see Figure 2-31).

The entire site is within an estimated rare species habitat and a groundwater protection district. There are also small areas of wetlands located on the site. A utility easement running east-to-west bisects the property roughly in the middle.

In order to minimize wetland impacts and aesthetic impacts on the neighboring residences, open sand beds were considered for this site in the portion of the site north of the utility easement and east of the wetland.

As this site was being considered for sand beds, it was decided to incorporate a portion of the High School property to maximize the potential recharge capacity. The portion of the High School property that was included is the corner of the property that lies north of the utility easement and west of the existing stormwater infiltration pond. Figure 2-32 illustrates the conceptual layout of the sand beds on these two sites. This layout would provide a potential recharge capacity of 2.5 mgd.

2.6 WASTEWATER TREATMENT ISSUES TO CONSIDER

If the towns within the Project Planning Area consider developing new treated water recharge sites (within their boundaries), potential future recharge limitations must be considered.

1. Treated water that is recharged into subsurface leaching facilities must have low suspended solids to avoid plugging the soil infiltration system, which can require costly repairs. Effluent filtration would reduce this potential for plugging.

2. Treated water recharges upgradient of freshwater ponds and lakes would need phosphorus removal to avoid the creation of a phosphorus plume that could migrate to the freshwater body and cause eutrophication. The Otis Air Force Base wastewater treatment facility discharge and the eutrophication of Ashumet Pond in Falmouth and Mashpee is a recent Cape Cod example of this issue. This case study is described in the 2003 report by the U.S. Geological Survey entitled *"Reactive-Transport Simulation of Phosphorus in the Sewage Plume at the Massachusetts Military Reservation, Cape Cod, Massachusetts."*

3. Treated water recharge into Zone II areas (drinking water supply areas) will need to meet the MassDEP *"Interim Guidelines on Reclaimed Water."* Effluent limits for this type of recharge would need to meet the following treatment and design standards (for recharge within the Zone II but beyond a two year time of travel to the nearest well):

- pH: 6 to 9
- BOD concentration: ≤30 mg/L
- Turbidity: <5 Nephelometric turbidity units (NTU)
- Fecal coliform content: <200 colonies/100 ml
- TSS concentration: ≤10 mg/L
- TN concentration: <10 mg/L

These standards are typically met by the addition of filtration facilities and disinfection.

Treated water recharge in a Zone II area with less than a two-year travel time to a public water supply would need to meet the following more stringent treatment and design standards:

- pH: 6 to 9

- BOD concentration: ≤10 mg/L
- Turbidity: ≤2 NTU
- Fecal coliform content: median of no detectable colonies/100 ml and no single sample to exceed 14 colonies/100 ml
- TSS concentration: ≤5 mg/L
- TN concentration: <10 mg/L

It is noted that MassDEP is currently revising this guidance to become new regulations. Revisions to these regulations and guidelines are anticipated in draft form in the summer of 2008.

These more stringent standards for recharge within a two year time of travel, as currently issued, are typically met by microfiltration and disinfection. Additionally, recharge through sand infiltration beds and groundwater travel through the aquifer will remove any bacterial pathogens through the natural filtration abilities of the soil. This has been well documented by George Heufelder of the Barnstable County Health and Environment Department in septic system evaluations. Viruses become inactivated after six months to one year of travel time in the groundwater.

A. **Spray Irrigation Reuse.** There has been much interest in some Cape towns on the possible reuse of treated water for spray irrigation of public lands and private properties. This alternative could save money because it would make productive use of what could be considered a waste product. Also, several applications of this technology in Florida and the western states were used as examples of how the technology could be used on Cape Cod.

This alternative would require the following components beyond the typical WWTF processes or upgrades to existing facilities:

- Microfiltration would be provided by advanced membrane materials. This process is similar to a reverse osmosis process that can desalinate sea water and produce a pure water product, except that it has a lower membrane pore size and lower capital and Operation & Maintenance (O&M) costs. It is effective at removing various pathogen cysts that may not otherwise be removed by a WWTF. This process would be required by MassDEP if the spray irrigation was to occur in a public place without restrictive site controls. The process would be installed and operated in a building at the proposed WWTF generating the water to be recharged.

- UV disinfection to the highest performance level would be required for further disinfection of the water.
- Storage facilities would be needed to store the treated water that is produced at the plant so that it could be available for peak irrigation demand times. This type of storage is typically provided in an elevated storage tank similar to those used by water departments to store and provide pressurized drinking water within parts of Barnstable, Falmouth, Mashpee and Sandwich.
- Dedicated treated water transmission pipes would be required to convey the water to the spray irrigation sites.
- Booster pump station(s) would be needed if the storage facilities were not elevated. These pumps could be located at each irrigation site to ensure sufficient pressure for the site or at the non-elevated storage tank to pressurize the whole system.
- Site controls at the irrigation sites would be as required by MassDEP permits. These permits would also require sampling and groundwater monitoring at the site.

Spray irrigation facilities would likely be used in conjunction with other recharge technologies as required to manage average treated water recharge requirements. The spray irrigation type technologies could be used to provide additional capacity during the peak demand expected during summer months.

There is precedent for this type of irrigation at golf courses in Massachusetts when the treatment plant is located at (or very near to) the golf course. The closest example is the seven-hole portion of the Bay Berry Hills golf course that is constructed on the capped Yarmouth landfill. The treatment facility already had a large elevated storage facility when the landfill cap and golf course was planned and designed. This site also uses Town drinking water for irrigation.

There is no precedent on Cape Cod for the irrigation on other Town or private properties that are accessible by the public. MassDEP is actively working on regulations regarding uses beyond those currently identified in their guidelines as stated previously.

2.7 WETLAND RESTORATION AT THE SANTUIT BOGS

As discussed previously, no effluent recharge sites were identified within the part of Barnstable that is within the Project Planning Area. However, discussions were held with various representatives from Barnstable. Barnstable purchased a large area of land within the boundaries of Mashpee with Land Bank funds. The property consists of abandoned cranberry bogs to the south of Santuit Pond. As part of the Popponesset Bay Pilot Project, these bogs were evaluated for potential modification to perform additional nitrogen attenuation. Barnstable representatives indicated that the use of these bogs would be highly acceptable for consideration as a site for treated water recharge to restore groundwater flow in the drainage basin. Before this option is considered further, it will need to be determined if Land Bank restrictions or Zone II issues will affect the feasibility of this option.

Further consideration of this as an option will require additional study and groundwater modeling to evaluate potential impacts on the ecosystem and surrounding properties. Therefore it is not currently included in the scenarios development; however, it could become a part of the recommended plan or an adaptive management plan as the additional studies are completed and appropriate approvals are received for these types of wetland restoration type projects.

Chapter 3

Alternative Scenarios

CHAPTER 3

ALTERNATIVE SCENARIOS

3.1 INTRODUCTION

After the Needs Assessment Report was released, the Mashpee Sewer Commission identified five different management scenarios that would be pursued for evaluation and analysis. This chapter identifies the general characteristics of each scenario and discusses the basic methodology for evaluating each scenario.

The five scenarios are:

- Scenario 1 – No expansion of existing wastewater treatment facilities
- Scenario 2 – Upgrade and expansion of existing facilities to a practical extent
- Scenario 3 – Nitrex decentralized approach (prepared by others)
- Scenario 4 – Fair Share
- Scenario 5 – Centralized approach

The term "Scenarios" in this report will refer to those evaluated by Stearns & Wheler: Scenarios 1, 2, 4 and 5. Scenario 3 has been developed by others and presented to the Sewer Commission under separate cover.

Scenarios 1, 2, 4, and 5 all incorporate some degree of sewer construction and the use of an "effluent pipeline" that carries treated effluent outside of the watershed for discharge. The pipeline concept is based on the assumption that a portion of the New Seabury Golf Course (Site 7) is used for subsurface infiltration. This property is privately owned and located at the southern-most tip of the Town and could therefore pose political and management issues further along in the process in transporting and recharging flows there. For this reason, each of the scenarios (1, 2, 4, and 5) was initially analyzed with and without consideration of the use of Site 7.

Preliminary scenarios developed as part of this effort were presented to the Sewer Commission for review and discussion. Issues associated with Site 7 including ownership and natural habitats were identified; however, due to its location outside of the watershed and the continued interest in the Site by the Sewer Commission, it remains under consideration. Following additional evaluation of scenarios, it was determined that the use of Site 7 will likely be necessary to achieve the Total Nitrogen TMDL goals. Therefore the remaining discussions in this Report on scenarios will be based on the consideration of using this site for treated water recharge and, as drafted, is currently a component of each of the four scenarios evaluated in this Report.

Each scenario evaluated by Stearns & Wheler will be described and include information on proposed treatment facilities, estimated lengths of sewers, force mains, grinder pumps/vacuum valve pits, and number of pumping stations. Technologies are not being selected as part of this evaluation; however, technologies considered for costing purposes are based on the recommendations of the Technologies Screening Report. In addition, order of magnitude costs are developed to allow comparison between scenarios using these technologies. The costs are discussed in Chapter 4.

All of the scenarios calculations are evaluated under build-out conditions. All associated costs and flows are estimated based on achieving build-out conditions. If build-out conditions are never attained, it is possible that fewer areas will need to be addressed by sewers to meet the total nitrogen TMDLs. Therefore, through an adaptive management approach, the extent of wastewater facilities can be modified.

Each of the five main scenarios (including Scenario 3 – Nitrex, which is being developed by others) is developed so that it can be run through the MEP Model to identify its ability to meet the TMDL and sentinel station threshold concentration in both the Popponesset Bay and Waquoit Bay East estuaries. The findings of these model results will be incorporated into the final Alternative Scenarios Analysis and will form the basis for identifying scenarios to be evaluated further and in greater detail as part of the next phase of this project.

Several workshops and presentations on the development of these scenarios were made to the Mashpee Sewer Commission in the fall and winter of 2007. Initially, the basis of all scenarios was the use of data by Planning Zones, as was done for the identification of areas of need in developing the Needs Assessment Report. Planning Zones, although useful for identifying demographics, are often not the most effective way to plan wastewater infrastructure.

Topography must also be considered. Watersheds are also excellent for use in the evaluation of the nitrogen impacts; however they often do not coincide with efficient wastewater infrastructure planning. Both watershed boundaries and Planning Zones provide the basis for identifying where wastewater infrastructure is necessary and therefore are still very important in the process of scenarios development.

After the preliminary analysis based on Planning Zones, “sewersheds” were laid out for the entire Project Planning Area. Sewersheds are developed to provide a reasonable estimation of the area that could effectively be served by a single pumping station. For example, all the properties that could flow by gravity to one pumping station (where wastewater is collected and pumped to a WWTF) would be grouped together in a sewershed. However, not all sewersheds consist of properties served entirely by gravity sewer; some sewersheds will require a combination of technologies. The sewersheds are used as the basis for the calculations performed in developing the various scenarios.

Sewersheds, like Planning Zones, do not necessarily conform to watershed lines. The sewersheds were used to refine the preliminary analyses and determine more realistic sewer scenarios. Because sewersheds are based on potential infrastructure layout and not watershed boundaries, use of nitrogen loadings generated by a “sewershed” could overestimate the effective nitrogen that reaches the estuary. Therefore the sewersheds were used as a guide and a means to estimate infrastructure; however, in each of the scenarios, nitrogen loading was refined using parcel-by-parcel data to determine in which sewershed and subwatershed each parcel lays. The final scenarios were developed based on this analysis. Since attenuation is best determined through the MEP analysis methods, it complicates the ability to assign an “attenuated” nitrogen load to each parcel. Depending on the analysis approach, if a general “attenuation” factor is applied, it will differ from the results of attenuation when the MEP “rainbow” spreadsheets are used. As a result, general attenuation factors were used to provide a reasonable approximation of the nitrogen loading; each scenario’s load was estimated based on parcels within MEP subwatersheds and, for the MEP modeling, input into the “rainbow” spreadsheets as described in Chapter 5 to estimate each scenario’s ability to achieve the goal.

This chapter summarizes the characteristics of each scenario as well as some potential variations on the scenarios. Chapter 4 summarizes the infrastructure components of each scenario, presents order of magnitude costs of the various scenarios, and discusses the advantages and disadvantages of each alternative.

Table 3-1 summarizes the wastewater flows and loads for all portions of the Project Planning Area. In addition, the number of wastewater-generating parcels is presented. The table is divided by both town and watershed.

3.2 SCENARIO 1 – NO EXPANSION OF EXISTING TREATMENT PLANTS

Scenario 1 involves the continued operation of existing private WWTFs and construction of additional treatment facilities as needed to achieve the nitrogen TMDLs. Existing WWTFs were identified and discussed in detail as part of the Needs Assessment Report and are as follows:

- New Seabury
- Willowbend
- Southport
- Mashpee Commons
- Mashpee High School
- Windchime Point
- Stratford Ponds
- South Cape Village
- Forestdale School (Sandwich)

Under this scenario, these existing WWTFs are expanded only to include areas that were identified as future connections in each WWTF's facility plan and under their existing Groundwater Discharge Permits (GWDP). New Seabury is the only exception to the no-expansion consideration. New Seabury is expected to have considerable capacity and is in close proximity to portions of Mashpee that are not near other WWTFs or the potential sites discussed in Chapter 2. Wastewater treatment requirements for the existing facilities are based on those limits stipulated in their GWDP at the time of this report. Therefore the effluent total nitrogen limits for these facilities are 10 mg/L or 5 mg/L, depending on their permit. The only exception is the Forestdale School WWTF, which does not have a nitrogen limit stipulated in the GWDP. Because proposed additional WWTFs have not been designed, an effluent nitrogen concentration of 3 mg/L (the current limit of technology) is used for future facilities due to the requirements of reducing total nitrogen within the Popponesset Bay and Waquoit Bay East watersheds.

The Falmouth Alternatives Screening Analysis Report developed for their currently ongoing Comprehensive Wastewater Management Plan has identified the potential for sewering portions of the Project Planning Area that are within the Town of Falmouth. As part of that plan, treated water generated from areas in Falmouth would be recharged outside of the Waquoit Bay East and Popponesset Bay watersheds. Essentially, any wastewater removed from the Project Planning Area and treated in Falmouth will stay outside of the Waquoit Bay East and Popponesset Bay watersheds, resulting in no nitrogen recycling from those areas.

This scenario was developed by first determining how much nitrogen reduction would be achieved by assuming all WWTFs are operating at build-out flows and treating to their respective GWDP nitrogen limit. The next step was to identify “clusters” within the Project Planning Area that would be suitable for small package WWTFs. The clusters were chosen by selecting sewersheds that could logically be connected together and that had relatively dense development. The clusters were generally selected based on the nearness to potential effluent recharge sites as discussed in Chapter 2.

The following are the basic characteristics of Scenario 1. New treatment facilities are indentified *in italics*.

<u>Scenario 1</u>

- WWTF at Forestdale School
- WWTF at Southport
- WWTF at Mashpee High School
- WWTF at Mashpee Commons
- WWTF at South Cape Village
- WWTF at Windchime Point
- WWTF at Willowbend
- WWTF at Stratford Ponds
- WWTF at New Seabury (expanded)
- *WWTF at Site 11 – 168 Route 130 (Sandwich)*
- *WWTF at Site 2 – Ashumet Road (recharge at Site 1 and at Site 2)*

- *WWTF at Site 4 – Transfer Station*
- *WWTF at Site 6 – Keeter Property (recharge at Site 7 – New Seabury Country Club)*
- Sewersheds 11 and 23 on I/A systems (to 10 mg/L)
- All parcels in the Waquoit Bay East watershed that are outside sewersheds are on I/A systems (to 10 mg/L)
- Falmouth would remove and treat all Falmouth wastewater

Treated water would be recharged at each of the existing WWTF sites. The Falmouth recharge would occur outside of both the Waquoit Bay East and Popponesset Bay watersheds. Figure 3-1 provides a flow chart of the proposed facilities, and Figure 3-2 illustrates this scenario with a layout of the Project Planning Area. Sewersheds that are treated at a common WWTF are coordinated by color. Parcels that are connected to the existing WWTFs are highlighted with a red outline.

A new WWTF is proposed for Site 2 under this scenario. However, due to the amount of wastewater nitrogen that needs to be removed from Waquoit Bay East, treated water recharge occurs on both Sites 1 and 2. Site 1 will receive approximately 60 percent of the recharge and Site 2 would receive the remaining 40 percent.

Because Site 6 is located upgradient of a drinking water supply well, no treated water is proposed to be recharged at this site under this scenario. For this reason, treated water is expected to be recharged at Site 7 – New Seabury Country Club. If Site 7 does not continue as a feasible option, Site 6 may be reconsidered. The preference of the sewer commission is for any recharge at Site 6 to be located within the Popponesset Bay watershed boundary to promote groundwater flow toward Popponesset Bay rather than the wells that are south of the property.

Sewersheds 11 and 23, which are located in the southwestern and southeastern corners of Mashpee, are proposed to be treated with individual onsite Innovative/Alternative (I/A) systems or cluster systems, with a goal of achieving an annual average concentration of 10 mg/L total nitrogen in their effluent. This approach was considered for these sewersheds because of their locations – Sewershed 11 is an island and Sewershed 23 is not contiguous with the other parts of Mashpee. In order to connect these sewersheds to collection systems in Mashpee, water bodies would have to be crossed. This type of construction would involve significant permitting and construction obstacles. In addition to sewersheds 11 and 23, all parcels in the Waquoit Bay East watershed that are *not* included in sewersheds are proposed to be on I/A systems.

Table 3-2 summarizes the number of sewersheds and properties that would be served by sewer or onsite/cluster I/A systems in the future. Table 3-3 summarizes the estimated flows for each treatment facility and treated water recharge site under this scenario.

It should be noted that the number of properties served by sewers does not include properties that were originally planned to be connected or already have been connected to the existing private WWTFs.

Several of the sewersheds that are proposed to be connected to WWTFs within the Town of Mashpee are located partially or completely in either Barnstable or Sandwich. If this scenario proceeds, there would be the need for an intermunicipal agreement or regional sewer district to facilitate wastewater treatment outside of respective town boundaries.

3.3 SCENARIO 2 – EXPANSION OF EXISTING TREATMENT FACILITIES

Development of this scenario began in a method similar to that used in Scenario 1 – Falmouth wastewater is considered to be treated and recharged outside of the Project Planning Area and existing WWTFs address those properties originally identified as being connected (now or in the future) to that WWTF.

This scenario varies from the first one in that the existing WWTFs are expanded to the extent feasible to address neighboring sewersheds and the treatment process is improved to achieve an effluent nitrogen concentration of 3 mg/L under the future condition. Construction of new WWTFs is considered only after the expansion potential of each existing WWTF is considered. The WWTFs that were not considered for expansion included the Forestdale School, Stratford Ponds, Windchime Point, and South Cape Village. These facilities either have limited space for expansion, will approach the facility's capacity under build-out conditions, or use a technology that is not easily expandable or reliable to treat to 3 mg/L on a consistent basis.

WWTFs typically have a design life of 20 years; therefore, any improvements for the WWTFs will likely be phased. As the flows increase and each facility approaches its design life or GWDP expiration date, improvements will be proposed to achieve greater nitrogen reduction (3 mg/L nitrogen concentration is estimated under the build-out condition), including considerations for replacement with a new wastewater process.

Table 3-4 presents the estimated design life (based on 20 years) and "current" GWDP renewal year for those facilities under consideration for expansion. This information is based on the permit information available at the time of this report. These dates will be taken into consideration when evaluating potential phasing scenarios in the future.

The following are the basic characteristics of Scenario 2. New treatment facilities are indentified *in italics*.

<u>Scenario 2</u>

- WWTF at Forestdale School
- WWTF at Southport (expanded)
- WWTF at Mashpee High School (expanded)
- WWTF at Mashpee Commons (expanded)
- WWTF at South Cape Village
- WWTF at Windchime Point
- WWTF at Willowbend (expanded)
- WWTF at Stratford Ponds
- WWTF at New Seabury (expanded)
- *WWTF at Site 2 – Ashumet Road (recharge at Site 1 and Site 2)*
- *WWTF at Site 4 – Transfer Station*
- *WWTF at Site 6 – Keeter Property (Recharge at Site 7)*
- *WWTF at Site 11 – 168 Route 130*
- Falmouth would remove and treat all Falmouth wastewater
- All parcels in the lower portions of the Waquoit Bay East watershed (Hamblin Pond, Jehu Pond, and Quashnet River subwatersheds) that are not served by sewers are on I/A systems (to 10 mg/L)

As in Scenario 1, treated water from a new WWTF at Site 6 is recharged at Site 7 in order to remove the nitrogen from the watersheds and to eliminate recharge upgradient from drinking water supply wells. Also, recharge from a WWTF at Site 2 is recharged mostly at Site 1 (90 percent), with the remainder being recharged at Site 2.

Table 3-2 includes a summary of the number of sewersheds and properties that would be served by a sewer in the future and the number of properties on I/A systems. Table 3-3 summarizes the estimated flows for each treatment facility and treated water recharge site under this scenario.

Figure 3-3 provides a schematic of the sewersheds, WWTFs, and treated water recharge sites. Figure 3-4 illustrates the layout of this scenario. Sewersheds that are treated at a common WWTF are color coordinated.

3.4 SCENARIO 3 – NITREX™

The analysis of this scenario was performed by Lombardo Associates, Inc., the representative and distributor of the Nitrex™ system, an alternative septic system technology for providing denitrification. Evaluation of this scenario (by others) included consideration of individual Nitrex™ systems (new and retrofit); cluster Nitrex™ systems; upgrades to existing wastewater treatment facilities (WWTFs) with Nitrex™ systems; and Nitrex™ groundwater treatment systems.

The draft findings (February 2008) of this study has been documented in a separate report prepared by Lombardo Associates, Inc. and issued to the Sewer Commission under separate cover.

3.5 SCENARIO 4 – FAIR SHARE REDUCTION

This scenario is based on evaluations initially considered as part of the MassDEP-funded Mashpee Pilot Project. The Pilot Project team determined that a 49.2 percent reduction of all existing (2001) nitrogen sources (not including benthic flux or atmospheric deposition directly onto the embayment) throughout the entire Popponesset Bay watershed would achieve the nitrogen reduction necessary to restore estuary health. Once this homogeneous reduction rate was decided upon, the scenario was evaluated by the MEP, and it was concluded that this reduction would achieve the MEP goals. A similar analysis that attempted to mimic the Popponesset Bay "fair share reduction" scenario was applied to the Waquoit Bay East watershed as well. The calculations for that watershed (under existing conditions) resulted in a fair share reduction of approximately 63 percent.

There are some differences between the approach taken by the Pilot Project and the approach taken as part of the WNMP that should be noted.

(1) The Pilot Project analysis included a 49.2 percent reduction in nitrogen from all sources, with the exception of atmospheric deposition on the estuary surface. The WNMP analysis does not consider a reduction in nitrogen loading to natural surfaces (forests, fields, etc.) or atmospheric deposition to freshwater body surfaces to achieve the nitrogen limits. Instead, a nitrogen mass equivalent to the amount removed based on the MEP analysis is achieved through reduction of *only* wastewater nitrogen. This is the most controllable source of nitrogen and is therefore the easiest to quantify and achieve.
(2) The Pilot Project analyzed a 49.2 percent nitrogen reduction for the Popponesset Bay watershed only, which is the focus of that effort. The WNMP's goal is to determine management plans for the entire Project Planning Area. The Waquoit Bay East watershed is estimated to require a 63 percent nitrogen reduction.
(3) Wastewater was assumed to be completely removed from the watershed for the Pilot Project analysis. A more likely situation will include effluent recharge somewhere within the watershed. This will result in some recycling of nitrogen, which is considered as part of the WNMP evaluation.
(4) The original Pilot Project and MEP work was based on "existing" conditions; however the analysis used for this project is based on the future (build-out) nitrogen load being removed and therefore the amount of nitrogen to be removed will be larger.

This scenario is intended to provide one means of achieving a consistent nitrogen reduction in the various towns that make up the Project Planning Area. Each town is considered separately when presenting methods of nitrogen reduction – i.e. 50 percent of the Barnstable nitrogen is removed by Barnstable, 50 percent of the Sandwich nitrogen (in the Popponesset Bay portion) is removed by Sandwich, etc. Each Town will also be responsible for the facilities necessary to reduce the nitrogen loads. Therefore under this scenario, no inter-municipal agreements and no sharing of resources are considered.

Although Falmouth wastewater is still considered to be treated and recharged outside of the watersheds, this scenario involves removal of only the required "fair share" of the Falmouth wastewater generated within the Project Planning Area, unlike the other scenarios where 100 percent of this flow was considered removed. Because this scenario is based on the Fair Share concept, approximately 63 percent of the existing Falmouth wastewater plus build-out is proposed to be treated and recharged outside of the watersheds.

The following are the basic characteristics of Scenario 4. New treatment facilities are indentified *in italics*.

<u>Scenario 4</u>

- WWTF at Stratford Ponds
- WWTF at Willowbend
- WWTF at South Cape Village
- WWTF at Windchime Point
- WWTF at Forestdale School
- WWTF at Southport (expanded)
- WWTF at Mashpee High School (expanded)
- WWTF at Mashpee Commons (expanded)
- WWTF at New Seabury (expanded)
- *WWTF at Site 4 – Transfer Station*
- *WWTF at Site 6 – Keeter Property (Recharge at Site 7)*
- *WWTF in Barnstable*
- *WWTF in Sandwich – Site 11*
- Falmouth removes and treats Falmouth's wastewater
- Sewershed 23 on I/A systems (to 10 mg/L)
- No inter-municipal agreements and no sharing of resources are considered

Under this scenario, wastewater from the various towns within the Project Planning Area are treated and recharged within each Town's boundaries.

Once again, Sewershed 23 is proposed to utilize I/A systems to treat to lower nitrogen levels than are achieved with Title 5 septic systems. This sewershed consists of 130 parcels.

Table 3-2 presents the number of sewersheds and properties that would be served by a sewer in the future under this scenario. Table 3-3 summarizes the estimated flows for each treatment facility and treated water recharge site under this scenario.

The flow schematic for Scenario 4 is shown on Figure 3-5, and Figure 3-6 illustrates the layout of the scenario.

3.6 SCENARIO 5 – CENTRALIZED WASTEWATER TREATMENT

Scenario 5 involves wastewater treatment by means of centralized (municipal) wastewater treatment facilities. Although this scenario proposes that the flow from both watersheds be treated at a WWTF located on Site 4 (in the Popponesset Bay watershed), treated water recharge occurs at multiple sites within the two watersheds, with the intention of reducing the impact of significant changes to the volume of groundwater flow in either watershed.

This scenario includes the conversion of each of the existing private WWTFs (with the exception of New Seabury) within the Popponesset Bay and Waquoit Bay East to a pumping station. Wastewater treatment activities would cease at these facilities. New Seabury has significant capacity, is outside of the watersheds, and has the potential to service sewersheds that are at significant distances from proposed centralized facilities, therefore the continued use of this facility is recommended. The Forestdale School would serve as a pumping station to pump flow to a new WWTF located in Sandwich (Site 11).

The facilities required for this scenario are summarized as follows:

Scenario 5

- WWTF and recharge at Site 4 – Transfer Station
- Recharge at Site 5 – Mashpee High School
- Recharge at Site 1 – Heritage Park Ball Fields
- Recharge at Site 7 – New Seabury Country Club
- WWTF and recharge at Site 11 – 168 Route 130
- WWTF at New Seabury (expanded)
- Falmouth wastewater treated and recharged by Falmouth

Table 3-2 summarizes the number of sewersheds and properties that would be served by a sewer in the future. Table 3-3 summarizes the estimated flows for each treatment facility and treated water recharge site under this scenario.

This scenario involves one Mashpee sewershed being treated at a Falmouth WWTF and several Barnstable sewersheds being treated and recharged within the Mashpee Town boundaries. For this scenario to work successfully there would need to be agreements or sewer districts to deal with treating wastewater outside of its respective Town boundaries.

Treated effluent recharge under this scenario is distributed over a number of properties. The proposed WWTF is located at Site 4, where 1,000,000 gpd can be recharged. Another 200,000 gpd can be recharged at Site 7, which removes the nitrogen recycle from the watershed. The remaining recharge is split between Sites 1 and 5. Site 1 receives 75 percent of the effluent and Site 5 receives the remaining 25 percent. Although Site 5 has the capacity to handle additional flow, the amount of nitrogen removal required for Waquoit Bay East limits the recharge that can occur within that watershed.

A general schematic and a layout of Scenario 5 are shown in Figures 3-7 and 3-8.

3.7 SUMMARY

Table 3-2 summarizes the number of sewersheds and properties served for each scenario. Scenario 5 is anticipated to achieve the TMDL goals by providing sewers and/or I/A systems to the fewest number of parcels.

In general Scenario 5 appears to manage the smallest number of parcels, followed by Scenarios 2 and 4, leaving Scenario 1 managing wastewater from the largest number of parcels within the Planning Area. Wastewater flows, as would be expected, reflect the same findings. Scenario 5 requires the least amount of wastewater treatment and Scenario 1 the greatest amount.

Each scenario has been developed to achieve nitrogen reduction through wastewater management. Each scenario will require the Towns of Mashpee and Sandwich to acquire, operate and maintain some or all of the existing wastewater treatment facilities within these two towns and in the case of Scenario 5, obtain easement rights to convert these facilities into pumping stations. Scenario 1 requires the least amount of dealing with existing facilities, however all scenarios discussed here involve each Town's accessibility to site pumping stations within each of the various sewersheds identified for connection.

Technologies identified in the Technology Screening Report and identified within this document were considered for use under each of the various scenarios; however, for comparison and cost estimating purposes, only a limited number of technologies were used. These were selected based on known performance and general acceptance in similar locations and applications; they provide a reasonable approach for comparison purposes. However, the technologies identified in Chapter 4 used for costing and infrastructure layouts will not necessarily remain the recommended technologies. Because the WNMP is still in the early development stages, the recommendation of technologies for any future plan for the WNMP will come after the Alternatives Screening Analysis Report and as part of the Draft and Final Recommended Plan.

Efforts were made in each scenario to reuse existing facilities (as constrained by each individual scenario); selection of wastewater treatment and recharge sites was based on minimizing the number of facilities, while managing the impacts of treated water recharge within each watershed. It was beneficial under each scenario to locate wastewater treatment facilities at the same site as the treated water recharge location, or to maintain the two facilities within reasonable proximity.

Chapter 4 provides information on order of magnitude costs for each scenario. Chapter 4 will also summarize the monetary and non-monetary considerations for each of the 4 scenarios discussed above. Although the nitrogen loading analysis developed and discussed in Chapter 5 indicates that all of the scenarios are expected to achieve the TMDL requirements, further adjustment of the scenarios may be required as a result of the MEP analysis of each scenario.

Because a final recommended scenario will not be identified as part of this process, permitting, public acceptance, cost distribution and management issues can only be discussed in general terms. The scenarios are based on a build-out condition which is based on estimates of growth in the future, therefore public acceptance of any of the proposed scenarios as currently laid out would likely be low due to the high estimated costs expected and the extent of the infrastructure required to achieve the nitrogen TMDL limits. An adaptive management approach similar to those sought by other Cape communities as a way to manage long term capital plans is an appropriate approach for the Project Planning Area.

Key steps in facilities planning process that will help shape the recommended plan will be:

- Completion of the MEP modeling efforts for these and future scenarios to gauge the effectiveness of each approach.
- MassDEP direction on the enforcement and permitting issues associated with the TMDLs, such that each Town within the project planning area will have a clear understanding of their regulatory obligation and therefore will be able to create the necessary structure to monitor, manage and enforce TMDL compliance, whether that be through a Board of Health, Sewer Commission, Department of Public Works, Sewer Department, Sewer District or other structure.
- Development of a monitoring program. Because the groundwater travel patterns and times and estuary flushing conditions are influenced by a number of factors, an appropriate plan will need to be developed by the Towns and the regulatory agencies to monitor the effectiveness of the plan in meeting the TMDLs.
- Development of a flexible management approach that allows change based on the permitting and monitoring requirements identified above. As part of the WNMP it is anticipated that a cost effective approach to water quality improvement in the estuaries will be established, setting the framework of fiscally achievable goals with a long term plan (likely greater than 20 years) to work towards the TMDL compliance.

Chapter 4

Scenario Evaluation and Costs

CHAPTER 4

SCENARIO EVALUATION AND COSTS

4.1 INTRODUCTION

The purpose for developing the various alternative scenarios is to evaluate each alternative's ability to achieve sufficient nitrogen removal to restore the health of the estuaries. These alternative scenarios will then be modeled by MEP as discussed in Chapter 5; the findings will be used to develop recommended alternatives for additional evaluation as part of the Alternative Screening Analysis Report and development of the Draft and Final Watershed Nitrogen Management Plan and Environmental Impact Report. The purpose of this chapter is to compare the various scenarios presented in Chapter 3 and summarize the infrastructure needs and estimated order of magnitude costs. The Chapter also summarizes some of the advantages and disadvantages of each scenario.

Information developed as part of this chapter and the final results of the MEP modeling analysis will be used to formulate recommendations for more detailed scenarios development.

Although nitrogen comes from many sources, wastewater is the primary source and is also the most controllable. As a result, it was decided early on in the development of the scenarios that the entire nitrogen load to be removed would be achieved by addressing wastewater nitrogen. The Technology Screening Report discussed a variety of options to reduce the other sources of nitrogen. However, because of the variability in the concentration of nitrogen from non-wastewater sources and the difficulty in controlling the other sources, any reduction achieved by other nitrogen management alternatives will not be considered as part of this analysis. It is understood that the value of these additional reductions and their contributions in achieving a lower nitrogen load to the watershed will be considered as part of the development of any recommended plan. These additional nitrogen mitigation efforts will be part of adaptive management. The effectiveness of any recommendation will be determined through a monitoring program developed to validate the recommended plan's performance in achieving the goals of the TMDLs.

In order to compare the different scenarios, it is necessary to estimate sewer coverage area and the size of any additional treatment facilities. As discussed in Chapter 3, this was initially done on a planning zone level but then was refined by creating sewersheds. The total nitrogen loads that need to be removed for each watershed are based on the MEP technical reports and total nitrogen TMDLs. As the scenarios were developed and sewersheds were identified for sewering, the wastewater nitrogen load from each selected sewershed was subtracted from the total nitrogen identified to be removed. Sewersheds were connected to treatment facilities until the necessary amount of nitrogen was removed. Recharge from these facilities was then introduced at specific recharge sites within and outside of each watershed as shown in the flow charts presented in Chapter 3. Scenarios were then iteratively readjusted based on the impacts of recharge.

The following sections identify each Scenario as outlined in Chapter 3 and identifies the estimated infrastructure required for its implementation within the Project Planning Area. Sewer layouts as presented only represent a preliminary layout and approach; only after detailed surveys and pumping station site selection can a final layout be determined. All lengths are considered approximations and are provided for cost and scenario comparison purposes. All scenarios assumed the same lengths of gravity and pressure sewer within a particular sewershed. Force main lengths varied from scenario to scenario based on the location of sewersheds selected and on the WWTF and treated water recharge sites recommended.

4.2 SCENARIO 1 – EXISTING TREATMENT PLANTS PLUS CONSTRUCTION OF NEW TREATMENT PLANTS

This scenario is based on the premise that existing facilities continue to treat the existing flows and expand only to the planned build-out. Additional WWTFs are constructed as needed in order to achieve the necessary nitrogen reductions. This scenario assumes that Falmouth removes and treats the wastewater that originates in the Falmouth portion of the Waquoit Bay East watershed. It is assumed that the treated wastewater is recharged outside of the watershed, thereby eliminating recycling of the nitrogen. Falmouth properties were identified as being addressed under Falmouth's comprehensive wastewater management planning project which is currently ongoing.

Table 4-1 summarizes the infrastructure components of this scenario.

Under this scenario 62 sewersheds were identified for sewering. This equated to approximately 70 miles of gravity and 100 miles of low pressure collection sewers; an additional 40 miles of force mains are required to connect potential pumping stations to the proposed WWTFs and to connect these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 2, 4, 6, and 11 with new treated water recharge at sites 1, 2, 4, 7, and 11. The Falmouth treatment and recharge is not included in these sites. The scenario also includes approximately 380 properties on new I/A systems.

4.3 SCENARIO 2 – EXPANSION OF EXISTING TREATMENT FACILITIES

Many of the package treatment plants in the Project Planning Area have moderate to significant capacity available. The potential for expansion of each facility was considered for this scenario. Nearby sewersheds were assumed to be connected to an existing facility to the extent possible. This may require some of the WWTFs to expand for additional flow, but the excess flow was kept to moderate levels based on the availability and suitability of the site. The planned upgrade of the Mashpee Commons WWTF and the capacity of the existing sand beds (estimated at 300,000 gpd) made it seem more logical to continue using the existing site.

This scenario assumes that Falmouth removes and treats the wastewater that originates in the Falmouth portion of the Waquoit Bay East watershed. It is assumed that the treated wastewater is recharged outside of the watershed, thereby eliminating recycling of the nitrogen. Falmouth properties were identified as being addressed under Falmouth's comprehensive wastewater management planning project which is currently ongoing.

Table 4-2 summarizes the components of this scenario.

Under this scenario 61 sewersheds were identified for sewering. This scenario requires approximately 70 miles of gravity and 90 miles of low pressure collection sewers; 40 miles of force mains would be required to connect potential pumping stations to proposed WWTFs and to connect these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 2, 4, 6, and 11 with new treated water recharge at sites 2, 4, 7, and 11. The Falmouth treatment and recharge is not included in these sites. The scenario also includes approximately 50 properties on new I/A systems.

4.4 SCENARIO 4 – FAIR SHARE REDUCTION

The concept behind this scenario was developed as part of the Popponesset Bay Pilot Project (funded by MassDEP). As discussed previously, the idea is to consider the overall percentage of nitrogen that needs to be removed and have each town in the watershed remove that percentage of its contribution.

This scenario assumes that each town collects and treats its own wastewater. It is assumed that both Barnstable and Falmouth treat and recharge the treated water outside of the watersheds. Sandwich, which has areas contributing to both watersheds, is assumed to treat and recharge the necessary nitrogen within its town boundaries. All of the Mashpee wastewater that is treated at new WWTFs is recharged within the Popponesset Bay watershed (with the exception of the portion that can be sent to the recharge site outside of the watersheds).

As with the other scenarios, the effluent pipeline and discharge site outside of the watersheds was maximized to remove as much nitrogen as possible from the watersheds.

Table 4-3 summarizes the components of this scenario.

Under this scenario 58 sewersheds were identified for sewering. This equated to approximately 65 miles of gravity and 90 miles of low pressure collection sewers; an additional 35 miles of force mains would be required to connect potential pumping stations to proposed WWTFs and to connect these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 4, 6, and 11 with new treated water recharge at sites 4, 7, and 11. The scenario also includes approximately 130 properties on new I/A systems. Wastewater originating in Falmouth or Barnstable is anticipated to be treated and recharged outside of the Project Planning Area.

4.5 SCENARIO 5 – CENTRALIZED TREATMENT FACILITIES

For this scenario, all of the existing WWTFs primarily serve as large pumping stations that pump to a centralized WWTF in Mashpee. The scenario actually includes four main facilities – one in Sandwich at site 11 (0.15 mgd average annual flow), the main WWTF at Site 4 in Mashpee (1.5 mgd average annual flow), the continued use of New Seabury (0.2 mgd average annual flow) and a new facility in Falmouth that is proposed under their current facilities planning project.

As stated above, this scenario assumes that Falmouth removes and treats the wastewater that originates in the Falmouth portion of the Waquoit Bay East watershed. It is assumed that the treated wastewater is recharged outside of the watershed, thereby eliminating recycling of the nitrogen. Falmouth properties were identified as being addressed under Falmouth's comprehensive wastewater management planning project which is currently ongoing.

Table 4-4 summarizes the components of this scenario.

Under this scenario 61 sewersheds were identified for sewering. This equated to approximately 70 miles of gravity and 75 miles of low pressure collection sewers; 35 miles of force mains would be required to connect potential pumping stations to proposed WWTFs and to connect these WWTFs to treated water recharge sites. New WWTFs are identified at Sites 4 and 11 with new treated water recharge at sites 1, 4, 5, 7, and 11. The scenario also includes approximately 120 properties on new I/A systems. As discussed, an additional treatment and recharge facility outside of the Project Planning Area is used to treat Falmouth wastewater flows.

4.6 COST ANALYSIS

Table 4-5 presents a summary of the required infrastructure for each scenario. These infrastructure totals were used to develop costs in order to compare the four scenarios (1, 2, 4 and 5). Scenario 3 – Nitrex™ was evaluated by others and is presented in a document issued under a separate cover. For the purpose of the cost evaluations the term "scenario" will refer to costs developed for scenarios 1, 2, 4, and 5.

Because each scenario could conceivably use any number of technologies identified and recommended as part of the Technology Screening Report analysis, specific technologies were identified in this report so that preliminary (order of magnitude) costs could be developed. The intent of the cost comparison presented here is to be able to compare each of these initial scenarios that have been identified by the Sewer Commission for MEP analysis. This analysis is not intended to represent the final cost or selection of technologies; rather, it is to provide a common basis for evaluating Scenarios 1, 2, 4 and 5. The technologies used as the basis for this cost evaluation are as follows:

- Gravity and pressure (grinder pump) collection systems
- Sand infiltration and subsurface leaching facilities

- Sequencing Batch Reactors and denitrification filters for new facilities
- Allowance for process expansion and modification at existing facilities

The technologies selected are applied to each scenario equally. Therefore, it is the intent of this analysis that if vacuum or STEP sewer systems were used in place of pressure and gravity sewers that these changes would be made in all scenarios and the relative change would not impact the findings of the evaluation, only the bottom line costs. The same methodology is true for the consideration of other wastewater technologies in place of SBRs. The ultimate goal of the development of these scenarios is to achieve the total nitrogen TMDLs. If each scenario achieves the TMDLs following MEP modeling, then the relative cost comparisons will be used as a guide for refining and selecting new scenarios to be evaluated further. As developed, the costs are intended to provide a means of side by side comparison.

Additional detailed analysis and cost evaluations will be developed as these scenarios are refined and when a recommended technology is selected and approved by the Sewer Commission. The refined cost evaluations for future scenarios and ultimately the recommended plan will be based on those findings.

Estimated capital costs for each scenario (1, 2, 4 and 5) were developed for the following:

- Individual I/A system costs
- Upgrades to existing facilities
- Collection system costs
- New wastewater treatment facilities
- Treated water recharge facilities

Table 4-6 presents a breakdown of typical values used in development of these costs including both component-specific costs and general cost allowances. Because a detailed design will not be prepared until after the completion and approval of a Recommended Plan, typical costs are applied. The preliminary layouts of collection system allowed for a certain level of detail based on linear feet of pipe, number of pumping stations, etc. Data from the Barnstable County Health Department's report for Eastham, Massachusetts was used as a basis for individual system costs. Allowances were made for additional treatment required to achieve closer to 10 mg/L total nitrogen in the effluent; O&M costs were adjusted to account for additional sampling requirements expected to achieve TMDL compliance.

Wastewater treatment facility costs were based on similar projects and equipment cost quotes from equipment suppliers with allowances for site work, yard piping, electrical and instrumentation, general conditions, etc. Additional allowances were made for engineering, contingencies and fiscal and legal issues. Costs for the four scenarios did not include allowances for acquisition of private facilities, land, or easements.

Estimates were also made on operational and maintenance (O&M) costs that could be expected for each facility. O&M costs for existing facilities were only presented as "estimated additional" O&M costs that might be expected for a substantial upgrade to an existing system in order to generate a reasonable estimate of present worth. Table 4-6 presents a summary of values used in developing this analysis. Gravity system O&M is based on the gravity system only, and the O&M associated with the force mains and pumping stations is included in the force main O&M number. I/A system O&M cost estimates are based on allowances for electrical, maintenance, lab analyses and sludge pumping.

O&M costs are converted into present worth cost in order to calculate an estimated total present worth of each scenario. Present worth analysis is based on February 2008, with a discount rate of 4.875 percent based on U.S Department of Treasury rates effective for Water Resource Development Act. The rate was applied for a 20 year period using the equation for uniform series present worth.

Estimated total capital costs are presented for each scenario in Table 4-7.

It is important to identify that costs for implementation of any recommended plan will be incurred over an extended time period based on the magnitude of the problem and the economic impacts associated with such a solution. Project phasing and actual future growth will also impact costs. Therefore, the use of adaptive management to monitor cost and performance will be discussed in more depth as part of the recommended plan. The monitoring of the embayment systems, implementation of growth controls through land use and zoning, and implementation of best management practices for control of run-off and other non-wastewater nitrogen contributions will all aid in the management of wastewater and may provide for a reduction in sewering. As Towns are forced to achieve higher levels of treatment to achieve nitrogen removal, phosphorus removal, or other wastewater constituents, the costs will likely increase to provide these higher levels of treatment.

4.7 SUMMARY

Overall, each scenario was compared based on monetary and non-monetary considerations. Although final recommendations will not be made until the results of the MEP modeling (as identified in Chapter 5) are complete, each scenario is presented side by side in Table 4-8. This table presents both capital cost summaries and O&M summaries.

Based on the order of magnitude costs developed as part of this phase, Scenarios 4 and 5 appear to be more cost effective than Scenarios 1 and 2. Although the estimated costs for Falmouth's infrastructure are presented (collection systems and pumping stations), none of the scenarios present the estimated costs associated with Falmouth's wastewater treatment and recharge, as Falmouth is currently proceeding with their own facilities planning and that information has not been published. Also, under Scenario 4, the costs for Barnstable to manage its wastewater (treatment and recharge) have not been identified, although collection system costs are included. The Town of Barnstable is currently proceeding with their own Nutrient Management Planning for the western portions of the Town. Because no sites were identified within this portion of Cotuit, management of wastewater under this scenario would fall outside the Project Planning Area; therefore costs were not developed.

Although Scenario 5 has the second lowest capital cost, it would require the abandonment of much of the existing wastewater treatment infrastructure within Mashpee and would require a much larger centralized facility. This provides consolidation of facilities and would likely reduce operations and maintenance costs. However, it is unlikely that this option would be considered unless a phased approach is considered, in which there may be economic benefits to the phasing out of smaller facilities and bringing that flow to a larger centralized facility.

Scenario 1 has high relative costs due to the limited future use of the facilities and no anticipated improvement in performance over their current permit levels. This burdens a larger area with sewering and requires the creation of new, larger facilities to make up the balance. The advantage is that if the existing facilities remain private, the Town is not burdened with operation and maintenance of a large number of wastewater treatment facilities.

Scenarios 1, 2 and 5 would require the development of inter-municipal agreements or creation of a sewer district to manage wastewater between the Towns of Barnstable, Sandwich and Mashpee, whereas Scenario 4 allows each Town to manage wastewater within their individual borders. Town appropriations and approvals may be simplified; however, MassDEP has expressed an interest in Town's seeking regional approaches and there may be the opportunity in the future to seek greater funding or lower interest loans for those projects with regional solutions.

Table 4-9 presents a side by side comparison of some of the monetary and non-monetary considerations for each scenario.

Chapter 5

Scenario Modeling

CHAPTER 5

SCENARIO MODELING

5.1 INTRODUCTION

Each of the scenarios described in this report are to be modeled through the Massachusetts Estuaries Project (MEP). The goal of the modeling effort is to verify the ability of each alternative to meet the total nitrogen TMDLs for both Popponesset Bay and Waquoit Bay East estuaries.

The five scenarios to be modeled are:

- Scenario 1 – No expansion of existing wastewater treatment facilities
- Scenario 2 – Upgrade and expansion of existing facilities to a practical extent
- Scenario 3 – Nitrex™ decentralized approach (prepared and submitted separately by others)
- Scenario 4 – Fair Share
- Scenario 5 – Centralized approach

Results of the modeling efforts will then be used to prepare recommended scenarios for further evaluation and conceptual design. The scenarios evaluated in the next phase will either be carried over from those modeled as part of this phase of the project or will be a modification of the five scenarios listed above. Because four of the five scenarios (1, 2, 4, and 5) were developed with a singular approach to allow a reasonable side by side comparison individually, they may not represent the most efficient and cost effective means of achieving the goal of the total nitrogen TMDLs. The four scenarios described in this report are limited in their ability to take advantage of favorable characteristics present in each of the five scenarios. Scenario 4 allowed for the greatest level of combination of approaches (i.e. improving some of the existing WWTF's while leaving some facilities unchanged, etc.), and therefore allowed for a higher level of flexibility with respect to implementation.

The findings from the comparison of these five scenarios and the results of the MEP modeling efforts on the effectiveness of each approach will be used to identify and develop two to three scenarios for further evaluation in the next phase of the project. Modifications to any of the scenarios presented above will be based on the results of the MEP modeling efforts and selection of the most favorable components of each of the original five approaches.

5.2 COMPARISON OF SCENARIOS WITH MEP REQUIREMENTS

In order to determine which scenario will be selected for further evaluation, it first needs to be determined how well the scenarios achieve the necessary nitrogen removals. It is also important to consider the relative costs of each scenario.

When considering the amount of nitrogen that is removed in each scenario, it is important to make sure that the results obtained from the Scenarios Evaluation are comparable to the results from either the MEP or TMDL reports. The following items are noted about the MEP numbers and tables that were used:

- Table IV-5 was used from both MEP reports. This table includes all sources with the exception of benthic flux. The "Water Body Surface Area" includes atmospheric deposition on both pond surfaces and estuary surfaces.
- MEP values in Table IV-5 are expressed in kilograms per year.

The following items are noted about the TMDL numbers and tables that were used:

- Table 5 was used from both TMDL reports. The "Target Watershed Threshold Load" column includes all nitrogen sources except benthic flux and atmospheric deposition *on the estuary surface*. The "Atmospheric Deposition" column accounts for the deposition on estuary waterbody surfaces. All other atmospheric deposition is included in the target watershed threshold load.
- TMDL values are expressed as kilograms per day.
- The TMDL number is the summation of the Target Watershed Threshold Load, Atmospheric Deposition, and Benthic Flux.

The scenario evaluations determined the amount of attenuated nitrogen that would reach the estuaries if sewers are installed and the treated water is recharged at the locations (sites) proposed for each scenario. When treated water is recharged outside of a watershed, nitrogen is considered to be completely removed from the watershed. Conversely, if a WWTF treated and recharged water within watershed boundaries, the remaining nitrogen in the recharged water is considered to be recycled within the watershed. The amount of wastewater treated at a WWTF is estimated and an effluent concentration is based on using 3 mg/L nitrogen under the build-out (future) condition. The flow and concentration provided a mass of nitrogen that is reintroduced to a watershed. Any natural attenuation that would occur from the recharge site to the estuary is taken into consideration.

In order to verify that the proposed scenarios are expected to achieve the TMDL values, the MEP wastewater nitrogen loading rates by subwatershed were compared to the WNMP Needs Assessment Report values reported by subwatershed and the estimated future values for each scenario. The comparison of the values is shown on Tables 5-1. The MEP nitrogen loading rates are based on an estimated 25 percent nitrogen reduction via the soil absorption system. These rates are multiplied by an estimated attenuation factor for a subwatershed based on those used by MEP. The Needs Assessment Report values presented did not include the 25 percent soil absorption system reduction. This reduction was applied to the Needs Assessment Report loads, and the loads were then reduced further by the appropriate subwatershed attenuation factors. Comparison of the Needs Assessment Report and the MEP values indicate that they are in reasonable agreement. The attenuation factors used in the development of Table 5-1 are an approximation of the attenuation estimated by MEP. Use of the MEP “rainbow” spreadsheets as discussed in the next section allows the attenuation factors to be applied as done by MEP. Because the attenuation values in Table 5-1 are only approximated, values will vary slightly from those presented in subsequent tables based on the Rainbow Spreadsheets. Values in Table 5-1 are also rounded to two significant figures.

The wastewater nitrogen loads to each subwatershed were reduced by varying degrees based on the proposed scenarios. The loads to each subwatershed were estimated based on what action is proposed for the scenario. Generally, the loads that remain in the subwatersheds are what are expected to come from properties that remain on Title 5 septic systems and loads that are recharged from wastewater treatment facilities. The wastewater loads for each scenario are then compared to the allowable wastewater portion of the nitrogen TMDL as shown in Table 5-1, provided that no reduction is made in other controllable sources.

5.3 MEP MODELING SCENARIOS

Each scenario developed as part of this report has been evaluated based on existing information and estimated build-out conditions to determine under projected conditions the level of wastewater treatment required to achieve the existing total nitrogen TMDLs for Popponesset Bay and Waquoit Bay East. An estimate of each scenario's ability to meet these thresholds, based on wastewater flows and loadings, is calculated as part of this project. For the purpose of this evaluation, nitrogen is managed though wastewater treatment only. The allowable amount of total nitrogen that can reach each estuary is estimated based on the MEP technical reports and the established TMDLs, and therefore any nitrogen removed is addressed through the management of wastewater.

The analysis considered the future build-out condition of nitrogen load from wastewater and the nitrogen load that could be generated through the addition of new lawn, road, and roof areas. Although each scenario is based on a reasonable approximation of the conditions within the watershed, the MEP model runs will provide the determination of each scenario's ability to achieve the TMDLs at the sentinel station.

Because the TMDLs issued by MassDEP and the findings of the MEP technical reports on the estimated amount of existing septic load required to be removed within a watershed or subwatershed are identified as only one approach to achieving the necessary water quality improvement to restore these waterbodies, the recommendations presented in the five scenarios listed above may deviate from those presented by MEP and MassDEP; therefore, the modeling is a necessary step in verification of these approaches.

Based on discussions with the Cape Cod Commission (CCC) regarding the data inputs for the MEP modeling, nitrogen loading information was entered into the MEP "rainbow" spreadsheets (Table IV-5 from the MEP reports) developed for the technical reports on both Popponesset Bay and Waquoit Bay East. Copies of the "rainbow" spreadsheets are included in Appendix A. The majority of the data developed by the CCC and reported in their technical reports was left unchanged. The wastewater (septic and wastewater treatment facilities) nitrogen loads were changed from existing (2001) values to an estimate of the load proposed to remain within each watershed under build-out conditions for each scenario. In addition, a column was added representing the increase in load anticipated from future development. This increase is related to estimates for new roofs, lawns, and paved surfaces created under a build-out condition.

Each scenario is developed to achieve the appropriate amount of nitrogen removal for Popponesset Bay and Waquoit Bay East by estimating the allowable load that can reach the watershed. Once the allowable load is established, the remainder of that load including all future wastewater and controllable sources in addition to the amount of existing wastewater loads estimated by MEP to be removed is addressed through additional wastewater treatment. Because the sewersheds differ from the subwatershed boundaries, the MEP recommended removals differ from those developed for each scenario. In this case, some subwatersheds may indicate larger nitrogen removals than proposed under the approach reported by MEP and the TMDLs; conversely, there are subwatersheds where less wastewater nitrogen is proposed to be addressed than shown by MEP. In addition, the subwatershed removals were impacted by the fact that the scenarios are based on build-out conditions as opposed to the existing conditions modeled by MEP.

Table 5-2 presents a summary of nitrogen loads for Popponesset Bay – the total existing nitrogen loads (as presented by MEP), the estimated build-out wastewater load (as estimated for the Needs Assessment Report), the amount of wastewater nitrogen proposed to remain under each scenario, and the amount of additional load anticipated from other "controllable" sources under build-out conditions.

As part of the MEP technical reports, it was estimated that if 57 percent of the existing septic load was reduced in the watershed the total remaining wastewater load reaching the watershed would be 23.50 kg/day. As shown in Table 5-1, each scenario developed for this report is anticipated to achieve this goal. (Scenario 3 was developed by others and is not included in the summary.)

Table 5-3 presents a summary of nitrogen loads for Waquoit Bay East – the total existing nitrogen loads (as presented by MEP), the estimated build-out wastewater load (as estimated for the Needs Assessment Report), the amount of wastewater nitrogen proposed to remain under each scenario, and the amount of additional load anticipated from other "controllable" sources under build-out conditions.

As part of the MEP technical reports, it was estimated that if 75 percent of the existing septic load in the lower reaches of the watershed (Hamblin Pond, Jehu Pond, and Red Brook) and 67 percent of the existing septic load in the upper reaches of the watershed (Quashnet River) was reduced in the watershed the total remaining wastewater load reaching the watershed would be

7.19 kg/day. As shown in Table 5-2 each scenario developed for this report is anticipated to achieve this goal. Although Scenario 5 does not include a total load that is below the TMDL, modeling of this scenario will indicate with more accuracy if the anticipated load achieves the threshold concentration at the sentinel station.

Tables 5-4 through 5-11 show the modifications to the rainbow spreadsheets with the new estimated wastewater loads and other build-out controllable source loads. Four input columns in the rainbow spreadsheets are the same as presented in the MEP technical reports – lawn fertilizers, impervious surfaces, water body surface area, and natural surfaces. The build-out non-wastewater column was added to account for estimated increases in impervious surfaces resulting from build-out conditions. The column entitled "From Septic Systems" presents the estimated loads from septic systems (Title 5 and I/A) only. The values presented indicate the nitrogen concentration after attenuation through the soil absorption system. For example, a septic system, which is estimated to have an effluent nitrogen concentration of 35 mg/L prior to entering the soil absorption system is reduced by 25 percent to an estimated concentration of 26.25 mg/L after the soil absorption system. Nitrogen loads from treated water recharge occurring at existing and proposed WWTFs is presented in the "From WWTF" column.

The calculation methodology used by MEP in estimating the attenuated loads remained unchanged (formulas, attenuation factors, percent pond outflow, etc.). As a result, the modified rainbow spreadsheets are a useful tool in determining the efficacy of each scenario in removing the necessary amount of nitrogen.

The attenuated wastewater nitrogen loads were obtained using the rainbow spreadsheets. Tables 5-2 and 5-3 (as previously discussed) present summaries of all of the nitrogen sources for each watershed. The summation of the loads from the controllable sources and the atmospheric deposition equate to the attenuated future loads presented in Tables 5-4 through 5-11 (values presented in Tables 5-2 and 5-3 are in kg/day; values presented in Table 5-4 through 5-11 are in kg/year). Tables 5-2 and 5-3 present values that have been rounded to two significant figures, which is considered a reasonable estimate for planning analyses; MEP did not round to two significant figures.

While developing the modified spreadsheets, it was observed that there is an apparent discrepancy in calculation methodology for one portion of the Popponesset Bay system spreadsheet. This discrepancy has been discussed with the Cape Cod Commission and is being investigated. If the discrepancy results in a change in the calculations, a reduction in the number of sewersheds addressed is possible. A determination will be made prior to issuance of the Final Alternative Scenarios Report.

5.4 MEP MODELING RESULTS

At the time of issuing this draft the MEP modeling has not been performed on any of the scenarios presented here. The results of these modeling efforts will be reported in the Final version of this Report.

5.5 SUMMARY AND RECOMMENDATIONS

Recommendations for the scenarios to be carried forward in the next phase of the project will be identified following the completion of the MEP modeling efforts. This information will be used in the identification of additional scenarios to be evaluated for completion of the Alternatives Screening Analysis Report.

At the point where the final recommendation is developed, the phasing, implementation and monitoring plans will be developed. This will allow the Town(s) to focus their efforts on those areas of the PPA that are currently developed and producing wastewater nitrogen loads. As the Town moves through its implementation and monitoring schedule, water quality data, future developments and related capital improvements projects should be considered in the ultimate implementation schedule. These and other considerations will be discussed as part of the Draft and Final Recommended Plan and Environmental Impact Report.

At this point in the process we recommend proceeding with the following:

- Submit the draft report and necessary data to MEP so that each of the scenarios as currently drafted can be modeled to determine their effectiveness in achieving the nitrogen threshold concentrations and total nitrogen TMDLs.

- Begin field evaluations of Site 4 – Transfer Station. This site is a key component to each of the identified scenarios.
- Sewer Commission should review the remaining sites identified in the report and provide recommendations and guidance on which sites also should be considered for field evaluations. It is recommended at this time that field work at any additional sites not begin until MEP model results are received.

Tables

<u>TABLE 1-1</u>

PERCENT NITROGEN REMOVALS FROM SEPTIC SYSTEMS [1]

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

Notes:

1. Source: Table B-1 of *Final Popponesset Bay Total Maximum Daily Loads for Total Nitrogen*, April 10, 2006 and 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.
2. Based on *one of many* potential scenarios to achieve the target concentration.
3. Indicates a surface water source.
4. 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.

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			√		√
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.					

TABLE 1-3 (Needs Assessment Report TABLE 7-9)

SUMMARY OF TOTAL NITROGEN LOADS PER TOWN (1)

Town	Wastewater Nitrogen Load (kg/yr)		Non-Wastewater Nitrogen Load (kg/yr)		Total Nitrogen Load (kg/yr)		% Wastewater Nitrogen Load(2)	
	Existing	**Future**	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**
Mashpee								
Waquoit Bay East	14,000	29,000	5,600	5,900	20,000	35,000	70%	83%
Popponesset Bay	28,000	41,000	8,900	9,300	37,000	51,000	78%	82%
Other	9,000	16,000	1,800	1,900	11,000	18,000	82%	89%
Total	51,000	86,000	16,000	17,000	68,000	100,000	76%	87%
Falmouth								
Waquoit Bay East	3,200	5,800	800	1,000	4,100	6,800	78%	85%
Sandwich								
Waquoit Bay East	4,500	5,400	1,200	1,300	5,700	6,700	79%	81%
Popponesset Bay	12,000	14,000	2,300	2,500	14,000	16,000	86%	88%
Barnstable								
Popponesset Bay	5,700	8,500	1,200	1,300	7,000	9,800	81%	87%
PLANNING AREA TOTAL	76,000	120,000	22,000	23,000	99,000	140,000		

Notes:

1. The nitrogen loads presented in this table do not assume any natural attenuation. Wastewater nitrogen loads are based on septic system nitrogen concentrations of 35 mg/L. All numbers are rounded to two significant figures.
2. Percent of total nitrogen load that comes from wastewater sources.
3. Nitrogen loads were calculated as discussed in this chapter.

TABLE 1-4 (Needs Assessment Report TABLE 8-2)

SUMMARY OF NITROGEN LOADS BY PLANNING AREA

Priority Area	Wastewater Flow (gpd)		WW Nitrogen Load (kg/yr)		Non-Wastewater Nitrogen Load (kg/yr)		Total Nitrogen Load (kg/yr)	
	Existing	Future	Existing	Future	Existing	Future	Existing	Future
Mashpee								
M-1 Johns Pond	140,000	380,000	6,600	15,000	1,600	1,700	8,200	16,000
M-2 Mashpee Central	94,000	210,000	4,700	10,000	960	1,000	5,700	11,000
M-3 Shoestring Bay	150,000	240,000	7,800	12,000	2,000	2,200	9,700	14,000
M-4 Santuit Pond	110,000	140,000	5,100	6,900	1,100	1,500	6,200	8,300
M-5 Mashpee River	76,000	160,000	3,600	7,000	890	1,000	4,500	8,000
M-6 Jehu Pond	95,000	150,000	4,600	7,200	980	1,100	5,600	8,300
M-7 Popponesset Creek	57,000	83,000	2,800	4,000	490	520	3,300	4,500
M-8 Mashpee-Wakeby Pond	44,000	99,000	2,100	4,800	690	750	2,800	5,500
M-9 MMR	0	140	0	7	350	350	350	360
M-10 Mashpee East	20,000	45,000	880	1,200	250	260	1,100	1,500
M-11 Quashnet River	45,000	78,000	2,200	3,600	640	700	2,900	4,300
M-12 Mashpee South	25,000	42,000	1,200	2,100	480	500	1,700	2,600
M-13 New Seabury	190,000	380,000	9,100	18,000	2,100	2,200	11,000	20,000
TOTAL	1,000,000	2,000,000	51,000	92,000	13,000	14,000	63,000	104,000
Barnstable								
B-1 Barnstable Fresh Water	0	560	30	30	30	30	30	60
B-2 Shoestring Bay	110,000	140,000	5,400	6,700	1,000	1,100	6,400	7,800
B-3 Pinquickset Cove	5,100	9,300	250	450	150	160	400	620
B-4 Popponesset Bay	3,900	5,900	190	290	80	85	270	370
TOTAL	120,000	160,000	5,900	7,500	1,300	1,400	7,100	8,900
Sandwich								
S-1 Sandwich West	48,000	61,000	2,300	3,000	750	800	3,100	3,700
S-2 J Well	19,000	22,000	920	1,100	170	180	1,100	1,300
S-3 Snake Pond	2,700	3,600	130	170	40	40	170	220
S-4 Sandwich Quashnet	22,000	25,000	1,100	1,200	190	190	1,300	1,400
S-5 Sandwich Popponesset	240,000	280,000	12,000	14,000	3,300	3,500	15,000	17,000
TOTAL	330,000	390,000	16,000	19,000	4,500	4,700	21,000	24,000
Falmouth								
F-1 Red Brook	23,000	58,000	1,100	2,800	310	380	1,400	3,200
F-2 Falmouth Quashnet	42,000	59,000	2,000	2,900	310	390	2,400	3,300
F-3 Falmouth North	1,700	1,700	80	80	30	30	120	120
TOTAL	67,000	120,000	3,200	5,800	670	800	3,900	6,600
PLANNING AREA TOTAL	1,500,000	2,700,000	76,000	120,000	19,000	21,000	95,000	140,000

TABLE 2-1

PRELIMINARY SITE CAPACITIES

Site Name and Discharge Technology Type	Total Property Area (acres)[1]	Total Available Area (ft^2)	Total Available Area (acres)[2]	Application Area (ft^2)	Application Area (acres)[3]	Potential Max Month Flow (mgd)[4]
Heritage Park Ball Fields Subsurface Facilities	26	600,000	14	540,000	12	1.0
Ashumet Road Sand Beds	19	370,000	8.4	200,000	4.5	1.0
Wampanoag Rod & Gun Club Sand Beds	33	730,000	17	390,000	8.9	1.9
Old Town Dump Sand Beds	6.2	100,000	2.3	53,000	1.2	0.3
Transfer Station Sand Beds	10	290,000	6.7	160,000	3.6	0.8
NStar Substation Sand Beds	10	140,000	3.3	80,000	1.8	0.4
High School Ball Fields Subsurface Facilities		770,000	18	690,000	16	1.3
Clipper Ship Village Sand Beds	2.7	8,800	0.2	4,700	0.1	0.02
Wading Place Road Sand Beds	6.4	110,000	2.4	57,000	1.3	0.3
Keeter Property Sand Beds	6.3	360,000	8.4	190,000	4.5	1.0
Bartlett Property Sand Beds	10	74,000	1.7	39,000	0.9	0.2
New Seabury Country Club[5] Subsurface Facilities		290,000	6.6	260,000	5.9	0.5

Notes:

1. From property maps provided by Town
2. For open sand beds, this is based on 100' undisturbed buffer area from property line and further 20% allowance for internal berms and access roads.

   For subsurface leaching, this is based on 50' undisturbed buffer area from property line and/or 50' cleared area for road access and pipe routing, and further 10% allowance for internal pipe routing.
3. Application area for open sand beds does not include the reserve area allowance in the available area. The reserve area is 50% of the application area; therefore, the application area is 0.667 times the available area.

   Leaching area for subsurface trenches is the 2' high side walls and 2' wide trench bottom. This provides 6 square feet per linear foot of trench. The trenches are 8' on center to provide 100% reserve area between trenches within the available area. Application area for subsurface leaching is the available area minus buffer and pipe routing areas.
4. For sand beds, this is based on 5 gpd/sf of application area.

   For subsurface leaching, this is based on 2.5 gpd/sf application area. This equals 15 gpd per linear foot of trench and 1.875 gpd/sf of available area.
5. Only 50' buffer area used on this site because site is already cleared/developed.
6. All values rounded to two significant figures.

TABLE 2-2

SELECTED SITES' CAPACITIES

Site Name and Discharge Technology Type	Total Property Area (acres)[1]	Total Available Area (ft^2)	Total Available Area (acres)[2]	Application Area (ft^2)[3]	Application Area (acres)[3]	Potential Max Month Flow (mgd)[4]
Heritage Park Ball Fields Subsurface Facilities	26	600,000	14	540,000	12	1.0
Ashumet Road Sand Beds	19	370,000	8.4	200,000	4.5	1.0
Old Town Dump Sand Beds	6.2	100,000	2.3	53,360	1.2	0.3
Transfer Station Sand Beds	10.4	290,000	6.7	160,000	3.6	0.8
High School Ball Fields Subsurface Facilities		770,000	18	690,000	16	1.3
Keeter Property Sand Beds	6.3	360,000	8.4	190,000	4.5	1.0
New Seabury Country Club[5] Subsurface Facilities		290,000	6.6	260,000	5.9	0.5

Note:
1. All figures rounded to two significant figures

TABLE 2-3

PRELIMINARY SITE IDENTIFICATION

Site ID	Description	Map Parcel	Town	Area [2] (acres)	Owner Type	Availability of Land [3]	Existing Land Use	Estimated Soil Type [4]	Estimated Site Access	Abutting Land Use [5]	Sensitive Receptors					Watershed			Potential Aesthetic Impacts (visual, noise, odors)	
											In ACEC	Contains Estimated and Priority Habitats	Contains Wetlands	In Groundwater Protection District	In ZoneII	Name	MEP Removal Requirement (%) [6]	Attenuation	Low; Moderate; High	Historic District
1	Heritage Park Ballfields	27-25	Mashpee	27	Town	Available	Open/Playing Field	Silt Loam	Available	Res/Com	No	Yes	No	Yes	Partially	Mashpee River	41%	Yes	High	No
2	Ashumet Road	26-10	Mashpee	19	Town	Available	Open Space	Silt Loam	Available	Res/Inst	No	Yes	No	Yes	Yes	Quashnet River	67%	No	Moderate	No
3	Old Town Dump	36-39	Mashpee	6	Town	Available	Open Space	Sand	Limited	Res/Com	No	No	No	No	Yes	Mashpee River	41%	Yes	Low	No
4	Transfer Station	61-3	Mashpee	53	Town	Available	Open Space	Loamy Sand	Available	Res	No	No	No	Yes	No	Mashpee River	41%	Yes	High	No
5	High School Ballfields	73-45	Mashpee	135	Town	Available	Open/Playing Field	Loamy Sand	Available	Res/Inst	No	Yes	No	Yes	Yes	Quashnet River	67%	No	High	No
6	Keeter Property	104-2	Mashpee	28	Town	Available	Open Space	Sand	Available	Res	No	Yes	No	Yes	Yes	Ockway Bay	100%	No	Low	No
7	New Seabury Country Club	127-17	Mashpee	16	Private [8]	Not	Golf Course	Sand	Available	Res/Inst	No	Yes	Yes	No	No	No Watershed	0%	No	High	No
8	Great Neck South	95-5,6	Mashpee	57	Conservation	Not	Open Space	Sand	Available	Res, Inst	No	No	No	No	No	Mashpee River (Lower)	100%	No	Low	No
9	Great Hay Road [1]	34-9,10,11	Mashpee	55	Town	Available	Open Space	Loamy Sand	Limited	Res, Inst	No	Yes	No	Yes	Yes	Mashpee River, Quashnet River	67%	No	Low	No
10	72 Cotuit Rd - Sandwich	8-198	Sandwich	106	Conservation	Not	Open Space	Silt Loam	Available	Res, Inst, Agr	No	Yes	No	X [7]	No	Santuit Pond	0%	Yes	Low	No
11	168 Route 130 - Sandwich	17-130	Sandwich	117	Conservation	Potentially	Open Space	Silt Loam	Available	Res, Com, Inst	No	Partially	No	X	Yes	Peter's Pond	0%	Yes	Low	No
12	Bartlett Property	94-3	Mashpee	10	Town	Available	Open Space	Coarse Sand; Sandy Loam	Limited	Conservation	No	Partially	Partially	Partially	Partially	Ockway Bay	100%	No	Low	No
13	Adjacent to HS	79-17	Mashpee	60	Town	Available	Open Space	Sandy Loam	Available	Inst, Res	No	Yes	Yes	Yes	Yes	Quashnet River	67%	No	Low	No

Notes:

1. Multiple lots associated with these sites
2. Estimated based on GIS information
3. Land Availability is based on the type of owner of the property
4. Soil Type based on MassGIS data and the Barnstable County Soil Survey
5. Abutting Land Use:
   - Residential (Res)
   - Commercial (Com)
   - Institutional (Inst) - Municipal, State, Federal, not for profit, etc.
   - Agricultural (Agr)
6. Sites located in multiple watersheds assumes most restrictive nitrogen removal requirement
7. Groundwater Protection Districts are for Mashpee only
8. The New Seabury Country Club is privately owned; however, the Town has indicated that use of this site may be a feasible alternative

TABLE 2-4

PRELIMINARY SITE SCREENING ANALYSIS [1]

Site ID	Description	Map - Parcel	Town	Owner Type	Availability of land	Soil Type	Estimated Site Access	Abutting Land Use	Sensitive Receptors					Watershed			Potential aesthetic impacts (visual, noise, odors)	Historic District/Site	Total Score [2]	Screening Rank
Mashpee Sites						Estimated			In ACEC	Contains Estimated and Priority Habitats	Contains Wetlands	In Water Protection District	In Zone II	Name	MEP Nitrogen Removal Requirement	Attenuation				
3	Old Town Dump	36-39	Mashpee	0	0	0	5	5	0	0	0	0	10	Mashpee River	20	0	1	0	41	1
4	Transfer Station	61-3	Mashpee	0	0	0	0	10	0	0	0	10	0	Mashpee River	20	0	3	0	43	2
5	High School Ballfields	73-45	Mashpee	0	0	0	0	5	0	10	0	10	10	Quashnet River	10	0	3	0	48	3
8	Great Neck South	95-5,6	Mashpee	5	10	0	0	5	0	0	0	0	0	Mashpee River	20	10	1	0	51	4
2	Ashumet Road	26-10	Mashpee	0	0	5	0	5	0	10	0	10	10	Quashnet River	10	0	2	0	52	5
12	Bartlett Property		Mashpee	0	0	0	5	0	0	5	5	5	5	Ockway Bay	20	10	1	0	56	6
1	Heritage Park Ballfields	27-25	Mashpee	0	0	5	0	5	0	10	0	10	5	Mashpee River	20	0	3	0	58	7
7	New Seabury Country Club	127-17	Mashpee	10	10	0	0	5	0	10	10	0	0	No Watershed	0	10	3	0	58	8
13	Adjacent to HS		Mashpee	0	0	5	0	5	0	10	10	10	10	Quashnet River	10	0	1	0	61	9
9	Great Hay Road	34-9,10,11	Mashpee	0	0	0	5	5	0	10	0	10	10	Mashpee River, Quashnet River	10	10	1	0	61	9
6	Keeter Property	104-2	Mashpee	0	0	0	0	10	0	10	0	10	10	Ockway Bay	20	10	1	0	71	11
Sandwich Sites																				
11	168 Route 130 - Sandwich	17-130	Sandwich	5	5	5	0	5	0	5	0	0	10	Peter's Pond	10	0	1	0	46	1
10	72 Cotuit Rd - Sandwich	8-198	Sandwich	5	10	5	0	5	0	10	0	0	0	Santuit Pond	10	0	1	0	46	1

Notes:

1. Relative ranking based on estimated or known conditions; used for preliminary screening purposes.
2. Total score is the sum of screening values assigned to each category.

RATINGS LEGEND	(The lower the number, the more favorable the rating)
CATEGORY	
Owner Type	Town = 0; Conservation = 5; Private = 10
Estimated Availability of Land	Available = 0; Potential= 5, Not Available = 10
Estimated Soil Type	Good (Sand and Loamy Sand) = 0; Moderate (Sands and Silty Loam) = 5; Poor (Silt or Clay) = 10
Estimated Site Access	Available = 0; Limited = 5, None = 10
Typical Abutting Land Use	All Town = 0; Multiple uses =5; All residential =10
In ACEC	Yes = 10; Partially = 5; No = 0
Priority Habitats	Yes = 10; Partially = 5; No = 0
Wetlands	Yes = 10; Partially = 5; No = 0
In Zone II	Yes = 10; Partially = 5; No = 0
Water Protection District (WPD)	Yes = 10; Partially = 5; No = 0
MEP Nitrogen Removal Requirement (based on MEP septic load reduction %)	0% = 0; 1%-49% = 5; 50%-89% = 10; >90% = 20
Attenuation	Yes = 0; No = 10
Potential Aesthetic Impacts	Low = 1; Medium = 2; High = 3
Historic District or Site	Yes = 10; No = 0

TABLE 3-1

SUMMARY OF PROJECT PLANNING AREA ESTIMATED
FLOWS AND NITROGEN LOADS

Location	Wastewater Generating Parcels	Build-out Wastewater Flow (mgd)
Popponesset Bay		
Mashpee	4,200	1.2
Barnstable	790	0.18
Sandwich	1,600	0.28
Falmouth	No Contribution	
Total	**6,600**	**1.7**
Waquoit Bay East		
Mashpee	2,200	0.65
Barnstable	No Contribution	
Sandwich	530	0.11
Falmouth	530	0.12
Total	**3,300**	**0.88**
Outside Watersheds		
Mashpee	1,500	0.31
Barnstable	No Contribution	
Sandwich		
Falmouth		
Total	**1,500**	**0.31**
Project Planning Area Total		
Mashpee	7,900	2.2
Barnstable	790	0.18
Sandwich	2,100	0.39
Falmouth	530	0.12
Total	**11,000**	**2.9**

Notes:
(1) Values rounded to two significant figures.

TABLE 3-2

ESTIMATED NUMBER OF PROPERTIES SERVED UNDER EACH SCENARIO
(1, 2, 4 AND 5)

Location	Total Wastewater Flow Addressed (mgd)	Number of Sewersheds Served	Number of Properties Served by Sewer	Number of Properties Served by I/A Systems
Scenario 1				
Mashpee	1.9	45	5,700	347
Barnstable	0.11	4	570	
Sandwich	0.30	6	1,300	28
Falmouth	0.10	17	530	
Total	2.4	72	8,100	375
Scenario 2				
Mashpee	1.7	41	5,500	36
Barnstable	0.11	4	570	
Sandwich	0.22	5	1,100	16
Falmouth	0.10	17	530	
Total	2.1	67	7,700	52
Scenario 4				
Mashpee	1.7	41	5,500	130
Barnstable	0.09	3	300	
Sandwich	0.27	6	1,300	
Falmouth	0.09	15	480	
Total	2.1	65	7,700	130
Scenario 5				
Mashpee	1.5	37	5,300	111
Barnstable	0.11	4	570	
Sandwich	0.15	3	700	12
Falmouth	0.10	17	530	
Total	1.9	61	7,100	123

Notes:

(1) Values rounded to two significant figures.

(2) Includes build-out flows from existing WWTFs, which is approximately 0.5 mgd.

<u>TABLE 3-3</u>

SUMMARY OF WASTEWATER TREATMENT AND RECHARGE

		Scenario 1		Scenario 2		Scenario 4		Scenario 5	
Facility Name/Location	**Permitted Flow (existing facilities)**	**Average Annual (gpd)**	**Maximum Month (gpd)**	**Average Annual (gpd)**	**Maximum Month (gpd)**	**Average Annual (gpd)**	**Maximum Month (gpd)**	**Average Annual (gpd)**	**Maximum Month (gpd)**
Wastewater Treatment Facilities									
Southport	172,000	110,000	140,000	260,000	330,000	130,000	170,000	-	-
High School	18,000	4,000	5,000	110,000	150,000	160,000	230,000	-	-
Windchime Point	40,000	22,000	31,000	22,000	31,000	22,000	30,000	-	-
Willowbend	113,000	60,000	108,000	105,000	188,000	60,000	110,000	-	-
New Seabury	300,000	180,000	250,000	210,000	300,000	200,000	280,000	200,000	280,000
Forestdale School	20,000	1,000	2,100	1,000	2,100	1,000	2,100	-	-
South Cape Village	24,000	16,000	18,000	16,000	18,000	16,000	20,000	-	-
Stratford Ponds	35,500	21,000	27,000	21,000	27,000	21,000	30,000	-	-
Mashpee Commons (upgrading to MBR)	180,000	120,000	180,000	270,000	400,000	230,000	350,000	-	-
Falmouth	-	100,000	150,000	100,000	150,000	94,000	140,000	100,000	150,000
Barnstable	-	-	-	-	-	93,000	140,000	-	-
Site 2	-	470,000	690,000	290,000	430,000	-	-	-	-
Site 4	-	810,000	1,190,000	390,000	580,000	690,000	1,000,000	1,500,000	2,200,000
Site 6	-	200,000	290,000	100,000	150,000	130,000	200,000	-	-
Site 11	-	260,000	390,000	220,000	330,000	270,000	400,000	150,000	220,000
Total Treated	**-**	**2,400,000**	**3,500,000**	**2,100,000**	**3,100,000**	**2,100,000**	**3,100,000**	**2,000,000**	**2,900,000**
Treated Water Recharge Sites	**Estimated Capacity**								
Site 1 (subsurface)	640,000	340,000	495,000	-	-	-	-	200,000	880,000
Site 2 (sand)	1,700,000	130,000	198,000	290,000	430,000	-	-	-	-
Site 4 (sand)	1,200,000	810,000	1,190,000	390,000	580,000	690,000	1,000,000	1,000,000	1,000,000
Site 5 (subsurface)	470,000	-	-	-	-	-	-	66,000	97,000
Site 7 (subsurface)	250,000	200,000	290,000	100,000	150,000	130,000	200,000	200,000	200,000
Site 11 (sand)	1,200,000	260,000	390,000	220,000	330,000	270,000	400,000	150,000	220,000
Falmouth	-	100,000	150,000	100,000	150,000	94,000	140,000	100,000	150,000
Barnstable	-	-	-	-	-	93,000	140,000	-	-
Southport	170,000	110,000	140,000	260,000	330,000	130,000	170,000	-	-
High School	20,000	3,500	5,000	110,000	150,000	160,000	230,000	-	-
Windchime Point	40,000	22,000	31,000	22,000	31,000	22,000	30,000	-	-
Willowbend	110,000	60,000	110,000	100,000	190,000	60,000	110,000	-	-
New Seabury	300,000	180,000	250,000	210,000	300,000	200,000	280,000	200,000	280,000
South Cape Village	20,000	16,000	18,000	16,000	18,000	16,000	18,000	-	-
Stratford Ponds	40,000	21,000	27,000	21,000	27,000	21,000	27,000	-	-
Mashpee Commons (upgrading to MBR)	180,000	120,000	180,000	270,000	400,000	230,000	350,000	-	-
Total Recharged	**-**	**2,400,000**	**3,500,000**	**2,100,000**	**3,100,000**	**2,100,000**	**3,100,000**	**1,900,000**	**2,800,000**

TABLE 3-4

EXISTING WWTF DESIGN LIFE AND PERMIT EXPIRATION YEARS

WWTF	Estimated Design Life Year	Year GWDP Expires (1)
Southport	2017	2011
Mashpee Commons	2010 (2)	2009
Willowbend	2013	2008
Mashpee High School	2015	2012
New Seabury	2020	2006

Notes:
(1) Based on MassDEP information as updated in January 2008.
(2) Mashpee Commons is planning an upgrade to the facility in 2008.

TABLE 4-1

SCENARIO 1 INFRASTRUCTURE SUMMARY

Sewershed	Wastewater Flows (gpd)		Pipe length(ft)	Pumping Stations	Gravity Sewer (lf)	Pressure Sewer (lf)	Properties on Gravity Sewer	Properties on Pressure Sewer	Force Main Length (lf)
	Existing	Future							
1	15,000	43,400	5,700	1	5,700	0	116	0	3,300
6	9,700	11,000	4,500	1	2,500	1,900	42	5	1,000
8	1,200	1,800	3,100	1	3,100	0	16	0	12,000
9	10,000	12,000	5,000	1	4,400	600	101	10	3,000
14	15,000	16,000	6,400	1	6,400	0	113	0	700
18	13,000	73,000	9,500	1	3,400	6,200	1	8	4,500
22	10,000	13,000	5,500	1	5,500	0	102	0	5,000
24	5,000	6,000	3,600	1	3,600	0	75	0	2,100
25	6,000	8,000	3,400	1	3,400	0	54	0	3,100
26	18,000	20,000	5,400	1	5,400	0	81	0	13,000
28	13,000	16,000	9,200	1	8,500	700	136	10	1,100
29	4,000	5,000	14,000	1	4,900	9,500	69	41	1,100
30	10,000	12,000	1,900	1	1,900	0	34	0	1,500
31	10,000	12,000	6,600	1	4,300	2,400	69	14	800
32	2,000	3,000	4,800	1	4,300	400	80	1	3,800
37(Barnstable)	12,000	12,000	2,400	1	2,400	0	25	0	2,700
38(Barnstable)	47,000	47,000	5,600	1	3,900	1,700	51	11	3,300
39(Barnstable)	20,000	20,000	46,000	1	8,700	37,000	68	193	1,900
40	46,000	110,000	15,000	1	11,000	3,600	101	21	3,400
41	24,000	27,000	17,000	1	8,700	8,300	62	14	4,600
21	14,000	14,000	24,000	1	11,000	13,000	105	110	2,000
42(Barnstable)	35,000	35,000	42,000	1	2,800	39,000	40	179	4,300
43	9,000	9,000	5,900	1	5,900	0	94	0	700
44	31,000	77,000	22,000	1	6,700	16,000	40	35	5,500
45	8,000	14,000	13,000	1	7,200	5,600	60	34	2,300
47	14,000	23,000	10,500	1	8,800	1,600	81	34	5,500
49	18,000	27,000	22,000	1	8,800	13,000	71	61	700
50	66,000	83,000	57,000	1	20,000	37,000	272	189	5,700
51	12,000	18,000	6,600	1	6,600	0	86	0	1,600
52	9,000	12,000	11,000	1	6,000	4,600	63	28	100
53	28,000	38,000	26,000	1	13,000	13,000	164	80	2,000
54	57,000	140,000	17,000	1	7,200	9,300	57	194	4,700
57	7,000	8,000	4,600	1	4,600	0	87	0	2,800
58	8,000	10,000	6,000	0	6,000	0	65	0	2,500
63	29,000	32,000	14,000	1	9,000	4,800	150	13	4,100
64	23,000	31,000	19,000	1	12,000	6,400	139	24	4,200
65	41,000	45,000	32,000	1	16,000	16,000	217	113	1,000
67	24,000	24,000	16,400	1	11,000	5,300	152	36	7,100
68	22,000	26,000	23,000	1	7,700	16,000	137	100	1,800
69	29,000	52,000	31,000	1	12,000	19,000	197	106	4,200
70	15,000	16,000	11,000	1	6,700	4,400	91	34	5,400
71	21,000	25,000	14,000	1	11,000	3,400	140	25	5,200
72	24,000	31,000	26,000	1	4,400	21,000	48	90	2,900
73	35,000	65,000	34,000	1	5,100	29,000	54	127	4,000
74	38,000	74,000	29,000	1	18,000	11,000	167	64	4,200
75	12,000	18,000	16,000	1	3,900	12,000	36	68	2,200
Fal 1	6,500	6,200	3,400	1	2,000	1,300	15	14	1,200
Fal 10	4,600	3,800	1,700	1	1,700	0	22	0	2,300
Fal 11	3,800	2,800	930	1	900	0	16	0	1,100
Fal 12	3,400	3,400	2,000	1	2,000	0	20	0	2,200
Fal 13	7,900	9,300	4,500	1	2,400	2,200	27	25	2,400
Fal 14	3,800	3,600	1,600	1	1,600	0	13	0	1,400
Fal 15	9,000	11,000	6,300	1	3,300	3,100	31	20	1,100
Fal 16	7,700	7,000	2,300	1	2,300	0	26	0	3,000
Fal 17	9,000	17,000	10,000	1	6,900	3,500	49	36	0
Fal 2	6,100	7,800	3,200	1	3,200	0	45	0	1,400
Fal 3	3,400	4,100	1,900	1	1,900	0	24	0	1,100
Fal 4	2,300	4,100	1,300	1	1,300	0	24	0	1,200
Fal 5	2,400	3,100	1,300	1	1,300	0	18	0	1,500
Fal 6	3,900	4,900	1,900	1	1,900	0	27	0	700
Fal 7	1,800	3,200	1,400	1	1,400	0	17	0	800
Fal 8	1,800	2,600	1,100	1	1,100	0	13	0	1,400
Fal 9	5,900	8,700	4,300	1	4,300	0	48	0	700
Sand 2	34,000	41,000	17,000	0	0	17,000	0	191	600
Sand 3	27,000	35,000	13,000	0	0	13,000	0	159	1,800
Sand 4	47,000	61,000	30,000	0	0	30,000	0	314	5,000
Sand 5	48,000	55,000	25,000	0	0	25,000	0	264	3,500
Sand 6	29,000	31,000	14,000	0	0	14,000	0	138	4,300
Sand 7	26,000	39,000	20,000	0	0	20,000	0	42	3,800
Sand 9	33,000	36,000	22,000	0	0	22,000	0	206	2,400
Mashpee Total	810,000	1,300,000	610,000	41	320,000	300,000	4,000	1,700	150,000
Barnstable Total	110,000	110,000	96,000	4	18,000	78,000	180	380	12,000
Sandwich Total	240,000	300,000	140,000	0	0	140,000	0	1,310	21,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,200,000**	**1,800,000**	**900,000**	**62**	**380,000**	**530,000**	**4,600**	**3,500**	**210,000**

TABLE 4-2

SCENARIO 2 INFRASTRUCTURE SUMMARY

Sewershed	Wastewater Flows (gpd)		Pipe length(ft)	Pumping Stations	Gravity Sewer (lf)	Pressure Sewer (lf)	Properties on Gravity Sewer	Properties on Pressure Sewer	Force Main Length (lf)
	Existing	Future							
1	15,000	43,000	5,700	1	5,700	0	120	0	3,300
6	9,700	11,000	4,500	1	2,500	1,900	42	5	1,000
8	1,200	1,800	3,100	1	3,100	0	16	0	12,000
9	10,000	12,000	5,000	1	4,400	570	100	10	3,000
14	15,000	16,000	6,400	1	6,400	0	110	0	700
18	13,000	73,000	9,500	1	3,400	6,200	1	8	2,800
22	10,000	13,000	5,500	1	5,500	0	100	0	5,000
24	4,900	5,700	3,600	1	3,600	0	75	0	2,100
25	5,900	7,900	3,400	1	3,400	0	54	0	3,100
26	18,000	20,000	5,400	1	5,400	0	81	0	13,000
28	13,000	16,000	9,200	1	8,500	720	140	10	1,100
29	3,600	4,800	14,000	1	4,900	9,500	69	41	1,000
30	9,600	12,000	1,900	1	1,900	0	34	0	1,500
31	10,000	12,000	6,600	1	4,300	2,400	69	14	800
32	2,400	3,000	4,800	1	4,300	410	80	1	3,800
37 (Barnstable)	12,000	12,000	2,400	1	2,400	0	25	0	7,100
38 (Barnstable)	47,000	47,000	5,600	1	3,900	1,700	51	11	3,300
39 (Barnstable)	20,000	20,000	46,000	1	8,700	37,000	68	190	1,900
40	46,000	110,000	15,000	1	11,000	3,600	100	21	3,400
41	24,000	27,000	17,000	1	8,700	8,300	62	14	4,600
21	14,000	14,000	24,000	1	11,000	13,000	110	110	4,500
42 (Barnstable)	35,000	35,000	42,000	1	2,800	39,000	40	180	4,300
43	8,600	9,300	5,900	1	5,900	0	94	0	700
44	31,000	77,000	22,000	1	6,700	16,000	40	35	4,900
45	7,700	14,000	13,000	1	7,200	5,600	60	34	2,300
47	14,000	23,000	10,000	1	8,800	1,600	81	34	5,900
49	18,000	27,000	22,000	1	8,800	13,000	71	61	700
50	66,000	83,000	57,000	1	20,000	37,000	270	190	5,700
51	12,000	18,000	6,600	1	6,600	0	86	0	11,000
52	9,000	12,000	11,000	1	6,000	4,600	63	28	3,300
53	28,000	38,000	26,000	1	13,000	13,000	160	80	2,000
54	57,000	140,000	17,000	1	7,200	9,300	57	190	4,700
57	7,100	7,700	4,600	1	4,600	0	87	0	2,800
58	8,300	10,000	6,000	0	6,000	0	65	0	2,500
64	23,000	31,000	19,000	1	12,000	6,400	140	24	6,100
65	41,000	45,000	32,000	1	16,000	16,000	220	110	1,000
67	24,000	24,000	16,000	1	11,000	5,300	150	36	2,800
68	22,000	26,000	23,000	1	7,700	16,000	140	100	3,100
69	29,000	52,000	31,000	1	12,000	19,000	200	110	14,000
70	15,000	16,000	11,000	1	6,700	4,400	91	34	5,400
71	21,000	25,000	14,000	1	11,000	3,400	140	25	5,200
72	24,000	31,000	26,000	1	4,400	21,000	48	90	2,900
73	35,000	65,000	34,000	1	5,100	29,000	54	130	3,900
74	38,000	74,000	29,000	1	18,000	11,000	170	64	4,200
75	12,000	18,000	16,000	1	3,900	12,000	36	68	2,400
Fal 1	6,500	6,200	3,400	1	2,000	1,000	15	14	1,200
Fal 10	4,600	3,800	1,700	1	1,700	0	22	0	2,300
Fal 11	3,800	2,800	900	1	930	0	16	0	1,100
Fal 12	3,400	3,400	2,000	1	2,000	0	20	0	2,200
Fal 13	7,900	9,300	4,500	1	2,400	2,200	27	25	2,400
Fal 14	3,800	3,600	1,600	1	1,600	0	13	0	1,400
Fal 15	8,500	11,000	6,300	1	3,300	3,100	31	20	1,100
Fal 16	7,700	7,000	2,300	1	2,300	0	26	0	3,000
Fal 17	8,800	17,000	10,000	1	6,900	3,500	49	36	0
Fal 2	6,100	7,800	3,200	1	3,200	0	45	0	1,400
Fal 3	3,400	4,100	1,900	1	1,900	0	24	0	1,100
Fal 4	2,300	4,100	1,300	1	1,300	0	24	0	1,200
Fal 5	2,400	3,100	1,300	1	1,300	0	18	0	1,500
Fal 6	3,900	4,900	1,900	1	1,900	0	27	0	700
Fal 7	1,800	3,200	1,400	1	1,400	0	17	0	800
Fal 8	1,800	2,600	1,100	1	1,100	0	13	0	1,400
Fal 9	5,900	8,700	4,300	1	4,300	0	48	0	700
Sand 1	27,000	30,000	12,000	0	0	12,000	0	150	2,600
Sand 2	34,000	41,000	17,000	0	0	17,000	0	190	600
Sand 3	27,000	35,000	13,000	0	0	13,000	0	160	1,800
Sand 4	47,000	61,000	30,000	0	0	30,000	0	310	3,900
Sand 5	48,000	55,000	25,000	0	0	25,000	0	260	5,800
Mashpee Total	780,000	1,300,000	600,000	40	310,000	290,000	3,900	1,700	160,000
Barnstable Total	110,000	110,000	96,000	4	18,000	78,000	180	380	17,000
Sandwich Total	180,000	220,000	97,000	0	0	100,000	0	1,070	15,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,200,000**	**1,700,000**	**840,000**	**61**	**370,000**	**480,000**	**4,500**	**3,300**	**220,000**

TABLE 4-3

SCENARIO 4 INFRASTRUCTURE SUMMARY

Sewershed	Wastewater Flows (gpd)		Pipe length(ft)	Pumping Stations	Gravity Sewer (lf)	Pressure Sewer (lf)	Properties on Gravity Sewer	Properties on Pressure Sewer	Force Main Length (lf)
	Existing	Future							
1	15,000	43,000	5,700	1	5,700	0	120	0	3,300
6	9,700	11,000	4,500	1	2,500	1,900	42	5	1,000
8	1,200	1,800	3,100	1	3,100	0	16	0	12,000
9	10,000	12,000	5,000	1	4,400	570	100	10	3,000
14	15,000	16,000	6,400	1	6,400	0	110	0	700
18	13,000	73,000	9,500	1	3,400	6,200	1	8	4,500
22	10,000	13,000	5,500	1	5,500	0	100	0	5,000
24	4,900	5,700	3,600	1	3,600	0	75	0	2,100
25	6,000	8,000	3,400	1	3,400	0	54	0	3,100
26	18,000	20,000	5,400	1	5,400	0	81	0	4,300
28	12,500	15,700	9,000	1	8,500	720	140	10	1,000
29	3,600	5,000	14,500	1	4,900	9,500	69	41	1,100
30	9,600	12,000	1,900	1	1,900	0	34	0	1,500
31	10,000	12,300	6,600	1	4,300	2,400	69	14	800
32	2,000	3,000	4,800	1	4,300	410	80	1	3,800
37(Barnstable)	12,000	12,000	2,400	1	2,400	0	25	0	7,100
38(Barnstable)	47,000	47,000	6,000	1	3,900	1,700	51	10	3,300
40	46,000	110,000	15,000	1	11,000	3,600	100	21	3,400
41	24,000	27,000	17,000	1	8,700	8,300	62	14	4,600
21	14,000	14,000	24,000	1	11,000	13,000	110	110	4,500
42(Barnstable)	35,000	35,000	42,000	1	2,800	39,000	40	180	0
43	8,600	9,300	5,900	1	5,900	0	94	0	700
44	31,000	77,000	22,000	1	6,700	16,000	40	35	4,900
45	7,700	14,000	13,000	1	7,200	5,600	60	34	2,300
47	14,000	23,000	10,000	1	8,800	1,600	81	34	5,900
49	18,000	27,000	22,000	1	8,800	13,000	71	61	700
50	66,000	83,000	57,000	1	20,000	37,000	270	190	5,700
51	12,000	18,000	6,600	1	6,600	0	86	0	2,000
52	9,000	12,000	11,000	1	6,000	4,600	63	28	3,300
53	28,000	38,000	26,000	1	13,000	13,000	160	80	2,000
54	57,000	140,000	17,000	1	7,200	9,300	57	190	4,700
57	7,100	7,700	4,600	1	4,600	0	87	0	2,800
64	23,100	31,000	19,000	1	12,400	6,400	140	24	6,100
65	41,000	45,000	32,000	1	16,000	16,000	220	113	1,000
67	24,000	24,000	16,000	1	11,000	5,000	150	36	2,300
68	22,000	26,000	23,000	1	8,000	16,000	140	100	3,100
69	29,000	52,000	31,000	1	12,100	19,000	200	110	4,200
70	15,000	16,000	11,000	1	7,000	4,400	90	30	5,400
71	21,000	25,000	14,000	1	11,000	3,400	140	25	5,200
72	24,000	31,000	26,000	1	4,400	21,000	50	90	10,800
73	35,000	65,000	34,000	1	5,100	29,000	54	130	3,900
74	38,000	74,000	29,000	1	18,200	11,000	170	60	4,800
75	12,000	18,000	16,000	1	4,000	12,000	36	68	2,200
Fal 10	5,000	4,000	2,000	1	1,700	0	22	0	2,300
Fal 11	3,800	2,800	900	1	900	0	16	0	1,100
Fal 13	7,900	9,300	4,500	1	2,400	2,200	27	25	2,400
Fal 14	3,800	3,600	1,600	1	1,570	0	13	0	1,400
Fal 15	8,500	11,200	6,300	1	3,300	3,100	31	20	1,100
Fal 16	7,700	7,000	2,300	1	2,300	0	26	0	3,000
Fal 17	8,800	17,000	10,000	1	6,900	3,500	49	36	0
Fal 2	6,100	8,000	3,200	1	3,200	0	45	0	1,400
Fal 3	3,400	4,100	1,900	1	1,900	0	24	0	1,100
Fal 4	2,300	4,000	1,000	1	1,300	0	24	0	1,200
Fal 5	2,400	3,100	1,300	1	1,300	0	18	0	1,500
Fal 6	3,900	4,900	1,900	1	1,900	0	27	0	700
Fal 7	1,800	3,200	1,400	1	1,400	0	17	0	800
Fal 8	1,800	2,600	1,100	1	1,100	0	13	0	1,400
Fal 9	5,900	8,700	4,300	1	4,300	0	48	0	700
Sand 2	34,000	41,000	17,000	0	0	17,000	0	191	600
Sand 3	27,000	35,000	13,000	0	0	13,000	0	159	1,800
Sand 4	47,000	61,000	30,000	0	0	30,000	0	314	3,900
Sand 5	48,000	55,000	25,000	0	0	25,000	0	260	5,800
Sand 6	29,000	31,000	14,000	0	0	14,000	0	140	1,500
Sand 8	38,000	45,000	26,000	0	0	26,000	0	220	8,100
Mashpee Total	770,000	1,300,000	590,000	40	300,000	290,000	3,800	1,700	140,000
Barnstable Total	94,000	94,000	50,000	3	9,000	41,000	120	190	10,000
Sandwich Total	220,000	270,000	125,000	0	0	130,000	0	1,280	22,000
Falmouth Total	73,000	94,000	44,000	15	35,000	9,000	400	80	20,000
Total	**1,200,000**	**1,800,000**	**810,000**	**58**	**340,000**	**470,000**	**4,300**	**3,300**	**190,000**

TABLE 4-4

SCENARIO 5 INFRASTRUCTURE SUMMARY

Sewershed	Wastewater Flows (gpd)		Pipe length(ft)	Pumping Stations	Gravity Sewer (lf)	Pressure Sewer (lf)	Properties on Gravity Sewer	Properties on Pressure Sewer	Force Main Length (lf)
	Existing	Future							
1	15,000	43,400	5,700	1	5,700	0	120	0	3,300
6	9,700	11,000	4,500	1	2,500	1,900	42	5	1,000
8	1,200	1,800	3,100	1	3,100	0	16	0	12,000
9	10,000	12,000	5,000	1	4,400	570	100	10	3,000
14	15,000	16,000	6,400	1	6,400	0	110	0	700
18	13,000	73,000	9,500	1	3,400	6,200	1	8	2,800
22	10,000	13,000	5,500	1	5,500	0	100	0	5,000
23	12,000	14,000	11,000	1	3,200	8,100	73	57	2,000
24	5,000	6,000	4,000	1	3,600	0	75	0	2,100
25	6,000	8,000	3,400	1	3,400	0	54	0	3,100
26	18,000	20,000	5,400	1	5,400	0	81	0	13,000
28	13,000	16,000	9,200	1	8,500	720	140	10	1,100
29	4,000	5,000	14,000	1	4,900	9,500	69	41	1,100
30	10,000	12,000	2,000	1	1,900	0	34	0	1,500
31	10,000	12,000	6,600	1	4,300	2,400	69	14	800
32	2,000	3,000	4,800	1	4,300	410	80	1	15,000
37(Barnstable)	12,000	12,000	2,400	1	2,400	0	25	0	2,800
38(Barnstable)	47,000	47,000	5,600	1	3,900	1,700	51	11	3,300
39(Barnstable)	20,000	20,000	46,000	1	8,700	37,000	68	190	1,900
40	46,000	110,000	15,000	1	11,000	3,600	100	21	3,400
41	24,000	27,000	17,000	1	8,700	8,300	62	14	4,600
21	14,000	14,000	24,000	1	11,000	13,000	110	110	2,000
42(Barnstable)	35,000	35,000	42,000	1	3,000	39,000	40	180	4,300
43	8,600	9,300	5,900	1	5,900	0	94	0	700
44	31,000	77,000	22,000	1	6,700	16,000	40	35	2,300
45	7,700	14,000	13,000	1	7,200	5,600	60	34	4,600
47	14,000	23,000	10,000	1	8,800	1,600	81	34	4,400
49	18,000	27,000	22,000	1	8,800	13,000	71	61	700
50	66,000	83,000	57,000	1	20,000	37,000	270	190	7,600
51	12,000	18,000	7,000	1	6,600	0	86	0	1,600
52	9,000	12,000	11,000	1	6,000	4,600	63	28	100
53	28,000	38,000	26,000	1	13,000	13,000	160	80	1,700
54	57,000	140,000	17,000	1	7,000	9,300	57	190	3,600
57	7,100	7,700	5,000	1	4,600	0	87	0	2,800
64	23,000	31,000	19,000	1	12,000	6,400	140	24	4,000
65	41,000	45,000	32,000	1	16,000	16,000	220	110	1,000
67	24,000	24,000	16,000	1	11,000	5,300	150	36	2,300
68	22,000	26,000	23,000	1	7,700	16,000	140	100	3,100
70	15,000	16,000	11,000	1	6,700	4,400	91	34	5,400
71	21,000	25,000	14,000	1	11,000	3,400	140	25	5,200
72	24,000	31,000	26,000	1	4,400	21,000	48	90	3,000
73	35,000	65,000	34,000	1	5,000	29,000	54	130	3,900
74	38,000	74,000	29,000	1	18,000	11,000	170	64	4,800
75	12,000	18,000	16,000	1	3,900	12,000	36	68	2,200
Fal 1	6,500	6,200	3,400	1	2,000	1,300	15	14	1,200
Fal 10	4,600	3,800	1,700	1	1,700	0	22	0	2,300
Fal 11	3,800	2,800	930	1	900	0	16	0	1,100
Fal 12	3,400	3,400	2,000	1	2,000	0	20	0	2,200
Fal 13	7,900	9,300	4,500	1	2,400	2,200	27	25	2,400
Fal 14	3,800	3,600	1,600	1	1,600	0	13	0	1,400
Fal 15	9,000	11,000	6,300	1	3,300	3,100	31	20	1,100
Fal 16	7,700	7,000	2,300	1	2,300	0	26	0	3,000
Fal 17	9,000	17,000	10,000	1	6,900	3,500	49	36	0
Fal 2	6,100	7,800	3,200	1	3,200	0	45	0	1,400
Fal 3	3,400	4,100	1,900	1	1,900	0	24	0	1,100
Fal 4	2,300	4,100	1,300	1	1,300	0	24	0	1,200
Fal 5	2,400	3,100	1,300	1	1,300	0	18	0	1,500
Fal 6	3,900	4,900	1,900	1	1,900	0	27	0	700
Fal 7	1,800	3,200	1,400	1	1,400	0	17	0	800
Fal 8	1,800	2,600	1,100	1	1,100	0	13	0	1,400
Fal 9	5,900	8,700	4,300	1	4,300	0	48	0	700
Sand 4	47,000	61,000	30,000	0	0	30,000	0	310	3,900
Sand 5	48,000	55,000	25,000	0	0	25,000	0	260	5,800
Sand 6	29,000	31,000	14,000	0	0	14,000	0	140	1,500
Mashpee Total	750,000	1,200,000	570,000	40	290,000	280,000	3,700	1,600	140,000
Barnstable Total	110,000	190,000	73,000	4	30,000	42,000	310	220	9,000
Sandwich Total	120,000	150,000	70,000	0	0	70,000	0	710	11,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,100,000**	**1,600,000**	**760,000**	**61**	**360,000**	**400,000**	**4,500**	**2,600**	**180,000**

TABLE 4-5

INFRASTRUCTURE SUMMARY BY TOWN AND SCENARIO

Town	Wastewater Flows (gpd)		Pipe length(ft)	Pumping Stations	Gravity Sewer (lf)	Pressure Sewer (lf)	Properties on Gravity Sewer	Properties on Pressure Sewer	Force Main Length (lf)
	Existing	Future							
SCENARIO 1									
Mashpee Total	810,000	1,300,000	610,000	41	320,000	300,000	4,000	1,700	150,000
Barnstable Total	110,000	110,000	96,000	4	18,000	78,000	180	380	12,000
Sandwich Total	240,000	300,000	140,000	0	0	140,000	0	1,310	21,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,200,000**	**1,800,000**	**900,000**	**62**	**380,000**	**530,000**	**4,600**	**3,500**	**210,000**
SCENARIO 2									
Mashpee Total	780,000	1,300,000	600,000	40	310,000	290,000	3,900	1,700	160,000
Barnstable Total	110,000	110,000	96,000	4	18,000	78,000	180	380	17,000
Sandwich Total	180,000	220,000	97,000	0	0	100,000	0	1,070	15,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,200,000**	**1,700,000**	**840,000**	**61**	**370,000**	**480,000**	**4,500**	**3,300**	**220,000**
SCENARIO 4									
Mashpee Total	770,000	1,300,000	590,000	40	300,000	290,000	3,800	1,700	140,000
Barnstable Total	94,000	94,000	50,000	3	9,000	41,000	120	190	10,000
Sandwich Total	220,000	270,000	125,000	0	0	130,000	0	1,280	22,000
Falmouth Total	73,000	94,000	44,000	15	35,000	9,000	400	80	20,000
Total	**1,200,000**	**1,800,000**	**810,000**	**58**	**340,000**	**470,000**	**4,300**	**3,300**	**190,000**
SCENARIO 5									
Mashpee Total	750,000	1,200,000	570,000	40	290,000	280,000	3,700	1,600	140,000
Barnstable Total	110,000	190,000	73,000	4	30,000	42,000	310	220	9,000
Sandwich Total	120,000	150,000	70,000	0	0	70,000	0	710	11,000
Falmouth Total	80,000	100,000	49,000	17	40,000	10,000	440	100	24,000
Total	**1,100,000**	**1,600,000**	**760,000**	**61**	**360,000**	**400,000**	**4,500**	**2,600**	**180,000**

Note: Does not include build-out flows from existing WWTF which is approximately 0.5 mgd.

TABLE 4-6

SUMMARY OF BASIS USED IN ORDER OF MAGNITUDE COST DEVELOPMENT FOR SCENARIOS 1, 2, 4 AND 5

Collection System	**Amount [1]**
Typical Gravity Connection	$ 12,000
Typical Pressure Connection	$ 11,000
Manholes (4-foot diameter)	$ 4,700
Average Gravity Sewer (per linear foot)	$ 140
Pressure Sewer (per linear foot)	$ 80
Force Main (Pumping Station and Effluent Disposal) (per linear foot)	$ 90
Small Pumping Station [2]	$ 180,000
Medium Pumping Station [2]	$ 450,000
Site Restoration	$ 29
General Conditions	15%
Contingency	30%
Design (engineering)	7%
Fiscal Legal	15%
Construction admin	7%
Individual Systems	**Amount [1]**
New I/A with additional nitrogen removal	$ 17,000
Complete New System	$ 27,000
Average I/A cost used for analysis	$ 22,000
Contingency	30%
Engineering (Design only)	7%
Wastewater Treatment Facilities	**Amount [1]**
Costs for WWTF, Effluent Disposal, and O&M costs based on manufacturers cost quotes for similar sized facilities, recently constructed facilities in the region	
General Conditions	15%
Contingency	30%
Design (engineering)	7%
Fiscal Legal	15%
Construction admin	7%
O&M Costs	**Amount [1]**
Gravity Sewers (per linear foot)	$ 0.20
Pressure Sewers (per linear foot)	$ 1.50
Force Mains (per linear foot) [3]	$ 4.50
I/A Systems Total [4]	$ 2,800
Electricity	*$ 200*
Sampling, Maintenance and Parts	*$ 650*
Lab Analysis (monthly)	*$ 1,800*
Sludge Pumping (annualized if done every 2 years)	*$ 180*
Present Worth	**Factors**
Interest (discount) Rate	4.875%
Design Life (years)	20
P/A (uniform series present worth)	12.6

Notes

1. Costs rounded to two significant figures. Based on 2008 ENR of 8094.
2. Pumping Station costs based on suction lift type, do not include land acquisition.
3. Includes pumping station operational costs.
4. Based on information in the May 2007 Barnstable County Report on On-Site Sewage Treatment System in Eastham, MA, and discussions with manufacturers representatives.

TABLE 4-7

COMPARISON OF ESTIMATED SCENARIO COSTS (SCENARIOS 1, 2, 4, AND 5) (1)

ESTIMATED COLLECTION SYSTEM COSTS	Scenario 1	Scenario 2	Scenario 4	Scenario 5
Collection System Construction Cost (2)	$ 210,000,000	$ 200,000,000	$ 190,000,000	$ 190,000,000
Force Mains (from Pump Stations, and to Treated Water Recharge Site	$ 19,000,000	$ 21,000,000	$ 18,000,000	$ 25,000,000
SubTotal	*$ 230,000,000*	*$ 220,000,000*	*$ 210,000,000*	*$ 220,000,000*
General Conditions	$ 35,000,000	$ 33,000,000	$ 32,000,000	$ 33,000,000
Total Construction Cost	*$ 270,000,000*	*$ 250,000,000*	*$ 240,000,000*	*$ 250,000,000*
Contingency	$ 81,000,000	$ 75,000,000	$ 72,000,000	$ 75,000,000
Fiscal, Legal	$ 41,000,000	$ 38,000,000	$ 36,000,000	$ 38,000,000
Engineering (Design and Construction)	$ 38,000,000	$ 35,000,000	$ 34,000,000	$ 35,000,000
Total Collection System Capital Cost	***$ 430,000,000***	***$ 400,000,000***	***$ 380,000,000***	***$ 400,000,000***
ESTIMATED WWTF COSTS	**Scenario 1**	**Scenario 2**	**Scenario 4**	**Scenario 5**
Construction Cost for Modification to Existing WWTFs (3)	$ -	$ 8,500,000	$ 9,000,000	$ 700,000
Construction Cost for New WWTFs (5)	$ 47,000,000	$ 33,000,000	$ 32,000,000	$ 33,000,000
Construction of Treated Water Recharge Facilities (4)	$ 4,200,000	$ 3,500,000	$ 2,300,000	$ 4,400,000
SubTotal Wastewater Treatment Facility Construction Costs	*$ 51,000,000*	*$ 45,000,000*	*$ 43,000,000*	*$ 38,000,000*
General Conditions	$ 7,700,000	$ 6,800,000	$ 6,500,000	$ 5,700,000
Total Construction Cost	*$ 59,000,000*	*$ 52,000,000*	*$ 50,000,000*	*$ 44,000,000*
Contingency	$ 18,000,000	$ 16,000,000	$ 15,000,000	$ 13,000,000
Fiscal, Legal	$ 9,000,000	$ 7,800,000	$ 7,500,000	$ 6,600,000
Engineering (Design and Construction)	$ 8,000,000	$ 7,300,000	$ 7,000,000	$ 6,200,000
Total WWTF Capital Cost	***$ 94,000,000***	***$ 83,000,000***	***$ 80,000,000***	***$ 70,000,000***
ESTIMATED INDIVIDUAL SYSTEM UPGRADE COSTS	**Scenario 1**	**Scenario 2**	**Scenario 4**	**Scenario 5**
Individual I/A Systems Construction Costs	$ 8,000,000	$ 1,100,000	$ 2,800,000	$ 2,600,000
Total Construction Cost	*$ 8,000,000*	*$ 1,100,000*	*$ 2,800,000*	*$ 2,600,000*
Contingency	$ 2,400,000	$ 330,000	$ 840,000	$ 780,000
Engineering (Design)	$ 560,000	$ 77,000	$ 200,000	$ 180,000
Total Capital Cost	***$ 11,000,000***	***$ 1,500,000***	***$ 3,800,000***	***$ 3,600,000***
2008 TOTAL SCENARIO CAPITAL COST	**$ 540,000,000**	**$ 480,000,000**	**$ 460,000,000**	**$ 470,000,000**

Notes:

1. Costs rounded to two significant figures. Based on 2008 ENR of 8094. Based on future build-out condition.
2. Collection System Costs include pumping station. Costs do not include land acquisition. Force main costs are based on estimated lengths of force mains from pumping station to pumping station or WWTF. Costs also include force main from WWTF to treated recharge site.
3. Does not include costs associated with acquiring the facility.
4. Costs do not include the siting and construction of new wastewater treatment facilities in Barnstable or Falmouth.
5. Costs include facilities at new sites and estimated expansion on some existing sites. Does not include costs associated with land acquisition.

TABLE 4-8

COMPARISON OF ESTIMATED SCENARIO TOTAL PRESENT WORTH COSTS (SCENARIOS 1, 2, 4, AND 5) (1)

COSTS (1,4)	Scenario 1	Scenario 2	Scenario 4	Scenario 5
ESTIMATED TOTAL CAPITAL COST (from Table 4-7)	**$ 540,000,000**	**$ 480,000,000**	**$ 460,000,000**	**$ 470,000,000**
Estimated Operations and Maintenance (O&M) Costs				
Collection Systems	$ 1,900,000	$ 1,900,000	$ 1,700,000	$ 2,000,000
New Wastewater Treatment Facilities (2)	$ 5,000,000	$ 3,500,000	$ 3,300,000	$ 2,700,000
Individual Innovative and Alternative Systems	$ 1,100,000	$ 150,000	$ 360,000	$ 340,000
Total O&M Costs	*$ 8,000,000*	*$ 5,600,000*	*$ 5,400,000*	*$ 5,000,000*
O&M Present Worth Costs	**$ 99,000,000**	**$ 70,000,000**	**$ 69,000,000**	**$ 64,000,000**
TOTAL PRESENT WORTH COST	**$ 640,000,000**	**$ 550,000,000**	**$ 530,000,000**	**$ 530,000,000**

Notes:

1. Costs rounded to two significant figures. Based on 2008 ENR of 8094. Under future build-out condition.
2. Does not include O&M on existing facilities.
3. Present worth costs based factors summarized on Table 4-6.
4. Costs do not include estimation for facilities in Barnstable or Falmouth.

TABLE 4-9

SCENARIO SUMMARY

SCENARIO	Regulatory Constraints	Suitability	Implementability	Performance	Long Term Maintenance	Environmental and Health Concerns	Efficient Use of Land	Public Acceptance/Political Feasibility and Institutional Concerns	Estimated Capital Costs in millions	Estimated Total Present Worth in millions
Scenario 1	Individual systems will require permits to achieve TMDL Requirements. Also, Towns will likely require inter-municipal agreements as wastewater is crossing Town lines.	All scenarios based on limit of technology for achieving less than 3 mg/L total nitrogen in the effluent.	This scenario requires the least amount of expenditure to acquire existing private facilities. Land acquisition is an issue for all new sites.	This scenario relies on the performance of existing WWTF managed privately. This scenario also relies on the largest number of individual I/A technologies.	Maintenance of private facilities would remain private. This scenario requires the largest amount of collection system infrastructure.	All scenarios are based on achieving the TMDLs and improving environmental and local health concerns.	Requires development of /use of 6 new sites in the Project Planning Area (Falmouth site has been identified outside the PPA). Two of the proposed sites can maintain secondary uses.	Some level of inter-municipal agreement is required, which could make it difficult for individual towns to approve, however MassDEP is supportive of regional efforts and solutions.	$540	$640
Scenario 2	Individual systems will require permits to achieve TMDL Requirements. Also, Towns will likely require inter-municipal agreements as wastewater is crossing Town lines.		Scenarios 2, 4 and 5 require Town/District to ultimately acquire private facilities. Land acquisition is an issue for all new sites. Scenario 5 requires the smallest number of new WWTFs	Technologies used in this analysis are based on those identified in the Technology Screening Report. Wastewater treatment facilities for non-individual systems based on achieving 3 mg/L total nitrogen in the effluent.	Inter-municipal agreements required to maintain infrastructure.		Requires development of /use of 6 new sites in the Project Planning Area (Falmouth site has been identified outside the PPA). One of the proposed sites can maintain secondary use.	Some level of inter-municipal agreement is required, which could make it difficult for individual towns to approve; however MassDEP is supportive of regional efforts and solutions.	$480	$550
Scenario 4	No inter-municipal agreements needed. Individual systems will require permits to achieve TMDL Requirements.				Towns have a greater flexibility to manage their own facilities.		Requires development of /use of 5 new sites in the Project Planning Area (Falmouth site has been identified outside the PPA). One of the proposed sites can maintain secondary use.	This scenario relies on each Town working independently. MassDEP has expressed interest in Towns working towards a regional solution together. However, individual town approval may be easier this way.	$460	$530
Scenario 5	Individual systems will require permits to achieve TMDL Requirements. Also, Towns will likely require inter-municipal agreements as wastewater is crossing Town lines.				Minimizes the number of WWTFs and consolidates operations.		Requires development of /use of 5 new sites in the Project Planning Area (Falmouth site has been identified outside the PPA). Three of the proposed sites can maintain secondary uses.	Some level of inter-municipal agreement is required, which could make it difficult for individual towns to approve; however MassDEP is supportive of regional efforts and solutions.	$470	$530

TABLE 5-1

COMPARISON OF NITROGEN LOADING RATES

	Location	MEP WW (kg/day)	Attenuated	WW N Load (1,2) (kg/year) Existing (NAR)	WW N Load Future (NAR)	WW N Load Future (Scenarios)	N Load (kg/day) Existing (NAR)	N Load Future (NAR)	N Load Future (Scenarios)	WW N With 25% Reduction (kg/day) Existing (NAR)	WW N 25% Red. Future (NAR)	WW N 25% Red. Future (Scenarios)	WW N Attenuated (kg/day) Existing (NAR)	WW N Att. Future (NAR)	WW N Att. Future (Scenarios)	Scenario 1 Future (kg/day)	Scenario 1 Attenuated (kg/day)	Scenario 2 Future (kg/day)	Scenario 2 Attenuated (kg/day)	Scenario 4 Future (kg/day)	Scenario 4 Attenuated (kg/day)	Scenario 5 Future (kg/day)	Scenario 5 Attenuated (kg/day)
Popponesset Bay	Mashpee-Wakeby Pond	13	4.4	6,300	9,500	9,200	17	26	25	13	20	19	4.5	6.9	6.6	6.0	2.1	9.5	3.3	6.0	2.1	9.5	3.3
	Santuit Pond	12	4.2	6,000	7,300	7,200	17	20	20	12	15	15	4.3	5.2	5.2	2.0	0.50	8.1	2.8	7.7	2.7	8.1	2.8
	Lower Mashpee River	9.8	9.8	3,700	6,800	6,800	10	19	19	7.6	14	14	7.6	14	14	1.0	1.1	0.60	0.56	0.56	0.56	0.24	0.24
	Upper Mashpee River	13	9.3	7,200	13,000	13,000	20	36	36	15	27	27	10	19	19	13	9.0	8.3	5.8	8.4	5.9	11	7.0
	Ockway Bay	2.4	2.4	1,200	2,400	2,400	3.4	6.6	6.6	2.6	4.9	4.9	2.6	4.9	4.9	0.0	0.03	0.13	0.13	0.13	0.13	0.13	0.13
	Popponesset Bay	1.6	1.6	730	920	920	2.0	2.5	2.5	1.5	1.9	1.9	1.5	1.9	1.9	1.0	0.65	1.5	1.5	1.7	1.7	1.5	1.5
	Popponesset Creek	4	4.0	2,000	3,000	3,000	5.4	8.2	8.2	4.1	6.2	6.2	4.1	6.2	6.2	0.0	0.44	1.0	1.0	1.3	1.3	1.3	1.3
	Cotuit Well #5	0.9	0.63	470	570	570	1.3	1.6	1.6	0.97	1.2	1.2	0.68	0.82	0.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Quaker Run Wells	1.8	1.8	990	1,100	1,100	2.7	3.0	3.0	2.0	2.3	2.3	2.0	2.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Quaker Run	2.6	2.6	580	1,600	1,600	1.6	4.4	4.4	1.2	3.3	3.3	1.2	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Santuit River	15	10	7,800	11,000	7,000	21	31	19	16	23	14	11	16	10	3.0	1.9	1.0	0.70	1.4	1.0	0.25	0.17
	Shoestring Bay	7	7.0	3,700	5,300	9,300	10	14	26	7.6	11	19	7.6	11	19	0.0	0.49	0.49	0.49	1.7	1.7	0.50	0.49
	Pimlico Pond	3.1	0.55	1,600	2,000	2,100	4.3	5.5	5.7	3.2	4.1	4.3	0.57	0.72	0.75	1.0	0.12	0.90	0.16	0.90	0.16	0.90	0.16
	Peters Pond	5.8	1.0	2,800	3,200	3,100	7.7	8.6	8.4	5.8	6.5	6.3	1.0	1.1	1.1	3.0	0.60	6.0	1.1	2.8	0.50	2.3	0.40
	Pinquickset	0.58	0.58	270	430	410	0.73	1.2	1.1	0.55	0.89	0.85	0.55	0.89	0.85	1.0	0.54	0.54	0.54	0.85	0.85	0.54	0.54
	SUMS	92	60				120	190	190	93	140	140	60	94	96		18		18		19		19

TMDL (kg/year) (4)		Benthic Flux (kg/year) (4)		Target and Atmospheric Load (5) (kg/year)		Non WW Nitrogen (6)		WW goal (7) (kg/year)		WW goal (kg/day)
16,000	-	-1,300	=	18,000	-	11,000	=	6,800	=	19

	Location	MEP WW (kg/day)	Attenuated	WW N Load (1,2) (kg/year) Existing (NAR)	WW N Load Future (NAR)	WW N Load Future (Scenarios)	N Load (kg/day) Existing (NAR)	N Load Future (NAR)	N Load Future (Scenarios)	WW N With 25% Reduction (kg/day) Existing (NAR)	WW N 25% Red. Future (NAR)	WW N 25% Red. Future (Scenarios)	WW N Attenuated (kg/day) Existing (NAR)	WW N Att. Future (NAR)	WW N Att. Future (Scenarios)	Scenario 1 Future (kg/day)	Scenario 1 Attenuated (kg/day)	Scenario 2 Future (kg/day)	Scenario 2 Attenuated (kg/day)	Scenario 4 Future (kg/day)	Scenario 4 Attenuated (kg/day)	Scenario 5 Future (kg/day)	Scenario 5 Attenuated (kg/day)
Waquoit Bay East	Weeks Pond	0.16	0.04	0	0	130	0.0	0.0	0.35	0.0	0.0	0.26	0.0	0.0	0.07	0.0	0.01	0.0	0.0	0.15	0.04	0.26	0.07
	Ashumet Pond	3.9	0.99	1,900	2,400	2,300	5.1	6.6	6.4	3.9	5.0	4.8	0.96	1.2	1.2	1.0	0.24	1.3	0.30	3.4	0.80	2.5	0.60
	Johns Pond	5	2.5	2,500	4,500	4,300	6.9	12	12	5.2	9.3	8.9	2.6	4.6	4.5	0.0	0.01	0.08	0.04	0.08	0.04	3.6	1.8
	Moody Pond	0.53	0.13	260	460	370	0.72	1.3	1.0	0.54	0.94	0.77	0.14	0.24	0.19	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.19
	Upper Quashnet River	7	7.0	5,800	14,000	14,000	16	38	37	12	29	28	12	29	28	4.0	3.9	3.5	3.5	3.0	3.0	3.2	3.2
	Turner Road Well No. 5	0.26	0.26	130	180	180	0.35	0.50	0.50	0.26	0.38	0.38	0.26	0.38	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mashpee Well No. 1	0.17	0.17	93	120	120	0.26	0.34	0.34	0.19	0.25	0.25	0.19	0.25	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MMR J Well (3)	-1.9	-1.9	920	1,100	1,200	-2.5	-3.0	-3.3	-1.9	-2.2	-2.5	-1.9	-2.2	-2.5	0.0	-0.23	-0.07	-0.07	-0.82	-0.82	-1.3	-1.3
	Middle Quashnet River	1.8	1.8	990	1,400	1,700	2.7	3.7	4.7	2.0	2.8	3.5	2.0	2.8	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Lower Quashnet River	0.57	0.57	430	590	590	1.2	1.6	1.6	0.88	1.2	1.2	0.88	1.2	1.2	0.0	0.0	0.0	0.0	0.06	0.06	0.0	0.0
	Red Brook	6.5	3.2	460	1,500	4,400	1.3	4.1	12	0.95	3.1	9.1	0.48	1.5	4.5	0.0	0.0	0.0	0.0	0.24	0.12	0.0	0.0
	Lower Red Brook	1.3	1.3	2,400	3,900	730	6.6	11	2.0	5.0	8.1	1.5	5.0	8.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Hamblin Pond	3.4	3.4	1,800	2,700	2,600	4.8	7.4	7.0	3.6	5.6	5.3	3.6	5.6	5.3	0.0	0.06	0.19	0.19	0.32	0.32	0.0	0.0
	Little River	0.92	0.92	390	710	710	1.1	2.0	2.0	0.79	1.5	1.5	0.79	1.5	1.5	0.0	0.05	0.16	0.16	0.16	0.16	0.0	0.0
	Great River	0.36	0.36	230	320	320	0.62	0.87	0.87	0.46	0.65	0.65	0.46	0.65	0.65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Jehu Pond	2.7	2.7	1,600	2,600	2,600	4.5	7.2	7.2	3.4	5.4	5.4	3.4	5.4	5.4	0.0	0.08	0.08	0.08	0.27	0.27	0.15	0.15
	Lower Great River	2.4	2.4	1,200	2,000	2,000	3.3	5.4	5.4	2.4	4.0	4.0	2.4	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Flat Pond	0.69	0.69	290	1,000	1,000	0.80	2.8	2.8	0.60	2.1	2.1	0.60	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Flat/Sage Lot Transition	0.45	0.45	220	390	390	0.60	1.1	1.1	0.45	0.79	0.79	0.45	0.79	0.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sage Lot Pond	0	0.00	0	0	0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SUMS	36	27				54	100	100	41	77	76	34	67	63		4.1		4.3		4.1		4.7

TMDL (kg/year) (8)		Benthic Flux (kg/year) (8)		Target and Atmospheric Load (5) (kg/year)		Non WW Nitrogen (6)		WW goal (7) (kg/year)		WW goal (kg/day)
20,000	-	10,500	=	9,500	-	7,900	=	1,600	=	4.3

Notes:
(1) MEP analysis includes split parcels; S&W analysis selects parcels based on centroid.
(2) There is a slight difference in the way MEP calculated water use and the way S&W calculated water use. This may account for some of the differences.
(3) MEP calculations subtract the load in the MMR J Well subwatershed.
(4) TMDL is 45 kg/day and Benthic Flux is -3.5 kg/day in Table 5 of TMDL report. Values in this table are presented in kg/year.
(5) Target load is from Table 5 of the TMDL reports. Target includes all sources (attenuated) *except* benthic flux.
(6) Non WW Nitrogen is the attenuated value of non-wastewater "controllable" sources, such as fertilizer, runoff, and atmospheric deposition on all surfaces.
(7) WW goal is the difference between the total nitrogen load and the non wastewater nitrogen load.
(8) TMDL is 54 kg/day and Benthic Flux is 28.69 kg/day in Table of TMDL report. Values in this table are presented in kg/year.
(9) All values are rounded to two significant figures.

TABLE 5-2

SUMMARY OF POPPONESSET BAY NITROGEN LOADS

	All values are in kg/day	MEP Existing Load	Estimated Build-out Load	TMDL	Scenario 1	Scenario 2	Scenario 4	Scenario 5
Popponesset Bay	Wastewater Recharge	0.5	86	40.3	12	7.0	7.0	7.6
	Septic Systems	58.6			6.1	12	12	11
	Fertilizer	7.4	7.4		7.4	7.4	7.4	7.4
	Impervious Surfaces	5.1	5.1		5.1	5.1	5.1	5.1
	Natural Surfaces	7.5	7.5		7.5	7.5	7.5	7.5
	Non-wastewater Build-out	N/A	1		1	1	1	1
	Subtotal	78.6	107	40.3	40	40	40	39
	Natural Deposition	8.3	8.3	8.3	8.3	8.3	8.3	8.3
	Benthic Flux	-4	-4	-4	-4	-4	-4	-4
	Total	82.9	112	44.6	44	44	44	44

TABLE 5-3

SUMMARY OF WAQUOIT BAY NITROGEN LOADS

	All values are in kg/day	MEP Existing Load	Estimated Build-out Load	TMDL	Scenario 1	Scenario 2	Scenario 4	Scenario 5
Waquoit Bay East	Wastewater Recharge	0.4	77	21.6	3.8	3.4	2.5	0.6
	Septic Systems	30.6			0.5	0.8	1.9	4.8
	Fertilizer	4.9	4.9		4.9	4.9	4.9	4.9
	Impervious Surfaces	4.9	4.9		4.9	4.9	4.9	4.9
	Natural Surfaces	6.4	6.4		6.4	6.4	6.4	6.4
	Non-wastewater Build-out	N/A	0.6		0.6	0.6	0.6	0.6
	Subtotal	47.3	77	21.6	21	21	21	22
	Natural Deposition	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Benthic Flux	28.7	28.7	28.7	29	29	29	29
	Total	80.3	110	54.6	54	54	54	55

Notes:

(1) Wastewater load from both septic systems and WWTFs is summarized for the Estimated Build-out Load.

(2) Non-wastewater Build-out includes additional fertilizer loads and loads from impervious surfaces.

TABLE 5-4

NITROGEN LOADS
WAQUOIT BAY EAST – SCENARIO 1

*All values in kilograms/year	Mashpee N Loads by Input:								Buildout N Loads		
Scenario 1	From Septic Systems	From WWTF	Lawn Fertilizers	Impervious Surfaces	Water Body Surface Area	"Natural" Surfaces	Buildout non WW	% of Pond Outflow	UnAtten N Load	Atten %	Atten N Load
E Waquoit Bay	**286**	**1369**	**1981**	**2910**	**3959**	**1413**	**500**		**12417**		**9440**
Quashnet River	221	1369	993	2419	2254	996	266		8518		5823
Upper Quashnet River	221	1369	888	2366	2040	943	204		8030		5335
Moody Pond (MP)	0	0	6	184	35	44	8	44%	278	50%	139
Turner Road Well No. 5	0	0	0	2	0	10	5		18		18
Mashpee Well No. 1	0	0	0	20	0	4	0		25		25
Johns Pond Summary (JPS)	131	0	164	1375	1562	270	54	67%	3557	50%	1453
Johns Pond (JP)	9	0	189	1412	1499	207	53		3368		3368
Snake Pond (SNP)	3	0	2	1	73	10	1	21%	89	50%	45
Moody Pond (MP)	0	0	7	231	44	55	10	56%	347	50%	174
Weeks Pond (WP)	13	0	5	8	86	9	3	70%	123	50%	49
Ashumet Pond (AP)	169	0	40	387	614	120	14	65%	1344	50%	672
Removed from AP watershed by J Well											
MMR J Well	85	0	48	47	0	30	10				
Weeks Pond (WP)	6	0	2	3	37	4	1	30%	42	50%	21
Middle Quashnet River	0	0	42	44	122	45	35		288		288
Lower Quashnet River	0	0	63	9	92	8	27		199		199
Hamblin Pond/Red Brook	37	0	319	278	635	217	182		1668		1386
Red Brook	0	0	165	157	0	146	96		564	50%	282
Lower Red Brook	0	0	45	37	20	20	26		148		148
Hamblin Pond	20	0	73	57	558	44	54		806		806
Little River	17	0	37	26	57	7	6		150		150
Jehu Pond/Great River	28	0	368	178	723	139	43		1480		1480
Great River	0	0	16	21	202	81	8		327		327
Jehu Pond	28	0	239	72	246	39	19		643		643
Lower Great River	0	0	113	85	275	20	17		509		509
Sage Lot/Flat Pond	0	0	300	35	346	61	8		751		751
Flat Pond	0	0	278	17	174	34	2		504		504
Flat / Sage Lot Ponds Transition	0	0	22	19	0	12	7		59		59
Sage Lot Pond	0	0	0	0	172	16	0		188		188

TABLE 5-5

NITROGEN LOADS
POPPONESSET BAY – SCENARIO 1

*All values in kilograms/year	***Popponesset Bay Subwatershed N Loads by Input:***							% of Pond Outflow	***Buildout N Loads***		
Scenario 1	**From Septic**	**From WWTF**	**Lawn Fertilizers**	**Impervious Surfaces**	**Water Body Surface Area**	**"Natural" Surfaces**	**Buildout non WW**		**UnAtten N Load**	**Atten %**	**Atten N Load**
Popponesset Bay System	**4443**	**6765**	**3762**	**2668**	**7584**	**1971**	**678**		**27775**		**17770**
Mashpee River	3144	5852	1455	1411	4238	1153	362		17520		9419
Upper Mashpee River	3056	5552	1203	1016	3996	941	291		15961	30%	7860
Mashpee-Wakeby Pond (MWP)	2885	816	674	513	3989	503	181	100%	9465	50%	4023
Direct to MWP	2240	0	420	321	3212	307	125		6625		
Snake Pond (SNP)	0	0	2	2	121	17	3	34%	50	50%	25
Pimlico Pond (PIP)	250	0	89	63	74	42	32	100%	550	50%	275
Peters Pond (PEP)	394	816	163	126	582	138	21	100%	2240	50%	1120
Lower Mashpee River	87	300	252	395	242	212	71		1559		1559
Shoestring Bay	693	913	1978	986	1379	636	251		6837		4932
Santuit River	514	913	1075	675	564	440	118		4299	30%	2394
Cotuit Well No. 5	0	0	33	16	0	11	7		67		67
Quaker Run	0	0	405	99	0	82	15		602		602
Quaker Run Wells	0	0	37	23	0	18	8		85		85
Santuit Pond (SAP)	570	0	428	326	758	216	62	100%	2359	50%	1180
Ockway Bay	10	0	103	90	399	83	26		712		712
GW Flow to Popponesset Bay	596	0	226	180	1568	98	39		2707		2707
Pinquickset Cove	198	0	19	10	106	40	10		383		383
Popponesset Creek	160	0	171	146	0	31	22		530		530
Popponesset Bay	238	0	36	24	1462	28	6		1794		1794

TABLE 5-6

NITROGEN LOADS
WAQUOIT BAY EAST – SCENARIO 2

*All values in kilograms/year	Mashpee N Loads by Input:							% of Pond Outflow	Buildout N Loads		
Scenario 2	From Septic Systems	From WWTF	Lawn Fertilizers	Impervious Surfaces	Water Body Surface Area	"Natural" Surfaces	Buildout non WW		UnAtten N Load	Atten %	Atten N Load
E Waquoit Bay	**494**	**1230**	**1981**	**2910**	**3959**	**1413**	**500**		**12486**		**9431**
Quashnet River	337	1230	993	2419	2254	996	266		8495		5722
Upper Quashnet River	337	1230	888	2366	2040	943	204		8007		5234
Moody Pond (MP)	0	0	6	184	35	44	8	44%	278	50%	139
Turner Road Well No. 5	0	0	0	2	0	10	5		18		18
Mashpee Well No. 1	0	0	0	20	0	4	0		25		25
Johns Pond Summary (JPS)	226	0	164	1375	1562	270	54	67%	3652	50%	1481
Johns Pond (JP)	30	0	189	1412	1499	207	53		3389		3389
Snake Pond (SNP)	3	0	2	1	73	10	1	21%	89	50%	45
Moody Pond (MP)	0	0	7	231	44	55	10	56%	347	50%	174
Weeks Pond (WP)	2	0	5	8	86	9	3	70%	111	50%	43
Ashumet Pond (AP)	300	0	40	387	614	120	14	65%	1475	50%	738
Removed from AP watershed by J Well											
MMR J Well	26	0	48	47	0	30	10				
Weeks Pond (WP)	1	0	2	3	37	4	1	30%	37	50%	19
Middle Quashnet River	0	0	42	44	122	45	35		288		288
Lower Quashnet River	0	0	63	9	92	8	27		199		199
Hamblin Pond/Red Brook	129	0	319	278	635	217	182		1760		1478
Red Brook	0	0	165	157	0	146	96		564	50%	282
Lower Red Brook	0	0	45	37	20	20	26		148		148
Hamblin Pond	71	0	73	57	558	44	54		856		856
Little River	59	0	37	26	57	7	6		191		191
Jehu Pond/Great River	28	0	368	178	723	139	43		1480		1480
Great River	0	0	16	21	202	81	8		327		327
Jehu Pond	28	0	239	72	246	39	19		643		643
Lower Great River	0	0	113	85	275	20	17		509		509
Sage Lot/Flat Pond	0	0	300	35	346	61	8		751		751
Flat Pond	0	0	278	17	174	34	2		504		504
Flat / Sage Lot Ponds Transition	0	0	22	19	0	12	7		59		59
Sage Lot Pond	0	0	0	0	172	16	0		188		188

<u>TABLE 5-7</u>

NITROGEN LOADS
POPPONESSET BAY – SCENARIO 2

*All values in kilograms/year	***Popponesset Bay Subwatershed N Loads by Input:***							% of Pond Outflow	***Buildout N Loads***		
Scenario 2	**From Septic**	**From WWTF**	**Lawn Fertilizers**	**Impervious Surfaces**	**Water Body Surface Area**	**"Natural" Surfaces**	**Buildout non WW**		**UnAtten N Load**	**Atten %**	**Atten N Load**
Popponesset Bay System	**9154**	**3956**	**3765**	**2668**	**7584**	**1971**	**678**		**29680**		**17798**
Mashpee River	5544	3682	1458	1411	4238	1153	362		17752		8730
Upper Mashpee River	5457	3564	1206	1016	3996	941	291		16375	30%	7353
Mashpee-Wakeby Pond (MWP)	5285	691	676	513	3989	503	181	100%	11742	50%	4894
Direct to MWP	3450	0	421	321	3212	307	125		7835		
Snake Pond (SNP)	0	0	3	2	121	17	3	34%	50	50%	25
Pimlico Pond (PIP)	329	0	90	63	74	42	32	100%	630	50%	315
Peters Pond (PEP)	1506	691	163	126	582	138	21	100%	3227	50%	1614
Lower Mashpee River	87	118	251	395	242	212	71		1377		1377
Shoestring Bay	2456	274	1978	986	1379	636	251		7961		5102
Santuit River	2277	274	1075	675	564	440	118		5423	30%	2564
Cotuit Well No. 5	0	0	33	16	0	11	7		66		66
Quaker Run	0	0	405	99	0	82	15		601		601
Quaker Run Wells	0	0	37	23	0	18	8		85		85
Santuit Pond (SAP)	2938	0	429	326	758	216	62	100%	4729	50%	2364
Ockway Bay	49	0	103	90	399	83	26		750		750
GW Flow to Popponesset Bay	1105	0	226	180	1568	98	39		3217		3217
Pinquickset Cove	198	0	19	10	106	40	10		382		382
Popponesset Creek	373	0	171	146	0	31	22		744		744
Popponesset Bay	534	0	36	24	1462	28	6		2091		2091

<u>TABLE 5-8</u>

NITROGEN LOADS
WAQUOIT BAY EAST – SCENARIO 4

*All values in kilograms/year	Mashpee N Loads by Input:							% of Pond Outflow	Buildout N Loads		
Scenario 4	From Septic Systems	From WWTF	Lawn Fertilizers	Impervious Surfaces	Water Body Surface Area	"Natural" Surfaces	Buildout non WW		UnAtten N Load	Atten %	Atten N Load
E Waquoit Bay	**1135**	**911**	**1981**	**2910**	**3959**	**1413**	**500**		**12808**		**9516**
Quashnet River	774	911	993	2419	2254	996	266		8612		5646
Upper Quashnet River	752	911	888	2366	2040	943	204		8103		5137
Moody Pond (MP)	0	0	6	184	35	44	8	44%	278	50%	139
Turner Road Well No. 5	0	0	0	2	0	10	5		18		18
Mashpee Well No. 1	0	0	0	20	0	4	0		25		25
Johns Pond Summary (JPS)	451	0	164	1375	1562	270	54	67%	3877	50%	1537
Johns Pond (JP)	30	0	189	1412	1499	207	53		3389		3389
Snake Pond (SNP)	3	0	2	1	73	10	1	21%	89	50%	45
Moody Pond (MP)	0	0	7	231	44	55	10	56%	347	50%	174
Weeks Pond (WP)	41	0	5	8	86	9	3	70%	151	50%	63
Ashumet Pond (AP)	594	0	40	387	614	120	14	65%	1769	50%	884
Removed from AP watershed by J Well											
MMR J Well	298	0	48	47	0	30	10				
Weeks Pond (WP)	18	0	2	3	37	4	1	30%	54	50%	27
Middle Quashnet River	0	0	42	44	122	45	35		288		288
Lower Quashnet River	21	0	63	9	92	8	27		221		221
Hamblin Pond/Red Brook	263	0	319	278	635	217	182		1894		1568
Red Brook	87	0	165	157	0	146	96		652	50%	326
Lower Red Brook	0	0	45	37	20	20	26		148		148
Hamblin Pond	116	0	73	57	558	44	54		901		901
Little River	60	0	37	26	57	7	6		192		192
Jehu Pond/Great River	98	0	368	178	723	139	43		1550		1550
Great River	0	0	16	21	202	81	8		327		327
Jehu Pond	98	0	239	72	246	39	19		713		713
Lower Great River	0	0	113	85	275	20	17		509		509
Sage Lot/Flat Pond	0	0	300	35	346	61	8		751		751
Flat Pond	0	0	278	17	174	34	2		504		504
Flat / Sage Lot Ponds Transition	0	0	22	19	0	12	7		59		59
Sage Lot Pond	0	0	0	0	172	16	0		188		188

<u>TABLE 5-9</u>

NITROGEN LOADS
POPPONESSET BAY – SCENARIO 4

*All values in kilograms/year	*Popponesset Bay Subwatershed N Loads by Input:*							% of Pond Outflow	***Buildout N Loads***		
Scenario 4	**From Septic**	**From WWTF**	**Lawn Fertilizers**	**Impervious Surfaces**	**Water Body Surface Area**	**"Natural" Surfaces**	**Buildout non WW**		**UnAtten N Load**	**Atten %**	**Atten N Load**
Popponesset Bay System	**7498**	**4011**	**3765**	**2668**	**7584**	**1971**	**678**		**28079**		**17789**
Mashpee River	2963	3834	1458	1411	4238	1153	362		15323		7883
Upper Mashpee River	2876	3715	1206	1016	3996	941	291		13945	30%	6505
Mashpee-Wakeby Pond (MWP)	2704	834	676	513	3989	503	181	100%	9303	50%	3966
Direct to MWP	2174	0	421	321	3212	307	125		6560		
Snake Pond (SNP)	0	0	3	2	121	17	3	34%	50	50%	25
Pimlico Pond (PIP)	329	0	90	63	74	42	32	100%	630	50%	315
Peters Pond (PEP)	200	834	163	126	582	138	21	100%	2064	50%	1032
Lower Mashpee River	87	119	251	395	242	212	71		1377		1377
Shoestring Bay	3078	177	1978	986	1379	636	251		8486		5636
Santuit River	2442	177	1075	675	564	440	118		5492	30%	2642
Cotuit Well No. 5	0	0	33	16	0	11	7		66		66
Quaker Run	0	0	405	99	0	82	15		601		601
Quaker Run Wells	0	0	37	23	0	18	8		85		85
Santuit Pond (SAP)	2824	0	429	326	758	216	62	100%	4615	50%	2307
Ockway Bay	49	0	103	90	399	83	26		750		750
GW Flow to Popponesset Bay	1409	0	226	180	1568	98	39		3520		3520
Pinquickset Cove	310	0	19	10	106	40	10		494		494
Popponesset Creek	473	0	171	146	0	31	22		843		843
Popponesset Bay	626	0	36	24	1462	28	6		2183		2183

TABLE 5-10

NITROGEN LOADS
WAQUOIT BAY EAST – SCENARIO 5

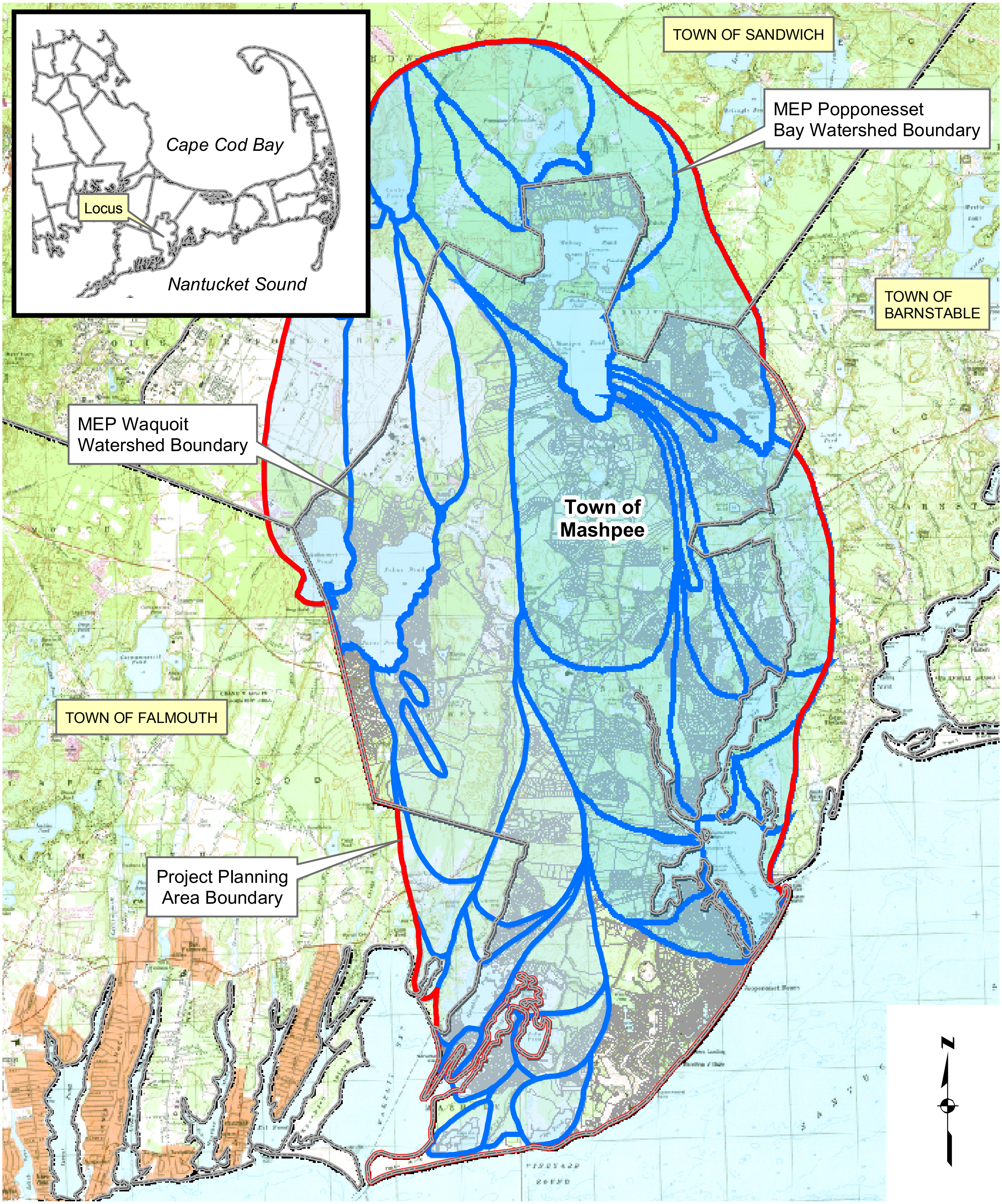
*All values in kilograms/year	Mashpee N Loads by Input:							% of Pond Outflow	Buildout N Loads		
Scenario 5	From Septic Systems	From WWTF	Lawn Fertilizers	Impervious Surfaces	Water Body Surface Area	"Natural" Surfaces	Buildout non WW		UnAtten N Load	Atten %	Atten N Load
E Waquoit Bay	**2615**	**205**	**1981**	**2910**	**3959**	**1413**	**500**		**13582**		**9837**
Quashnet River	2561	205	993	2419	2254	996	266		9693		6231
Upper Quashnet River	2561	205	888	2366	2040	943	204		9206		5743
Moody Pond (MP)	125	0	6	184	35	44	8	44%	403	50%	201
Turner Road Well No. 5	0	0	0	2	0	10	5		18		18
Mashpee Well No. 1	0	0	0	20	0	4	0		25		25
Johns Pond Summary (JPS)	1208	0	164	1375	1562	270	54	67%	4634	50%	1943
Johns Pond (JP)	1314	0	189	1412	1499	207	53		4674		4674
Snake Pond (SNP)	3	0	2	1	73	10	1	21%	89	50%	45
Moody Pond (MP)	156	0	7	231	44	55	10	56%	503	50%	252
Weeks Pond (WP)	69	0	5	8	86	9	3	70%	178	50%	77
Ashumet Pond (AP)	248	0	40	387	614	120	14	65%	1423	50%	711
Removed from AP watershed by J Well											
MMR J Well	486	0	48	47	0	30	10				
Weeks Pond (WP)	30	0	2	3	37	4	1	30%	66	50%	33
Middle Quashnet River	0	0	42	44	122	45	35		288		288
Lower Quashnet River	0	0	63	9	92	8	27		199		199
Hamblin Pond/Red Brook	1	0	319	278	635	217	182		1632		1350
Red Brook	0	0	165	157	0	146	96		564	50%	282
Lower Red Brook	0	0	45	37	20	20	26		148		148
Hamblin Pond	0	0	73	57	558	44	54		785		785
Little River	1	0	37	26	57	7	6		134		134
Jehu Pond/Great River	53	0	368	178	723	139	43		1505		1505
Great River	0	0	16	21	202	81	8		327		327
Jehu Pond	53	0	239	72	246	39	19		668		668
Lower Great River	0	0	113	85	275	20	17		509		509
Sage Lot/Flat Pond	0	0	300	35	346	61	8		751		751
Flat Pond	0	0	278	17	174	34	2		504		504
Flat / Sage Lot Ponds Transition	0	0	22	19	0	12	7		59		59
Sage Lot Pond	0	0	0	0	172	16	0		188		188

TABLE 5-11

NITROGEN LOADS
POPPONESSET BAY – SCENARIO 5

*All values in kilograms/year	*Popponesset Bay Subwatershed N Loads by Input:*							% of Pond Outflow	***Buildout N Loads***		
Scenario 5	**From Septic**	**From WWTF**	**Lawn Fertilizers**	**Impervious Surfaces**	**Water Body Surface Area**	**"Natural" Surfaces**	**Buildout non WW**		**UnAtten N Load**	**Atten %**	**Atten N Load**
Popponesset Bay System	**8142**	**4184**	**3765**	**2668**	**7584**	**1971**	**678**		**28896**		**17715**
Mashpee River	4432	4184	1458	1411	4238	1153	362		17142		8738
Upper Mashpee River	4345	4184	1206	1016	3996	941	291		15884	30%	7480
Mashpee-Wakeby Pond (MWP)	4173	458	676	513	3989	503	181	100%	10397	50%	4558
Direct to MWP	3450	0	421	321	3212	307	125		7835		
Snake Pond (SNP)	0	0	3	2	121	17	3	34%	50	50%	25
Pimlico Pond (PIP)	329	0	90	63	74	42	32	100%	630	50%	315
Peters Pond (PEP)	394	458	163	126	582	138	21	100%	1882	50%	941
Lower Mashpee River	87	0	251	395	242	212	71		1258		1258
Shoestring Bay	2456	0	1978	986	1379	636	251		7687		4910
Santuit River	2277	0	1075	675	564	440	118		5149	30%	2373
Cotuit Well No. 5	0	0	33	16	0	11	7		66		66
Quaker Run	0	0	405	99	0	82	15		601		601
Quaker Run Wells	0	0	37	23	0	18	8		85		85
Santuit Pond (SAP)	2938	0	429	326	758	216	62	100%	4729	50%	2364
Ockway Bay	49	0	103	90	399	83	26		750		750
GW Flow to Popponesset Bay	1205	0	226	180	1568	98	39		3316		3316
Pinquickset Cove	198	0	19	10	106	40	10		382		382
Popponesset Creek	473	0	171	146	0	31	22		843		843
Popponesset Bay	534	0	36	24	1462	28	6		2091		2091

Figures



*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)

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F1-1_ppa.mxd

Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

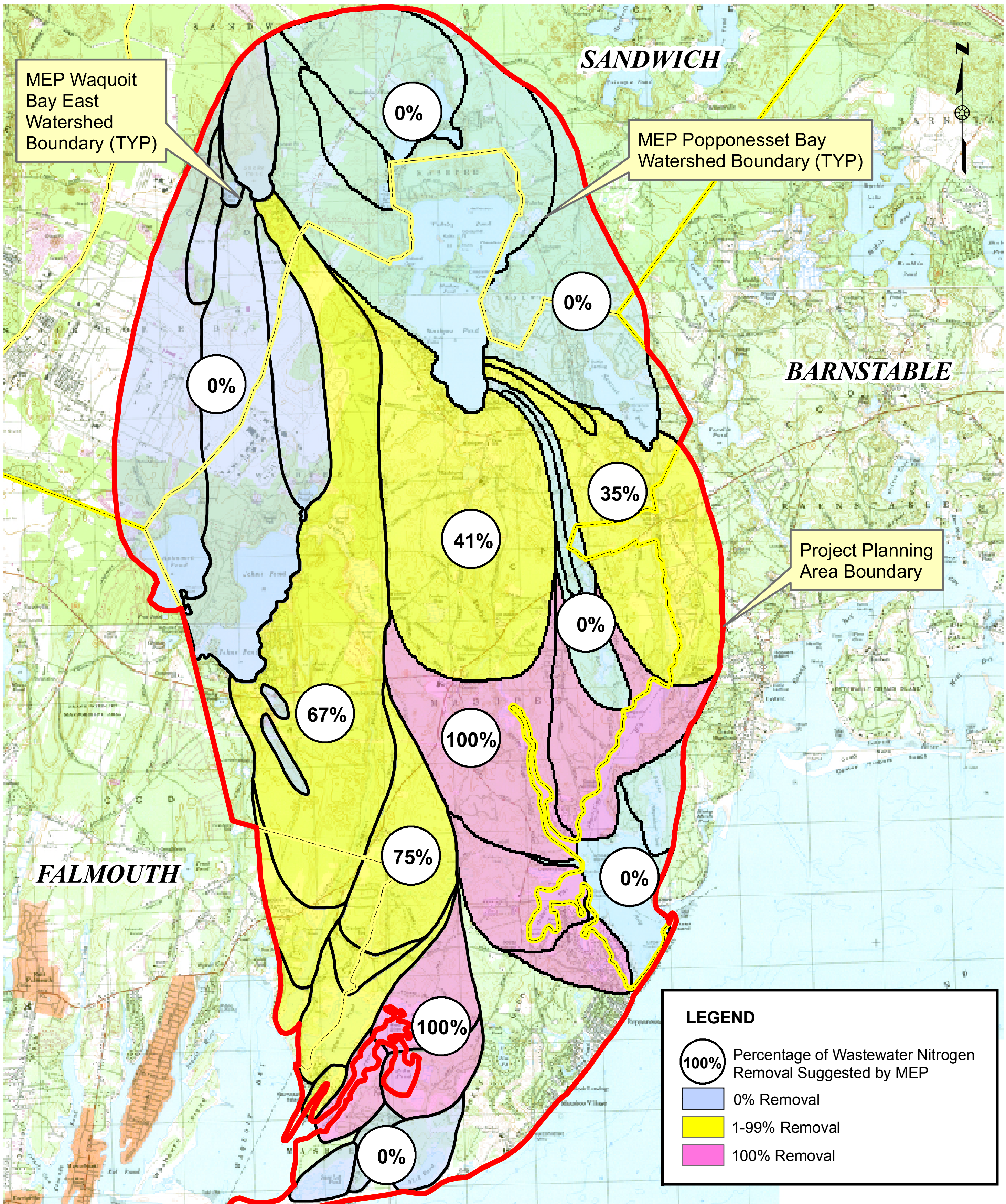
Date: 11/2007 Project No. 00074

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

PROJECT PLANNING AREA

FIGURE 1-1



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

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F1-2 MEP%removal.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

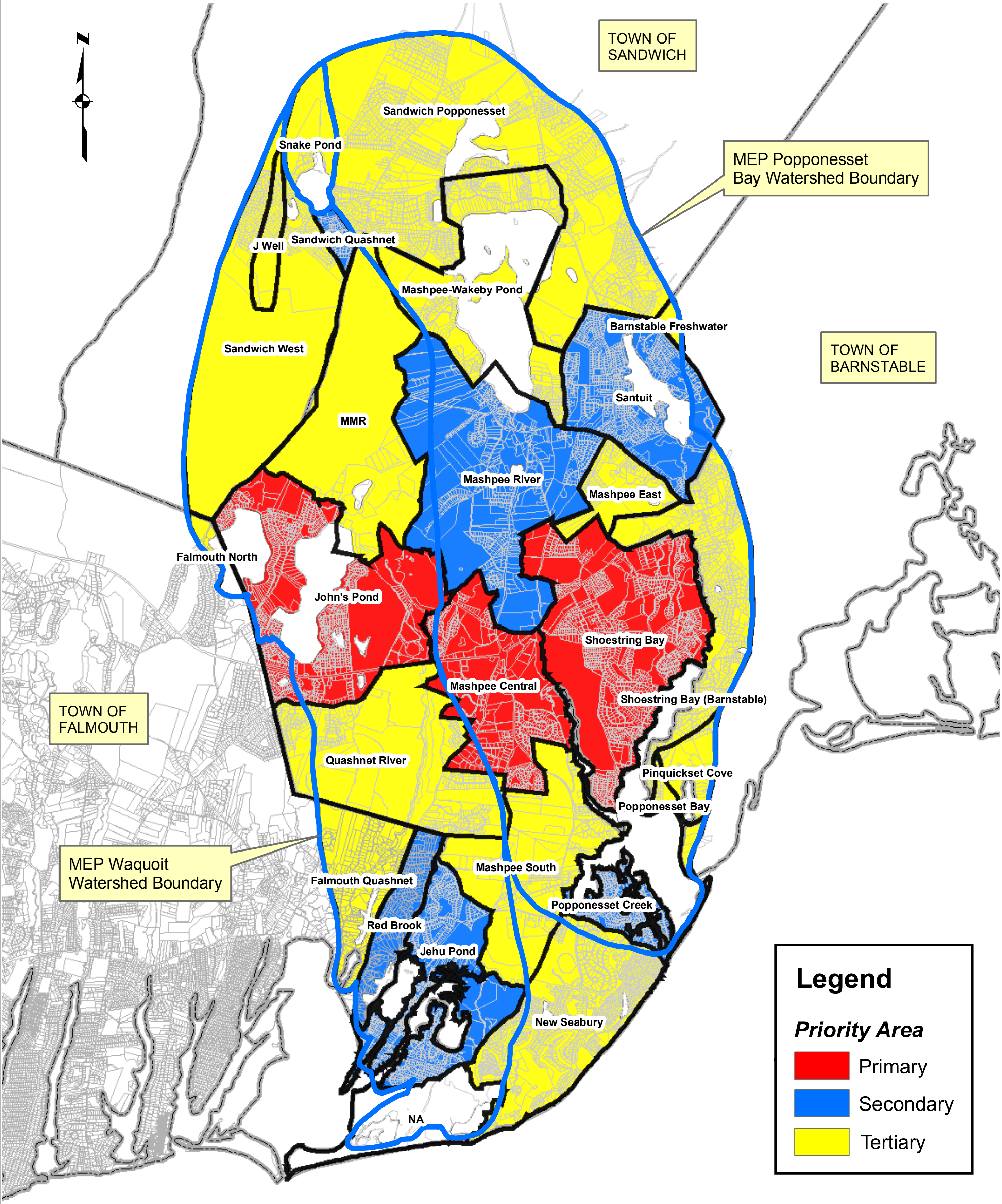
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MEP Percent Removals

FIGURE 1-2



Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F1-3_priority_areas.mxd

Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

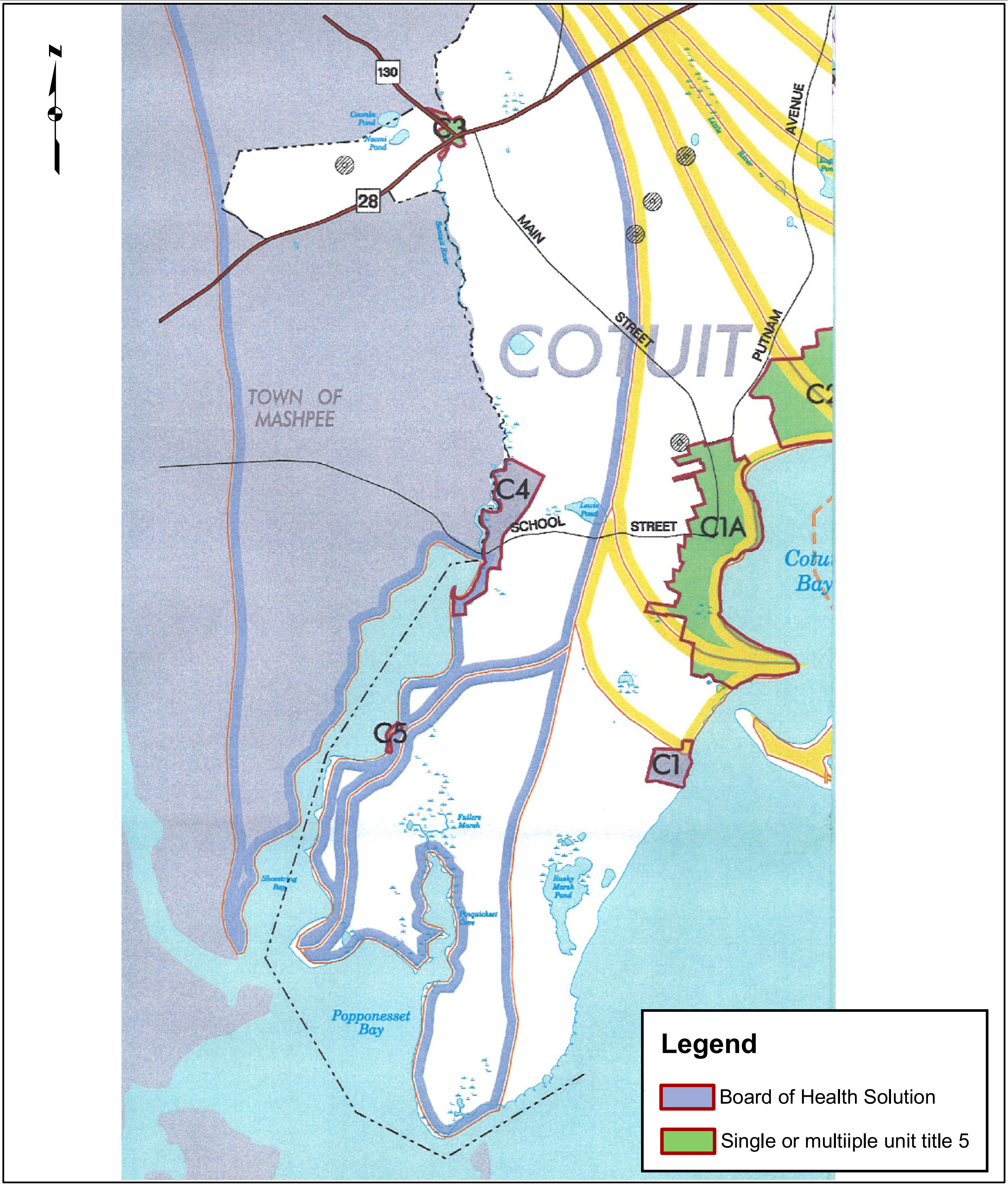
Date: 11/2007 Project No. 00074

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

PRIORITY AREAS

FIGURE 1-3



Data Source: Barnstable WW Facilities Plan Figure 3-1

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F1-4_AOCs.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

Date: 1/2008

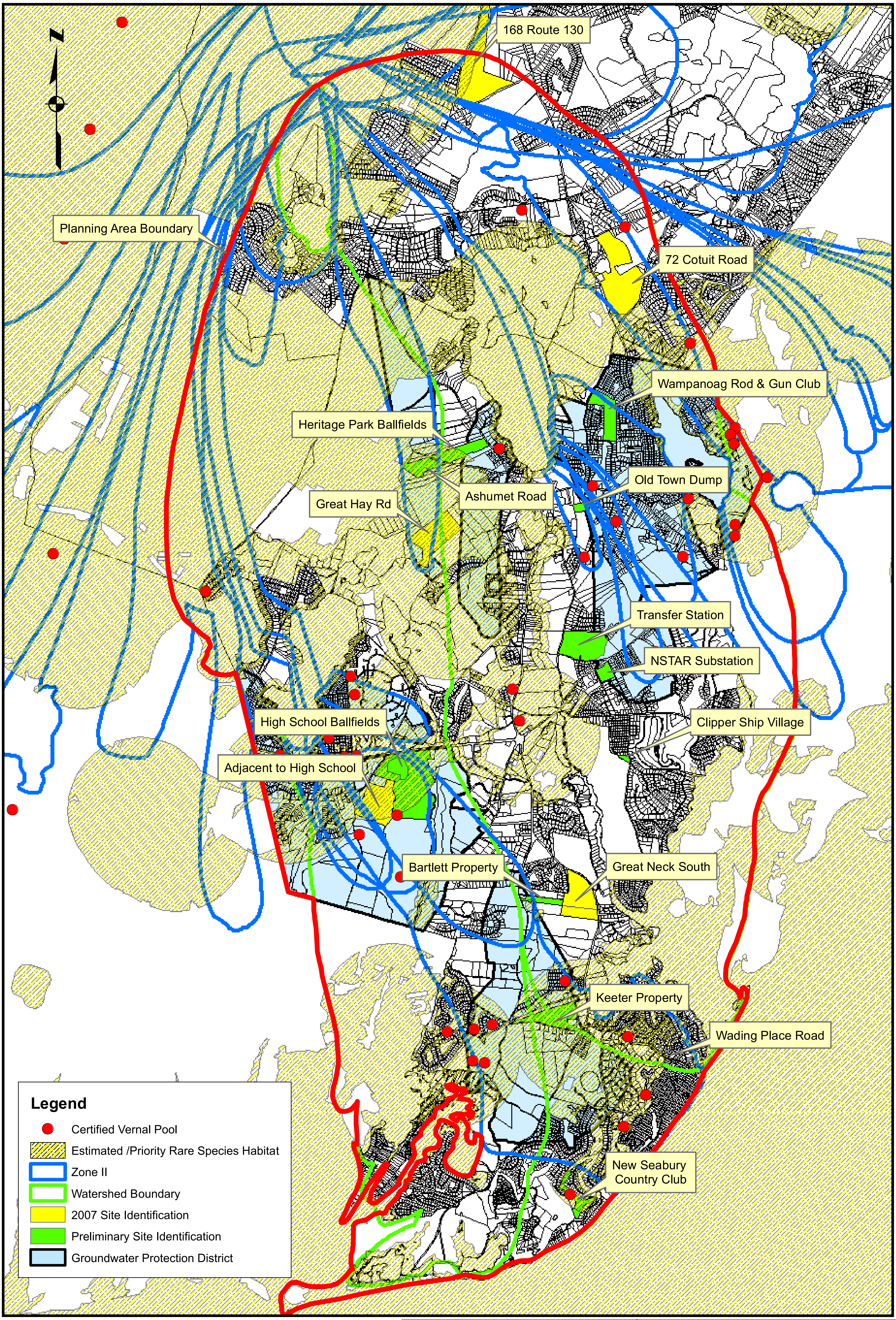
Project No: 00074

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

Barnstable Areas of Concern

FIGURE 1-4



Data Source: Town of Mashpee/MassGIS

0 0.45 0.9 1.8 Miles

1 inch = 4000 feet

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F02-1.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

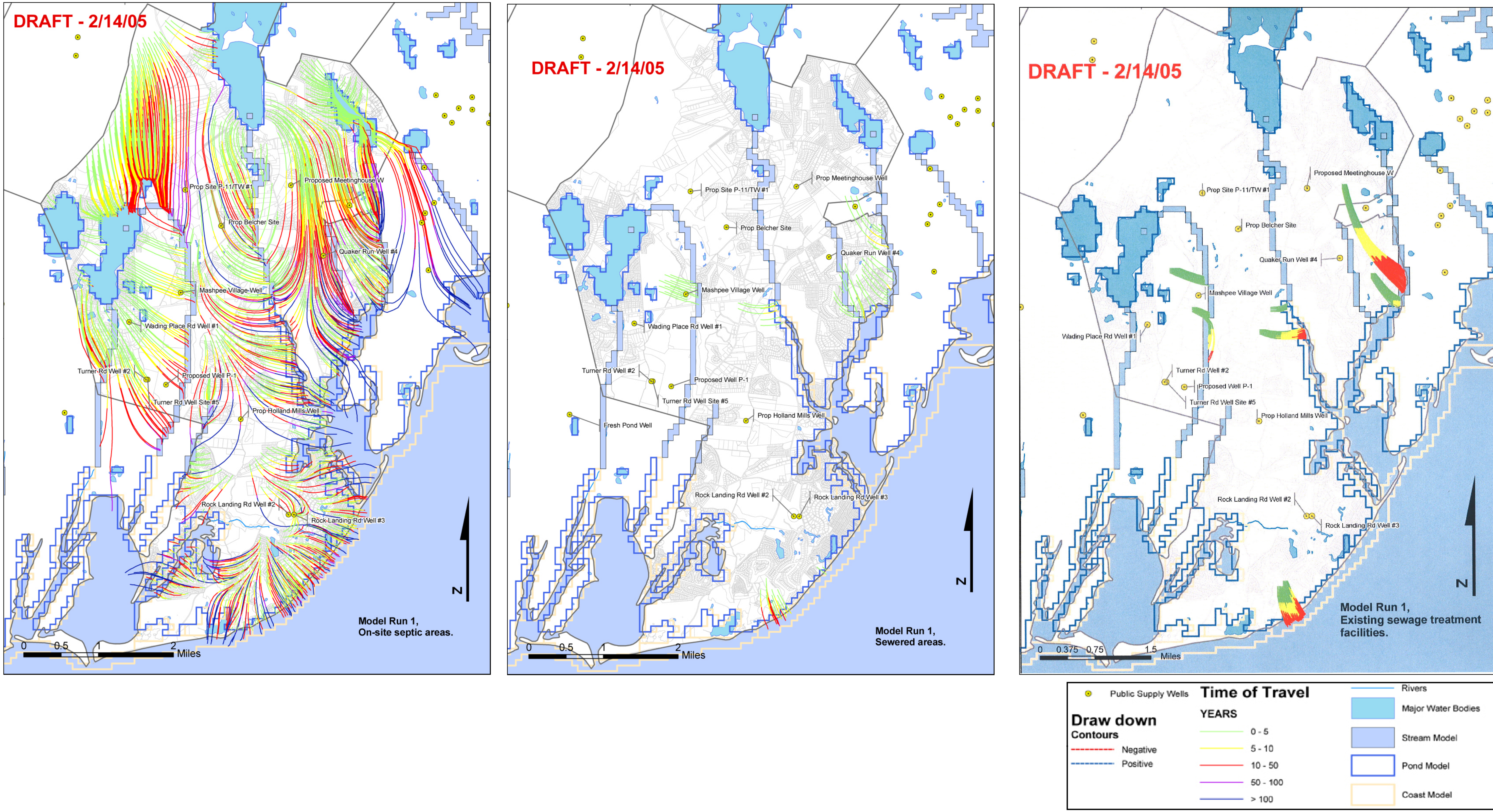
DATE: 01/08/08 PROJECT: 00074

MASHPEE SEWER COMMISSION

WNMP - Alternative Scenarios Report

POTENTIAL EFFLUENT RECHARGE SITES

FIGURE 2-1



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\.00074F2-2_M1.MXD

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

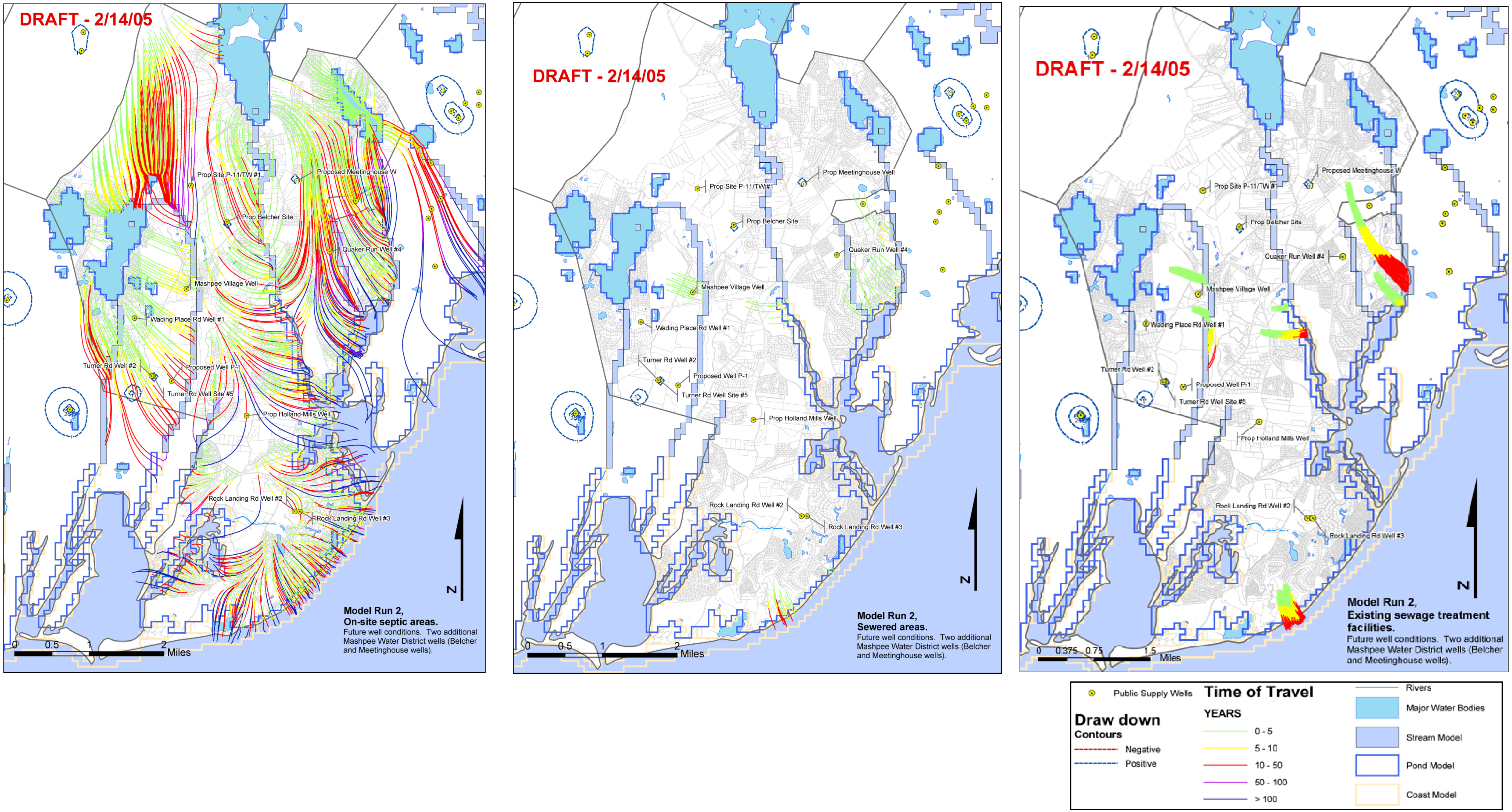
Date: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 1

FIGURE 2-2



Data Source: USGS

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

Date: 01/08/08

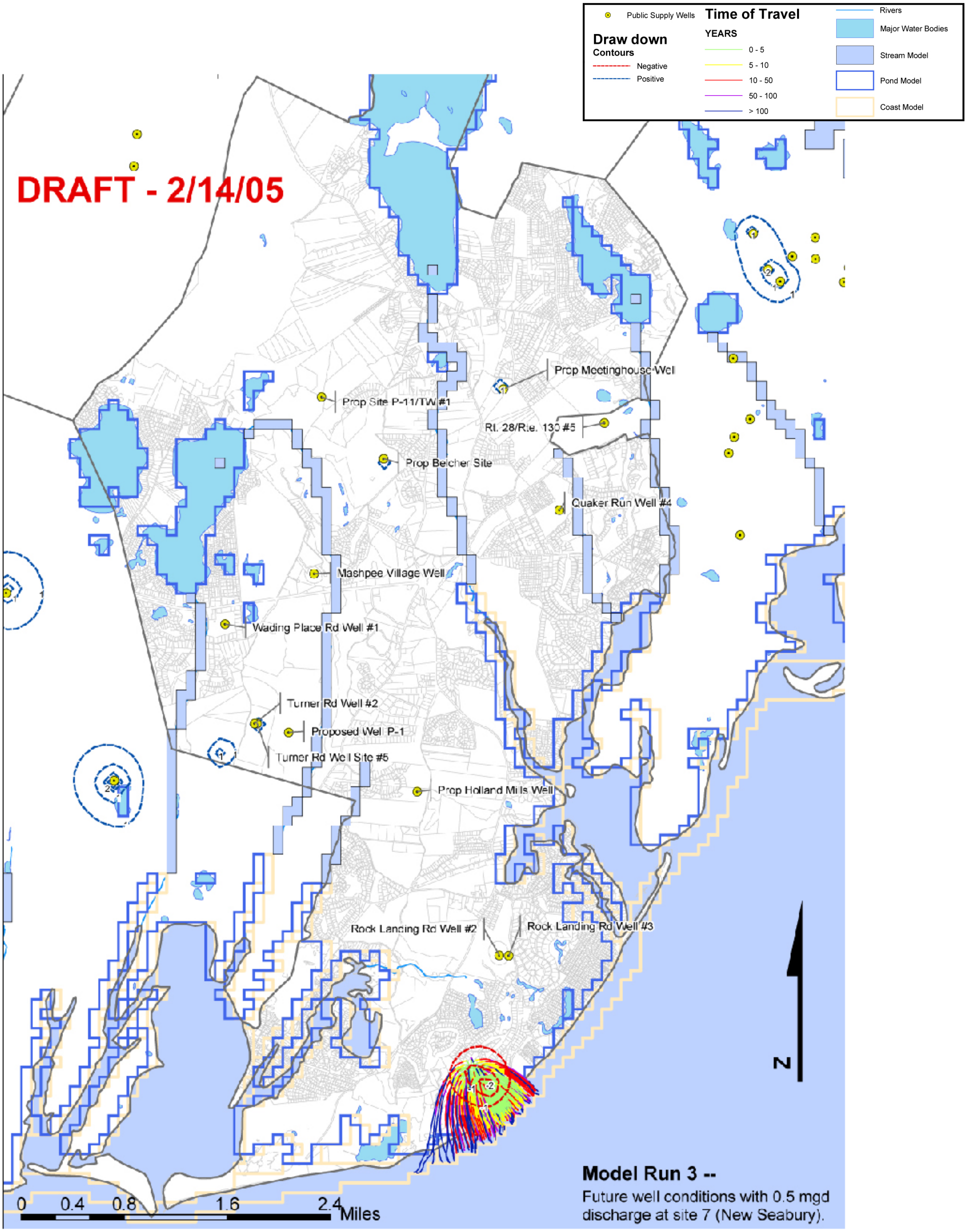
MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 2

FIGURE 2-3

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-3.mxd



Model Run 3 --
Future well conditions with 0.5 mgd discharge at site 7 (New Seabury).

Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\0007F42-4.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

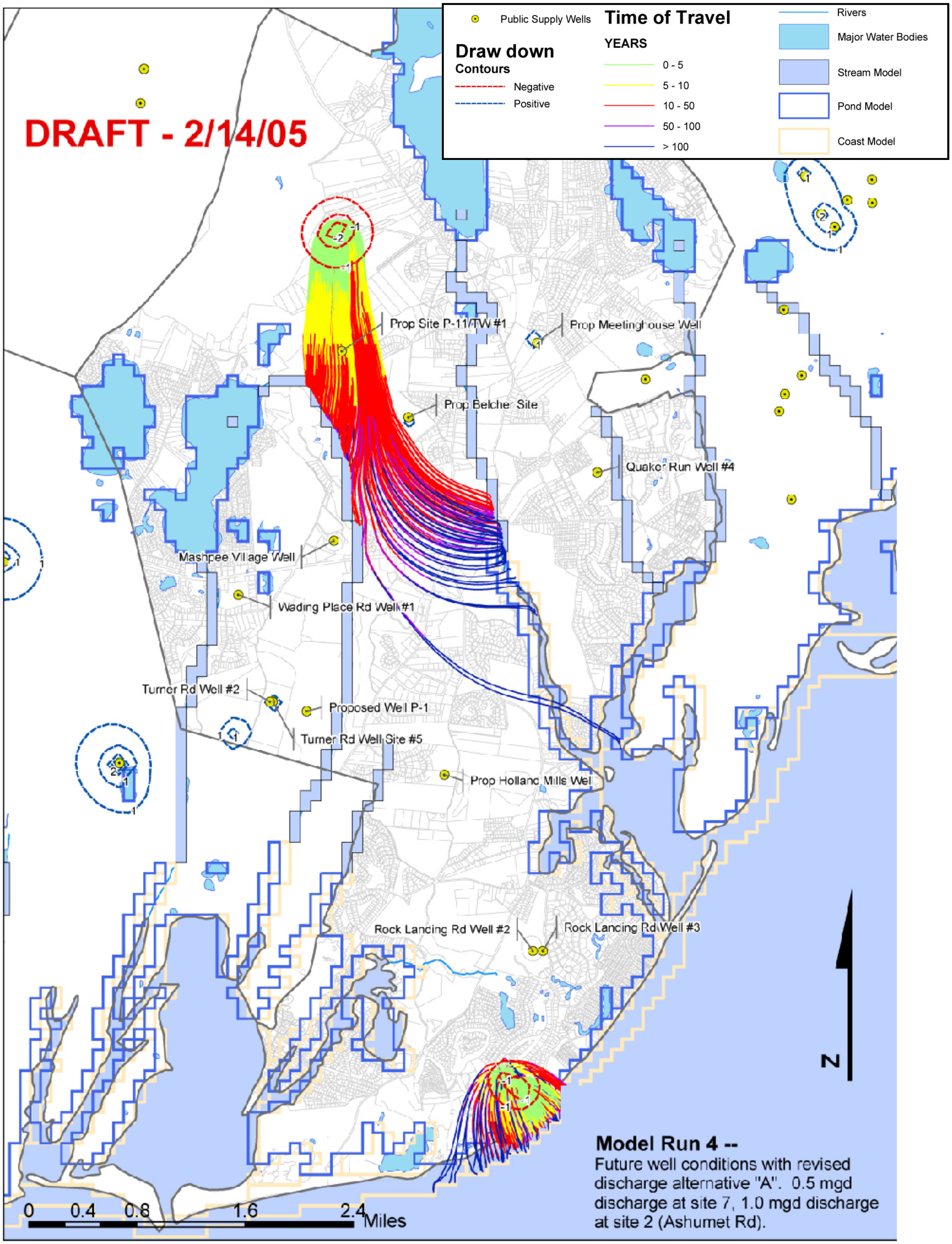
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 3

FIGURE 2-4



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-5.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

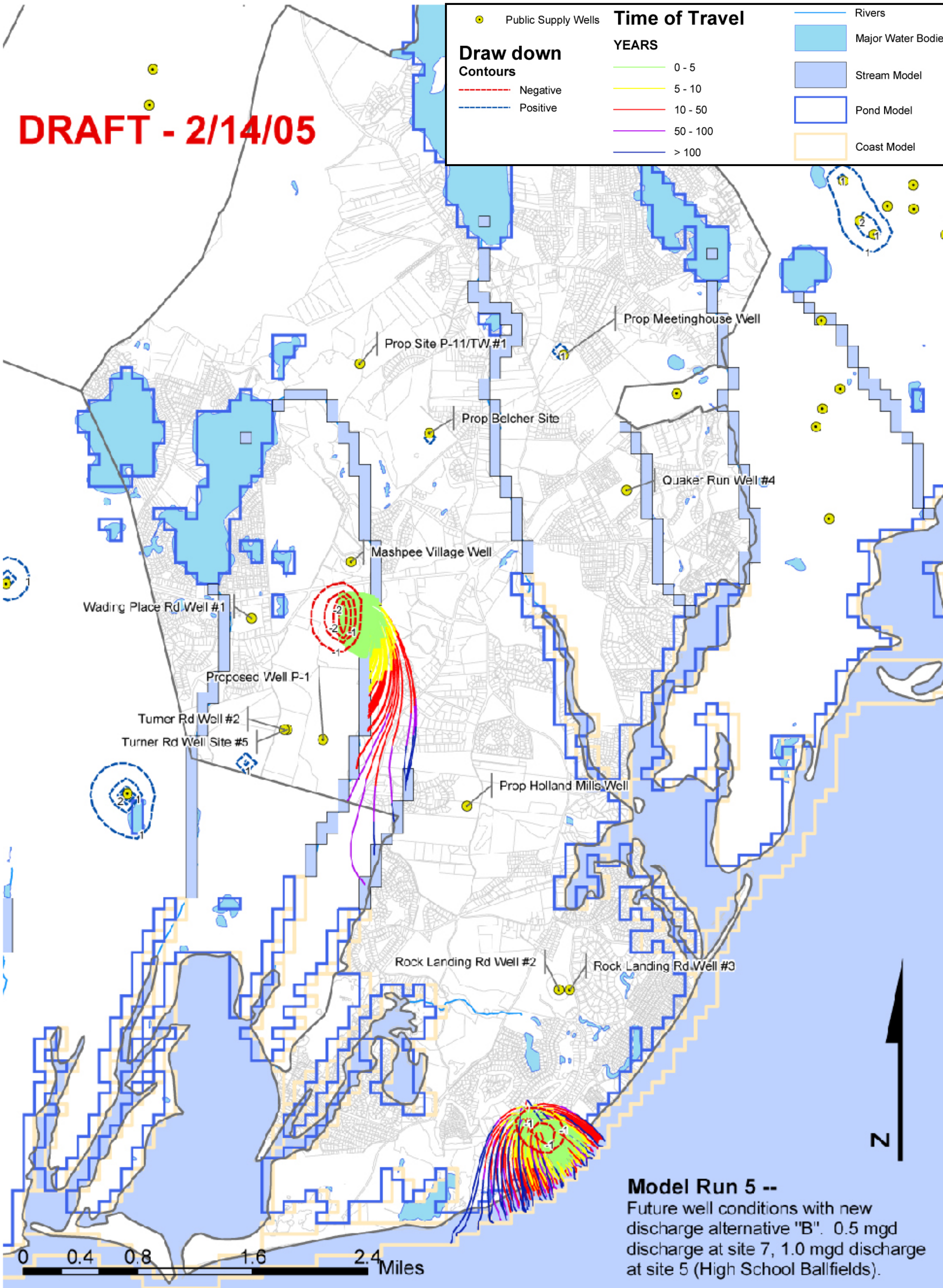
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 4

FIGURE 2-5



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-6.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

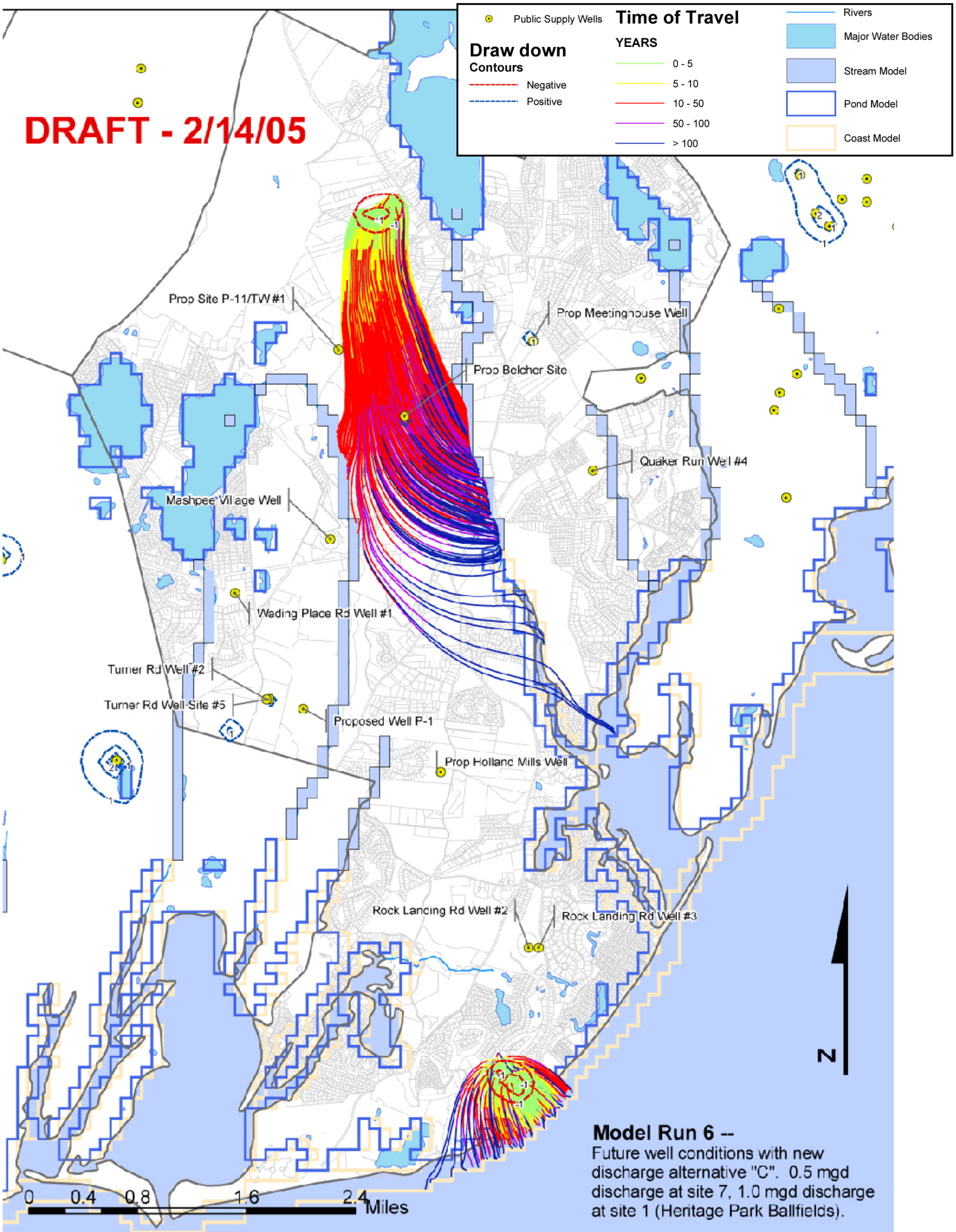
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 5

FIGURE 2-6



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-7.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

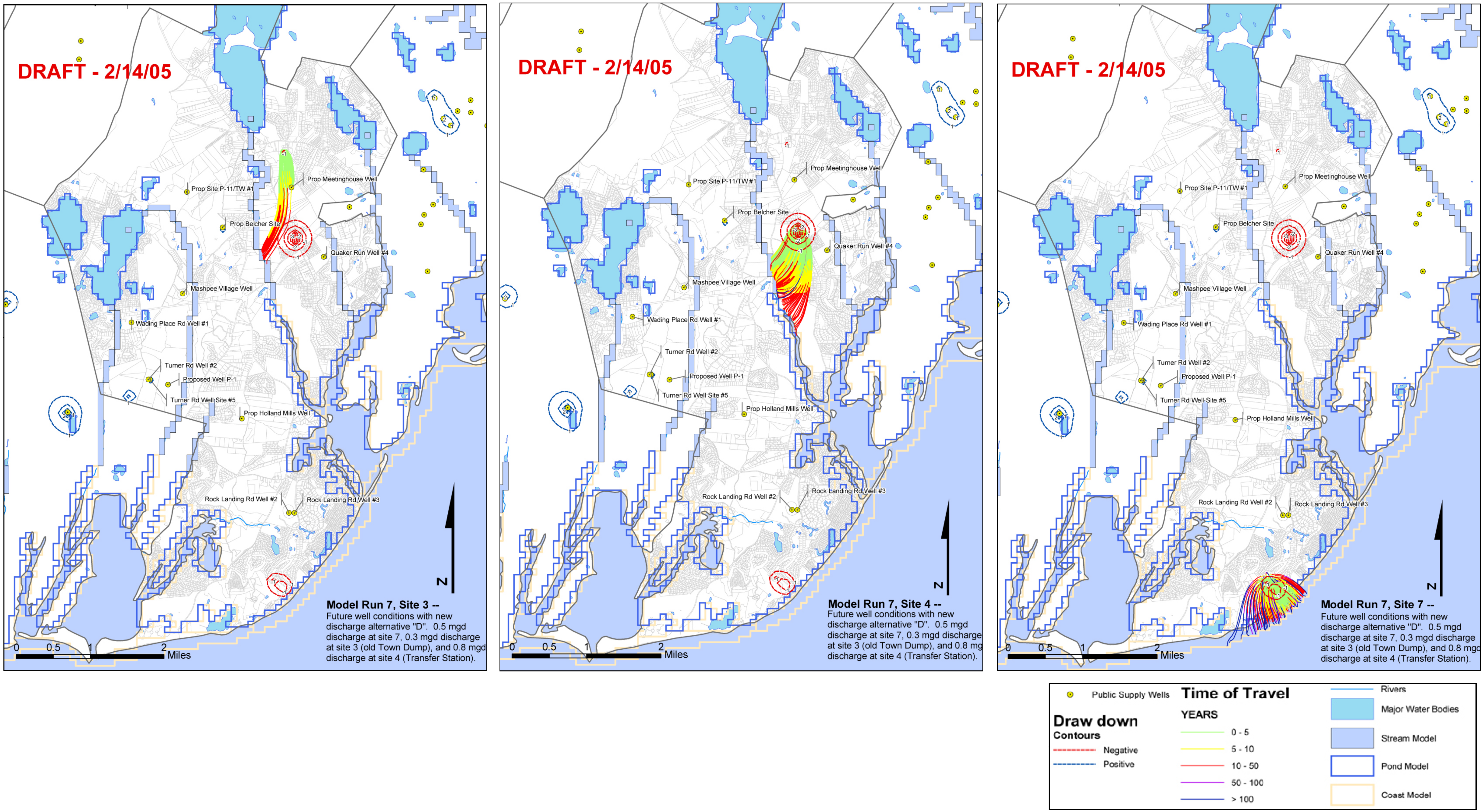
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 6

FIGURE 2-7



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-8.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists

HYANNIS, MASSACHUSETTS

Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

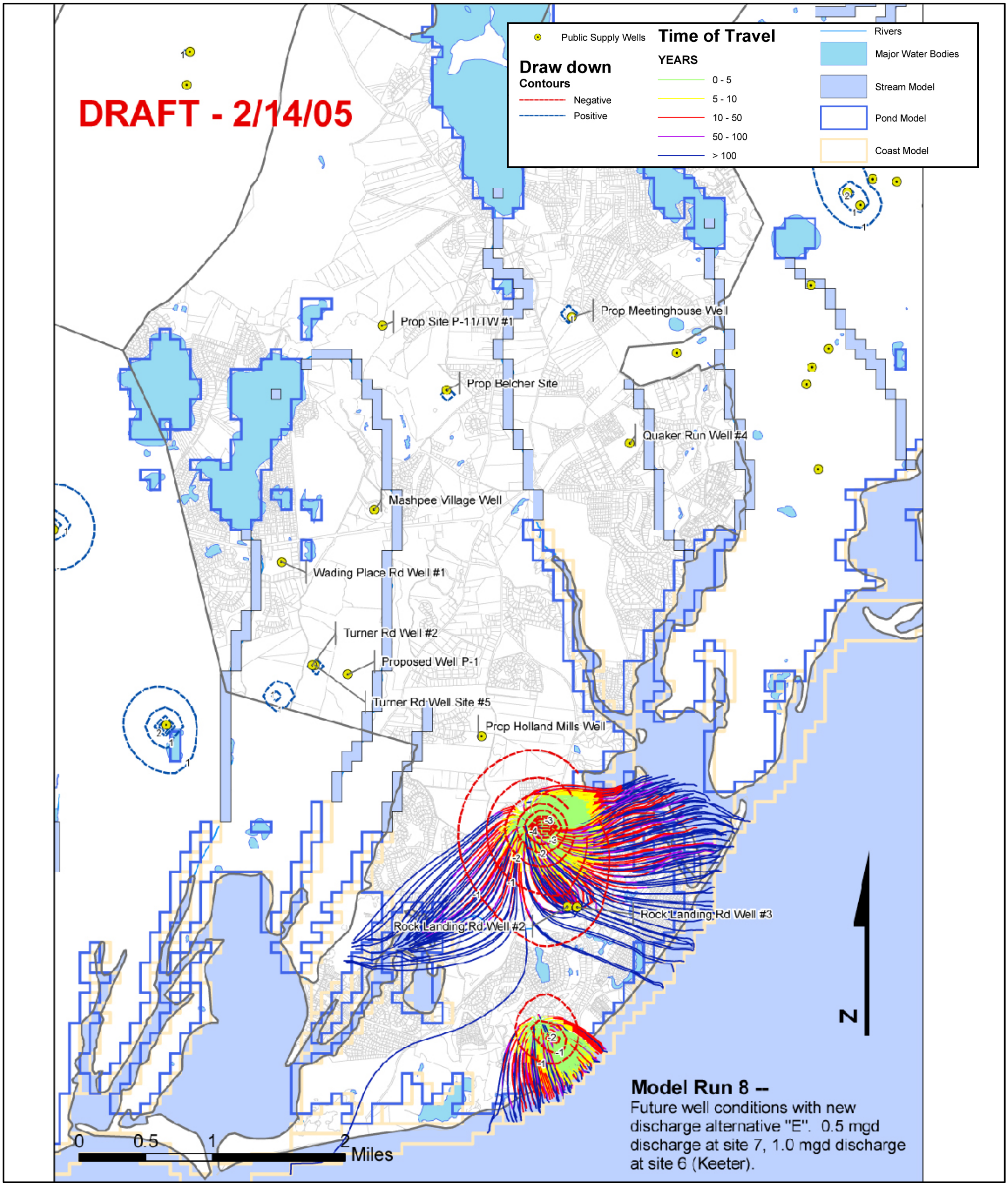
Date: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 7

FIGURE 2-8



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-9.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

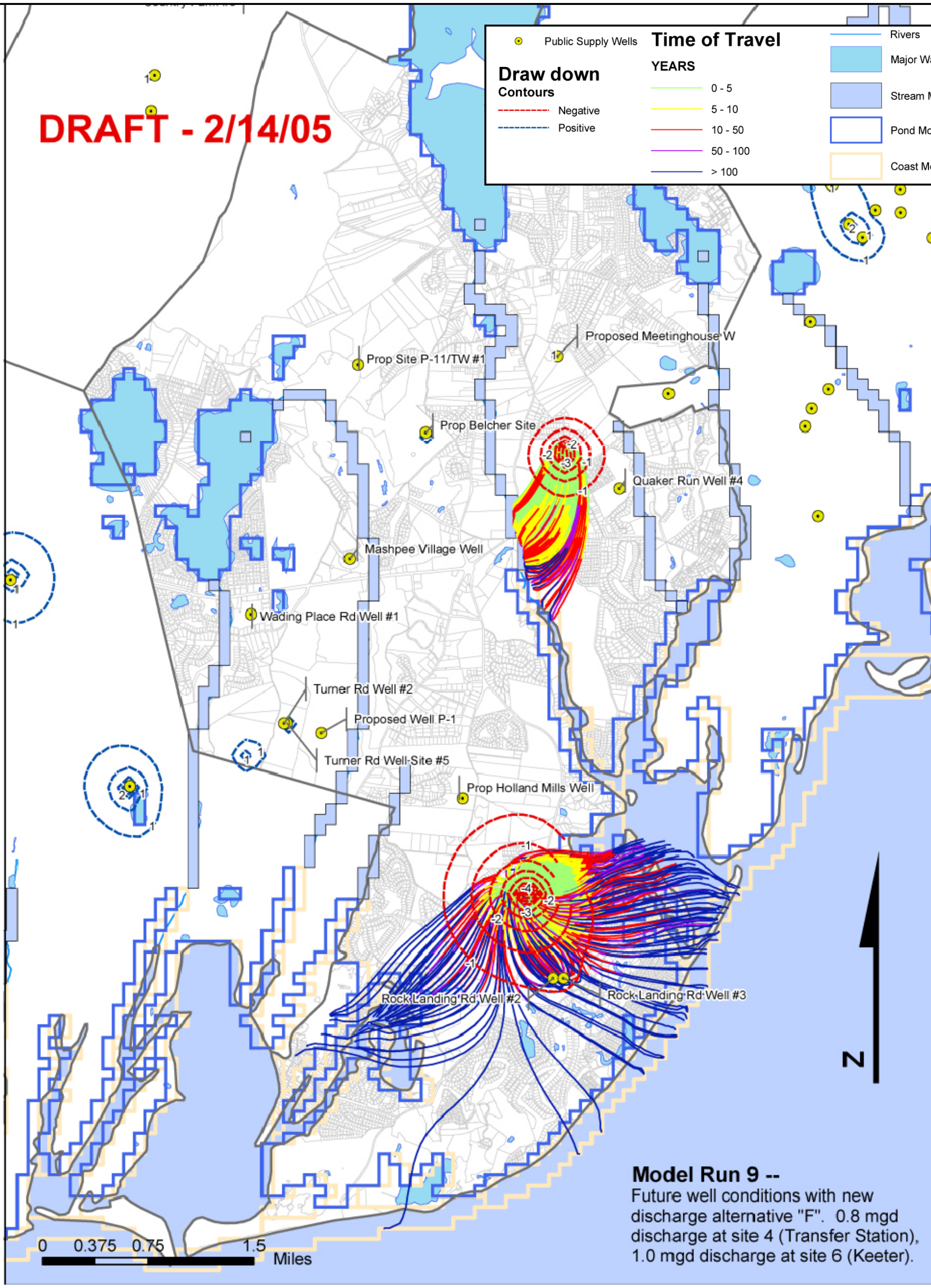
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 8

FIGURE 2-9



Model Run 9 --
Future well conditions with new discharge alternative "F". 0.8 mgd discharge at site 4 (Transfer Station), 1.0 mgd discharge at site 6 (Keeter).

Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-10.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

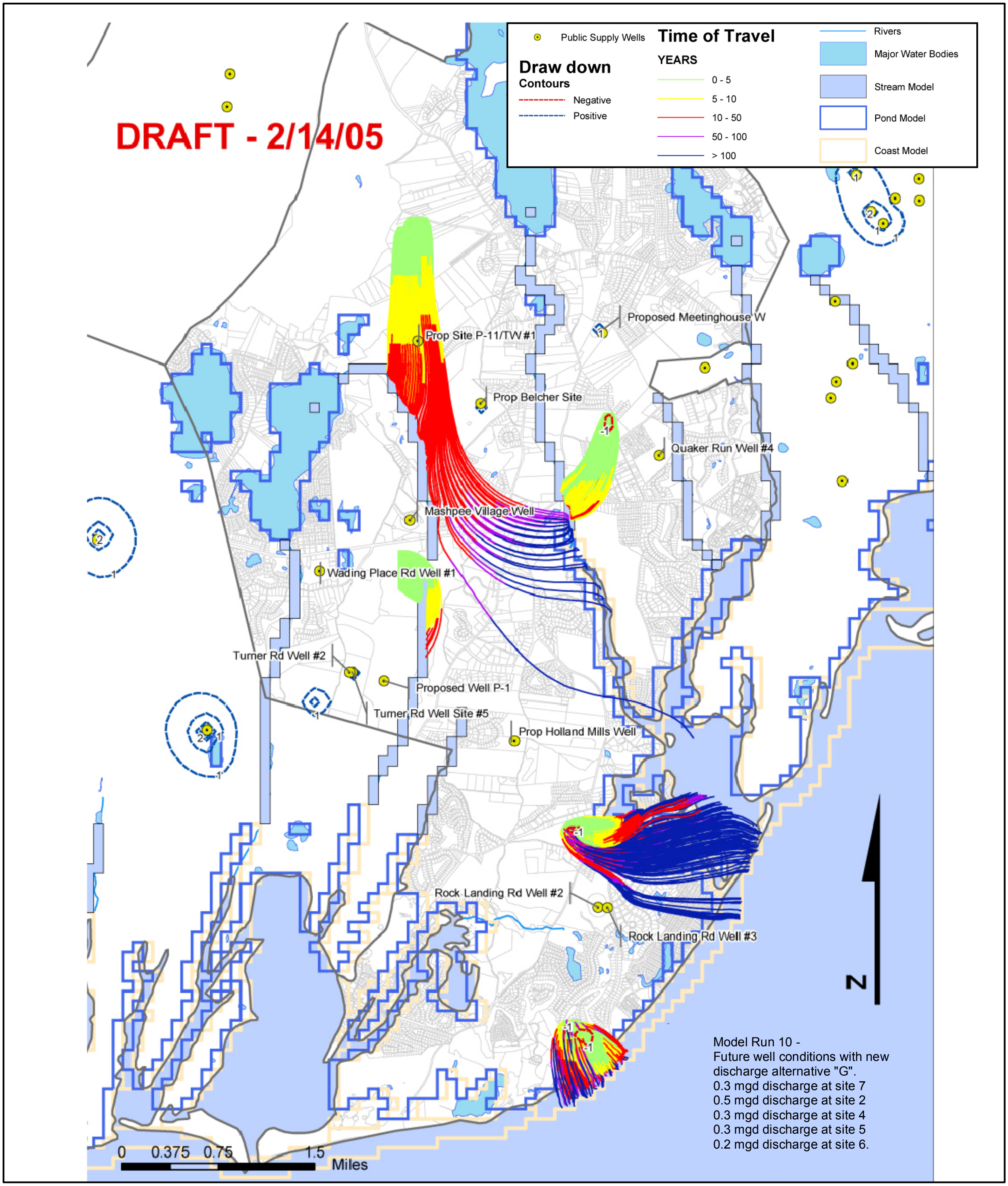
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 9

FIGURE 2-10



Data Source: USGS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-11.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists

HYANNIS, MASSACHUSETTS

Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

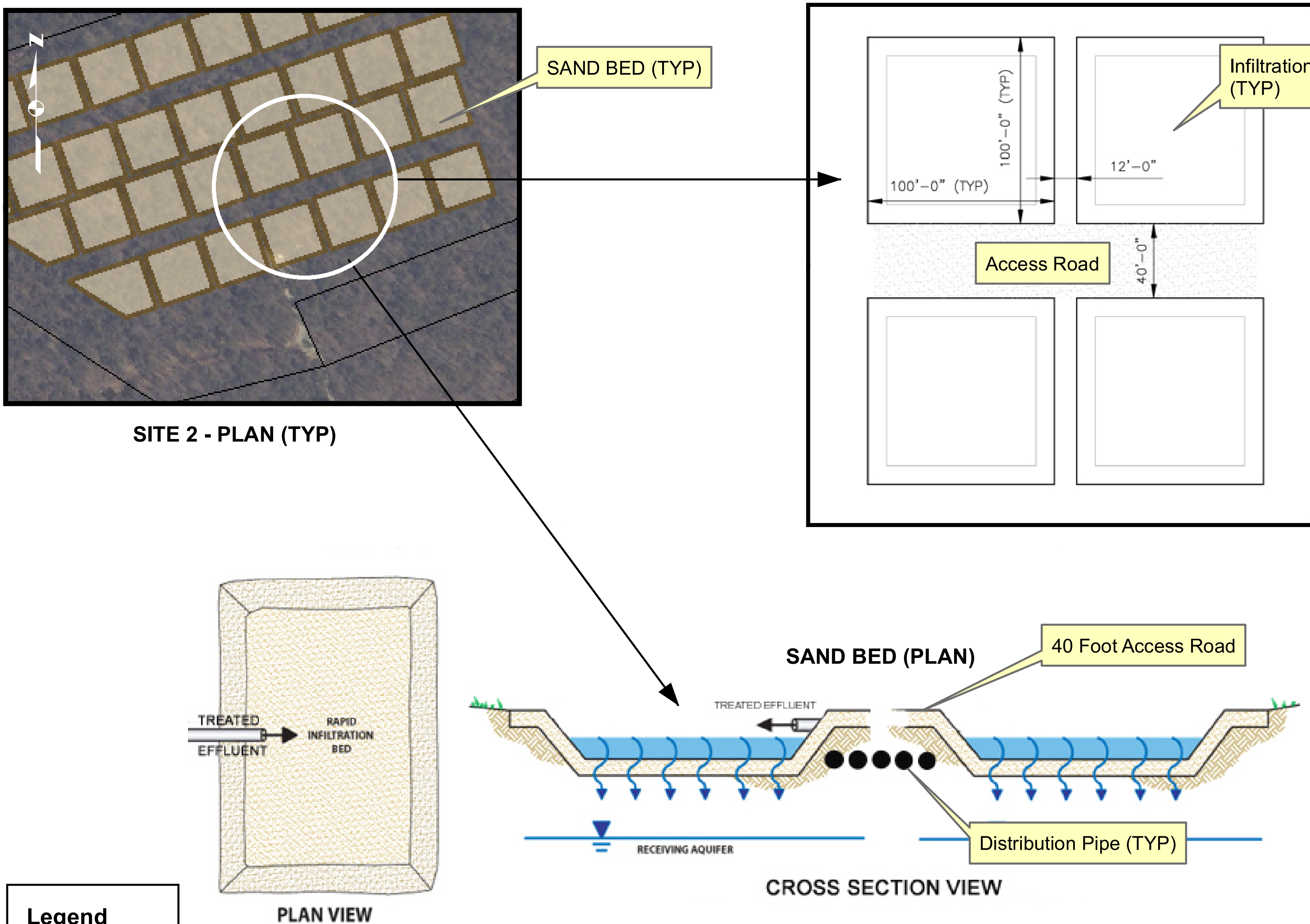
DATE: 01/08/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

MODEL RUN 10

FIGURE 2-11



Legend

Sand Bed

Data Source: Mass GIS/Town of Mashpee GIS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-12.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

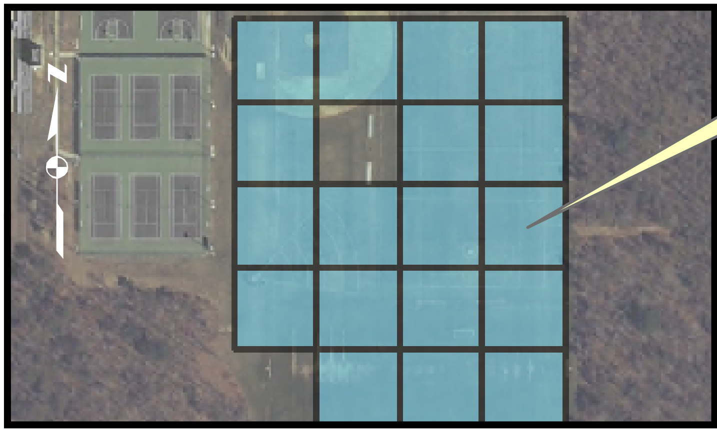
DATE: 1/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

TYPICAL SAND BED LAYOUT

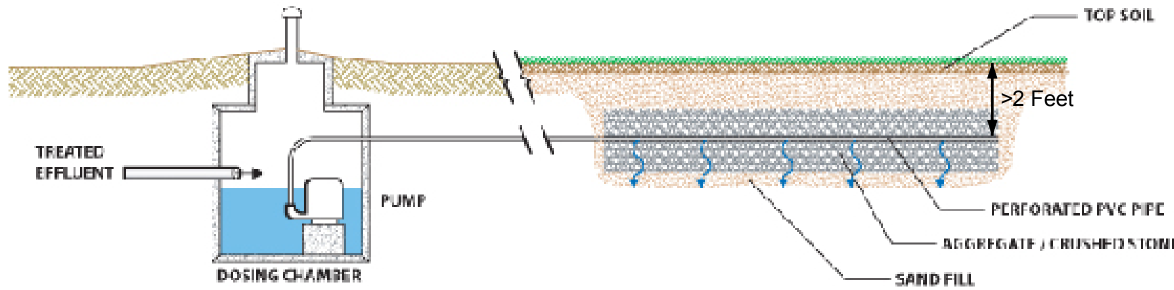
FIGURE 2-12

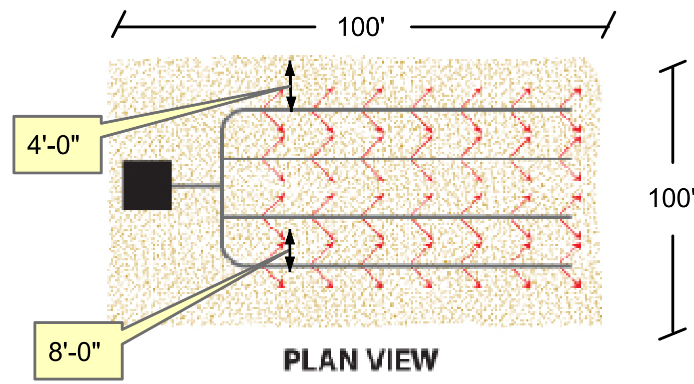


SITE 5 - PLAN (TYP)

SUBSURFACE INFILTRATION (PRESSURE DOSING)

CROSS SECTION VIEW





PLAN VIEW

Legend

Subsurface Infiltration

Data Source: Mass GIS/Town of Mashpee GIS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-13_infil_beds.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

DATE: 1/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

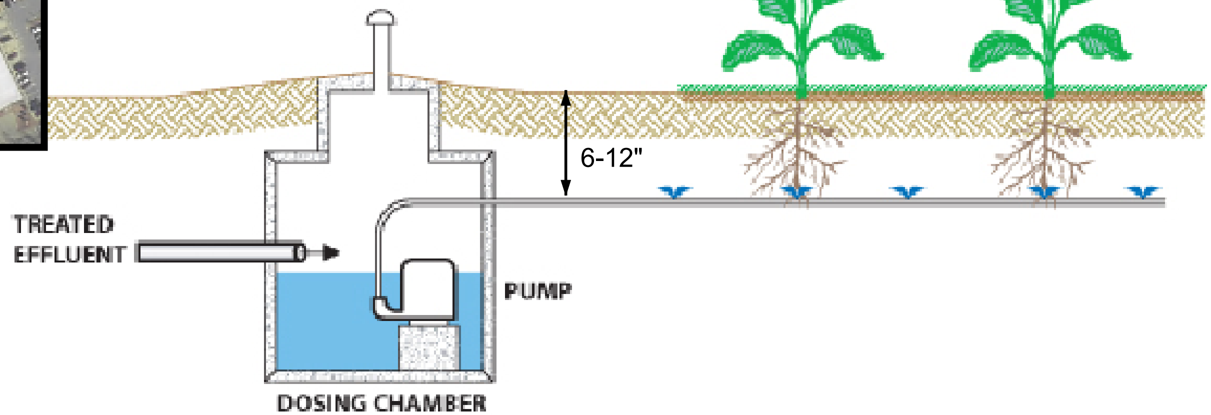
TYPICAL SUB SURFACE INFILTRATION LAYOUT

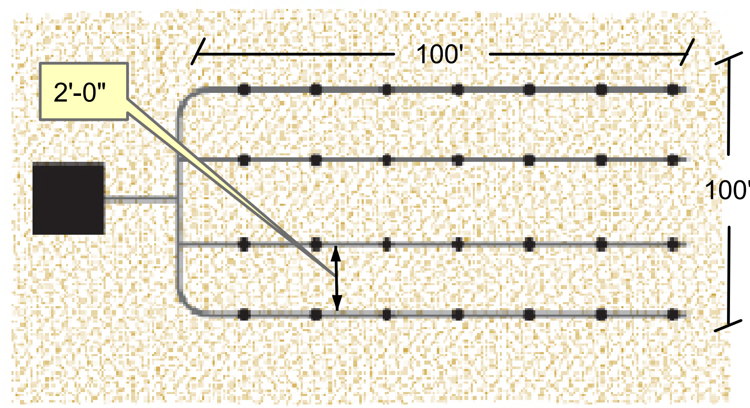
FIGURE 2-13

DRIP SYSTEM IRRIGATION

SITE 1- PLAN

CROSS SECTION VII





PLAN VIEW

Legend

Subsurface Infiltration

Data Source: Mass GIS/Town of Mashpee GIS

File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-14.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

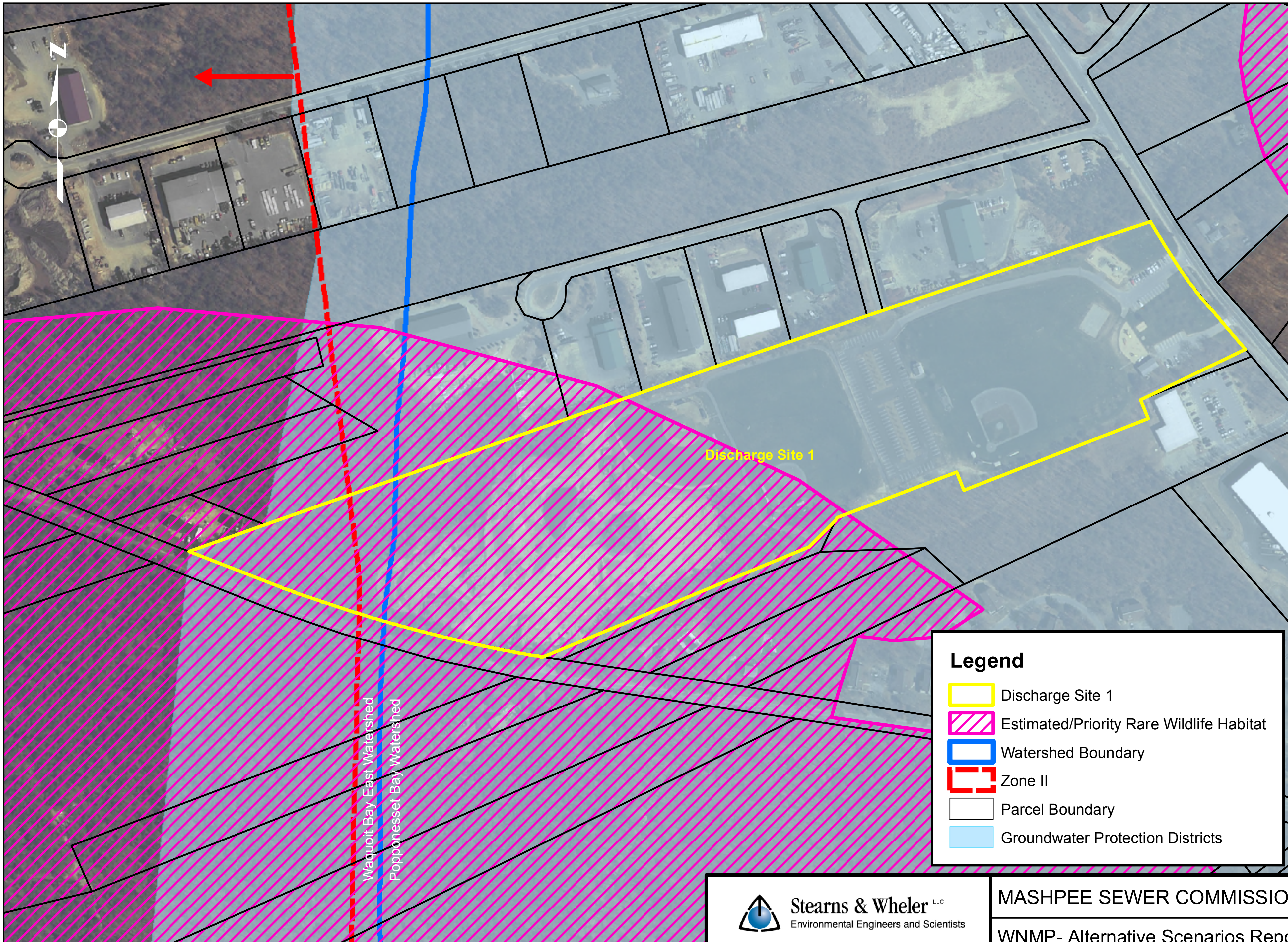
DATE: 1/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

TYPICAL DRIP SYSTEM IRRIGATION

FIGURE 2-14



Data Source: Barnstable WW Facilities Plan Figure 3-1
File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-15.mxd

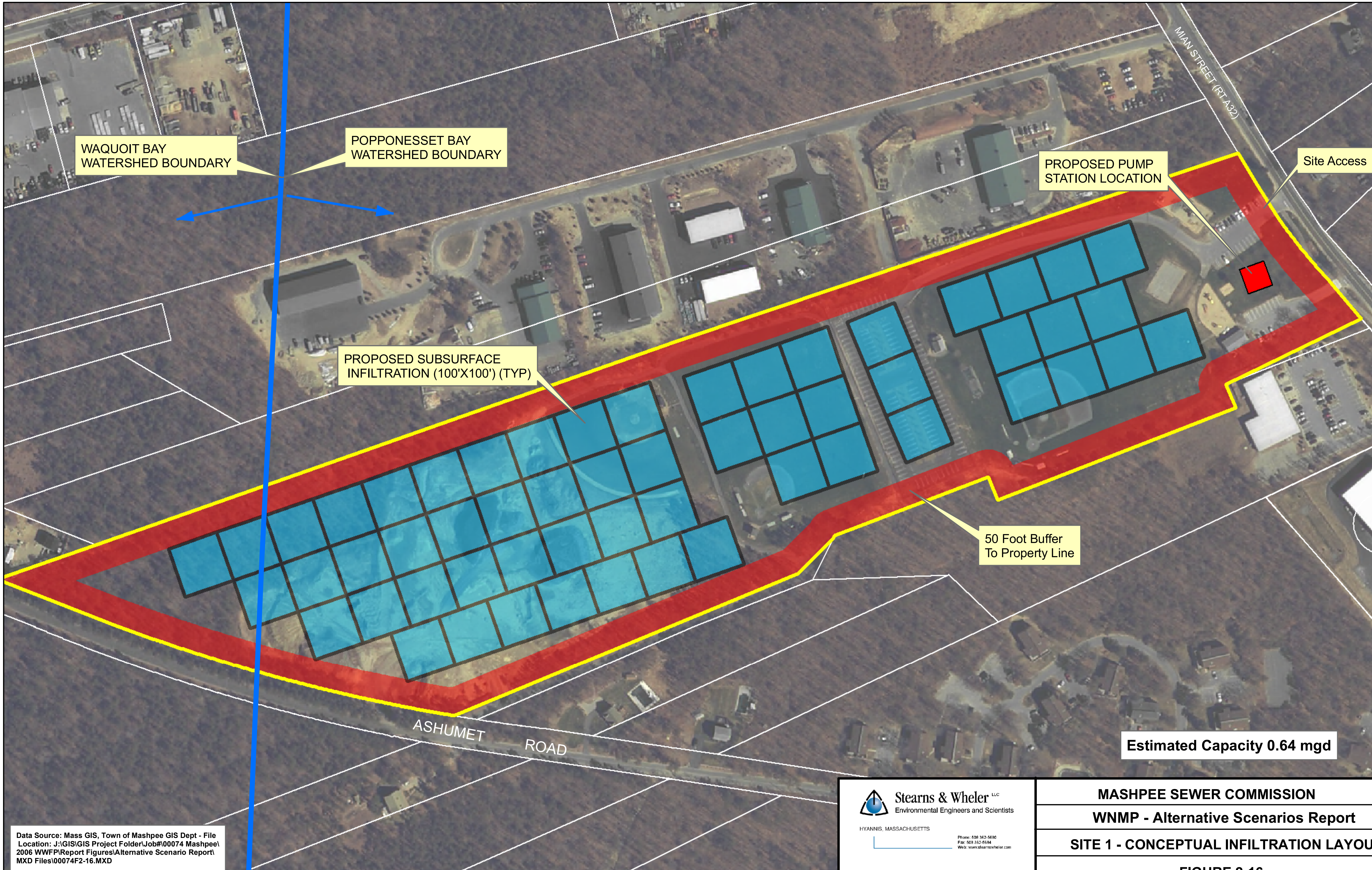
Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com

DATE: 1/08

MASHPEE SEWER COMMISSION

WNMP- Alternative Scenarios Report

Figure 2-15
Site 1 - Heritage Park Ballfields



Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS

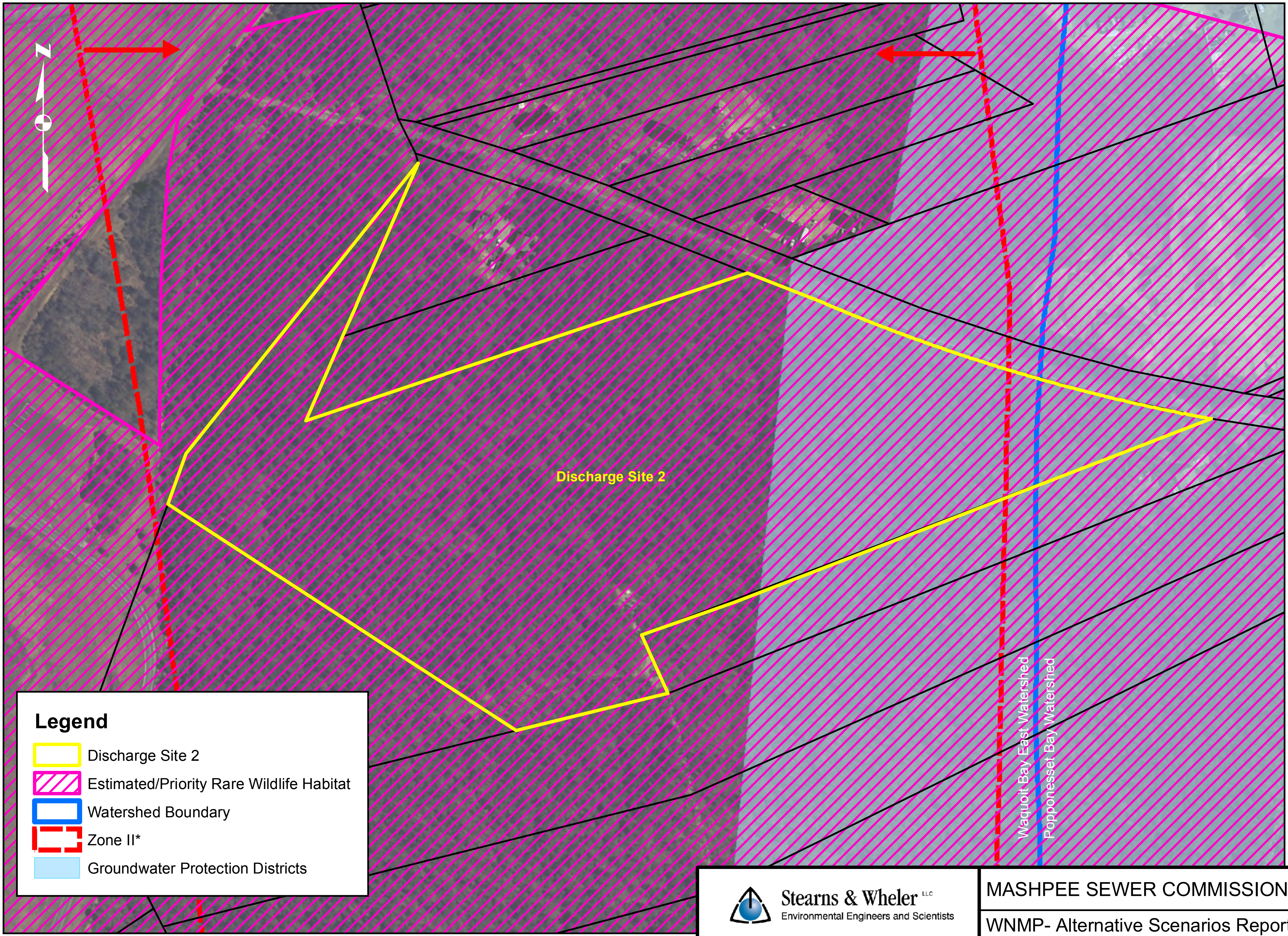
Date: 12/20/2007 Project No. 00074

MASHPEE SEWER COMMISSION

WNMP - Alternative Scenarios Report

SITE 1 - CONCEPTUAL INFILTRATION LAYOUT

FIGURE 2-16



Data Source: Mass GIS/Town of Mashpee GIS
File Location: J:\GIS\GIS Project Folder\Job#\00074 Mashpee\2006 WWFP\Report Figures\Alternative Scenario Report\MXD Files\00074F2-17.mxd

Stearns & Wheler LLC
Environmental Engineers and Scientists
HYANNIS, MASSACHUSETTS
Phone: 508 362-5680
Fax: 508 362-5684
Web: www.stearnswheler.com
DATE: 1/08

MASHPEE SEWER COMMISSION
WNMP- Alternative Scenarios Report
Site 2 - Ashumet Road
Figure 2-17